

LOWER PASSAIC RIVER RESTORATION PROJECT

REPORT OF PEER REVIEW OF CONCEPTUAL SITE MODEL

Prepared by

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February 2013



The summary and consideration of the peer review comments on the draft Comprehensive Conceptual Site Model as documented in this report were largely completed in 2008 and 2009. The report was finalized by The Louis Berger Group, Inc. in February 2013 (the date listed on the document) and formatted for publication in February 2014. The biographies of the peer reviewers provided in Section 2.0 of this report represent their experience, qualifications and affiliations at the time the peer review was conducted in the spring and summer of 2008.

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1.0 INTRODUCTION

In May 2008, Malcolm Pirnie presented a draft Comprehensive Conceptual Site Model (CSM) for the Lower Passaic River Restoration Project to six peer reviewers, chosen as experts in their fields. The CSM is an important decision-making tool in the U.S. Environmental Protection Agency's (EPA's) evaluation of a Source Control Action on the sediments of the lower eight miles of the Passaic River. The CSM developed a comprehensive model of the fate and transport of contaminants into and out of the sediments of the Lower Passaic River estuary from an extensive database of historical and recent data. The report analyzed sediment, water column and biota data from within the Lower Passaic River, as well as in sources of contaminants coming from tributaries, combined sewer overflows/storm water outfalls (CSO/SWOs), and the interconnected water bodies of Newark Bay and the Upper Passaic River. The CSM included a simultaneous Empirical Mass Balance (EMB) of solids and chemicals, along with an associated single-layer box model used to predict future sediment concentrations for a number of contaminants of potential concern (COPC) under various remediation options being evaluated for the Source Control Action.

EPA is evaluating taking a Source Control Action on the sediments of the lower eight miles of the Passaic River while a full Remedial Investigation/Feasibility Study (RI/FS) of the 17-mile, tidal portion of the Passaic River is on-going in the long term. A Focused Feasibility Study (FFS) is being developed to document that evaluation, including a risk assessment, detailed description of remedial alternatives and this Comprehensive CSM, once it is revised in accordance with peer review comments.

The reviewers were charged to comment on the CSM report and its conclusions to clarify any uncertainties or technical limitations in the draft report, so that the CSM report could

be revised to reflect sound technical information and analysis for use in EPA's Source Control Action evaluation. The peer reviewers were not expected to review the FFS or any other documents associated with the Source Control Action, although such documents were available publicly on the project web site, www.ourPassaic.org.

The review was structured as a "letter peer review" in accordance with the 2006 EPA Peer Review Handbook (EPA/100/B-06/002), which means that the panel members performed their review and provided their written comments separately, without physically convening. However, the reviewers were provided contact information for each of the panel members and encouraged to collaborate as desired by telephone and e-mail. The CSM report was delivered to the peer reviewers on May 31, 2008 and was accompanied by a set of charge questions for the reviewers to answer (presented in Section 3.0). Malcolm Pirnie convened an orientation conference call on June 4, 2008 to introduce the report and clarify the charge to the peer reviewers. During this call, the peer reviewers requested that Malcolm Pirnie provide them with the spreadsheets used to develop the EMB and the forecast trajectories. The spreadsheets were sent on June 11, 2008.

On June 18, 2008, Malcolm Pirnie convened a midpoint conference call with all of the reviewers, EPA and the U.S. Army Corps of Engineers (USACE) to follow up on progress and discuss any early issues. The peer reviewers' comment reports were due by June 27, 2008, and all comment reports were received by July 1, 2008, with a few supplemental comments received through July 7, 2008.

On July 9, 2008, Malcolm Pirnie convened a final conference call with the peer reviewers, EPA, USACE and consultants representing the New Jersey Department of Environmental Protection (NJDEP). The purpose of this call was to address conflicting comments submitted by the reviewers and to discuss recommendations on a path forward for EPA.

This report contains the peer reviewer's comments (Attachment A) and a compilation of the comments by topic, with responses (Attachment B). Chapter 2 below identifies the

peer reviewers and their fields of expertise, while Chapter 3 presents the charge to the peer reviewers at the start of their work. Chapter 4 summarizes several key issues distilled from the written comments and addressed in the final call. Chapter 5 describes several broad conclusions discussed during the summation of the peer review final call and Chapter 6 summarizes the actions that EPA has taken to address those conclusions.

2.0 PEER REVIEWERS

The six reviewers are listed in this section along with a short biography outlining their experience and background as applicable to the CSM.

Richard Bopp is an Associate Professor in the Department of Earth and Environmental Sciences at Rensselaer Polytechnic Institute. His educational background includes training in geological sciences and chemistry from Columbia University and the Massachusetts Institute of Technology. His areas of research include the analysis of persistent contaminants of concern in the Lower Passaic River and the dating of sediment cores using the analysis of radionuclides to determine contaminant level chronologies in water systems. Dr. Bopp has done extensive research in the Lower Passaic River, Dundee Lake and other nearby rivers, bays and estuaries. He served on the New York-New Jersey Harbor Estuary Contaminant Assessment and Reduction Program (CARP) Model Evaluation Group (MEG) and on the Lower Passaic River Restoration Project's Technical Advisory Committee (TAC). However, he was not involved in the day-to-day work of developing the May 2008 CSM and thus was not prohibited from performing this peer review, in accordance with the EPA Peer Review Handbook.

Bruce Brownawell is an Associate Professor at State University of New York at Stony Brook. His educational background is in Chemistry and Oceanography, and he holds degrees from DePaul University and the Massachusetts Institute of Technology. Dr. Brownawell's research has included sediment transport study and modeling, as well as studies of persistent chemicals in marine or estuarine environments. He served on the

CARP MEG and on this project's TAC. However, he was not involved in the day-to-day work of developing the May 2008 CSM and thus was able to perform this peer review.

Jonathan Butcher is a professional hydrologist working as an Assistant Director and Principal Engineer in Tetra Tech's Research Triangle Park, NC office. He holds degrees from Harvard College and Duke University in Water Resources and Civil and Environmental Engineering. Dr. Butcher is experienced in the use of estuarine hydrodynamic, hydrologic and water quality models. He previously served on this project's TAC, but was not involved in the day-to-day work of developing the May 2008 CSM and thus was able to perform this peer review.

Erik Christensen is the Civil Engineering Chair and a Professor at the University of Wisconsin, Milwaukee. He holds degrees in Electrical Engineering and Environmental Engineering from the Technical University of Denmark and the University of California. Dr. Christensen has done research in the areas of source apportionment of environmental pollutants and radiometric dating of sediments. He has published peer-reviewed literature regarding the use of a chemical mass balance (CMB) approach, which was used in the development of the mass balance model presented in the CSM.

Dominic Di Toro is the Edward C. Davis Professor of Civil and Environmental Engineering at the University of Delaware. His educational background is in Electrical Engineering and Civil and Geological Engineering and includes degrees from Manhattan College and Princeton University. His research interests include water quality modeling and sediment quality criteria models, organic chemical and metal sorption models and statistical models. In addition to his academic pursuits, Dr. Di Toro was a Principal Consultant to Hydroqual, Inc. until 2007 and was involved in the development of the CARP model.

Wilbert Lick is a professor of Mechanical and Environmental Engineering at the University of California at Santa Barbara. His education includes degrees in Aeronautical Engineering from Rensselaer Polytechnic Institute. Dr. Lick's expertise and research interests center on environmental fate and transport of contaminants in surface water and

groundwater, numerical methods and mathematical modeling. He is one of the developers of the sediment transport model, SEDZLJ, being adapted for use in the Lower Passaic River Restoration Project and has previously served on this project's TAC. However, he was not involved in the day-to-day work of developing the May 2008 CSM and thus was able to perform this peer review.

3.0 CHARGE QUESTIONS

A set of twelve charge questions in four broad categories was provided to the reviewers that identified the technical and scientific issues on which EPA wanted feedback. The questions are reproduced here.

Adequacy and Use of Data

1. Are the data used in the CSM adequate to support its conclusions? In addition to a general assessment, please comment on the following specific issues with regard to the adequacy of the current data set:
 - Are the sediment sample results collected in the lower eight miles used appropriately in characterizing the contaminant inventory and gradients in three dimensions for the purposes of the CSM and EMB?
 - Are the results of the high resolution cores collected above Dundee Dam sufficient to represent background loading levels for the system?
 - Are there sufficiently robust data of appropriate kinds to characterize the contaminant loads that enter the lower eight miles of the river from external sources, i.e., from tributaries, from combined sewer outfalls (CSOs) and storm water outfalls (SWOs), from in-stream sediments above RM8 and from Newark Bay?

- Are the available data adequate to verify that there are no important on-going, unquantified sources?
2. Is the use of the contaminant data associated with recently deposited, beryllium-7 (Be-7) bearing, surface sediment in the CSM-EMB sufficiently explained? For example, most reviewers of CSM documents readily understand that contaminant data from the upper 6-inches of sediment are used to evaluate exposure to biota and therefore to assess ecological risk. Is our description of the utility of data from Be-7 bearing sediments, intended to characterize material that was just recently transported through the water column and deposited on the sediment surface, similarly clear in its implications for assessing fate and transport?

Explanation of Assumptions and Uncertainties

3. Is sufficient attention given to quantifying and evaluating the impacts of uncertainties in developing the CSM-EMB, particularly with respect to the ability to use these tools in evaluating potentially large and very costly remedial alternatives? Are the magnitudes of the uncertainties associated with the data supporting the EMB predictions sufficiently bounded? Are the uncertainties associated with predicted post-remedial surface sediment concentrations and estimates of contaminated sediment transport into the lower eight miles from above RM 8 and from other external sources adequately described?
4. Since the use of a deterministic model (a model where outputs are described using mechanistic descriptions of the processes occurring in the system of interest) may be more common in a physically complex surface water body such as this partially stratified estuary, has the use of a receptor model, such as the EMB (where concentrations measured at sources and receptors are used to identify the presence of and to quantify source contributions to receptor concentrations) been sufficiently justified?

5. Is the premise credible that the loads from atmospheric deposition and groundwater are considered negligible in the formulation of the EMB?
6. Does the CSM adequately justify the premise that the various external contaminant source profiles utilized in the EMB (tributaries, CSOs, etc.) are independent?
7. Please comment on the appropriateness of the constructs and assumptions used in the mathematical formulation of the EMB.

Clarity and Correctness of Data Evaluations

8. Are the available data and the observations made from them sufficient to support the following findings of the conceptual site model (CSM) regarding sediment fate and transport?
 - Although the Lower Passaic River is a partially-stratified estuary, the recently deposited sediments between RM2 and RM12 are sufficiently similar (and likely mixed by tidal action over time) that they can be represented by single average concentrations of each contaminant in the EMB relative to the gradients observed for external sources and end members.
 - Approximately 95% of the dioxin currently accumulating in the recently-deposited sediments on the river bottom is due to resuspension and subsequent deposition of the bedded legacy sediments; i.e., an internal source is driving the dioxin concentration in recently deposited sediments.
9. Is the EMB's exclusive focus on conservative, particle-reactive contaminants appropriate to understanding and predicting future surface sediment concentrations of interest in the risk assessment, or should alternate consideration be given to dissolved constituents, such as lighter molecular weight PCBs?

10. Please comment on the appropriateness of the process and outcome of the selection of the resuspension source term input for the EMB. Is the justification of the selection sufficiently robust? Do the lines of evidence derived from sediment stability evaluations support the source term selection?

Appropriateness of Conclusions

11. Are the dated sediment cores and analyses of Be-7 bearing surface sediment samples sufficient as the basis for estimating post-remediation contaminant concentrations in sediment in the Lower Passaic River? Please comment on whether the predictions of post-cleanup sediment concentrations are sufficiently supported and realistic given what is known about the system. Are the appropriate pre- and post-remediation conditions (including contaminant sources and the potential for recontamination) adequately represented in the predictions?
12. Sediment stability evaluations (presented in the CSM) have led to the development of remedial alternatives that address the entire sediment bed of the lower eight miles of the river for comparison with No Action. Please comment on the significance of the uncertainties involved in this evaluation with respect to whether the entire bed of the lower eight miles of the river needs to be remediated, or whether remedies addressing only part of those sediments might be effective to reduce the surface concentrations in the Lower Passaic River to meet cleanup goals. In light of the uncertainties involved, are sufficient lines of evidence used in comparing the effects of the different remedial approaches to justify eliminating actions more limited than the entire lower eight miles? Is there additional evaluation of the available data that might provide adequate justification to add one or more limited early action alternatives that address smaller, highly contaminated erosional areas within the lower eight miles?

4.0 KEY ISSUES

The comments and answers to the charge questions from each of the reviewers are provided in Attachment A.

Several key issues were distilled from the written comments and addressed in the final call on July 9, 2008. In this section, these key issues are summarized and the reviewers' responses, suggestions and dissenting views are presented.

4.1 Forecast for Recovery of the Surface Sediments

One of the primary topics of discussion during the consensus call was the relatively 'flat' trend for contaminant concentrations in surface sediments over the last two decades, as indicated in the upper segments of the dated, high resolution cores. The high resolution core data interpretation in the CSM suggests an approximately 25-year concentration decay half-life for Lower Passaic River surface sediments. Based on a lack of agreement with the CARP model, which forecasts a concentration decay half-life for Lower Passaic River surface sediments of approximately 10 years, one reviewer expressed concern that the flat trend might indicate the presence of a currently unidentified dioxin source, which could be disruptive to a remediation project, or signify a problem with the high resolution core data interpretation, which is central to the CSM. This reviewer asserted that a numerical model of the Lower Passaic River would forecast dilution resulting in a continual decrease in surface sediment concentrations, unlike the findings of the EMB.

It was acknowledged by this reviewer and concurred by a second that the CARP model lacked adequate resolution (it includes only six model segments in the Lower Passaic River and perhaps has inadequate resolution in northern Newark Bay also) to fully answer this question, but this reviewer felt strongly there was value in re-running the CARP model with the new data to obtain additional lines of evidence for comparison with the EMB trajectories. A third reviewer recommended use of the current sediment transport model (SEDZLJ) for the Lower Passaic River to predict future contamination levels. Although this model is not completely calibrated, it was this reviewer's opinion

that it can be used to simulate contaminant fate and transport with the assumption that the contaminants of concern are all tightly bound to the sediment particles in the system. The first reviewer also recommended a biphasic evaluation of the data in his comments, rather than an exponential decay curve as used in the EMB forecasts.

4.2 Potential Sources of Recontamination

Three of the peer reviewers were concerned by high concentrations of dioxin found in sediments above RM8. There was concern that remediation of the lower 8 miles might not be effective in the long term, based on the potential for erosion and sediment transport from fine-grained sediment deposits located between RM8 and RM12 to recontaminate the remediated areas in RM0-8. One of these reviewers asked for further information regarding the potential second dioxin source at RM11.5. A fourth reviewer added that the smaller cross-sectional area of the river near RM12 is also associated with higher velocities, so that the potential for erosion is increased, and releases during storms or flood could be particularly problematic. In addition to concerns regarding remedial effectiveness, one reviewer asked if releases from RM8-RM12 (along with other potential, currently uncharacterized areas) might not be responsible for the lack of recovery of surface sediment concentrations.

The peer reviewers re-stated that the sediments between RM8-RM12, and perhaps to a lesser extent, sediments in Newark Bay, are of concern for implementation of a remedy in RM0-RM8. One panel member concluded that there is not a general belief among the peer reviewers that surface concentration projections associated with the remedial alternatives are reliable, without further investigation of potential erosional areas. This member did not believe the RM0-RM8 can be remediated without experiencing significant recontamination from RM8-RM12.

Another member agreed that the CSM presents a convincing argument that the main source of dioxin contamination resides in the main stem of the Passaic River, but noted that the EMB is not a good tool for examining remedial options on a finer spatial scale.

The EMB itself cannot be used to evaluate the benefits or weaknesses of remediating specific areas of the river.

4.3 Potential for Targeted Remediation

Three of the reviewers felt that a remedial action should be focused on erosional areas with high contaminant concentrations close to the current sediment surface elevation. One of these reviewers also indicated that special attention should be paid to erosional areas near the 80 Lister Avenue plant site, while another advised against any dredging in depositional areas to avoid unnecessary release of contaminants during construction (dredging resuspension).

Along with these comments, one reviewer indicated that a detailed 3-D visualization of bathymetry and contaminant concentrations normalized to sediment type, with consideration of lateral variability, would allow an evaluation of high contaminant concentration areas with respect to depositional characteristics. Such an identification of important contaminant flux areas would be very useful for remedial design. He noted that there is an ongoing need to understand the geological and hydraulic drivers for change in the system, since it is not a steady-state system. A fourth panel member suggested that the progression in the shape of the channel be examined, to see where erosion is potentially exposing legacy sediment areas.

One reviewer seemed to be concerned that the bathymetry data, which forms much of the basis for the hypothesis that the erosional and depositional areas are not static, is not sensitive enough for these conclusions. Another countered that even highly erosional and highly depositional areas were shown by the data to change character with time, lending weight to the CSM's conclusion that it is not possible to design a remedy focused on specific, non-contiguous areas in the river.

5.0 CONCLUSIONS

Several broad conclusions were discussed during the summation of the peer review final teleconference on 9 July 2008, and are reflected in the peer reviewers' comments in Attachment A, as described below.

The peer reviewers stated at various times during the teleconference and in their comments that they agreed with the major CSM hypotheses, data interpretation and the characterization of the comparative magnitude of various contaminant sources (*e.g.*, that resuspension is a major source, while CSOs/SWOs, tributaries and Newark Bay are minor sources). Some of the peer reviewers had a lingering concern regarding the extremely 'flat' recovery trajectories projected for surface sediment concentrations in the Lower Passaic River in the absence of remedial action. During the teleconference, Malcolm Pirnie reviewed the CSM hypothesis that the tidal resuspension of contaminated, legacy sediment is the factor preventing significant improvement in surface sediment concentrations over time. While the peer reviewers accepted that this was a plausible hypothesis, almost all of the peer reviewers recommended additional use of numerical models, such as the CARP model or the hydrodynamic and sediment transport models developed for the Lower Passaic River Restoration Project, to add additional lines of evidence to evaluate the trajectories based on the EMB. It was suggested that modeling efforts should continue during the Source Control Action design period.

While the peer reviewers agreed that the EMB was convincing in its assertion that remedial action was required, it was generally felt that the EMB cannot support remedial decision-making on a small spatial scale within the river (*e.g.*, the EMB cannot be used to evaluate the benefit of remediating a particular small stretch of the river). The EMB can be used to comparatively evaluate remedial alternatives, but it cannot forecast with accuracy the future years during which certain benefits will be achieved (*i.e.*, the year in which surface sediment concentrations will comply with desired risk-based concentrations). A number of reviewers stated that the lack of forecasting resolution was

their primary concern regarding the EMB, and that they otherwise agreed with the major CSM conclusions.

The peer reviewers recommended that contaminated, fine-grained sediments detected between RM8 and RM12 required further evaluation before a Source Control Action remedy could be selected for RM0-8 alone. The concern centered on potential recontamination of the remediation area in RM0-8 due to erosion and transport of sediments from RM8-12. Some peer reviewers opined that there was a benefit to further examining the RM0-RM12 portion of the river in detail for depositional areas, erosional areas, and the depth of contamination, with the objective of tightening the spatial focus of the Source Control Action remediation; however, others pointed out in response that there is too much change from year to year in the location of depositional and erosional areas to confidently design such a targeted remedy.

There was general consensus around the recommendation that the CARP model (updated with recent Passaic River-specific data) and the hydrodynamic-sediment transport model developed for the Lower Passaic River-Newark Bay should be used as a mechanistic approach to predict sediment concentrations into the future under the various remedial scenarios for comparison to those derived empirically.

6.0 NEXT STEPS

In response to the peer reviewers' concerns and recommendations summarized above, EPA undertook a series of tasks to strengthen the CSM and EMB as key decision-making tools for the FFS. While the peer reviewers' written comments have resulted in a number of detailed changes to the CSM and EMB, as documented in Attachment B, this section describes the major new modeling and analytical tasks that have been undertaken. EPA has undertaken the following:

- Update the CARP model with both the Passaic River-specific data and the hydrodynamic-sediment transport model developed for the Lower Passaic River-Newark Bay (named SEDZLJ) and use CARP to predict sediment concentrations into the future under various remedial scenarios. Focus in particular on resolving the difference between the CSM's high resolution core data interpretation showing a 25-year concentration decay half-life for Lower Passaic River sediments and the 10-year half-life projected by the original Harbor-wide CARP modeling effort.
- Use the SEDZLJ model to investigate the following concerns expressed by the peer reviewers:
 - Should a remediation of the Lower Passaic River start with the lower eight miles (RM0-8) as proposed in the Focused Feasibility Study or the upper nine miles (RM8-17)? Focus on comparing the level of recontamination of the remediated portion by the unremediated portion.
 - Would targeted remediation focused on erosional areas be feasible?
- Use a Monte Carlo technique to estimate the uncertainty in the empirical mass balance for current contaminant and solids loads to the Lower Passaic River to provide an empirically determined estimate of the range of contributions from each of the internal and external sources to the contaminant loads in the river.
- Use a Monte Carlo technique in combination with the single-layer sediment box model employed in the CSM to estimate the uncertainty in the prediction of sediment concentrations into the future under the various remedial scenarios.
- Use a geostatistical application of the Monte Carlo technique, known as conditional simulation, on a series of bathymetric surveys to better define the probability of sediment stability or instability at varying temporal and spatial scales. Focus on whether the bathymetry data, which form much of the basis for

the hypothesis that the erosional and depositional areas are not static, provide sufficient precision to support the CSM's conclusion that it is not possible to design a remedy focused on specific erosional areas of the river.

These new modeling and analytical efforts became a resource-intensive, multi-year undertaking. The results of these tasks were incorporated into a new Remedial Investigation report, the EMB and the FFS to further bolster the evaluation of whether an action would be effective and what type of action should be taken on the sediments of the lower eight miles of the river.

ATTACHMENT A

Peer Review Comment Submittals with Individual Comment Delineations

June 27, 2008

To: Alice Yeh, USEPA, Region 2
Bruce Fidler, Malcolm Pirnie, Inc.

Re: Peer Review of Lower Passaic River CSM

In this review of the Lower Passaic River Restoration Project, Peer Review Draft of the Comprehensive Conceptual Site Model (CSM), I will attempt to answer directly and in order, the charge questions posed in the Correspondence from Malcolm Pirnie dated May 31, 2008.

- ***Adequacy and Use of Data; Specific Issues***

1. Are the data used in the CSM adequate to support its conclusions?

a) Are the sediment sample results collected in the lower eight miles used appropriately in characterizing the contaminant inventory and gradients in three dimensions for the purposes of the CSM and EMB?

In general, my answer is yes. The analyses, with a few exceptions, notably DDT-related compounds and the limited suite of PAHs, appear to be research quality and the number and distribution of samples seems appropriate.

1

While DDT-related compounds would not be at the top of the list of COCs, a large amount of DDT **was** manufactured at the 80 Lister Avenue Site and with a **most unusual** history. Consequently, the levels and geographic distribution of DDT-related compounds have significant potential as a lower Passaic River source tracer (see Bopp et al., ES&T, 1991). I have brought up this point previously and the “problems” experienced with the DDT analyses of these samples have been discussed directly Ed Garvey and other Malcolm Pirnie personnel.

3

With respect to PAHs, the attempts at “source characterization” employing normalization to dieldrin (or is it benz [a] anthracene??, Figure 6-8) could certainly have been improved with more extensive (and expensive) analyses of PAH and related compounds.

4

A more general related comment on sources and the CSM – I was amazed at the lack of description of “point” sources. Is this “typical” of a CSM? I prepared a summary of the 80 Lister Avenue Site (2,3,7,8-TCDD and DDT) and its fairly well-known history of operations in the late 1980s (see file 80 Lister Ave RFB.pdf). With respect to 2,3,7,8-TCDD, the CSM contains the briefest mention of a second source of 2,3,7,8-TCDD in the vicinity of RM 11

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(p. 13-6). The importance of such information to an informed peer-review was demonstrated by the fact that one of the other reviewers specifically brought up the question of other 2,3,7,8-TCDD sources in the midpoint conference call. A scan of the classic dioxin reference (Hay, The Chemical Scythe, 1982) and information available on the web indicates that manufacture of hexachlorophene at a Givaudan plant near the confluence of the Third and Passaic Rivers is the likely source. A NIOSH/CDC report (Piacetelli et al., 1990) available on the web provides the following details related to 2,3,7,8-TCDD -

- i. Givaudan manufactured 2,4,5-trichlorophenol (2,4,5-TCP) (the source of 2,3,7,8-TCDD) as a starting material for synthesis of hexachlorophene (HCP) from 1945 through 1949.
- ii. Between 1949 and 1984, they purchased “purified” 2,4,5-TCP from several suppliers, mainly Hooker and Dow Chemical.
- iii. Between 1947 and 1984, HCP production at the plant ranged from 17,000 to 3.5 million pounds per year.
- iv. From 1970-1972 HCP production was increased by “adding a building,” but in 1972, the building was devoted to “non-HCP” processes.

Some very approximate calculations I have done suggest that discharges from the plant could account for on the order of a kilogram of 2,3,7,8-TCDD – highly uncertain, potentially significant.

One final comment – Why does this question refer specifically to “sediment sample results collected in the lower **eight** miles”? Obviously, I have addressed results from the lower **twelve** miles.

2

- b) Are the results of the high resolution cores collected above Dundee Dam sufficient to represent background loading levels for the system?

The answer is yes, with a few qualifications. Note, however, that I collected the cores (with Steve Chillrud and Damon Chaky) and performed the dating analyses.

7

Willy Lick in his preliminary comments of 06/16/08 disagreed –

“The sources of chemicals above Dundee Dam are assumed to be characterized by core(s) from a depositional zone. By definition, these sediments are non-erosional and therefore are not characteristic of sediments which have eroded from above Dundee Dam. The eroded sediments probably have higher chemical concentrations indicative of past contamination as compared with sediments that have been recently deposited.”

I strongly disagree with Willy. Based on decades of work in the Hudson, depositional zones in rivers - and Dundee “Lake” is as much a river (i.e. a relatively narrow and continuously flowing water body that happens to be

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located behind a dam) as a lake – remove and store a sample of the suspended matter as the vast majority moves by and is transported downstream, in this case to the lower Passaic. Some of the best recent description of such behavior can be found in Chillrud et al. (*Chemical Geology* 199, 53-70, 2003 and *Water, Air and Soil Pollution: Focus* 4, 469-482, 2004) where historical levels of several contaminants in a series of dated cores from depositional areas along the Hudson are explained in terms of levels at the farthest upstream site “diluted” by relatively clean inputs of particles from intervening tributaries.

The cores from above the Dundee Dam are the two “best dated” cores in the CSM and additional work involving Damon Chaky and Steve Chillrud is currently underway to further interpret the dating information, relate historical contaminant levels to those observed in the lower Passaic, and certify that the analyses of dried samples from these cores can be compared directly to the “wet” analyses carried out on all the samples collected in the lower Passaic River and Dundee Lake by Malcolm Pirnie.

This additional work will also investigate another factor related to the “appropriateness” of these cores as indicators of “background loading levels” which I interpret as loadings from the upper Passaic basin. That factor is grain size. Our field and lab notebooks related to the collection and processing of these cores noted that the upper few sections, while dominantly fine-grained, were relatively sandy. This could be a reflection of the influence of ongoing construction/development observed along the shore near the sampling site. The surface section of these cores did contain detectable levels of Be-7 and there are several other Be-7 bearing surface grabs from Dundee Lake collected by Malcolm Pirnie that will be compared with Be-7 bearing samples from the lower Passaic in our evaluation.

8

- c) Are there sufficiently robust data of appropriate kinds to characterize the contaminant loads that enter the lower eight miles of the river from external sources, i.e., from tributaries, from combined sewer outfalls (CSOs) and storm water outfalls (SWOs), from in stream sediments above RM 8 and from Newark Bay.

In general, yes. Certainly for in stream sediments above RM8 and current inputs from tributaries (the suspended matter samples). While a more comprehensive sampling of CSOs and SWOs would have been nice, the available data are “sufficiently robust” in light of their small relative contributions to contaminant loadings. I do have reservations about the Newark Bay sampling, especially as the overall project proceeds to a consideration of that waterway and contiguous systems. A focus on dated sediment cores (see Bopp et al., ES&T, 1991) and greater attention to and consistency in collecting Be-7 bearing surface sediments should be part of any future sampling.

9

- d) Are the available data adequate to verify that there are no important on-going, unquantified sources?

I am convinced.

10

2. Is the use of the contaminant data associated with recently deposited, Be-7 bearing, surface sediment in the CSM-EMB sufficiently explained?

I am most familiar with the use and interpretation of Be-7 data in sediments. Based on comment at the midpoint conference call and the central role of Be-7 bearing samples in data interpretation, I would suggest further explanation focusing on the role of sediment mixing and a discussion of absolute activities of this nuclide.

11

- ***Explanation of Assumptions and Uncertainties***

I will consider questions 3 through 7 together, partly because of my lack of expertise in the details of EMB formulation, but mostly because of my strong reservations concerning *specific* outputs of the EMB.

With respect to specific outputs of the EMB –

- Future predictions depend on the dating assignments of the five high resolution cores. As a group, the Cs-137 profiles on which the dating is based (Figures 13-2 and 13-3) are by no means “ideal”. The activities do not in general define a single peak (1963 horizon) and little consideration is given to absolute activities (the activity in the section assigned to the 1963 time horizon in the RM 11 core is approximately double that in the RM 12.6 core (?)).

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To be fair, these are perhaps the best profiles that could be expected in such a dynamic sedimentary environment as documented by the historic bottom profiling analysis (Chapter 11).

The dating assignments do, however lead to significant inconsistencies in the contaminant chronologies (for example, factor of 2 to 5 differences in 2,3,7,8-TCDD concentrations at the same assigned time horizons between the cores at RM 1.4 and 2.2 (Figure 13-4)) which necessarily lead to uncertainties (largely unexplored) in the Natural Recovery (No Action) projections of the EMB.

13

Continuing to focus on 2,3,7,8 TCDD (arguably the contaminant of greatest concern) the “exponential trend line” from 1980 to 2006 shows a best fit half life of 25 years. To my eye, the data could be reasonably “fit” with half lives between 10 and about 40 years (!?). Where is the uncertainty estimation?

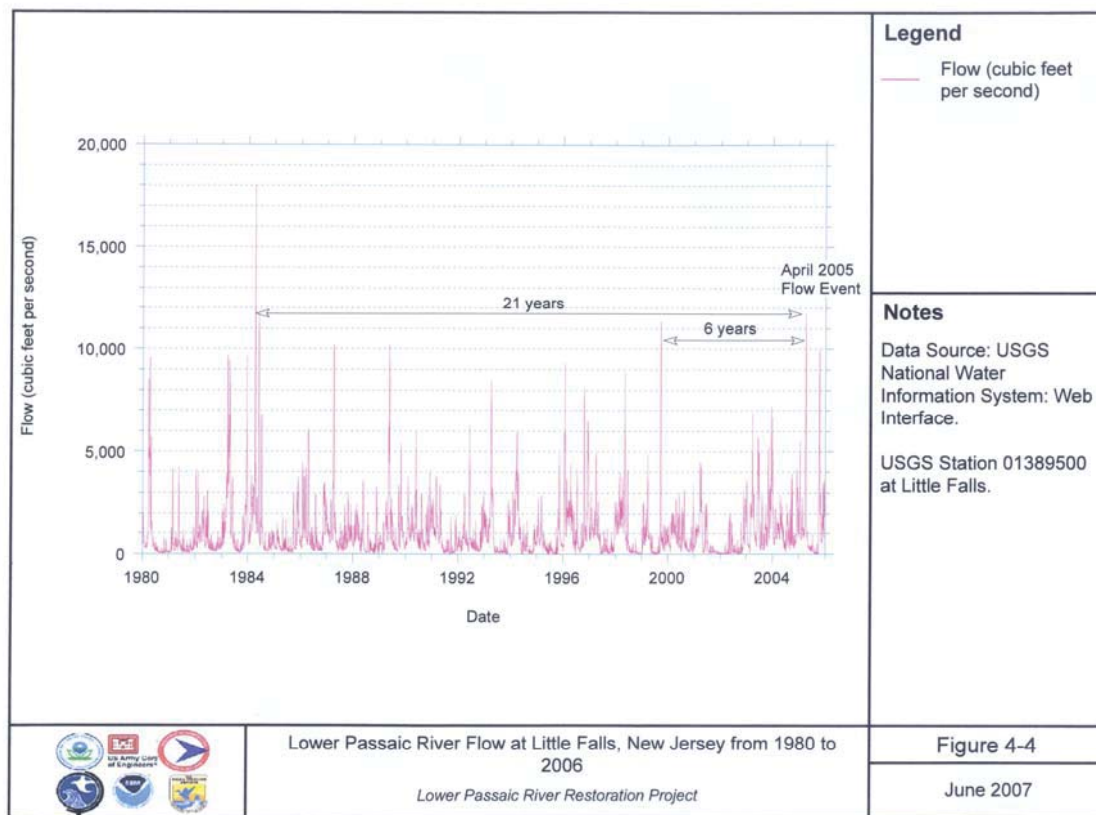
14

Furthermore, it seems clear from that figure that the RM 11 and 7.8 points tend to fall above the plotted “exponential trend line” while the RM 1.4 and 12.6 points tend to fall

below. This pattern is not particularly consistent among contaminants (although the mp 12.6 points are generally relatively low), but it does seem to warrant further consideration/explanation as a source of uncertainty.

14

- Of considerable concern to me is the lack of any significant discussion/consideration of the 1984 high flow event in the Passaic River. The following figure from a draft of the EMB apparently failed to make the final cut for inclusion in the CSM.



15

The event of April 1984 was the most intense high flow event recorded by the USGS at Little Falls since 1936. The only recent event that approaches its magnitude occurred from April 17-19, 2007 which is more recent than the relevant sediment core collections.

Deposition associated with the 1984 event has been noted in Dundee Lake, lower Passaic River and Newark Bay cores (Bopp et al., ES&T, 1991) and as I recall, there are accounts of flooding at the 80 Lister Avenue site in April of 1984.

Given the evidence of complex, relatively unpredictable patterns of deposition and erosion presented in Chapter 11, it is difficult for me to imagine that such an event had little effect on the profiles observed in the high resolution cores (as is assumed by the dating assignments) and that the possibility that some of the sites may have experienced significant erosion during that event was not considered/discussed.

All of these concerns relate directly to the uncertainty of specific EMB outputs and predictions and inform the following general assessment of the CSM –

15

- The “best fit” half times for Natural Recovery (No Action) determined from the EMB are highly uncertain.

However, the general conclusion that levels of all contaminants (except perhaps dieldrin) are decreasing rather slowly over time is **very well supported** by the data analysis and consistent with expectations based on particle and contaminant source analysis.

16

Furthermore, the general projections of surface sediment trends following remediation portrayed in the figures in Chapter 20 (i.e. dramatic initial improvement followed by some degradation as a result of sources uncontrolled by the remedial efforts) is most likely and highly defensible on the basis of simple, rational analysis of the generally excellent data that was collected on a well-chosen suite of samples.

17

Most importantly, from my perspective, the very well documented complex nature of sedimentation along the lower 12 miles of the Passaic compounded by our inability to reliably predict the occurrence and/or effect of major high flow events such as those in 1984 and 2007, makes it highly unlikely that additional efforts at complex modeling (either extending or refining the EMB or invoking more complex models such as CARP) would be particularly useful.

18

Rather than the current level of uncertainty limiting or delaying remedial options, I believe that a basic data analysis strongly supports a focused preliminary remedial effort as discussed below.

19

- **Clarity and Correctness of Data Evaluations**

8. Are the available data and the observations made from them sufficient to support the following findings of the CSM regarding sediment fate and transport?
 - a) Although the lower Passaic River is a partially-stratified estuary, the recently deposited sediments between RM 2 and RM 12 are sufficiently similar (and likely mixed by tidal action over time) that they can be represented by a single average concentration of each contaminant in the EMB relative to the gradients observed for external sources and endmembers.

I find the relevant plots (presented as several “panels” of Figure 14-4) most convincing **to an uncertainty of a factor of 2 or 3** (consistent with uncertainty in the EMB). Consequently, from a modeling and remediation perspective, I tend to agree, however, from a geochemical perspective, I have several concerns. For example, the highest levels of dieldrin (by about a factor of 5!) in the high resolution cores occur at RM 11 and 12.6 (although significantly “offset” in time based on current dating assignments) and do not appear to have “mixed”

20

downstream (!?). A similar situation exists for the “second source” 2,3,7,8-TCDD noted in the upper sections of those two cores (page 13-6) discussed above. I also find the salt-front penetration arguments for tidally driven upstream sediment transport and contaminant mixing (Chapter 10) to be rather weak.

20

IF the extent of upstream particle transport/mixing is deemed to be critical information, the best approach would be additional exploitation of particle-reactive geochemical tracers. As discussed above, DDT-related compounds derived from production at 80 Lister Avenue have potential as tracers of at the “downstream end,” as does hexachlorobenzene (based on the PhD thesis of Damon Chaky that has been shared with Malcolm Pirnie). As tracers of “upstream” particles entering over the Dundee Dam, the composition of the persistent flame-retardant chemicals, PBDEs (PhD thesis and draft ms of Luci Benedict from my group) and perhaps alkylphenol ethoxylates or other surfactant chemicals that Bruce Brownawell is working on have significant potential.

21

b) Approximately 95% of the dioxin (**NOTE: I assume that the assertion meant to say 2,3,7,8-TCDD**) currently accumulating in the recently-deposited sediments on the river bottom is due to resuspension and subsequent deposition of the bedded legacy sediments; i.e. an internal source is driving the dioxin (2,3,7,8-TCDD) concentration in recently deposited sediments.

22

I find this most important assertion to be very well supported by the data and analysis.

9. Is the EMB’s exclusive focus on conservative, particle-reactive contaminants appropriate to understanding and predicting future surface sediment concentrations of interest in the risk assessment, or should alternate consideration be given to dissolved constituents such as lighter molecular weight PCBs?

While clearly a geochemical question, the answer requires a risk assessment perspective that I do not possess. I did find the PRGs (Table 20-10) to be rather arbitrary and not particularly related to risk assessment (!?).

23

10. Please comment on the appropriateness of the process and outcome of the selection of the resuspension source term input for the EMB. Is the justification of the selection sufficiently robust? Do the lines of evidence derived from sediment stability evaluations support the source term selection?

While I am convinced of the importance/dominance of the resuspension source for most of the contaminants, I am concerned that the areas supplying the resuspended contaminated sediment have not been (and, given the convincing analysis of erosional and depositional regimes presented in Chapter 11 probably could not be) specified in space or time. From my perspective, it seems unlikely that further measurement/determination of current mixing depth or “erodability” as a function of location would prove particularly useful. Indeed, it seems quite possible that the high

24

flow event of April 2007 may have changed the sedimentary environment significantly at specific sites since samples were collected.

Such considerations lead to the concern that any remedy other than large scale source removal will result in significant recontamination. To me this suggests a strategy based on dredging that maximizes inventory removal, enhances deposition in the remediated areas, and allows for future dredging following recontamination. A few additional suggestions are provided below.

24

- ***Appropriateness of Conclusions***

Many of my comments above address aspects of questions 11 and 12. Some other specific observations include –

a. Because the areas that supply the resuspension flux have not been located and may not be consistent over time, a preliminary remediation strategy that should be considered would involve dredging an area near the mouth of the Passaic. This could remove a large fraction of the contaminant inventory and significantly address the problem of 2,3,7,8-TCDD, arguably the contaminant of greatest concern.

25

b. Capping this area should not be considered as the “hole” would serve as a trap for sediments and associated contaminants both from Newark Bay and further upstream in the Passaic. Such an area would be expected to accumulate contaminated sediments at a rapid rate. Our one core from the lower Passaic from a recently dredged area (a marina near RM 8) had an estimated net accumulation rate based on the Be-7 profile of over a meter per year. Future dredging of the area would continue the remediation.

26

c. In general, I would be concerned about capping anywhere in the lower Passaic based on the unstable patterns of deposition and erosion and lack of information related to the effects of major high flow events.

27

d. A similar dredging operation in Dundee Lake as part of the preliminary remediation could be considered to significantly decrease future inputs of PAHs (Figures 19-7 and 19-8) and, to a somewhat lesser extent, total PCBs (Figure 19-6).

28

I certainly look forward to seeing results of the distillation and compilation of comments from the peer-review panel!

Plant History

pre 1914 - mid 1940's - Lister Agricultural Chemical Co

mid 1940's - 1951 Acquired by Kolker Chemical
who produced

100 million lbs DDT (beginning before
the end of WWII)

start by 85 million lbs 2,4D } Agent orange
1948 25 " " 2,4,5T } (source of dioxin)

10 million lbs of HCB + unknown
lindane +
low γ -BHC

1951-1960 Diamond Alkali / Shamrock

produced 2,4 D
2,4,5T And A # of
di. tri chlorophenols estees

late 1958 ended DDT production

→ 1955 ended lindane production

→ 1957 or 8 ended low γ -BHC production

1960 (Fire) ended HCB production

1967-71 1967 TCP purification via carbon
filtration (removes dioxin)

1969-71 no 2,4 D or 2,4,5T produced
(plant shut 8/69)

80 Lister Avenue

Fallout Cs-137
↓
Maximum

? < low γ -BHC >

? < lindane >

? < HCB >
10⁷ pounds

(dioxin source) < 2,4 D 2,4,5 T + esters >
10⁸ pounds
Carbon filtration
2,4 D

< DDT Production >
10⁸ pounds

1940 1950 1960 1970 1980

Lister Ag. Chem. ? Kolker Chem. X Diamond Alkali/Shamrock X Chemicals >

July 7, 2008

To: Alice Yeh, USEPA, Region 2
Bruce Fidler, Malcolm Pirnie, Inc.

Re: Peer Review of Lower Passaic River CSM; Submission 2

I was particularly inspired by the comments of Dominic DiToro to provide some additional observations on the modeling, particularly with respect to his reference to the CARP model.

- Model Evaluation, pages 3 and 4 – From “simple exponential” to “initially exponential with little recent decline” to “biphasic exponential” to CARP.

The “evolution of exponentials” has taken place in the analysis of persistent contaminant (PCBs, pesticides) and radionuclide tracers (Cs-137 et al.) data in **very well-dated** (see my original CSM comments of June 27, 2008 on the dating of the lower Passaic high-resolution cores) sediments of the Hudson basin beginning in 1982 (Bopp et al. 1982; Bopp and Simpson 1989; Bopp and Walsh 1994; Chillrud 1996; Robinson 2002). A figure from Chillrud (1996) is presented below for illustration. Trends in some of our data will be used below for comparison to CARP model outputs cited by Dominic.

29

A further thought on the uncertainty in dating assignments of the high resolution cores – CSM Figure 13-11c shows that the trans chlordane levels in all sections of all the high resolution cores that “dated” between ca. 1982 and 1988 were incredibly consistent. The total range of concentrations was from about 30 to 45 ppb. Bopp et al. (1991) reported on seven samples (three Be-7 bearing core sections and four suspended particulate samples collected in 1985 and 1986 between about RM 1 and RM 8 on the lower Passaic that also had incredibly consistent trans chlordane levels – 106 ± 27 ppb (!).

30

It should also be noted that the “early, more rapidly declining” section of the time trend analysis presented by Dominic includes the extreme **(yet, to the CSM, invisible)** high flow event of 1984 that flooded the 80 LA site (see my original CSM comments).

31

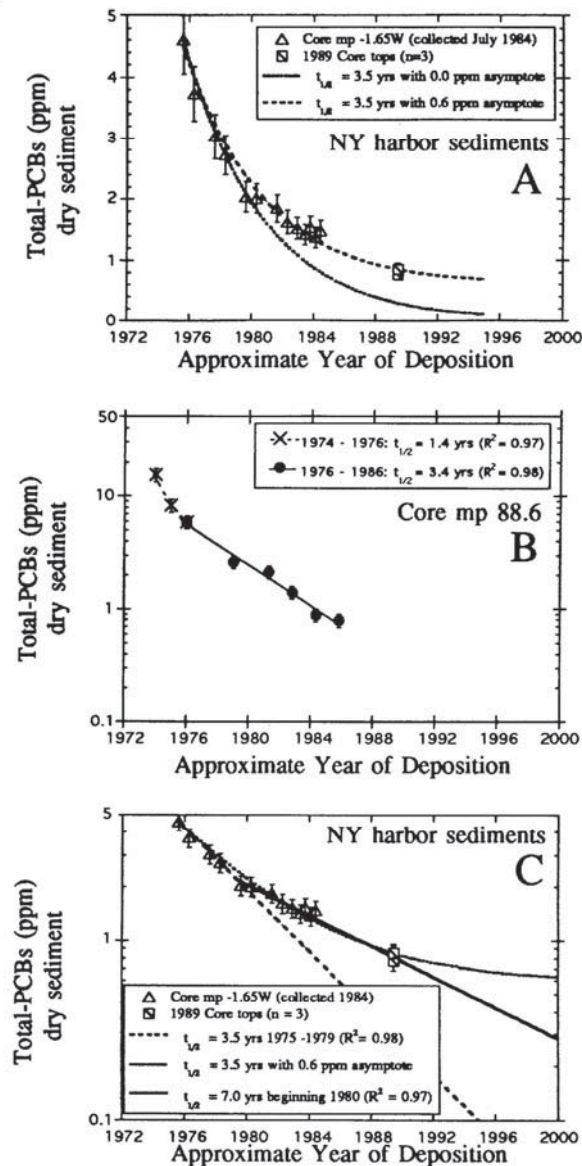


Figure 4-3A: Total-PCBs in harbor sediments plotted versus approximate year of deposition (after Bopp and Simpson 1989). Only core tops collected between ~mp -2 and mp 4 were used since core top samples collected upstream of mp 6 were typically 30% lower in various contaminant concentrations than those collected between mp -2 and mp 4.

Figure 4-3B: Total-PCBs in sediments collected at mp 88.6 plotted versus approximate year of deposition.

Figure 4-3C: Total-PCBs in harbor sediments plotted versus approximate year of deposition. This plot compares the asymptote function of Bopp and Simpson (1989) to a description that has two periods that decline at different exponential decay rates. The latter projects additional significant improvements in total-PCB levels of harbor sediments after 1989.

- On the ~exponential half times and conflicting concerns.

On one hand, Dominic points out that the more recent half times of contaminant decline appears **slower** than the EMB-modeled average (ca. 25 yrs for 2,3,7,8-TCDD) and raises the possibility of an unaccounted-for dioxin source and/or a poorly understood process.

A bit later, he indicates that the CARP model suggests (page 34 of his figures – nice wiggles, but no data....) that 2,3,7,8-TCDD will decline with an average (No-Action) half time of ten years, significantly **faster** than the EMB modeled average. This is used to suggest that the No-Action alternative could be somewhat more attractive than suggested by the EMB model outputs.

Questions that might be considered/discussed –

- 1) How can the CARP 10 year half time of decline be defended/explained in light of the high resolution core data?
- 2) If the CARP model could be “tweaked” to be more consistent with the data, how would that help with a decision on remediation?

32

- On CARP and the “hindcast” justification.

Cs-137 may not be the “ideal tracer” for a hindcast exercise in a model of Passaic contaminants. Its dominant input of Cs-137 in that system was to drainage basin **soils**. Many of the Passaic COCs (and certainly 2,3,7,8 – TCDD) had dominantly direct inputs to the river. Cs-137 is certainly an excellent “recent” tracer, i.e. in the era of resuspension dominance of inputs, but direct analogy to many Passaic COCs becomes poorer as one approaches the 1984 high flow event, and the era of major fallout inputs of Cs-137 and direct industrial inputs of contaminants.

33

I was not particularly impressed with the CARP Cs-137 hindcast results (pages 37-41 of Dom’s figures). One specific point – if I remember correctly, some “initial time” Cs-137 activity (1963?) at each location was provided to the hindcast as a starting point. I do not believe that the hindcast started from the “raw” Cs-137 loading data (atmospheric deposition since the early 1950s and Indian Point releases since the mid 1960s).

I believe that, at my suggestion, a more detailed CARP hindcast model for Cs-137 accumulation in sediments in the cove adjacent to the Indian Point nuclear reactors was performed. If the CARP model continues to be an issue for this peer review, that should be discussed.

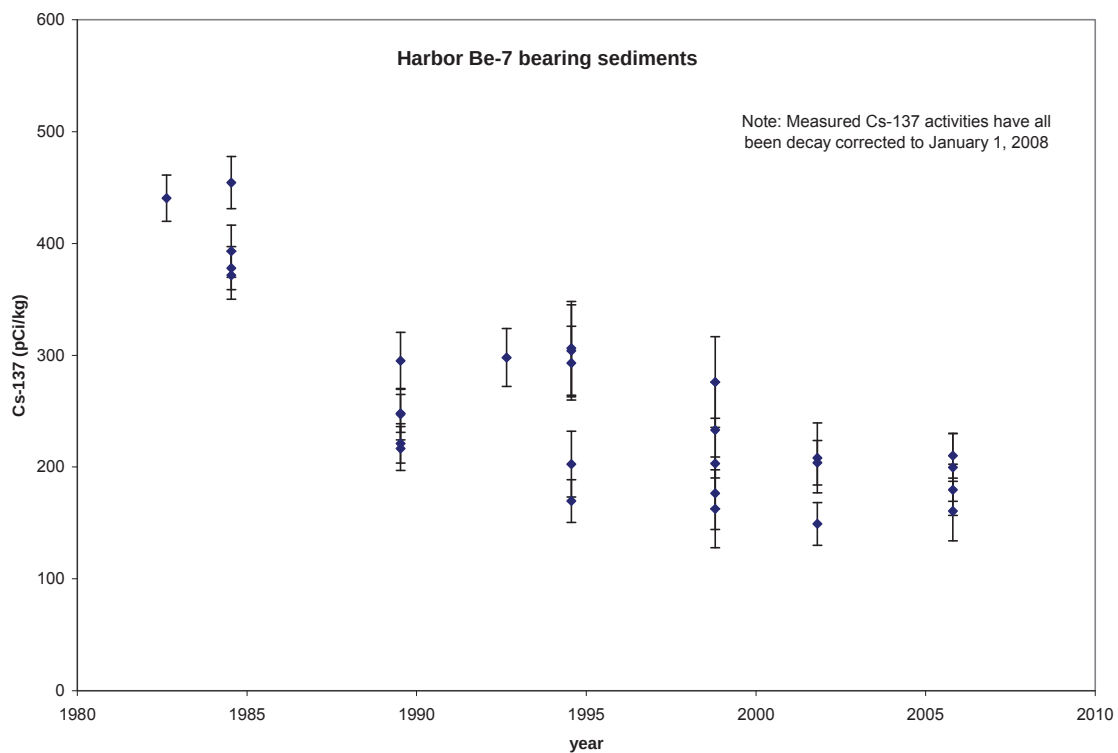
34

I also suggested a “full Cs-137” hindcast (i.e. starting before any global fallout inputs) **and** a hindcast of the 1984 extreme flow event in the Passaic. Neither was carried out.

- On Dom's observation that the "CARP model predicts a relatively rapid response that is reflected in the Cs data."

We have noted that the in recent sediments of the Hudson, the half time of decrease of Cs-137 activity has been increasing – approaching perhaps 30 years in individual cores.

Perhaps more analogous to the Passaic data, we have been collecting Be-7 bearing sediments at several sites along the mainstem of the Hudson in NY harbor every few years since the early 1980s. Like the lower Passaic, the mainstem harbor is quite well-mixed. So that our discussion of response times may be more data (less model) grounded, I have included below a plot that summarizes that data over time.



35

The plot includes data on all of the individual Be-7 bearing sediment samples that we collected along the mainstem of the Hudson in NY Harbor between mp -1.7 and mp 9.7.

I would have a difficult time projecting forward a relatively rapid response (half time of ca. 10 years) based on this Cs data.

Reference:

Bopp, R.F., H.J. Simpson, C.R. Olsen, R.M. Trier and N. Kostyk, Chlorinated Hydrocarbons and Radionuclide Chronologies in Sediments of the Hudson River and Estuary, New York, *Environ. Sci. Technol.*, 16, 666-676, 1982.

Bopp, R.F. and H.J. Simpson, Contamination of the Hudson River: The Sediment Record, *In: Contaminated Marine Sediments Assessment and Remediation*, pp 401-416, National Research Council, NAS, Washington, D.C., 1989.

Bopp, R.F. and D.C. Walsh, Rivers and Estuaries: A Hudson Perspective, *In: Environmental Science in the Coastal Zone: Issues for Further Research*, pp. 49-66, National Research Council, NAS, Washington, D.C., 1994.

Chillrud, S.N. 1996. Transport and fate of particle associated contaminants in the Hudson River Basin. Ph.D. Thesis. Columbia University, New York. 277 pp.

Robinson, K. 2002. DDT and Chlordane in the Hudson River Basin. M.S. Thesis. Rensselaer Polytechnic Institute, Troy, NY. 130pp.

Jun 28, 2008 – Initial comments on the Lower Passaic River Restoration Project: Comprehensive Conceptual Site Model

The responses to the questions charged are provided at the end. I decided that to answer these inter-related questions without a broader context would not provide the rationale for the those responses.

This is an ambitious piece of and for the most part extremely well done piece of work. The tremendous amount of thought and expert data analysis comes through – I am also very impressed with the internal consistency of the PCDD data, a noble task. My global view of the EMB is that the approaches used are well justified and appropriate for dealing with this complex system, and that the conceptual model that forms the basis of the EMB is more than useful for describing the distribution and sources of many contaminants in the lower Passaic as well as some of the dynamics of net sediment transport and deposition. The ability to describe time and space varying contaminants in 7-Be bearing sediments (not a huge number) to describe a justifiable interpretation of longitudinal transport and source of contaminants within and outside the lower Passaic works surprisingly well in my opinion. Without going into great detail (earlier version of this critique), it is my belief that the geochemical, mass balance, and forensic approaches that are emphasized in this Conceptual Site Model have yielded much more insight and confidence in conclusions than if the effort placed in this work had instead been heavily focused on high spatial resolution modeling, in part because of highly dynamic sediment transport and hydrologic system, where historical boundary conditions are poorly characterized. Excluding the problems of adequately describing sediment transport in a high resolution model (an art in any situation, and still can't think of a similar high dep and episodic transport system that has been successfully modeled), the generally preferred calibration endpoints (especially dissolved 2,3,7,8-TCDD – *as I only discuss 2,3,7,8 in my comments below I have abbreviated it as TCDD*) such as dissolved concentrations and tissue concentrations are either nearly impossible to determine or have not been sufficiently characterized - or perhaps too spatially variable to provide much calibration or validation power. I commend the team for such a thorough and informed synthesis of much of the data.

By far my biggest criticisms and concerns involve the application of the EMB in its current state to project contamination in the future – I contend that the application of the EMB in Chapter 20 is neither well thought or described, nor is it reflective of the thought and good work that precedes it. It brings up the question as to whether the type of large scale box model used (with many steady state assumptions) is/can be adequate for assessing or even defining alternative remedial action scenarios. I have also tried to make suggestions as to what might be considered, with respect to additional data analysis to test, and refine the EMB and to provide a better tool for understanding the response of the system to changes over time in sedimentary processes and rationalize and optimize remedial scenarios.

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In my long-winded and often redundant comments below, I focus on concerns primarily rather than the many strengths of the report.

On a global scale, my biggest concerns with the conceptual model involve what the report does try to do, and questions not asked or addressed. I do not know whether this is a result of not

expending as much energy on how the data analysis and EMB could or should be used to assess the design and response to remedial measures – in its current form Chapter 20 highlighted to me some of the uncertainties in the predictions of the EMB, and whether the data could be better analyzed to improve understanding of system and test important assumptions, and that the EMB presently provides little assistance in helping to define alternative measures and provide confidence in the comparing the likely impacts associated with approaches to dredging, capping, and even long term no-action responses of the system.

Most of my comments below focus on TCDD because of obvious reasons that make it the most likely candidate to drive decisions related to remedial risk-based response and the possible “bang for the buck” if it is remediated with an engineered solution. My views and understanding are based on my study of all the COPC and sedimentological data. As the huge source of TCDD can be seen to some extent in areas outside of Newark Bay, reduction in risk could be even more widespread than for other COPCs. Successful remedial alternatives have the potential to also improve conditions locally or in Newark Bay for other COPCs more than might be imagined, if they act to protect the system from erosion of hotspot that occur (and may be affected by the rapidly changing bathymetry, or especially deep erosion during the “big storm” where “relic” contaminants either buffer or worsen contamination of the system. Just as importantly TCDD, provides in many ways the best test of the EMB (a notable exception is in the calculation of the resuspension term because it is not nearly as sensitive to external inputs) because it has the biggest gradients, best known sources and source history, is the most persistent and particle reactive, and there is the greatest amount of spatial heterogeneity in surface sediments not characterized as 7-Be bearing (measured or unmeasured)....I will keep coming back to the last point about spatial heterogeneity and hotspot areas because understanding this better will not only provide tests of the model, provide tremendous insight for the EMB, potentially cast doubt on the utility of the model for f projections, and just as importantly assist in guiding remediation scenarios.

Comments on my personal perspective on questions that arise or should arise in considering remedial action responses.

There are many possible goals of remediation and greater number of questions and concerns that arise in decision making when it comes to contaminated sediment remediation. Here I focus on a couple, and ignore (as has been done in the report) other factors that arise in choosing the best alternative; e.g., maintenance of navigation channels, alteration or restoration of ecological habitats, and consideration of separating the liability of the responsible parties (addressed in small part in the report). Some of the issues raised below are better addressed in the report than others:

1. what are the current and future sources of contaminants to the system, where are they transported, and what significance do those source have to other areas? While there are some weakness, there are really a very large number of complementary tools that provide a wealth of information about sources and transport of sediments and contaminants along the axis of the system – as I mentioned above, on a global scale, I have few major problems with the interpretations of the distributions of the most persistent and particle reactive contaminants in areas that are highly depositional and reflective of integrated fine grain sediment/contaminant sources and transport. **However**, the CMB does not do a good enough job describing or

providing an understanding of where the important areas of resuspension sources of **contaminants** are, perhaps especially important for TCDD –see below – there could be much more insight given to interpretation of the exceptionally variable TCDD surface concentrations not characterized as 7-Be bearing (given the very sharp gradients of TCDD with depth and space, it may not be surprising that the sometimes observed hotspot concentrations of TCDD – and relatively higher compared to means than for other contaminants) – here and in more detail below, I’m only worried about understanding the distribution, biogeochemical controls, and impacts now and in the future of changing erosional areas. Note the log rather than linear scale for TCDD used to show variation in the contaminant in Figure 14-4i, and this Figure does not nearly show all the high surface concentrations measured in other Figures 14-1, 14-2, and especially, in non 7-Be bearing sediments from above MP 8 in samples collected in 2005-2007. – the high TCDD can be most easily hypothesized to be the result of fine grain sediments that were once depositional and have now become exposed – if this is not the case, how can these high levels occur and occur in many areas in the River, seemingly characteristic of depositional areas on the maps. The Conceptual model and interpretation of the EMB are actually explicit in source areas of the resuspension term being impacted to by areas where “relic”/legacy contaminants have been exposed by erosion (or they could be mixed back up to the surface by non-steady-state processes). However, the Model does not address to the extent I think important as to where the contaminant loads (the product of resuspension zones and COPC concentration) occur. Essentially the EMB and model projections infer a steady state condition of resuspension is a dynamic system where the erosional areas are non-steady state (i.e., formerly deposited contaminants are exposed). I would be more inclined to buy into this assumption if the low Passaic River bathymetry/deposition rates/hydrodynamics were not changing so rapidly. Even if deposition of sediments had not been so great in the Passaic since dredging this past century, there would to some extent be oscillations of sedimentary regimes between being net depositional and erosional – the fact that it has now been filled to more uniform 12 foot water depths, and as well demonstrated in the report, there are areas (large and grid size scales) that were once depositional that have or may become net erosional – this can be a huge problem with respect to buffering or potentially increasing the “resuspension” loading, especially for contaminants like TCDD where the gradients in vertical concentrations can be so dramatic. I would worry that the change in bathymetry that has, is and will occur can have dramatic impacts on source terms and definition of the problem.....this may not be the case, but I would like to see the data further analyzed to define and test this problem –). Below, I focus perhaps too heavily on this issue (lots of redundancy), but it is tied to many of my most fundamental concerns. I would at least like to see this type of concern better discussed by Malcolm Pirnie and the review team.

36

The Conceptual model and interpretation of the EMB are actually explicit in source areas of the resuspension term being impacted to by areas where “relic”/legacy contaminants have been exposed by erosion (or they could be mixed back up to the surface by non-steady-state processes). However, the Model does not address to the extent I think important as to where the contaminant loads (the product of resuspension zones and COPC concentration) occur. Essentially the EMB and model projections infer a steady state condition of resuspension is a dynamic system where the erosional areas are non-steady state (i.e., formerly deposited contaminants are exposed). I would be more inclined to buy into this assumption if the low Passaic River bathymetry/deposition rates/hydrodynamics were not changing so rapidly. Even if deposition of sediments had not been so great in the Passaic since dredging this past century, there would to some extent be oscillations of sedimentary regimes between being net depositional and erosional – the fact that it has now been filled to more uniform 12 foot water depths, and as well demonstrated in the report, there are areas (large and grid size scales) that were once depositional that have or may become net erosional – this can be a huge problem with respect to buffering or potentially increasing the “resuspension” loading, especially for contaminants like TCDD where the gradients in vertical concentrations can be so dramatic. I would worry that the change in bathymetry that has, is and will occur can have dramatic impacts on source terms and definition of the problem.....this may not be the case, but I would like to see the data further analyzed to define and test this problem –). Below, I focus perhaps too heavily on this issue (lots of redundancy), but it is tied to many of my most fundamental concerns. I would at least like to see this type of concern better discussed by Malcolm Pirnie and the review team.

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2. Under what conditions is it an important objective to try to reduce inventories of particle reactive contaminants as part of a dredging plan, especially in a system in which most of the inventory is buried and buried relatively deeply in many areas of high inventory? This requires addressing a number of site and problem specific or related questions: e.g., how

deep are the penetrations of contaminant?; cost-benefit - how many cubic yards as a function of the percent of the inventory removed or more importantly reduction in risk; what can be done with the spoils (not our problem)?; what will be the change in bioaccumulation or transport when surficial or re-exposed hot sediment are introduced to the surface and water column during the dredging process after dredging? – always a big question in similar RIFS battles I’ve been exposed to; can a “100 year storm” cause re-exposure of highly contaminated sediments and

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importantly to what depths does one then want to dredge (or rather can capping mitigate this risk) to be protective – the effects of the “100-yr storm” is of course difficult to answer, generally modeled or based on historical evidence, but in this case can be addressed in part by the great depths of contaminant penetration into the bed. If bathymetry were changed by dredging, then one also wants to be able to describe the changes in hydrology and sediment transport/deposition/erosion that may occur – there is a lot known here about depths of penetration and likely reasonable estimates of inventory....but better understanding of the 3-D distribution of sediment will not only help frame these questions, but I think shed a tremendous amount of insight related to questions and uncertainties that I’ve raised – again a bit more below.

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I would say that the EMB and presentation of data in this report address some of these questions, but I’m concerned that other important questions can not be adequately addressed as the EMB is presently presented; as a result the assumptions used in Chapter 20 become very very tenuous in my opinion. In fact in balance, I believe that there are negative consequences of publication of Chapter 20, as written, that not only highlight uncertainties in the EMB, but projections presented may predispose reviewers (managers) to view the reduction of long term risk provided by expensive clean-up to modest to consider based on cost/benefit (think Palos Verdes which

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thru
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was many square miles so the analogy is not great) – From a technical perspective (not political) it can be argued that the Hudson River Remedial Action decision was based not only on projected risk reduction under steady-state conditions, but also on removing the risk associated with finite risk associated with removing buried contaminants that could become mobile under conditions of very high erosion..... The EMB could go much farther to address a range of questions that are going to be asked or should be asked.

3. How do different actions affect the risks of contaminants, locally to other areas, under different alternatives and under different assumptions? this overlaps with the types of questions above, but, additionally one needs to similarly understand the effects of capping scenarios (not adequately described here as the details of the actions in this dynamic system would be critical and bear on statements or conclusions made) or with the no action scenario. Again the focus of the report is on interpretation of the present and past distributions of contaminants in sediments and the integrated concentrations of contaminants that are being “sloshed about”, and assumes that the dynamics of the system (primarily sediment transport and deposition) remain constant into the future. As inferred or mentioned above, the question needs or could be better addressed is whether or not the conceptual model, which impacts the mass balance calculations need to consider the how sediment transport will change with no action (e.g., will erosion increase as the river is filled and where) and with changes in bottom depth or hardness after engineered remediation.

The reliance on a conservative particle tracer model that is primarily tested with geochemical mass balances and forensic evidence, and includes sediment textural properties Fe and TOC. What are the effects of changing the percent of deposition coming from resuspension of erosional areas?

This is one of the questions in the charge but I discuss my thoughts here:

- On balance, I believe (could be better convinced with receptor mass balance modeling with different sets of parameters) that this simplification is justified and leads to perhaps

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more confident predictions and understandings than would a model calibrated with equilibrium or kinetic exchange into the water.....

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- As mentioned above, I really like the geochemical emphasis used in this approach – I don't often agree with Richard when it comes to the value of water quality type models, but, in this case the geochemical insight and box model approach seems to work exceptionally well – the high deposition rates help one to ignore a lot of concerns that I and others would have with the this type of conservative COPC particle tracking method.
- The assumptions that all COPCs are perfectly conservative particle tracers is probably useful in this sediment transport dominated system for many of the contaminants – best for TCDD, maybe some or most PAHs that are associated with particles in “resistant” phases or they would not be there or last, some more chlorinated PCBs, DDE or sum of DDT residues, (and perhaps some pesticides if the data is good enough) and more particle reactive metals Pb (esp.), Cu, and Hg being the best, not sure about Cr or Co, that associate with different phases based on redox chemistry and particle surface chemistry; I know much less about Ni geochemistry.. It is well known that in seawater that Cd, Zn, and As are primarily in the dissolved phase in the water column, even in a somewhat turbid estuaries , although Cd is about two orders of magnitude more particle reactive in freshwater than in chloride rich seawater, a potential complication – additionally, in marine or estuarine sedimentary environments without local Cd external loads, the distribution of Cd in sediments is controlled by two processes associated with high reduced and sulfidic sediments and anoxic bottom waters. The fact that more soluble metals, low molecular weight PCBs, and relatively soluble and biodegradable 3-4 and more-ring PAHs are preserved in sediments near and away from sources, can be due to many possible factors Getting back to redistribution of resistant particle associated phases, we and others have seen high relative concentrations of very very soluble and easily degradable 2 ring PAHs and mon-chlorinated benzenes in sediments (let alone 3 - ring PAH that should be dissolved or degraded in the water column based on predictions that even include “soot”), but you can't get them to desorb sometimes for months into continuously stripped seawater – so maybe treating all most of the organic chemicals as conservative particle tracers is not as unreasonable as it might be predicted.....However, the fact that the calibrated model predicts does a good job of describing the soluble metals mentioned actually gives me pause, as makes me wonder how well constrained the model predictions are when the longitudinal contaminant gradients are either not great, or have to be driven by local sources (TCDD)..... The fact that sediment transport must be largely event driven with high suspended solid (or bedload transport) and that sedimentation rates are so high, are additional reasons why the particle tracking model would be expected to work better than if one applied it to a scenario with more steady state transport where suspended sediment loads were much lower than I guess that they are during high flow events; big Spring or storm tides, or at this depth, maybe even really big winds??? There are but a couple of suspended particle samples collected that might test the particle tracer assumptions to some degree, and there are hints of more soluble metals being lower in the water column, but it is also true for a couple more particle reactive contaminants – if there were more data I'd be tempted to look at tide data as some of the outliers are contaminants that have sediment gradients at very near the locations of the water samples.....I should not really go into this last point, as it is too speculative given the data, but perhaps there is more data, or could be additional

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interpretation than my quick looks. **So the bottom line** is I do worry to an extent about neglecting the dissolved phase/particle-solution exchange may bias the EMB – but the calculation make reasonable sense and are constrained by other bathymetry and sediment load data available and interpreted. Given some thoughts I’ve briefly mentioned above, I suspect that for much of the EMB (predicting the nearfield receptor sediment concentrations), this approach actually works better than what one would get in a model including exchange between particulate and dissolved/colloidal phases.

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- Inclusion of TOC and Fe in the contaminant source based EMB calculation? I have another question about the EMB calibration that is also related to the assumptions that parameters are conservative and track fine grain sediment from the source they derive: what are the effects of adding TOC and Fe in the EMB calculation? I ascertain that relative to the lower Passaic, Fe is low in the upper Passaic sediments (I’m assuming coarser? as are the upper reaches of the lower Passaic where coarser sediments are expected to have preferentially fallen out, but there are other possibilities) and TOC is significantly lower in Newark Bay than in the upper and lower Passaic where it is very high (TOC is not always coating fine grain sediment. Were the sediments sieved before TOC analysis? - suspect plant detritus or maybe other anthropogenic particles from external sources – some that may be carrying high PAHs as well?, and I’m pretty sure not enough sewage input to get TOC up to 10% or more, and certainly not enough primary productivity here either – without bottom water anoxia – autochthonous TOC does not get up to 10% in estuarine sediments from eutrophication, only one example I can think of and Chl A is 300 ug/L there); the one line rationale in the text for including Fe and TOC in the text is therefore not well enough developed in my view. It may be that dropping these properties leads to non-intuitive results ???? – Excluding TOC would seem to reduce the percentage of Passaic sediment source; excluding Fe would seem to go the other way....perhaps stabilizing the solution...does the exclusion of TOC and Fe in the EMB mass balance change the important resuspension term greatly?? my gut suspects that the amount of calculated “resuspension” goes down if one takes them out of the calculation.....pure speculation but a point that I would like addressed.
- The choice of EMB calibration tracers can affect both the mass balance of solids (although sensitivity to some assumptions was tested) which can then affect the estimate of the contaminant in resuspension source areas – a pre-occupation of mine. There are other sediment mass balance estimates (especially analysis of changes in bathymetry) that support, or are not inconsistent, with the quantitative estimate of the sediment resuspension mass. While I’m convinced that the source apportionment of solids is not factors of 3-5 off, it seems to me that the calculation that about 50% of the deposition is from within lower Passaic River resuspension could have larger error than suggested??? On page S-13, an estimate of the sediment load over the Dundee Dam is given as 50,000 cubic yards/yr with another 20% of that from other tribs....and when compared to the estimated total net deposition of about 190,000 cubic yards/yr in the lower Passaic it appears to be spot on with the EMB calculation. However, this comparison depends on reliable flux estimates going over the dam (tough to do for episodic high flow events even with in-situ measurements, but this comparison assumes that little of the sediment that has come over the dam ever escapes the lower Passaic and that which does is transported back in by estuarine sediment transport—under important high flow conditions I wonder if that is reasonable to expect??? Furthermore, given the sediment pile at the

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mouth of the lower Passaic, it would not be a surprise to me if the percentage of sediment mass deposited from a Newark Bay source were greater than estimated – however, this last comment gets sticky because the gross flux from Newark Bay is a combination of sediment included in the upper Passaic and Resuspension sources – sediment escapes and is pumped back in.....

More on understanding the source areas of the TCDD/COPC resuspension

- I come back again to what has been burning me and that is that there are enough high TCDD (in particular) surface sediment concentrations reported, to make me think we need to know more about these potential source areas and geological settings where these hotspots occur, and if the EMB can provide the most use understandings/predictions as to where the most important contaminant erosion occurs today and most likely will occur in the future. The importance the resuspension term and that it likely reflect net erosion of older sediments is central to the EMB. However as presented there is not enough insight or analysis provided with respect to the nature of these resuspension sources and their controls. Given the data available, there could be much much more evidence and rationale presented to support the conclusions about where these areas are and where they have the potential to be most important in the future. To perhaps illustrate my concern better, I think it is instructive to look at some of the locations and magnitudes of the high TCDD “outlier” concentrations. As I mentioned, the data in Figure 14-4 does not reflect all the data in Figures 14-1, 14-2 and 14-3, and vice versa. The latter Figures show that from early 1990s sampling that there were a modest number of samples with measured TCDD above 3 ppb and one above 10 ppm (Figure 14-1a); in figure 14-2b, it is seen that there are lower levels and fewer hotspots found near banks (1999-2000); in more extensive sampling along the river in 2005-2008 period, which focused more on locations above MP 8, there are at 2 sites with concentrations between 3 and 10 ppb and 2 above 10 ppb in the stretch of River between MP 8.5 and 10.4. These relatively very high values can be compared to average concentrations of TCDD of 0.83 (1995) and 0.37 ppb (2005-2008) for 7-Be bearing sediments (Table 14-1); the later value or something close to it is used as the receptor concentration that the EMB was fit to. While there are other areas of the lower Passaic with high TCDD concentration (Figure 14-4), it may be of interest to note that the area between MP 8.5 and 10.4 is a stretch of the river where long term depositon has not been nearly as great due to less dredging in part(Figure 2-14). It seems to follow that **on average** TCDD concentration maxima would not be buried as deeply in this part of the River as in lower stretches of the River, where long term depositon is generally much higher; and thus erosion need not be nearly as deep to expose potentially important hotspots – yes, it is clear that I’m obsessed with developing conceptual understanding concerning the locations of hotspots for erosional TCDD fluxes and how those areas have or might change with time is not considered in enough detail in the report and than considered in the EMB. There are many possible implications for this, and two of them include the ability to project into the future, and whether limiting consideration of remedial actions to the area below MP 8. The estimate of the resuspension term for the sediment mass balance is around 50% leading to an estimate of TCDD in erosional areas that is twice that (0.81 ppb – Table 18.3) of the 7-Be bearing sediment average value – the integrated source concentration has to be about double the receptor concentraton because the resuspension term is well above 90% for TCDD in

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comparison to about 50% for the sediment mass input. However, if the estimate of the resuspension load of sediment were in fact 25% of the total rather than 50%, it would require the average concentration of TCDD in the source area to four times greater than the receptor concentration (about 1.5 ppb) – if the area of TCDD resuspension were a fraction of the area that is not depositional, then we could be chasing source areas with very high concentrations...and the impacts on remediation strategies might be more apparent.

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- In Chapter 20 the rationale for areas to remediate states that it would be most prudent to isolate portions of the primary erosional area that is the largest source now and be inference into the future. In doing so, it neglects the areas defined by bathymetry to be near neutral with respect to net deposition.....; there is no a priori reason in my mind to make this assumption – I need to be shown with data and rationale that this is true. In this highly dynamic system is dynamic, these contentions need in my opinion to be much better tested with existing data (e.g., to address this and prior concerns, I would start to try to better form and test conceptual understanding/model by considering relationships between surface concentrations and sediment profile distributions/penetration of COPC, measured sediment properties like texture in the same samples, and grid scale estimates of deposition and sediment type, all of which are already calculated; as discussed more below, the creation and interpretation of maps depicting the best estimates of 3-D distributions of COPCs should I think be extremely valuable)

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Some additional considerations for developing a framework useful for scenario develop, optimization and comparison for remedial action alternatives.

Does the EMB need to be better developed and justified to define useful remediation scenarios and project with confidence the effectiveness of remediation alternatives: a few more that come to mind:

- there is likely a reasonable estimate of the inventory of COPCs in the lower Passaic, but the rationale for interpolating and extrapolating the reliable 82 Cores and those with uncharacterized bottom inventories (which could be estimated from long term dep. estimates) could be better explained.....; Yes the question of inventories will come up, but I believe that in this case, one should be much more interested in understanding present and future source areas and to have a much clearer understanding of how one should frame questions concerning where and how to best remediate. In doing so I really would prefer to see an effort **made to create a 3-D map of COPCs**. There is lots of complementary data to do this and to this and should be done to better explain the conceptual model and as well as test the reasonableness of interpretations in this report. Such maps would allow better the basis for review, provide more clear tests of the conceptual model/EMB, and provide an important tool for those designing remedial action strategies and modelers to frame questions about. A 3-D picture of contamination should provide much better insights into not only current areas of COPC (not bulk sediment) but the susceptibility and controls on where important areas of erosion that control contaminant loadings are most likely to occur. Furthermore, such maps would

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greatly help in the defining questions such as what needs to be modeled to address questions such as the importance of the “100 yr storm”.

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- If it were found to be feasible (money and risk considerations), I still think that deep dredging of areas in the lower River could provide important benefits and might be considered as part of a number of remedial action alternatives: the river is filling up with sediment and the ability of cleaner sediments to mix and dilute the contaminated sediment in the lower Passaic will continue to be reduced; a source area and inventory would be reduced under some engineered approaches; although I wonder if the increased sink for sediment may affect net erosion of relic sediments in other parts of the system????.....While the actual modeling should be left to an RIFS study, any improvements in developing or supporting the EMB approach or extending the data analysis would be of great assistance in assessing any number of remedial options.

Comments on the COPC projections

1. The extrapolation of surficial sediment data trends over time or sediment core profiles to project into the future and estimate response times for improvement should be better supported. Forgetting about my comments above for now, given the variability in the temporal data over recent years, I am skeptical that there is enough statistical power to provide significant estimates of past half-lives.....I’ve already stated my concerns about extrapolating these surface sediment response times into the future, but I would like to see more statistical analysis of the existing estimates based on the historical records.
2. In addition to my concerns about the non-steady-state sediment transport and deposition that can be expected, the historical record here and elsewhere suggest that the rate of contaminant reduction tends to slow over time, especially in tidally flushed areas where there are point sources (dispersal, etc.).
3. The remedial scenarios are much too poorly explained and developed to allow the best critical assessment of all the assumptions and model results provided Chapter 20. Without the better understandings of most important source zones driving the resuspension term, the selection of the remedial option used for illustration appears to be based on intuition rather than a quantitative underpinning....Not having specifics of the remediation design or goals was frustrating and made worse by the lack of reference and integration with the sections in Chapter 11 about area and time dependent estimates of net deposition.....Some of these concerns could be readily addressed.
4. More importantly, is that the assumptions used in these scenario projections are quite tenuous and for me highlighted potential weaknesses in the current state of the EMB and associated framework. To illustrate there are 7 bulleted assumptions provided (and many implicit ones) in section 20.2.2 for the active remediation scenario. Perhaps some of my comments are off-mark if the scenario only involves remediation of the 68 acre Erosional Zone, but it reads as if it includes also the Primary Inventory Zone, which I read to mean it is defined as depositional or perhaps deposition neutral. A couple of comments on them:
 - assumption 3 – what does this assumption really mean – the resuspension model (while in reality the resuspension exchange is to some extent bi-directional, the EMB is explicit about this area not contributing to the resuspension term – As I read it the assumption is inconsistent with the EMB – without looking back now that I’m editing, perhaps I recall incorrectly that it is stated that the resuspension

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term derives from the erosion areas??...if I'm correct though I don't understand what is meant by the impact of the remedy is proportional to the fraction of fine sediment impacted by the remediation scenario.....perhaps this phrase is not precisely written and should read that it is proportional to the area of these sediments in the erosional zone.....this point brings up the underlying problem of doing Chapter 20 without discussing explicitly the goals and more details of the scenarios I think. Following the logic of the EMB and the rationale provided – scenario alone, what is the reason to remove or cap any part of the Primary Inventory Zone, where will the contaminated sediments go – please clear up my confusion...

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- assumption 4 – this assumption assumes both that the sedimentation rate locally or elsewhere is not affected by any deepening by dredging that might be considered (again a hypothetical simulation without details is frustrating and I think dangerous), and of course assumes that the sedimentation rates are unchanged over the next 70 years.....While one needs to make some kind of assumption within this EMB framework, it seems unreasonable to think that sediment accumulation rates will not change greatly in the lower Passaic as they have changed greatly as the River filled up over the past 80-90 – a danger of extrapolation using a steady-state model. Addressing this question, is an example of why one might want a more detailed sediment transport modeled that at one level could be calibrated with a combination of historical bathymetry and sediment property data.
- assumption 5 assumes that isolating and reducing significant source areas will neither have a positive effect on inputs to other source areas (I wouldn't remediate if this were the case), nor would it affect deposition or erosion in other areas by changing bathymetry/hydrodynamics/sediment sinks, etc. the language in the scenario seems to infer that the projections are independent of whether the action affects bathymetry and sediment sinks...
- assumption 6 is many assumptions....all tenuous....e.g., does resuspension of already depositional areas of inventory actually occur in the EMB framework or in the calculation; the question of bioturbation (I will not go there at this point as we will get into an argument – but it is at the least an uncertainty that others will comment on), and all the assumptions related to projecting resuspension terms are just not logical to me as they are presented –what is the justification for coming up with 0.27 cm/yr dep rate following remediation in any zone if sediment depth or hardness is altered, or as the River is filled even morethis set of assumptions is just too difficult to follow with respect to the conceptual basis behind them.
- assumption 7 is also several assumptions that are about as conservative (slow response times) as one can imagine within the conceptual framework of the EMB – it says that source reduction in the lower Passaic will have no discernable impact on fluxes from above MP 8 (we know already that there is extensive longitudinal transport by tidal pumping up to MP 10-12 and higher and the it follows that reduction in the upstream flux from remediation will result in some reduction in the upstream source back to the Lower Passaic – ultimately, a big reduction of the source from downstream will significantly reduce the “return

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load” – it was after all contaminated from downstream sources... The assumption about the nature of the response in Newark Bay to reduction in source from the Passaic is similarly “conservative” –; the assumptions also seem to implicitly assumes that sediment from the Kills/Harbor will not dilute concentrations in southern Newark Bay – and despite the fact that they will both experience decreases in COPC concentrations. As written - the N. Newark Bay concentration, that is important to the long term response in the entire system as it homogenizes, asymptotes to the current level in the south part of the Bay; this assumption not only drives projections of Newark Bay risks, but ultimately affects the long term response of the Passaic as the tidal exchange dilution term can never fall below S. Newark Bay levels – without more development, it is hard for me to make any suggestions....however, at the very least, much more work needs to be done if Chapter 20 scenarios and projections are to be left in the report. In its present form it really minimizes the great work done in the rest of the EMB study and report

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Response to the Questions Charged

I’ve not organized my comments to directly answer the Charge question, as it is too hard for me to answer them without a broader context that I’ve tried to provide, although in a convoluted way. Below are some shorter answers to the questions:

1. The data are adequate to develop and test the EMB and conceptual framework in its present form. Ideally there would be much more sediment data from the upper couple cm of the sediments, and more of those sediments would have been collected in ways that would have better characterized spatial variability of surface sediment sources such that one could better understand why and where very high concentrations exist in samples that have not been characterized as 7-Be bearing. I have suggested that the data (chemical properties and other measures of deposition) be used to create good maps of 3-D distributions of COPC’s in the Lower Passaic.....while there is lots of data, it is not considered (or at least presented) in a way that best describes the 3-D distributions of contaminants – information I would want to better inform any scenarios for dredging. I am not worried by uncertainties surrounding external sources from storm/waste water/atmosphere and groundwater – earlier I wrote some concerns about the pore water advection model; I’ve not read the appendix, but the parameters included in the model (e.g. mixed layer depth) lead me to believe that the model that I would object to the model used.....some of the parameter estimates are likely way off as well; However, I have convinced myself, as others have done in other sedimentary environments that the advective term is trivial, especially in the face of high deposition.....(I do not know the much about the groundwater table/head depths, but it is likely that most of the discharge occurs on River sides/banks or through low contaminant course sediments anyways. Diffusive fluxes would be much more significant using most model formulations, but again, the depositional nature of this system, combined with the obvious utility of the EMB for at least some important contaminants (TCDD e.g.), suggests that in the lower Passaic it may not be serious to neglect it. I do expect that ignoring diffusive fluxes out the bed in much less depositional areas (e.g., large areas of Newark Bay) will/can result in low response time estimates for clean-up.

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2. The answer to most of this question is that interpretation of 7-Be distributions do a great job of explaining transport of resuspended sediments and contaminants. With respect to bioaccumulation, I believe that careful analysis would show that the available data are insufficient to test this question with the accuracy that one would like. E.g., the high variability in local small fish and crab concentrations of TCDD could be the result of exposure to widely varying and seemingly patchy sediment concentrations, that have not been interpreted with this EMB. 55 56
3. See extensive comments above that pertain to this....
4. To summarize extensive comments above, the model is well tested (it could always be tested better) and critically evaluated with respect to understanding the distributions observed presently and in the historic record. I would like to become just a bit more confident in how well constrained the receptor model is to parameters used, with respect to allocating the sediment mass balance that is important in many ways.....As argued it is my conclusion that the conceptual EMB approach should be better tested and probably refined to understand both important local variability and for projecting responses into the future in this dynamic setting. 47 48
5. Am I convinced – yes!; am I convince by the report of the groundwater part – not yet, but I should look at the Appendix before that comment – However, I suggest considering taking the advective flux of pore water contaminants out of the report completely unless the much more likely to be important contribution of diffusive fluxes is considered adequately. 54
6. I'm not sure of what is meant by independent – the stormwater and potentially CSO fluxes, and other trib. fluxes can be largely controlled by atmospheric deposition (big impervious watershed and small Passaic River) – however, these sources are described with little doubt that they are independent...without going any farther, I'd just say I have no questions here. On the other hand in Chapter 20, it might be argued that these external sources are too independent (at least from understandings) as there is no allowance that these external loads will decrease.....this assumption impacts projections of long-term response, with or without active remediation. I would point out here what everyone knows - that reliable estimation of CSO and stormwater inputs of most of these contaminants is near impossible with the resources available.....furthermore, if I thought these sources could be at all important in this system, I would be more concerned about the incredibly low CV's associated with measurements used for these inputs – CSO and stormwater loads and measurements can not be expected to be precise (for theoretical and measurement problem reasons), especially true in the case of stormwater fluxes 57
7. See extensive comments above
8. my answer to the first question is the EMB is sufficient for this purpose – and done very well in a system that is especially amenable to this approach I believe. The importance of internal cycling (resuspension term) of TCDD can not be explained easily otherwise. Differences in the assumptions/parameters in the EMB and the resulting model fits would affect other conclusions but the very high percentage of TCDD load calculated to be from local sources is one prediction that is not at all sensitive to the calculation – without a missing higher concentration source – there can be no other result from this calculation. 58
9. I have commented extensively above.....I would only say that there are strengths and weaknesses of this major assumption. The lower the chlorination of PCBs the more it is it is expected that the conservative particle tracer approach will underestimate recovery

over time.....it is interesting to note however, that the observed dependence of hydrophobicity on particle association is not as great as predicted from the lab when compared to lab/theory based predictions, of this Richard will be quick to point out (but still the lighter PCBs are still found to a much greater extent in the dissolved phase). However – it is not surprising to me that lighter PCBs seem to be transported more or less with more particle reactive heavier PCBs – this I believe (see Achman et al., maybe 1994 or so, for the rationale/evidence) because the water is relatively well buffered with all the resuspended solids as solids go up and down into water flowing by – thus the amount of PCB or similar contaminant that desorbs during a resuspension event may be very low.

10. I have commented on this too much already....I would like to see more testing of the parameters that drive the estimate of the resuspension term. I have no doubt that it is high, but I want to be convinced that the estimate is as robust as suggested. As I expounded on, my concern revolves around 2 issues.....first if the resuspension term is lower, then the source concentration where TCDD is “eroding” would need to be relatively high.....if this is true, I think the case would be more compelling that one would want to place much more effort (I already do) on understanding the responsible erosional/hotspot areas. A factor of four over the whole area means that there are important areas that are more than a factor of four higher in concentration. The resuspension term comes very much into play if one uses it in projecting changes of concentrations as a function of actions or no-action....I’ve written too much about these concerns above.
11. This is where I think the report is weakest and as written unacceptable, and I comment extensively on this above – but the problem is not at all related to 7-Be interpretation in my view
12. No I don’t think any of this is justified satisfactorily at this point. As it is written I am not persuaded by the arguments or data analysis provided.....as I point out some of the biggest potential hotspot concentrations of TCDD have been observed above MP 8 – there are many muddy areas that are not as depositional and they may be important sources of erosion of relic COPCs.

MEMORANDUM

To: Alice Yeh (USEPA Region 2)

Date: June 26, 2008

cc: Bruce Fidler (Malcolm Pirnie)

Project: Passaic River

Subject: Peer Review of Comprehensive Conceptual Site Model

Tt Pjn: 100-RTP-T18082-05

Ref: Task 2.34 (WAD2, WO 2)

1 Responses to Charge Questions

Malcolm Pirnie, Inc. released the Peer Review Draft of the Comprehensive Conceptual Site Model of the Lower Passaic River on May 31, 2008. The report has three main components: the Conceptual Site Model (CSM) itself, an Empirical Mass Balance Model (EMBM), and a forecast model. General comments on each of these components are provided in Sections 2-4 of this review. Malcolm Pirnie also provided a list of specific charge questions. In this section, I have provided relatively brief responses to each of the charge questions, in several cases referring to more extensive discussions in the following sections of the review. The charge questions are reproduced below in indented italic form, interleaved with responses in normal font.

Adequacy and Use of Data

1. Are the data used in the CSM adequate to support its conclusions?

The report draws conclusions in a number of different areas. The general conclusions of the CSM that (1) legacy contaminants within the Lower Passaic are the main source of ongoing contamination of surface sediments, (2) the majority of resuspension of legacy contaminants occurs between RM 0 and RM 8, (3) contributions occur from the Upper Passaic and Newark Bay, but are of lesser importance than the contributions from legacy sediments, and (4) contributions from other sources appear to be minor, are adequately supported by the data – although some minor caveats are expressed below. More significant problems pertain to the conclusions of the EMBM, but this question is construed to refer to the CSM only.

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In addition to a general assessment, please comment on the following specific issues with regard to the adequacy of the current data set:

- Are the sediment sample results collected in the lower eight miles used appropriately in characterizing the contaminant inventory and gradients in three dimensions for the purposes of the CSM and EMB?

Yes, these results appear to be used appropriately.

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- Are the results of the high resolution cores collected above Dundee Dam sufficient to represent background loading levels for the system?

Both dated cores and fine-grained surface sediment samples are available above Dundee Dam. Although one could wish for more data, these samples are sufficient to represent the pollutant concentrations in depositing sediments above the dam. Whether they are adequate to represent upstream loads is less certain. Solids that move across the dam during major flow events could well differ from those solids retained in consistently depositional areas above the dam. Unfortunately, no direct evidence on this point seems to be available and I believe the use of the available depositional sediment data is adequate for the purposes of the CSM.

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- Are there sufficiently robust data of appropriate kinds to characterize the contaminant loads that enter the lower eight miles of the river from external sources, i.e., from tributaries, from combined sewer outfalls (CSOs) and storm water outfalls (SWOs), from in-stream sediments above RM8 and from Newark Bay?

There is a shortage of data to characterize inputs from external sources to the lower river, particularly from CSOs and SWOs. This is discussed further in Section 2 below. Individual CSOs and SWOs can have very different pollutant signatures, and use of average or typical values could hide the presence of elevated pollutant concentrations from individual stormsheds. It appears likely, however, that the CSO/SWO input is a minor fraction of the total pollutant mass balanced, as is argued in the report.

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- Are the available data adequate to verify that there are no important on-going, unquantified sources?

This question asks us to prove a negative, which is always difficult. The analysis of the mass balance for the entire Lower Passaic does provide a reasonably conclusive argument that the major sources are known and correctly identified. This does not preclude the possible presence of locally important, on-going, unquantified sources. For example, longitudinal TCDD profiles continue to show a concentration gradient from RM 12 downstream, despite the argument that the system is well mixed longitudinally between RM 2 and RM 12. This suggests that it is possible that there are on-going loads in stormwater from the former facility that was cited as being in this area.

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2. Is the use of the contaminant data associated with recently deposited, beryllium-7 (Be-7) bearing, surface sediment in the CSM-EMB sufficiently explained? For example, most reviewers of CSM documents readily understand that contaminant data from the upper 6-inches of sediment are used to evaluate exposure to biota and therefore to assess ecological risk. Is our description of the utility of data from Be-7 bearing sediments, intended to characterize material that was just recently transported through the water column and deposited on the sediment surface, similarly clear in its implications for assessing fate and transport?

Yes.

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Explanation of Assumptions and Uncertainties

3. Is sufficient attention given to quantifying and evaluating the impacts of uncertainties in developing the CSM-EMB, particularly with respect to the ability to use these tools in evaluating potentially large and very costly remedial alternatives? Are the magnitudes of the uncertainties associated with the data supporting the EMB predictions sufficiently bounded? Are the uncertainties associated with predicted post-remedial surface sediment concentrations and estimates of

contaminated sediment transport into the lower eight miles from above RM 8 and from other external sources adequately described?

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Uncertainties are, in general, adequately described throughout the CSM chapters. I do not feel, however, that the impacts of these uncertainties on EMBM conclusions are sufficiently acknowledged. A detailed discussion of some of these issues regarding the EMBM is contained in Section 3 of my comments, and the impacts of this uncertainty on post-remedial forecasts is provided in Section 4. In particular, the uncertainties associated with the forecast evaluations of remedial alternatives are not adequately described. This is especially true for all statements that depend on predicted time to reach a target or asymptote, which in many cases provide a single quantitative statement of number of years, despite the fact that these calculations depend on estimated half lives that are highly uncertain (see Section 4 below). Chapter 20 and the Summary in the report both should provide additional discussion of the uncertainties associated with the forecasts and the potential impacts of such uncertainties on remedial decision making.

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4. Since the use of a deterministic model (a model where outputs are described using mechanistic descriptions of the processes occurring in the system of interest) may be more common in a physically complex surface water body such as this partially stratified estuary, has the use of a receptor model, such as the EMB (where concentrations measured at sources and receptors are used to identify the presence of and to quantify source contributions to receptor concentrations) been sufficiently justified?

The general use of a receptor model to evaluate source contributions as one among multiple lines of evidence is sufficiently justified in the report. However, as noted above, too much precision has been attributed to the results of the EMBM application and uncertainties associated with EMBM forecasts have not been fully acknowledged.

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5. Is the premise credible that the loads from atmospheric deposition and groundwater are considered negligible in the formulation of the EMB?

The premise that atmospheric deposition and groundwater flux (separate from resuspension) are negligible contributors to the total mass balance of most pollutants under current conditions is generally credible and intuitively obvious given the large reservoir of near-surface pollutants in the Lower Passaic. For a few pollutants, such as low molecular weight PAHs, direct atmospheric deposition might be more significant. Further, additional discussion should be provided as to why atmospheric deposition can continue to be considered negligible in the lower-loading conditions after remediation.

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6. Does the CSM adequately justify the premise that the various external contaminant source profiles utilized in the EMB (tributaries, CSOs, etc.) are independent?

The receptor model approach assumes that the different source area profiles are independent of one another. This is commonly stated as a requirement for receptor models, as correlation between profiles can interfere with solution of the inverse problem, and may refer to either time series inputs or pollutant spectra. In the case of the Passaic the receptor model application is steady state, so the potential issue is correlation among the pollutant spectra. For example, the mercury concentration in one source should not be fully predictable from the TCDD concentration and the relationship between TCDD and mercury in another source. In fact, complete independence of source profiles is not required to solve such problems; rather, they must not be exactly correlated, as that would cause a situation in which the inverse problem does not have a unique solution (because the transfer matrix cannot be inverted). Presence of partial correlation will cause problems, but not preclude a solution.

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For the Passaic, not all source profiles are fully independent of one another. For instance, the Newark Bay source profile is clearly related to the Upper Passaic legacy sediment profile, as well as to the other sources. The report makes an assertion of independence, but does not actually test the extent to which this is true (for instance, by calculating the cross-correlations between source profiles). However, as noted above, the real need is for the source profiles to be sufficiently independent to allow solution of the inverse problem.

Solving the receptor model is analogous to fitting a linear regression model, which requires an assumption that there are not *exact* linear relationships among the independent variables. When partial correlation is present among the independent variables (a condition commonly dealt with in linear regression problems and termed multicollinearity), development of a least squares solution is still possible, but there are consequences for the estimation. Minimizing the sum of squared errors still provides a best linear unbiased estimator, but the power of the model is reduced. A summary of the consequences of multicollinearity in regression problems is fully applicable to the receptor model case¹: “The major undesirable consequence of multicollinearity is that the variances of the... estimates of the parameters of the collinear variables are quite large. These high variances arise because in the presence of multicollinearity the... estimating procedure is not given enough independent variation in a variable to calculate with confidence the effect it has on the dependent variable... Having high variances means that the parameter estimates are not precise (they do not provide the researcher with reliable estimates of the parameters) and hypothesis testing is not powerful (diverse hypotheses about the parameter values cannot be rejected).” Among the various appropriate responses to multicollinearity is to use extraneous information to constrain one or more of the coefficients. The EMBM properly takes this approach by introducing constraints on parameter ranges based on the relative proportion of solids loading from different sources that is believed to be reasonable based on physical evidence and relative areas. While this does help to address the multicollinearity problem, I will argue below that some of the constraints (e.g. the watershed area constraint on CSO/SWO loads) may be too restrictive.

70

7. Please comment on the appropriateness of the constructs and assumptions used in the mathematical formulation of the EMB.

There are some significant potential problems with the mathematical implementation of the EMBM. Fitting is to mean-normalized squared errors, not chi-square as stated, which weights the fit to contaminants that have a low concentration instead of toward those with high precision. The solution presented does not appear to be the optimal solution, and model results are sensitive to small changes in assumptions. These issues are discussed in detail in Section 3 of these comments.

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Clarity and Correctness of Data Evaluations

8. Are the available data and the observations made from them sufficient to support the following findings of the conceptual site model (CSM) regarding sediment fate and transport?

○ Although the Lower Passaic River is a partially-stratified estuary, the recently deposited sediments between RM2 and RM12 are sufficiently similar (and likely mixed by tidal action over time) that they can be represented by single average concentrations of each contaminant in the EMB relative to the gradients observed for external sources and end members.

Representation of recently deposited sediments between RM2 and RM12 as fully mixed is somewhat problematic as there do appear to be consistent spatial gradients. For instance, 2,3,7,8-TCDD in ⁷Be-bearing samples appears to decline by a factor of about 2-3 between RM 12 and RM 2 (Figure 14-4j) and somewhat smaller gradients are also evident for many metals. These internal gradients are sufficiently small relative to the external sources and end members that use of a receptor model, based on average concentrations, is acceptable as a means of investigating the overall mass balance of pollutants in the Lower Passaic. This simplification does create problems for evaluating and comparing remedial scenarios, as is discussed further in Section 4 of these comments.

111

○ Approximately 95% of the dioxin currently accumulating in the recently-deposited sediments on the river bottom is due to resuspension and subsequent deposition of the bedded legacy sediments; i.e., an internal source is driving the dioxin concentration in recently deposited sediments.

¹ Kennedy, P. 1979. *A Guide to Econometrics*. MIT Press, Cambridge, MA.

The finding that the majority of the dioxin currently accumulating in the recently-deposited sediments is derived from resuspension of legacy sediments is supported by multiple lines of evidence. Due to uncertainties in the EMBM formulation, I would characterize this as “90% or more” rather than “approximately 95%.”

112

9. Is the EMB’s exclusive focus on conservative, particle-reactive contaminants appropriate to understanding and predicting future surface sediment concentrations of interest in the risk assessment, or should alternate consideration be given to dissolved constituents, such as lighter molecular weight PCBs?

Human and ecological risk at the site is dominated by dioxins, followed by higher molecular weight PCBs particularly dioxin-like congeners with high TEQs. These substances are strongly particle-reactive and long-lived in the environment, making the focus on the movement of particle-bound pollutants appropriate. Various other contaminants are also present above target levels, and some of these are less dominantly transported in association with particulate matter. However, it is particularly appropriate for an Early Action decision to focus on the major sources of risk, which are particle-reactive and relatively conservative. A full analysis of site risks and responses to remedial options would require a more comprehensive examination that accounts for transport in the dissolved phase – and don’t forget the DOC-sorbed phase (typically resolved as “apparently” dissolved in sample results) that can play an important role in the transport of hydrophobic contaminants.

113

10. Please comment on the appropriateness of the process and outcome of the selection of the resuspension source term input for the EMB. Is the justification of the selection sufficiently robust? Do the lines of evidence derived from sediment stability evaluations support the source term selection?

The resuspension source term is characterized as equivalent to 1995 core tops in the Lower Passaic. Earlier iterations of the EMBM revealed that there were multiple solutions to the receptor model, with rather different implications, depending on which sediment concentrations were chosen to represent the resuspension source. The evidence for resuspension of legacy sediments does appear clear; what is less clear is whether this is a phenomenon that occurs throughout the Lower Passaic or is dominated by erosion of specific hotspots. The specific selection of the 1995 layer to represent this source appears somewhat arbitrary. As stated on p. S-41, “the mean concentrations of the 1995 0 to 6 inch layer were applied and found to yield a satisfactory fit in terms of both chemistry as well as sediment mixing volume.” It does appear that some other specifications, such as use of LWA concentrations, may yield a satisfactory fit on the EMBM but are inconsistent with available evidence on sediment dynamics in the system. However, representation of the resuspension source by the 1995 core tops is a gross approximation at best, and multiple other solutions consistent with the weight of geochemical data are still likely to be feasible. Within the context of the EMBM this could be investigated by synthesizing other “years” based on exponential decay formulations applied to the 1995 concentrations, in addition to evidence from dated cores. But, it appears more likely that the actual process of recontamination results from erosion of legacy sediments of a variety of ages – something that cannot be represented in the simplified form of the EMBM. Use of the 1995 core tops appears to provide a reasonable approximation to the ensemble behavior, but it should be recognized as a gross spatial approximation that obscures actual site processes. For this reason (among various others) the EMBM approach is not really competent to make distinctions more subtle than that between near total remediation and natural attenuation. An optimal approach to remediation could well involve more focused (and less costly) remediation of specific high-risk source areas, but such scenarios cannot be evaluated within the current framework. If the EMBM forecasts are used as a basis for an Early Action decision, other lines of geochemical evidence need to be used to remediate the highest-risk locations first, with provisions for adaptive management to adjust the remedy as additional information is collected.

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Appropriateness of Conclusions

11. Are the dated sediment cores and analyses of Be-7 bearing surface sediment samples sufficient as the basis for estimating post-remediation contaminant concentrations in sediment in the Lower Passaic River? Please comment on whether the predictions of postcleanup sediment concentrations are sufficiently supported and realistic given what is known about the system. Are the appropriate pre- and post-remediation conditions (including contaminant sources and the potential for recontamination) adequately represented in the predictions?

Model forecasts based on decay rates are highly problematic given the variability in the data used to estimate these rates, as discussed in Section 4 of these comments. The uncertainty in estimating decay rates has significant effects on the predicted ability of remedial actions to achieve goals; however, the effect on relative performance of the remedial alternatives and their comparison to natural attenuation is less severe. The EMBM approach is significantly limited in its ability to represent pre- and post-remediation conditions – and thus the potential for recontamination – due to its assumption of completely mixed, homogenous conditions between RM 2 and RM 12.

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12. Sediment stability evaluations (presented in the CSM) have led to the development of remedial alternatives that address the entire sediment bed of the lower eight miles of the river for comparison with No Action. Please comment on the significance of the uncertainties involved in this evaluation with respect to whether the entire bed of the lower eight miles of the river needs to be remediated, or whether remedies addressing only part of those sediments might be effective to reduce the surface concentrations in the Lower Passaic River to meet cleanup goals. In light of the uncertainties involved, are sufficient lines of evidence used in comparing the effects of the different remedial approaches to justify eliminating actions more limited than the entire lower eight miles? Is there additional evaluation of the available data that might provide adequate justification to add one or more limited early action alternatives that address smaller, highly contaminated erosional areas within the lower eight miles?

It is clear, as stated (p. 11-40), that “much of the river bottom is subject to large movements of several inches of sediment, resulting in multiple layers of deposition of alternating silts and sands.” It does not necessarily follow from this observation that remedial alternatives must address the entire sediment bed of the lower eight miles of the river – although that is the only alternative that the EMBM approach is really capable of evaluating. Significant stores of contaminants are present in areas that were consistently depositional during the periods of maximum pollutant discharge to the river. Recontamination from legacy stores occurs from areas that are currently erosional (but were previously depositional).

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Significant loads are most likely from areas that have recently shifted from a depositional to erosional status, perhaps from lateral migration of the channel thalweg. It seems likely that the major resuspension load source areas change over time, although the average rate of resuspension loading across the entire Lower Passaic River may be approximately constant.

94

The spatially averaged EMBM approach is not capable of evaluating remedial options at a finer spatial scale than the entire length of the Lower Passaic below RM 12 or some specified fraction of that reach (e.g., RM 0 to RM 8) based on the assumption of complete longitudinal mixing. It is likely that more limited early action alternatives that address smaller, highly contaminated erosional areas would be more cost-effective than broad-scale remediation, but the tools are not in place to evaluate this. Use of a detailed hydrodynamic and sediment erosion would obviously be useful to evaluate targeted remediation. The currently available data may provide some clues suitable for early action intervention. For instance, the bathymetric profiles could be reanalyzed to provide some indication of areas in which erosion is progressing into areas with significant stores of legacy contamination. Such areas would be natural high priority candidates for early action.

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2 Comments on Conceptual Site Model

The report has three main components: the Conceptual Site Model (CSM) itself, an Empirical Mass Balance Model (EMBM), and a forecast model. The CSM (Chapters 2-16) is the heart of the report, and assembles the available physical, hydrological, and geochemical data – despite their limitations – into a convincing account of the processes that determine conditions in the Lower Passaic. The EMBM and forecast model are, in a sense, add-ons that attempt to extrapolate the CSM beyond what the data will support.

Although I found the CSM to be, in general, a comprehensive and well-supported analysis of the evidence, the report did raise a number of questions that may need to be further addressed.

1. The report focuses on contaminants of potential concern (COPCs) on sediment, largely ignoring mass and transport in the dissolved phase or sorbed to dissolved or colloidal organic matter (both of which are in most cases analytically resolved as part of the dissolved phase). This is, in part, a function of the available data, as water column monitoring is sparse at best. It is also a reasonable approximation for hydrophobic contaminants that occur predominantly in particle-sorbed form. The approach also assumes that boundary condition concentrations on sediment are equivalent to concentrations on depositing sediment within the river, ignoring any transformations in the water column. However, these approximations may not be adequate for all COPCs. This appears to be the case for lower molecular weight PAHs, the distribution of which is not explained well by the CSM or EMBM, and may also be the case for mercury which can experience transport in the dissolved elemental form, transformation from elemental to particle-reactive ionic form due to photoionization, and methylation to organic form in the water column (as well as the sediment). 93
2. The focus on sediment-sorbed concentrations could be particularly problematic for organics in SWOs/CSOs. It is quite possible that these stormwater sources could include non-aqueous phase loads of hydrophobic contaminants from industrial sources, not associated with sediment loads. 65
3. The report contends that stormwater loads of contaminants are relatively insignificant relative to resuspension and upstream/downstream loads in the Lower Passaic; however, samples collected from stormwater outfalls were excluded from the analysis on the argument that these samples were collected from below the high tide mark and were influenced by recontamination from the river (Chapter 4 and 8). This could well be the case, but making this case means that there is little valid evidence on SWO contributions. The CSM makes the argument that the SWO contributions should be similar to contributions monitored in the monitored tributaries that drain similar land areas. This may be reasonable in general, but does not preclude the possibility that stormwater contributions from individual source areas could be significant to the mass balance in the Lower Passaic. The calculations to support the argument that SWO loads of contaminants are a small percentage of the mass balance in the Lower Passaic are not documented in the report. In addition, there are large differences (in some cases statistically significant) between the 2007-08 CSO/SWO samples and the CARP CSO/SWO data that are not adequately explained. 65
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4. The long-term solids loads from CSO/SWO sources are basically unknown. Chapter 8 indicates that these loads were based on unit-area loading from the Saddle River, and work out to 65.1 $\text{yd}^3/\text{mi}^2/\text{yr}$, or about 137 $\text{kg}/\text{ha}/\text{yr}$. The loading rates for the gaged Saddle River (along with the assumed density of about 0.712 g/cm^3) are taken from Lowe et al. (2005)². The cited article provides no details on this calculation, but instead refers to an earlier LMS report³. That report also provides few details, saying only that “Flow and TSS measurements at USGS station 68

² Lowe, S., K. Abood, J. Ko, and T. Wakeman. 2005. A sediment budget analysis of Newark Bay. *Journal of Marine Science and Environment*, C3: 37-43.

³ LMS. 2004. A Macro Assessment of Newark Bay Sediment Budget. Prepared for The Port Authority of NY & NJ. Lawler, Matusky & Skelly Engineers, LLP, Pearl River, NY.

- #01391500 in Saddle River at Lodi, NJ were used to estimate loads...” The undocumented method for estimating load could be important here, as the strong correlation between flow and load can often introduce bias into sediment load calculations. The delivered loading rates for Saddle River do appear reasonable, but are clearly less than near-source literature values for solids loading from urban sources. For instance, the PLUARG studies⁴ cited solids loading rates from general urban land uses of 200 – 4800 kg/ha/yr, with loads from industrial land uses ranging from 450 – 1700 kg/ha/yr. The delivered load at Lodi is presumably substantially less than the generated land side load due to retention and trapping. However, the sediment delivery ratio is generally a function of watershed area, which is 54.6 mi² at Lodi. Indeed, the sediment delivery ratio at Lodi should be on the order of 9%⁵, using the relationship $SDR = 0.31 A(mi^2)^{-0.3}$, implying that the at-source loading rates are on the order of 1500 kg/ha. Individual stormwater drainage basins are much smaller, and will typically have higher delivery ratios. For example, a 1 mi² stormwater drainage should have a sediment delivery ratio around 31%, leading to a delivered load rate of about 470 kg/ha/yr, 3.4 times the rate assumed for characterization of the SWOs. All this suggests that the CSO/SWO solids load may be significantly under-estimated. It does appear, however, that the contribution of solids from CSOs/SWOs is at most a few percent of the total solids balance, and may be of much greater concern that the pollutant concentrations in CSOs/SWOs are not well known. It may be that the watershed area constraints on CSO/SWO loads employed in the EMBM (which allow for only a 50% deviation from the unit area loading rates) are too restrictive.
5. The discussion of the pore water boundary contribution in Chapter 9, using the Reible model, concludes that this is not a major source of contaminant flux to the river. The conclusion appears reasonable; however, there are problems with the way the argument is made. The Reible approach evaluates equilibrium partitioning between sediment and porewater, then uses the porewater velocity and sediment area to calculate load to the water column. The seepage velocity is a key parameter here. Apparently areal groundwater discharge rates were estimated by baseflow separation, then applied to the Passaic River direct drainage (the calculations are not given in detail). It seems clear that this approach will drastically overestimate seepage velocity through contaminated fine-grained sediments, because (1) groundwater discharge will occur predominantly through coarse-grained sand lenses, and (2) a significant portion of the total groundwater discharge from the direct drainage is likely intercepted by the stormwater conveyance system in this relatively flat topography. Other types of non-erosional flux out of the sediment (including diffusion, biological pumping by benthic organisms, and methane ebullition) are not discussed here, presumably because they would be lumped into the general “resuspension” term in the EMBM.
6. The discussion of atmospheric boundary conditions (Section 9.2) is very brief, and begins with an assumption that this is a minor contribution, “not expected to be substantial transport mechanisms.” Atmospheric contributions are essentially dismissed based on observed metals, TCDD, chlordane, and PCB concentrations, although the actual data supporting this claim is not documented in any detail. Clearly, atmospheric deposition is not the major source of many of the contaminants in the Lower Passaic – but this does not mean that it does not play a role in the mass balance of contaminants, particularly in the evaluation of future conditions as in situ regeneration of loads declines. Nearfield combustion sources of PAHs via atmospheric deposition might be of particular importance, but are not discussed here, despite the fact that PAHs are included in the EMBM fit.
7. The discussion of salinity data in the hydrodynamic evaluation notes problems with probes, attributed to “debris.” The observed problems with these data seem more likely to be due to

⁴ Sonzogni, W.C. et al. 1980. Pollution from land runoff. *Environ. Sci. Technol.*, 14(2): 148-153.

⁵ Maidment, D.R., ed. 1992. *Handbook of Hydrology*. McGraw-Hill, New York

biofilm development. The QC procedures cited in regard to the salinity data appear fairly arbitrary; there are no detailed notes on quality evaluation, and no discussion of drift correction.

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Analysis of fit of the hydrodynamic model to salt front position should ideally employ a harmonic analysis. These issues are, however, mitigated because the analysis of salt front position in the CSM is used only in a qualitative way to establish that the water between RM 2 and RM 12 is tidally mixed.

8. In the discussion of solids transport (Chapter 11), the apparent lack of strong correlation between depositional rate estimates from bathymetric surveys and core classification (p. 11-37) is disappointing, particularly as the reason is cited as “unknown.” This calls into question whether the bathymetry is sufficiently accurate to establish sedimentation/erosion rates and/or whether the ¹³⁷Cs data interpretations are valid. I suspect both analyses are valid (although you will need to support this in stronger terms) and that the lack of correlation is primarily due to scale issues, with a core representing only a 6” segment of the bottom. That, however, suggests that erosion and deposition in the Lower Passaic is extremely heterogeneous at a fine scale, making the identification of high-risk erosional hotspots problematic.

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9. The characterization of historical sediment (Chapter 13) discusses apparently higher sedimentation rates prior to the 1963 ¹³⁷Cs marker than occurred subsequently. This is likely related to the gradual return of the river to quasi-steady state conditions after the cessation of navigational dredging. The analysis assumes that one constant deposition rate applies prior to 1963, and another lower rate applies after 1963. If the decline in deposition rates is due to gradual filling of the dredged channel, wouldn’t it be more appropriate to assume a deposition rate that declines exponentially over time, rather than imposing a step change?

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10. The Chapter 15 discussion of contaminant fingerprinting is generally well done. One concern here is the discussion of PCBs derived from the Upper Passaic. The Upper Passaic (above Dundee Dam) is described as an important source of total PCBs to the Lower Passaic, but the fraction of highly chlorinated PCBs above Dundee Dam is much greater than seen in the Lower Passaic. This suggests a situation in which PCBs in the Dundee pool are being dechlorinated, with preferential transport (perhaps in DOC-sorbed form) of the lighter congeners into the Lower Passaic.

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3 Comments on Empirical Mass Balance Model

An Empirical Mass Balance Model (EMBM) was constructed to synthesize the results of the CSM and is presented in Chapters 17 – 19 of the report. The EMBM is a receptor-type model, which attempts to explain observed concentrations in surface sediment in the Lower Passaic River based on fitted coefficients that account for the proportion of loading due to each source.

Receptor models are often used, with some success, in air toxics modeling. In a typical application, observed concentrations at a given monitoring location are described in terms of the fractional contribution from multiple emission sources. In most cases, these are point-to-point relationships, although diffuse sources may also be included. Solution may be sought either in terms of temporally averaged concentrations or by fitting to time series.

It is important to note that the Passaic River application is not based on a point-to-point relationship. The output or receptor concentration is the average concentration in ⁷Be-bearing sediments in the Lower Passaic, while the input or source concentrations include average concentrations in Lower Passaic legacy sediment, average concentrations in upper Newark Bay surface sediments, and average concentrations in multiple CSOs and SWOs. Contributions from the Upper Passaic, Saddle River, and Second River are essentially point-in-space inputs; however, their spatial relationship to the receptor is lost because the receptor concentration is an average over the Lower Passaic. All these inputs are also specified as temporal averages, although the time-basis for the data averaging is unavoidably inconsistent for the various sources.

Many techniques have been developed for receptor modeling. These generally fit into two classes: source profiles known, and source profiles unknown. Where source profiles are known, the model can be solved by a simple mass balance approach or through use of multivariate calibration methods like partial least squares, artificial neural networks, or genetic algorithms. When the number and strength of source profiles is unknown, the problem is much more difficult, although techniques such as positive matrix factorization have been applied.

The EMBM application for the Passaic reduces the problem to the simplest possible formulation: consideration of a single receptor site, with the assumption that the source profiles are known. Both are somewhat problematic. First, the receptor is actually an average over about 10 miles of river. Even though strong evidence is presented for longitudinal mixing throughout this length, there are also evident variability and spatial trends within surface sediment concentrations in the Lower Passaic. For example,

Figure 14-15a shows that the 2007-2008 surface sediment concentrations of 2,3,7,8-TCDD decline by about a factor of about 2-3 between RM 10 and RM 2. The number of sources is considered known only

due to considerable lumping. For instance, all SWOs are represented as a single source, although they could be very different from one another depending on the land that is drained. The source profiles are also highly uncertain: there are severe data limitations for some sources, as well as indication of significant spatial gradients within some unitarily defined source areas, such as Upper Newark Bay. The problem is particularly acute for the key internal resuspension source. Not only is this somewhat arbitrarily defined as equivalent to the 1995 core tops, but the data are highly variable for many parameters, with coefficients of variation in excess of 200% for 2,3,7,8-TCDD and total TCDDs.

In fact, every depositional area within the Lower Passaic is a somewhat different receptor, and every eroding hotspot is a separate source. Obviously, analytical complexity precludes distinguishing all these different receptors and sources; however, the analysis could have been done in a variety of different ways –for instance by subsetting the length of the Lower Passaic into more than one receptor (and more than one source) and solving the model using a multivariate approach

Targets for the receptor analysis were selected via a cluster analysis to identify independent contaminants that “provide a relatively unique pattern for each of the various sources.” This is a necessary step to

reduce multicollinearity, but also contains subjective components that may influence model results. In theory, the EMBM is predicting only solid-phase transport. One identified cluster of PAH compounds “was not included because it contained mostly 2- and 3-ring PAH compounds, which likely have significant dissolved phase concentrations.” On the other hand, TOC is included, and TOC can also have a significant dissolved phase concentration. It can also be created *in situ* through algal growth, which may make it a poor candidate for a solids-based EMBM. Some other constituents may also have significant non-solids phases. For example, mercury can be transported as dissolved gaseous mercury and converted to solid phase on photo-ionization. For the organics, solubility is expected to be low (total PCBs is defined as the sum of Aroclors 1248, 1254, and 1260, and thus likely does not include most of the mono- and dichlorobiphenyls that can have significant dissolved fractions); however, as we have seen in the Hudson, these type of compounds can have significant fractions sorbed to DOC in the water column, which move independent of sediment and are often with the filtered (apparently dissolved) fraction in sample results.

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Application of a receptor model is a classic problem in inverse modeling, and inverse modeling problems are inherently difficult in the face of data uncertainty. The text (Equation 18-2) presents the model as:

$$Y_i = \sum_{j=1}^p f_j X_{ij},$$

where Y_i is the receptor concentration of constituent i , f_j is the fraction contributed by the j th source, and X_{ij} is the concentration of constituent i in the j th source. This simplistic presentation ignores the presence of measurement uncertainty in both the Y and X . The uncertainty in the Y_i implies that the receptor model should properly be written with a disturbance term as

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$$Y_i = \sum_{j=1}^p f_j X_{ij} + \varepsilon_i,$$

from which it is evident that the receptor model is actually a multiple linear regression problem – as is acknowledged through proposed use of a chi-square fit criterion in the parameter optimization. However, there are also considerable uncertainties in the source (regressor) terms, the X_{ij} . Stochastic regressors can cause problems with chi-square optimization. In general, if the disturbances in the regressors are independent of the disturbances in the receptor measurements no bias is introduced; however, if the disturbances in the regressors are correlated with the disturbances in the receptor measurements the resulting fit may exhibit systematic biases, because some of the disturbance-generated variation of the dependent variable is incorrectly ‘credited’ to the regressor with which that disturbance is correlated. For example, if the estimated value of the receptor mean concentrations are overestimated relative to the true average (due to choice of sampling locations, for instance), then too much weight will be assigned to sources whose strength is also over-estimated.

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Fitting of the EMBM is done through numerical optimization, rather than solution of the normal equations for the regression problem, but is subject to some of the same problems. First, high variability in the source terms results in high uncertainty in the estimated values of the f_j . Second, the solution may be impacted by heteroscedasticity. For instance, if the disturbances in measurements are positively scale-dependent, then a chi-square fitting procedure will tend to exaggerate the effect on the fit of disturbances in larger observed concentrations. It appears likely that a log transformation might improve the model fit approach. Indeed, on p. 18-6 it is noted that “ σ_i was ultimately replaced by Y_i itself in the objective function because the magnitude of the variability was found to depend on the magnitude of the detected concentration.” This approach – which implies that the chi-square optimization was not actually used – is, I believe, an incorrect response to this problem. Instead, suitable data transformations (e.g., log transformation) should have first been used to reduce the scale-dependence of the disturbance term. In essence, each chi square term in the summation has been multiplied through by the square of the CV, as $CV = \sigma/\mu$. This has the effect of weighting the fit toward those constituents that have a lower concentration (e.g., TCDD) rather than toward those that have a lower variance. The approach taken leads one to suspect that the fit was purposely weighted toward TCDD.

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The optimization problem for the EMBM is set up with a series of constraints on the range of the relative proportions of solids loading from different sources, derived from the analyses in the CSM, and a requirement that the source fractions sum to 1. The constraints on relative proportions of solids appear reasonable, except that the range may be too small for the CSO and SWO sources as noted above, and some such constraints are likely required to obtain a physically meaningful fit in the face of multicollinearity. However, the four constraints listed in the text on p. 18-7 differ from those set up for Solver in the copy of the model provided to the peer reviewers. The constraint that the source fractions sum to 1 is not necessarily appropriate, given uncertainty in the regressors, and some variation about a sum of 1 should likely be allowed.

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According to Malcolm Pirnie staff, the final fit of the EMBM model was obtained using Crystal Ball, a commercial add-in to Excel. This version was not supplied to the peer review. However, exploration of the model response surface reveals a difficult optimization problem, in which the Excel Solver gradient approach tends to become trapped in local minima. In part, this may be due to the constraint that the sum of the factors exactly equal 1. Parameter uncertainty and correlation introduced by multicollinearity in the source data also likely plays a role.

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The Base Case EMBM results reported in Table 19-2 **do not** appear to be correct and do not entirely match the electronic file. Table 19-2 shows the fractions as 46% resuspension, 27% Newark Bay, 22% Dundee Dam, 0.5% Third River, 1.3 % Second River/SWO, and 0.3% CSO. First, these fractions sum to 97.1%, apparently because Saddle River is omitted from the table. Second, the ratio of CSO to Dundee Dam (Upper Passaic) is 0.0136, which violates the constraint stated in Equation 18-4d. The electronic file, which appears to match Figure 19-2 (but not Table 19-2), gives the fractions as 46.1% resuspension, 27.1% Newark Bay, 22.0% Dundee Dam, 2.4% Saddle River, 0.5% Third River, 1.3% Second River/SWO, and 0.5% CSO – and does meet all the stated constraints. This set of parameters yields an objective function value of 0.385 (incorrectly labeled “Chi square”, as noted above). The Excel Solver will not improve the model from this point – but the supposed fit can readily be shown **not** to be a global minimum. Holding all but the first two components (resuspension and Dundee Dam) constant, a better fit, with objective function value of 0.371, is readily obtained with 43.5% resuspension and 29.7% Newark Bay (Figure 1). All constraints stated in the text are met with this revised solution.

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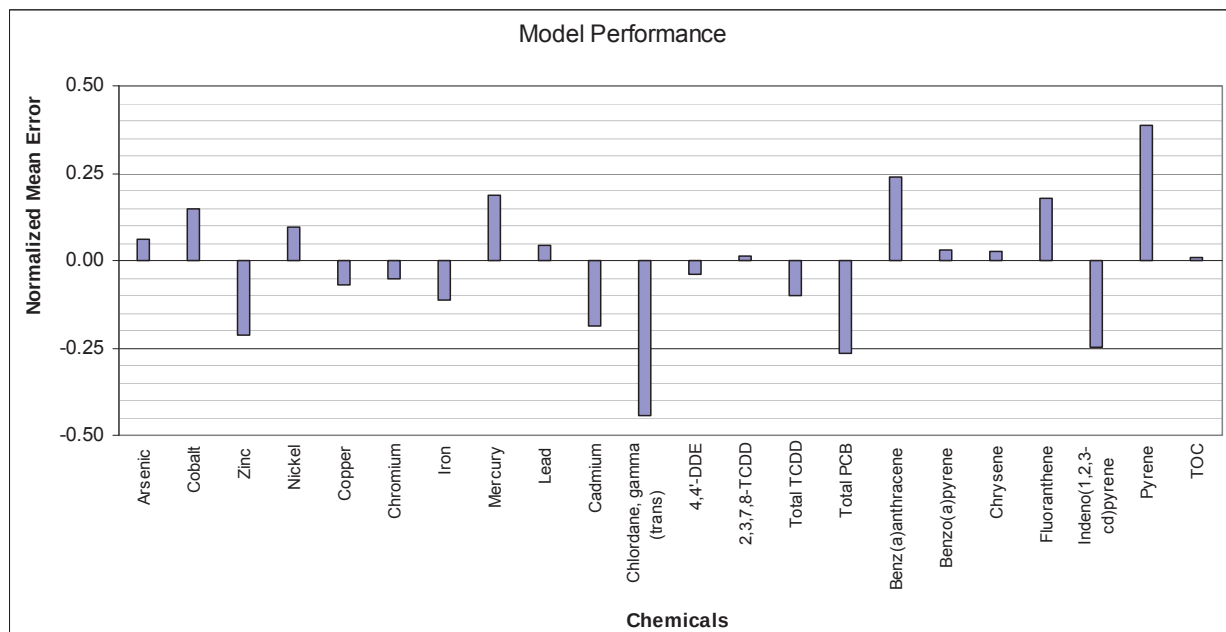


Figure 1. Alternate Model Fit, Base Case with Resuspension = 43.5%

Why the Crystal Ball application failed to find a better fit (at least as good as the one shown above) is unclear and needs to be explained.

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Certain aspects of the EMBM solution emerge naturally from the data. Most notably, the receptor TCDD concentration is higher than any of the sources other than the resuspension source. This is also the case for chromium, cadmium, and total PCBs. Thus, a solution that minimizes apparent error on any of these parameters will tend to show a relatively large contribution from resuspension. In contrast, for chlordane only the local tributary sources (Saddle River, Second River, Third River, CSO/SWO) are greater than the target concentrations – guaranteeing that a non-zero contribution from these sources will be estimated if chlordane is included in the sum of squares. Other pollutants have less unique signatures that can be synthesized in multiple ways.

This suggests that the apparent solution is sensitive to the constituents that are included in the optimization – and indeed this seems to be the case, within limits. Optimization (using the non-chi-square objective function and the constraints provided in the sample file) on the PAH, organics, and metals contributors as separate groups yields resuspension contributions ranging from 53.5 to 59.7%, contributions from Newark Bay ranging from 3.6 to 15.5%, and contributions from the Upper Passaic ranging from 23.6 to 26.6 %. All of these differ from the Base Case calibration in having higher contributions from resuspension. One reason for this is revealed by a calibration to TOC only, which produces an estimated contribution from resuspension of only 27.3%.

A fit to the same set of variables used in the base case that minimizes chi-square error (rather than mean-normalized error) while meeting the stated constraints yields rather different results, with 37.3% from resuspension, 37.1% from Newark Bay, and 20.9% from Upper Passaic River. As expected, this fit deemphasizes TCDD (Figure 2).

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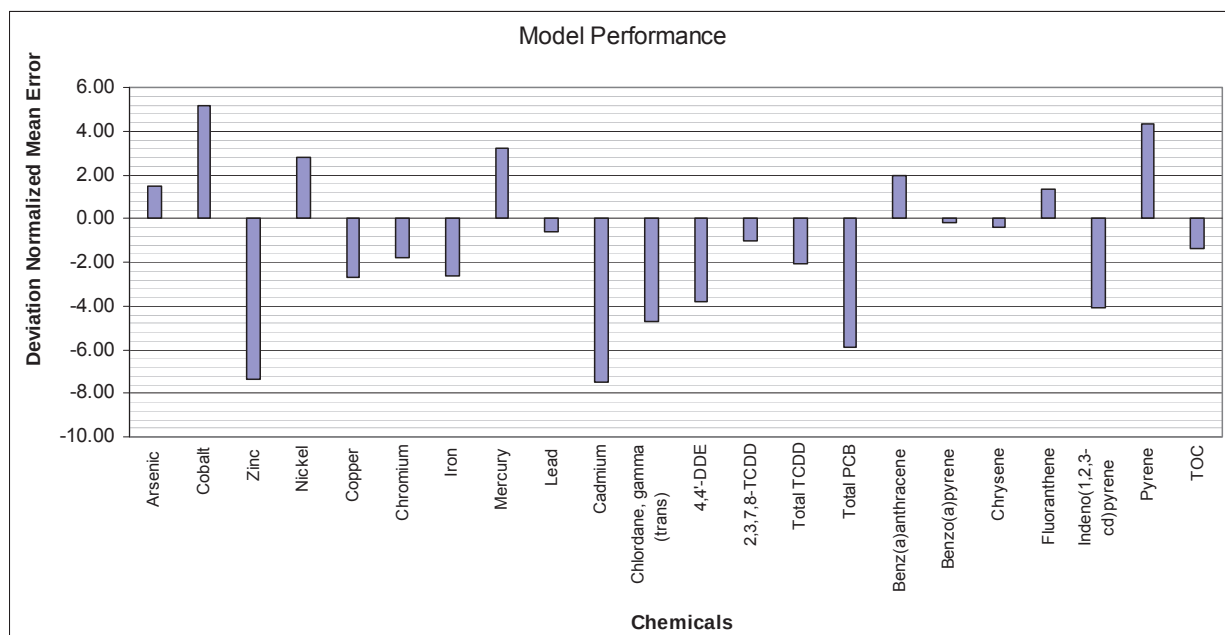


Figure 2. Chi-Square Fit for the EMBM

One way to evaluate the impacts of regressor uncertainty on the EMBM results would be to do a comprehensive Monte Carlo simulation, in which the regressor concentrations are either generated from statistical distributions or obtained by bootstrap resampling from the data. This has not been done (and might well not be worth the effort, as noted below). Instead, the CSM report presents a limited number of sensitivity analyses. The sensitivity analyses evaluate use of iron normalization, use of southern Newark Bay source data, separation of SWOs from Second River data, and lognormal transformation with MVUE

fit. The sensitivity analysis results (in Appendix H) are shown only in graphical form, but all appear to result in an estimated contribution from resuspension in the 40-50% range. It should be noted that the reported sensitivity scenarios do not evaluate use of subsets of the target parameters or use of the chi-square (rather than mean normalized) criterion.

In sum, the EMBM is beset by many forms of uncertainty. Results should be regarded as rough approximations only. It should also be kept in mind that the EMBM is an analysis of correlation, not causation, as it is not a physically based model. Essentially, what the EMBM tells us is that the largest contributor to contaminant concentrations in current depositional sediment as an average across the Lower Passaic River is resuspension of buried contaminants from within the Lower Passaic, with smaller contributions from the Upper Passaic and Newark Bay. We already knew this from the TCDD profiles.

The EMBM adds lines of evidence to support the geochemical interpretation of the CSM, but given the levels of uncertainty, the EMBM results should be regarded as more qualitative than quantitative.

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The qualitative confirmation of the CSM is a useful result of the EMBM. Does the lack of reliable quantitative results from the EMBM matter? The EMBM is not directly used as a basis for decision. However, it indirectly impacts the analysis of remedial options because the EMBM is used to evaluate the fraction of loads that are not subject to control by remediation within the Lower Passaic.

4 Comments on Forecasting Applications

The third major section of the report addresses forecasting concentrations in recently deposited sediment, which is used to compare remedial options

The forecasts consist of two components: a reconstitution of sediment sources that depends on the EMBM results and an estimate of half-life for the resuspension and Newark Bay sources. While the resuspension and Newark Bay sources are assumed to naturally decline with time, the other sources are not. The calculation of half-lives must address only the resuspension and Newark Bay components, obtained by difference, so this estimate also depends on the EMBM results. In sum, uncertainty in the EMBM propagates into the forecast concentrations in two ways: through the mixing equation and through the estimation of half lives.

The half-lives are based on logarithmic regression through dated core segments (after 1980 only) in the Lower Passaic, after correction for the estimated portion of the load due to external sources. Source concentrations in Northern Newark Bay (which lacks recent high resolution cores) are assumed to decline at the same rate as the resuspension source in the Lower Passaic River – an assumption that is cited as “rational, and perhaps conservative.” I am not sure the selection is rational, as the Northern Newark Bay source is conceived of as active surface sediments, while the Lower Passaic River resuspension source is supposed to represent buried legacy contaminant mass in place since ca. 1995, but there do not seem to be data to support an alternative.

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Results produced by the forecasting for a given contaminant will depend on the fraction of load that is estimated to be derived from external sources and the relative length of the constituent half life. If the fraction derived from external sources is large, then remedial options in the river (including natural recovery) will have little effect. If the external source is large and the half-life is long, river concentrations should asymptote to the mixed concentration associated with the external load, while if the half-life is short they will asymptote to a low value. If the external load fraction is low then exposure concentrations in the river can be reduced. If the half life is short, then natural recovery will compare well with active remediation; if the half life is long and the external load fraction is low, then active remediation will show a distinct advantage over natural recovery.

The comparison between remedial options depends critically on the estimated half life. It is therefore somewhat disturbing to see the high levels of uncertainty present in the half-life estimates. In particular, for 2,3,7,8-TCDD, which is the major contributor to risk, the R^2 value cited for the half-life regression is only 0.19, and values for several other compounds are not much better.

2,3,7,8-TCDD is the compound for which we might expect the most unambiguous results, as it is well studied and dominantly derived from resuspension in the Lower Passaic (and thus is not much affected by errors in source fraction attribution in the EMBM). The relatively poor fit appears to be a direct result of the simplifying assumption that concentrations are longitudinally mixed throughout the Lower Passaic below RM 12. This can be seen by examining the individual core trajectories (Figure 3). The half-life used in forecasting (25.6 years) is based on simultaneous analysis of all the data. However, most of the cores show parallel, but not collocated trajectories, while one core (RM 1.4) appears to show a distinctly different slope. In other words, the cores do not represent longitudinally constant conditions, and lumping the different cores together obscures the underlying trend in individual cores.

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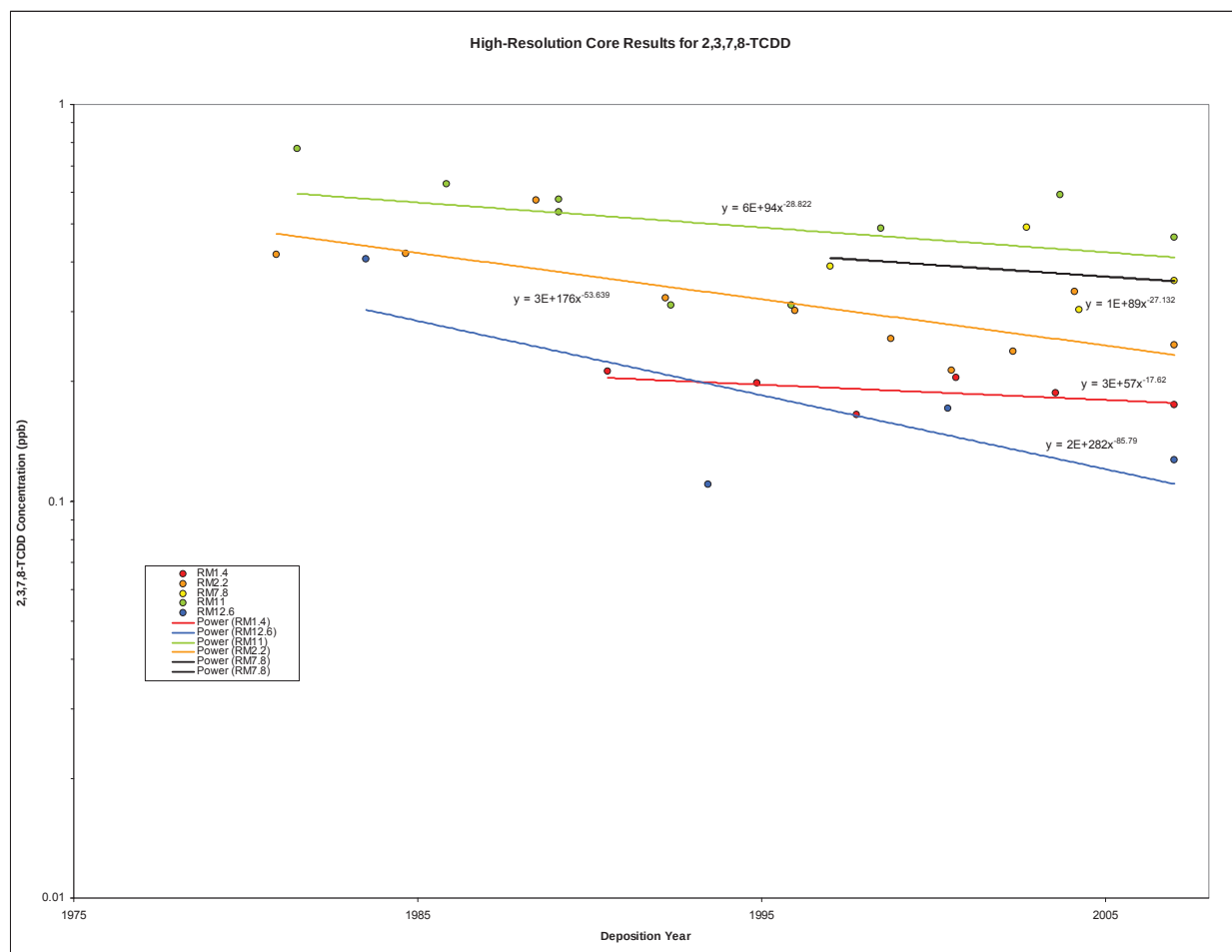


Figure 3. Individual Core Trajectories for 2,3,7,8-TCDD

Fitting trajectories to individual cores yields much higher R^2 values, but also reveals spatial differences in rates of attenuation (Table 1).

Table 1. 2,3,7,8-TCDD Half Life Calculated from High Resolution Cores

Location	Half Life (yrs)	Lambda	R^2
RM 1.4-12.6 (report)	25.6	0.027	0.19
RM 1.4	79.2	0.009	0.286
RM 2.2	25.8	0.027	0.572
RM 11	48.2	0.014	0.153

As shown in the table, the trajectory at RM 2.2 is similar to the ensemble trajectory, but half lives are much longer at RM 1.4 and RM 11. The core at RM 1.4 appears to be in a part of the river that has not yet returned to equilibrium with sediment supply after the last dredging operations. At a minimum, the analysis suggests that the assumption of a single half-life across the entire Lower Passaic may not be reasonable.

A comparison of estimated trajectories with different half lives (Figure 4) shows that the reduction in concentration associated with the remediation options changes little, on average, although the trajectory slope changes, resulting in a 2080 concentration that is higher by a factor of about 3 when the half life is increased by a factor of 3.

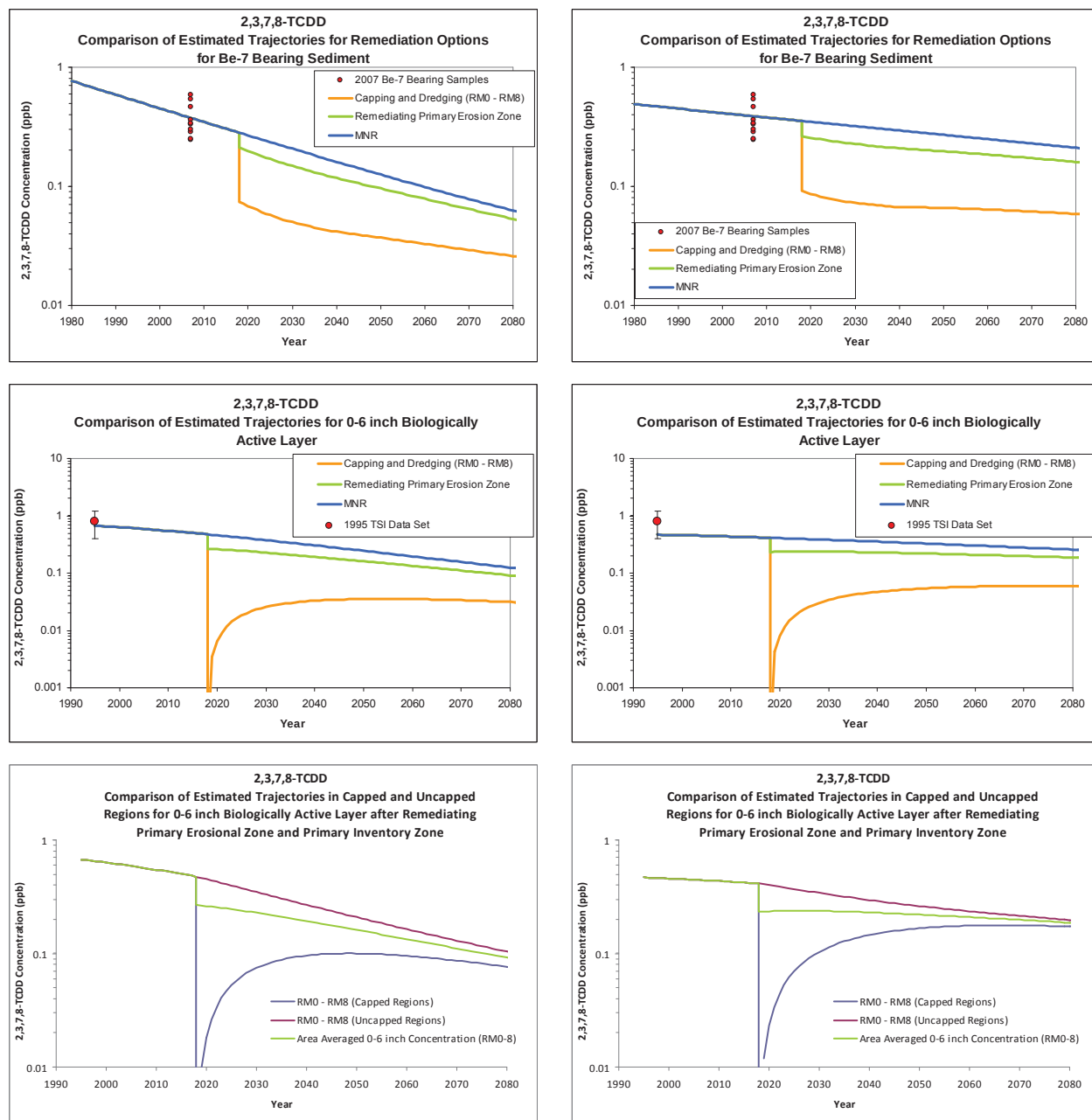


Figure 4. Comparison of 2,3,7,8-TCDD Results at Half-Life of 25.6 (left) and 79.2 Years (right)

Substitution of a different EMBM solids fraction solution appears to have only a small impact on 2,3,7,8-TCDD forecasts. To test this, I examined the chi-square solution cited in the previous section, which leads to fractions of 37.3, 37.1, and 20.9% for resuspension, Newark Bay, and Upper Passaic, respectively. This does not change the half-life estimate significantly, as most of the 2,3,7,8-TCDD derives from resuspension in any case. The resulting forecasts look similar to those contained in the report, but the 2080 concentrations are lower (0.080 vs. 0.092 ppb for the 6-inch biologically active zone

forecast). Substituting the chi square solution into the PCB trajectory forecast also results in only small changes, although the half life estimate declines from 22.8 to 22.5 years.

The model forecasts are also sensitive to specification of the “bioturbation thickness” – the depth to which sediments are annually mixed. This is set at 6” in the forecast spreadsheets. This value seems rather large, if bioturbation is indeed the mixing mechanism. The SPI results for the Lower Passaic⁶ suggest that bioturbation is not effectively mixing more than a few cm at many locations, consistent with a more general survey of bioturbation provided by Dr. Lick⁷. Instead, the SPI results and other considerations suggest that many sites experience several inches of hydrodynamic scour and redeposition per year as a result of cycles of sediment erosion and deposition. This may look like bioturbation in a ¹³⁷Cs profile, but is a substantially different process, because the sediments are not mixed in place. This issue is probably not a major problem for the EMBM because a simplifying assumption that depositional surface sediments are well-mixed throughout the Lower Passaic is already incorporated, so deposition of several inches of mixed sediment derived from locations throughout the Lower Passaic is equivalent to an assumption of the same depth of in-place bioturbation (for the EMBM). Nonetheless, the assumption of a mixed depth of 6” appears to be on the high side of the likely range (greater than both the typical surface layer thickness and typical depth of the redox discontinuity observed in the SPI results). Thus, a smaller mixed depth (which should not be called a bioturbation depth) may be appropriate for the forecasts.

The effect of reducing the mixed depth is to make both remediated and unremediated areas asymptote more quickly to the current year estimate of total loads. The impacts of reducing the mixing depth from 6” to 1” on 2,3,7,8-TCDD forecasts are examined in Figure 5. The effect on general trajectories is small, and largely confined to the first years after remedial intervention. However, the comparison of capped and uncapped regions under the alternative in which only the primary erosional zone and primary inventory zone are remediated are dramatic, with the two regions coming into equilibrium with one another much more quickly with a reduced mixing depth.

⁶ Germano & Associates. 2005. Final Report, Sediment Profile Imaging Survey of Sediment and Benthic Habitat Characteristics of the Lower Passaic River, Germano & Associates, Inc., Bellevue, WA.

⁷ Lick, W. (in press, 2008) The sediment-water flux of HOCs due to “diffusion” or is there a well mixed layer? If there is, does it matter? *Environ. Sci. Technol.* (accepted)

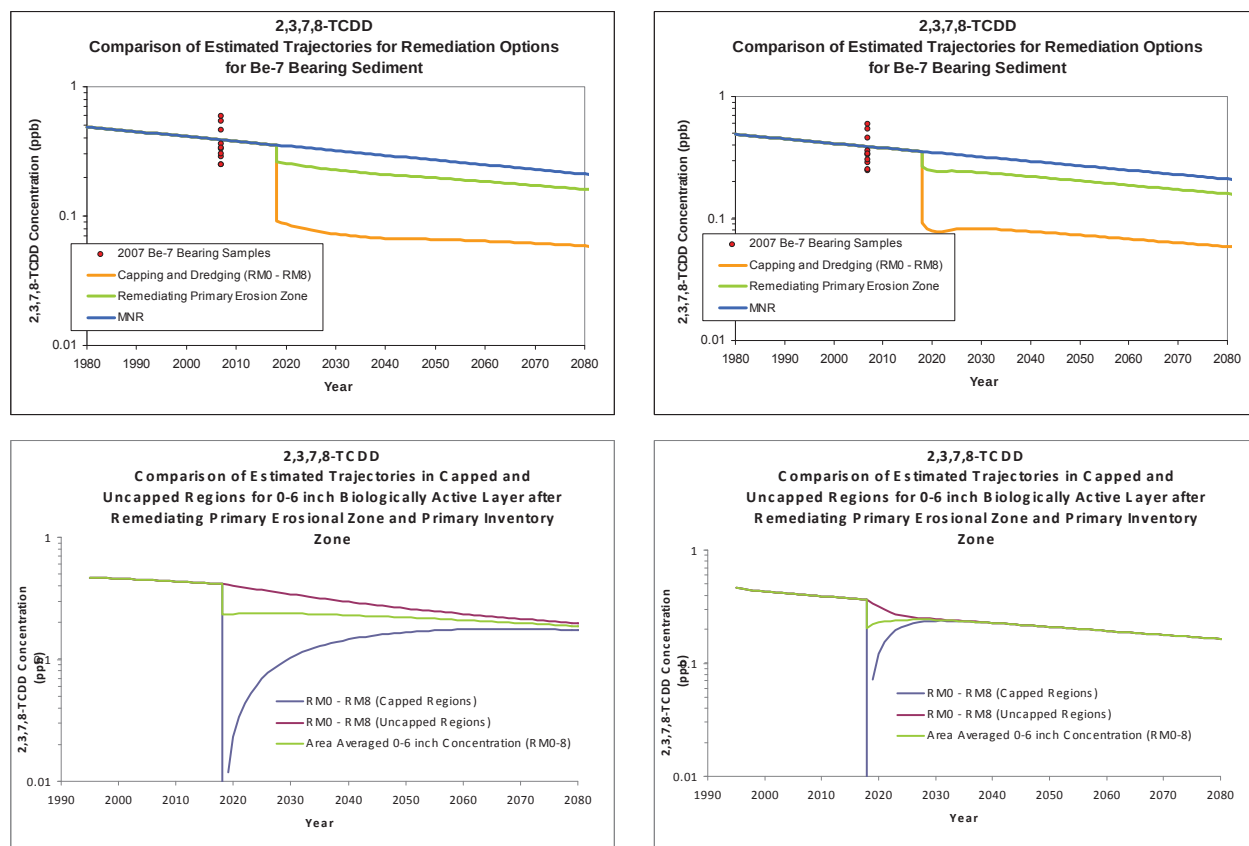


Figure 5. Comparison of 2,3,7,8-TCDD Forecasts for Mixing Depths of 6" (left) and 1" (right)

In general, the EMBM forecasts appear fairly robust to the effects of altered source fractions or recalculated half life, while the mixing depth assumption primarily impacts the partial remediation scenario. There is, however, a larger issue of interpretation relative to remediation. Both the EMBM and the forecasts are based on a number of simplifying assumptions, including:

- The Lower Passaic is assumed to be longitudinally mixed from RM 2 to RM 12, with assumed constant concentrations in newly deposited sediment.
- Resuspension of legacy contaminants occurs from approximately 1995 layer sediments, which can be represented by an average across the length of the Lower Passaic.
- Contributions from tributaries, SWOs, and CSOs are mixed throughout the Lower Passaic, without localized impact, minimizing their importance.

The TCDD longitudinal profiles show that spatial gradients in surface sediment concentrations are indeed present in the Lower Passaic. Further, the implicit assumption that all "1995" sediments are equally likely to contribute to resuspension is unlikely to be true in practice.

One effect of this broad spatial averaging on the analysis is that only broad-scale scenarios can be evaluated, such as remediating all sediment from RM 0 to RM 8 or remediating the Primary Erosional Zone and Primary Inventory Zone, as represented not by a spatially explicit formulation but as a weighted fraction of the total sediment area. In reality, the resuspension loading is likely associated with a limited number of specific areas where changes to flow patterns have resulted in the down-cutting of older, highly contaminated sediments. Further, the impact of such down-cutting is likely more pronounced locally, although the remobilized contaminants will gradually spread across the length of the Lower

Passaic. The EMBM approach cannot evaluate such effects because it is not spatially explicit within the Lower Passaic.

In sum, the EMBM adds to our understanding of pollutant dynamics in the Lower Passaic and reinforces many of the conclusions from the CSM. The EMBM forecasts provide a useful basis for bounding the remediation problem. They do not, however, provide sufficient power or precision to serve as the primary basis for the design and implementation of a costly remediation plan.

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Comprehensive Conceptual Site Model – Peer Review Draft Lower Passaic River Restoration Project

June 26, 2008

Charge Questions

The investigation into the contaminated sediments of the Lower Passaic River (LPR) parallels similar studies across the country, for example the Fox River and the Sheboygan River, Wisconsin (PCBs), and the Black (PAHs) and Ashtabula River (PCBs and PAHs), Ohio. In these cases it is desired to assess the status of pollution and design and implement remedial action plans to the extent warranted by the severity of pollution.

For the LPR, previous studies include a EPA Superfund program for a 6-mile stretch of the river around the Diamond Alkali land site in Newark, New Jersey and a following project on the 17-mile LPR restoration project. The purpose of the present focused feasibility study (FFS) is to use the previous data supplemented with sampling and analysis efforts between December 2007 and March 2008 to look at the possibility of remediating the lower eight miles of the LPR.

The external review, of which this document constitutes one contribution, is designed to evaluate the completeness of data, the comprehensive conceptual site model (CSM), and an empirical mass balance (EMB) model to design an appropriate site remediation plan.

Accuracy and Use of Data

1. *Are the data used in the CSM adequate to support its conclusions?*

The data base collected is quite impressive. Of course, we have to assume that sufficient QA/QC procedures have been followed and that the analytical methodologies are well documented or standardized. I didn't find suspended solids concentration for

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the water column which can be an alternate way of estimating resuspension. It is stated

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that the biologically active (mixing) layer is 0-6 in. How accurate is that number? There

is clearly a great deal of heterogeneity with respect to erosion and deposition, see Figs

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11-7 – 11-9. In addition to sediment cores from depositional areas there should be some measurements of pollutant concentrations of eroded, upstream sediment.

In addition to a general assessment, please comment on the following specific issues with regard to adequacy of the current data set:

- *Are the sediment sample results collected in the lower eight miles used appropriately in characterizing the contaminant inventory and gradients in three dimensions for the purposes of the CSM and EMB?*

Yes, in most cases. Note that for the version of EMB considered here where the sum of the solids fractions f_j equals one, the assumption is that the particle size distribution is similar at different sample sites. This is not necessarily the case, however.

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- *Are the results of the high resolution cores collected above Dundee Dam sufficient to represent background loading levels for the system?*

For the most part, yes. One has to make sure that upstream eroded sediment carried downstream has similar concentrations, but I believe that was checked.

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- *Are there sufficiently robust data of appropriate kinds to characterize the contaminant loads that enter the lower eight miles of the river from external sources, i.e., from tributaries, from combined sewer outfalls (CSOs) and stormwater outfalls (SWOs), from in-stream sediments above RM8 and from Newark Bay?*

One wonders about the variability of the contaminant concentrations of suspended solids from these sources. The higher the variability, the more data are required for a reliable analysis. High SWO 2008 concentrations around RM 10 of BaP (Fig. 14-13a), mercury (Fig. 14-10l), cadmium (Fig. 14-10c), and lead (Fig. 10j) point to the possibility of having best management practices (BMPs) in place in order to reduce the concentrations of these pollutants before they reach the estuary.

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- *Are the available data adequate to verify that there are no on-going, unquantified sources?*

With the regard to the pollutants investigated, the answer is yes, for the most part. However, as far as other pollutants are concerned, we don't know. For example, brominated flame retardants such as polybrominated diphenyl ethers (PBDEs) are not considered here, probably because they are not known to be an environmental threat in this area. However, the question of other pollutants, including those that are not especially particle reactive such as atrazine merits some consideration.

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2. *Is the use of the contaminant data associated with recently deposited, beryllium-7 (Be-7) bearing surface sediment in the CSM-EMB sufficiently explained? For example, most reviewers of CSM documents readily understand that contaminant*

data from the upper 6-inches of sediment are used to evaluate exposure to biota and therefore to assess ecological risk. Is our description of the utility of data from Be-7 bearing sediments, intended to characterize material that was just recently transported through the water column and deposited on the sediment surface, similarly clear in its implications for assessing fate and transport?

Be-7 is cosmogenic with a half-life of 53 days. One should realize that what is recent is really a matter of definition. Sediment that has been added 6 months ago may be recent in a sense, yet it may have lost most of its Be-7 radioactivity. However, Be-7 is easy to measure by gamma counting and quite useful for sediment characterization.

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Explanation of Assumptions and Uncertainties

3. *Is sufficient attention given to quantifying and evaluating the impacts of uncertainties in developing the CSM-EMB, particularly with respect to the ability to use these tools in evaluating potentially large and very costly remedial alternatives? Are the magnitudes of the uncertainties associated with the data supporting the EMB predictions sufficiently bounded? Are the uncertainties associated with predicted post-remedial surface sediment concentrations and estimates of contaminated sediment transport into the lower eight miles from above RM 8 and from external sources adequately described?*

One has to realize, of course, that the EMB model is another version of the chemical mass balance (CMB) used by Friedlander (1973), Henry et al (1984) in the air environment and Singh et al (1993) and Christensen et al (1997) for contaminated sediments the aquatic environment. Note also that although some source information

must be available, more advanced receptor modeling can determine not just source contributions but also source profiles as in singular value decomposition (SVD) modeling for PCB congener patterns of sediments of the Milwaukee Harbor Estuary (Rachdawong and Christensen 1997) and PAHs in Lake Calumet, Illinois (Bzdusek et al 2004). Another related technique is polytopic vector analysis used for PCB congener patterns of suspended sediment of the San Francisco Bay area (Johnson et al 2000).

Two source apportionment methodologies that are now supported by the U.S. EPA on the internet are the SVD method named Unmix developed by Henry (2003) and positive matrix factorization (PMF) developed by Paatero (1997a, b). Bzdusek et al (2006a, b) have demonstrated how PMF can be used effectively to characterize PCB congener patterns and anaerobic dechlorination of PCBs for the Sheboygan River Inner Harbor, Wisconsin, and Lake Hartwell, South Carolina.

In the present case, for the EMB applied to the Lower Passaic River, the expression for the tracer concentration Y_i , eq. 18-2 should contain an error term e_i as shown in eq. 1 below:

$$Y_i = \sum_{j=1}^p f_j X_{ij} + e_i \quad (1 \leq i \leq m) \quad (1)$$

Note that the number of degrees of freedom is $df = m - p$ that is the difference between the number of chemicals and the number of sources. Also, the weighted variance expression, eq. 18-3 must reflect the errors of the source profiles X_{ij} where i and j represent the i th chemical and the j th source:

$$\chi^2 = \sum_{i=1}^m \frac{(Y_i - \sum_{j=1}^p f_j X_{ij})^2}{(r.e.)_k^2 Y_i^2 + \sum_{j=1}^p (r.e.)_j^2 (f_j X_{ij})^2} \quad (2)$$

In order to have a statistically valid solution one must require that the value of χ^2 is comparable to the degrees of freedom df. The relative errors of measurements and source profiles are here $(r.e.)_k$ and $(r.e.)_i$, respectively. Note that in minimizing χ^2 , one must have at least preliminary information about the source contribution factor f_j , meaning that χ^2 will be minimized by iteration.

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4. *Since the use of deterministic model (a model where outputs are described using mechanistic descriptions of the processes occurring in the system of interest) may be more common in a physically complex surface water body such as this partially stratified estuary, has the use of a receptor model, such as the EMB (where concentrations measured at sources and receptors are used to identify the presence of and to quantify source contributions to receptor concentrations) been adequately justified?*

The use of a receptor model in this system such as the EMB with modifications is fine as long as there are some alternate evaluations of contributions of contaminants from these sources. These alternate estimates can be simple products of flow and concentrations of contaminants and suspended solids. I looked for suspended solids concentrations in the water column but couldn't find any.

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5. *Is the premise credible that the loads from atmospheric deposition and groundwater are considered negligible in the formulation of the EMB?*

I believe the atmospheric input is negligible. During combined sewer overflows in Milwaukee, we found that up to 8 % of the flow came from groundwater.

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6. *Does the CSM adequately justify the premise that the various external contaminant source profiles utilized in the EMB (tributaries, CSOs, etc.) are independent?*

That's a good point but a bit difficult to judge based on Tables 18-6 – 18-8. For example, PCB concentrations do seem higher in Saddle River than in Third and Second Rivers. A sensitivity analysis using Monte Carlo variations of each profile would help answer this question. If I were to do this kind of modeling I would compare the source profiles in linear or log plots. One good thing is that error analysis as shown for example in Dominic DiToro's error plots are mostly satisfactory, that is most errors are less than about 25%.

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7. *Please comment on the appropriateness of the constructs and assumptions used in the mathematical formulation of the EMB.*

The requirement that the sum of source contribution factors f_j should equal one is not necessary in general; only if the particle size distribution is the same for all sources and the receptor. If large particles, containing only small amount of contaminants, are settled out before reaching the receptor, this sum is greater than one (Christensen et al 1997).

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Our recent experience using a CMB model for source apportionment of pollutants and flows of combined sewer wastewater (Soonthornnonda and Christensen 2008), shows that source profiles can be obtained as arithmetic means of 500 or more measurements.

Using the frequently encountered log-normal distribution of pollutants in the environment leading to the minimum variance unbiased mean (MVU) as done for the Lower Passaic River makes sense.

In applying the EMB to the Lower Passaic River, I do question the role of the suspended sediments (eq. 18-1). While the sources including the Upper Passaic River, Newark Bay, Saddle River, Third River, Second River and SWOs, and CSOs make sense, I believe that the suspended sediment category should belong to the surface sediment receptor category. The constraints on the relative proportions of each of the sources to the Lower Passaic River, eqs. 18-4a – 18-4d, seem to be reasonable. My guess is that some of these limits are reached through the optimization procedure. See other comments above under point 3.

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Clarity and Correctness of Data Evaluations

8. *Are the available data and the observations made from them sufficient to support the following findings of the conceptual site model (CSM) regarding sediment fate and transport?*

- *Although the Lower Passaic River is a partially-stratified estuary, the recently deposited sediments between RM2 and RM12 are sufficiently similar (and likely mixed by tidal action over time) that they can be represented by single average concentrations of each contaminant in the EMB relative to the gradients observed for external sources and end members.*

As mentioned previously, I believe that surface sediment and suspended sediment should belong to the same category, that is the receptor. Regarding local variations, one

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should look for individual partially protected sites, if any, where pollution may be high due to former manufactured gas plants, certain industries, etc. This was the case for the Kinnickinnic River and Sheboygan River, Wisconsin.

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- *Approximately 95% of the dioxin currently accumulating in the recently-deposited sediments on the river bottom is due to resuspension and subsequent deposition of the bedded legacy sediments; i.e., an internal source is driving the dioxin concentration in recently deposited sediments.*

I have some reservation, as did Willy Lick, with the idea of only remediating fine grained depositing, but also resuspending, sediment in the RM0- 8 compartment. From Fig. 7-1 it is apparent that there is a significant dioxin source at RM11.5. Before remediating the RM0-8 stretch one should consider removing high dioxin sediment erosion source areas such as those around RM11.5.

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9. *Is the EMBs exclusive focus on conservative, particle-reactive contaminants appropriate understanding and predicting future surface sediment concentrations of interest in the risk assessment, or should alternate consideration be given to dissolved constituents, such as lighter molecular weight PCBs?*

Yes, one should also look at more soluble low molecular weight compounds including PCBs and PAHs. Other compounds of interest is atrazine and MTBE, and personal care products and pharmaceuticals. In the category of particle associated compounds one could screen for PBDEs.

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10. *Please comment on the appropriateness of the process and outcome of the selection of the resuspension source term input for the EMB. Is the justification of the selection sufficiently robust? Do the lines of evidence derived from sediment stability evaluations support the source term selection?*

As mentioned above I believe the resuspended sediment should be classified as a receptor not as a source.

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Appropriateness of Conclusions

11. *Are the dated sediment cores and analysis of Be-7 bearing surface sediment samples sufficient as the basis for estimating post-remediation contaminant concentrations in sediment in the Lower Passaic River? Please comment on whether the predictions of post-cleanup sediment concentrations are sufficiently supported and realistic given what is known about the system. Are the appropriate pre-and post-remediation conditions (including contaminant sources and the potential for recontamination) adequately represented in the predictions?*

In order to properly address this question one should look at the way the predictions were made. It looks like they were made mainly based on empirical extrapolations such as the one shown in Fig. 20-15 for 4,4'-DDE. Remediation scenarios are based on various perturbations of these as shown for example in Fig. 20-25 for the same pollutant.

However, these are only valid if upstream pollution is curtailed significantly. Especially for dioxin, this is something that should be considered around RM11.5.

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Note that one can obtain an estimate of the half-life of clean-up from this mass balance equation expressing that the amount of contaminant lost from the mixed layer per year is the amount added to the historical layer per year:

$$L \frac{dc}{dt} = -vc \quad (3)$$

where c is the concentration of a pollutant in the mixed layer, L is the mixed layer thickness, t is time, and v is the sedimentation rate. This is under the assumption of no new input of pollutants to the system. The solution is,

$$c = c_0 e^{-\frac{v}{L}t} \quad (4)$$

where c_0 is the initial concentration. From this equation we obtain the following half-life,

$t_{1/2}$:

$$t_{1/2} = \frac{\ln 2L}{v} \quad (5)$$

With a mixed layer thickness of 6 in and a sedimentation rate in the RM0-8 stretch of 0.25 in/yr we obtain a half-life for cleanup of 17 years. The contribution of suspended sediment to this half-life is probably minor. At 20' water depth, 500 mg/l suspended solids concentration, and a sediment porosity of 0.6, the equivalent sediment thickness is only 0.3 cm compared to the 6 in = 15.2 cm.

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12. *Sediment stability evaluations (presented in the CSM) have led to the development*

of remedial alternatives that address the entire sediment bed of the lower eight miles of the river for comparison with No Action. Please comment on the significance of the uncertainties involved in this evaluation with respect to whether the entire bed of the lower eight miles of the river needs to be remediated, or whether remedies addressing only part of those sediments might be effective to reduce the surface concentrations in the Lower Passaic river to meet cleanup goals. In light of the uncertainties involved, are sufficient lines of evidence used in comparing the effects of the different remedial approaches to justify eliminating actions more limited than the entire lower eight miles? Is there additional evaluation of the available data that might provide adequate justification to add one or more limited early action alternatives that address smaller, highly contaminated erosional areas within the lower eight miles?

I think remediation should proceed in three stages: First remediate upstream hotspots such as dioxin around RM11.5. Considering the heterogeneity of the RM0-8 stretch with respect to contaminant concentrations and sedimentation rates, I think one should next design a remediation plan for perhaps 20% of the RM0-8 stretch concentrating on sites with high contaminant concentrations that are likely to undergo resuspension frequently. The third step, if necessary, would be removal or capping of most of the remainder of the river stretch.

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Peer Review of the Conceptual Site Model Report

Responses to Charge Questions

June 30, 2008

The answers to these questions are based on the analysis presented in the accompanying document “Evaluating the Modeling Frameworks” and the references to Page numbers are from the file: Di Toro CSM review Model Evaluation Figs pdf. I recommend that these documents be read before the answers to the questions.

Adequacy and Use of Data

1. *Are the data used in the CSM adequate to support its conclusions? In addition to a general assessment, please comment on the following specific issues with regard to the adequacy of the current data set:*

The adequacy of the data can only be judged in comparison to the model being employed. Since the models are completely inadequate – see comments below and the analysis in “Evaluating the Modeling Frameworks”, the question as it stands cannot be answered. The data certainly will be useful if a mechanistic model is employed to predict the consequences of various remedial actions.

141

2. *Are the sediment sample results collected in the lower eight miles used appropriately in characterizing the contaminant inventory and gradients in three dimensions for the purposes of the CSM and EMB?*

The surface sediment data is used to compute averages and other statistics for the EMB. For this purpose they are adequate.

142

3 *Are the results of the high resolution cores collected above Dundee Dam sufficient to represent background loading levels for the system?*

It appears that this is the only data available. It would be much better if actual data were collected from the inflow to the Passaic River to confirm the conclusions from the analysis of the cores.

143

4. *Are there sufficiently robust data of appropriate kinds to characterize the contaminant loads that enter the lower eight miles of the river from external sources, i.e., from tributaries, from combined sewer outfalls (CSOs) and storm water outfalls (SWOs), from in-stream sediments above RM8 and from Newark Bay?*

The only really convincing data are actual measurements of the sources. There appears to be little of this actual data available. In the light of the plateau behavior of the TCDD (Pages 17-19), a concerted effort to make real loading estimates would be very useful. Toward this end, the CARP data should be the starting point.

144

5. *Are the available data adequate to verify that there are no important on-going, unquantified sources?*

The plateau behavior (Pages 17-19) suggests that there may be such a source or sources. It is imperative that this issue be settled before **any** remediation is commenced.

145

6. *Is the use of the contaminant data associated with recently deposited, beryllium-7 (Be-7) bearing, surface sediment in the CSM-EMB sufficiently explained? For example, most reviewers of CSM documents readily understand that contaminant data from the upper 6 inches of sediment are used to evaluate exposure to biota and therefore to assess ecological risk. Is our description of the utility of data from Be-7 bearing sediments, intended to characterize material that was just recently transported through the water column and deposited on the sediment surface, similarly clear in its implications for assessing fate and transport?*

No, and it should be. I have attempted an analogy using sediment trap data as the equivalent in Evaluating the Modeling Frameworks. However, there are issues to be settled. Is Be-7 irreversibly sorbed? I doubt it. Can legacy particles become

146

contaminated in the sediment without exposure to the water column? Probably not but it should be addressed. What is the magnitude of the partition coefficient? The modeling of ^{137}Cs requires a partition coefficient to account for the dissolved concentrations. Why not ^7Be ? In fact it is not clear to me that the use of Be-7 as an absolute marker of recently deposited sediments is as fool proof as the analysis in CSM assumes.

146

What happens if Be-7 tagged sediments are mixed with untagged sediment particles by sediment mixing? Do the untagged particles become tagged, and are therefore mistakenly labeled as “recently deposited?” This seems to me to be a serious problem that needs addressing. The whole rationale in the CSM depends on the absolute unambiguous tagging via Be-7.

147

Explanation of Assumptions and Uncertainties

8. *Is sufficient attention given to quantifying and evaluating the impacts of uncertainties in developing the CSM-EMB, particularly with respect to the ability to use these tools in evaluating potentially large and very costly remedial alternatives? Are the magnitudes of the uncertainties associated with the data supporting the EMB predictions sufficiently bounded? Are the uncertainties associated with predicted post-remedial surface sediment concentrations and estimates of contaminated sediment transport into the lower eight miles from above RM 8 and from other external sources adequately described?*

The uncertainties are clearly large and not accounted for in the modeling. An incorrect statistical model is applied to estimating the fractional contributions – see below. Further it is clear that the computation is **very** sensitive to small errors in the concentrations used (e.g. averages or medians). Therefore, where approximately ~50% of the recently deposited particles are coming from: Upper Passaic River or Newark Bay is unclear (Page 9).

148

9. *Since the use of a deterministic model (a model where outputs are described using mechanistic descriptions of the processes occurring in the system of interest) may be more common in a physically complex surface water body such as this partially*

stratified estuary, has the use of a receptor model, such as the EMB (where concentrations measured at sources and receptors are used to identify the presence of and to quantify source contributions to receptor concentrations) been sufficiently justified?

No. And I am mystified by the neglect of the CARP model. At least it is mechanistic and it is calibrated using long term hind casts (Pages 37-49). The two models used in the CSM: the one segment steady state EMB and the single exponential are simply too crude and unconvincing to be of any real use.

149

10. Is the premise credible that the loads from atmospheric deposition and groundwater are considered negligible in the formulation of the EMB?

This is the common assumption but I did not see any direct evidence. This is a difficult issue. The plateau in TCDD concentration is suggestive of something like a diffuse, continuous source.

150

11. Does the CSM adequately justify the premise that the various external contaminant source profiles utilized in the EMB (tributaries, CSOs, etc.) are independent?

I'm not sure what "independent" means. The use of sediment cores to infer loadings is sometimes necessary for historical loadings. However they are no substitute for actual loading measurements.

151

12. Please comment on the appropriateness of the constructs and assumptions used in the mathematical formulation of the EMB.

As discussed in my review, the statistical formulation (Eq. 3 in Evaluating the Modeling Frameworks) is not appropriate. The Errors in Variables formulation (Eq. 4) is what is required. Furthermore, it is assumed that Be-7 containing particles can be treated as though they are water column particles. This needs to be justified by direct

152

measurements. Finally the steady state assumption needs testing, as well as the implicit assumption of irreversible sorption.

152

Clarity and Correctness of Data Evaluations

13. *Are the available data and the observations made from them sufficient to support the following findings of the conceptual site model (CSM) regarding sediment fate and transport?*

It's not data alone that is used to support predictions. It is models and data together and the models (EMB and the single exponential extrapolation) are simply not up to the task.

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14. *Although the Lower Passaic River is a partially-stratified estuary, the recently deposited sediments between RM2 and RM12 are sufficiently similar (and likely mixed by tidal action over time) that they can be represented by single average concentrations of each contaminant in the EMB relative to the gradients observed for external sources and end members.*

The top 6 inch data is highly variable. The Be-7 tagged TCDD concentrations are reasonably uniform. The model assumes that both are uniform. Is this reasonable? I think not. But why do it that way? Models that can actually take the spatial inhomogeneity into account are being developed. The CARP model is available now for use in at least exploring the consequences of varying concentrations.

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15. *Approximately 95% of the dioxin currently accumulating in the recently-deposited sediments on the river bottom is due to resuspension and subsequent deposition of the bedded legacy sediments; i.e., an internal source is driving the dioxin concentration in recently deposited sediments.*

As I understand the EMB, 50% not 95% is from the lower eight miles. The rest is from either the Upper Passaic or Newark Bay. I gather that this statement refers to all the within river sources.

155

16. *Is the EMB's exclusive focus on conservative, particle-reactive contaminants appropriate to understanding and predicting future surface sediment concentrations of interest in the risk assessment , or should alternate consideration be given to dissolved constituents, such as lighter molecular weight PCBs?*

All modern contaminant transport models consider both dissolved and particulate fractions. The proper modeling of ¹³⁷Cs requires an explicit consideration of the dissolved component. It would be a simple exercise to run the CARP model with infinite partitioning and test the assumption.

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17. *Please comment on the appropriateness of the process and outcome of the selection of the resuspension source term input for the EMB. Is the justification of the selection sufficiently robust? Do the lines of evidence derived from sediment stability evaluations support the source term selection?*

There is probably not too much error in the approximately 50% resuspension fraction. However, this should be backed up with an actual sediment transport model, which is being constructed. The real question is: what is the source of the other 50% and is there an ongoing unknown source of TCDD.

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Appropriateness of Conclusions

18. *Are the dated sediment cores and analyses of Be-7 bearing surface sediment samples sufficient as the basis for estimating post-remediation contaminant concentrations in sediment in the Lower Passaic River? Please comment on whether the predictions of post-cleanup sediment concentrations are sufficiently supported and realistic given what is known about the system. Are the appropriate pre-and post-remediation conditions (including contaminant sources and the potential for recontamination) adequately represented in the predictions?*

I worry about the plateau in the time course data for TCDD. I worry about the discrepancy between the various half life estimates: less than 10 yrs from the CARP model, 25 yrs from the exponential analysis, and a by-phasic behavior in the data suggesting a continuing source. Until this is sorted out, there is no strong reason for believing that we can forecast the outcome of remediation alternatives.

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19. *Sediment stability evaluations (presented in the CSM) have led to the development of remedial alternatives that address the entire sediment bed of the lower eight miles of the river for comparison with No Action. Please comment on the significance of the uncertainties involved in this evaluation with respect to whether the entire bed of the lower eight miles of the river needs to be remediated, or whether remedies addressing only part of those sediments might be effective to reduce the surface concentrations in the Lower Passaic River to meet cleanup goals. In light of the uncertainties involved, are sufficient lines of evidence used in comparing the effects of the different remedial approaches to justify eliminating actions more limited than the entire lower eight miles? Is there additional evaluation of the available data that might provide adequate justification to add one or more limited early action alternatives that address smaller, highly contaminated erosional areas within the lower eight miles?*

At this stage of analysis, the models are too crude and too uncertain, see the above comments and the analysis in Evaluating the Modeling Frameworks, to be able to discriminate between selective dredging or capping alternatives. Also, a detailed dredging or capping plan needs to look at the effects of large storms as well as the gradual effects of dilution by clean sediments. The present uncertainty of the source of sediments to the 8 mile reach: Newark Bay vs Upper Passaic River, and the uncertainty of the future concentrations in these sediments makes the projections in the CSM very uncertain.

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I would not endorse any remediation plan based on the present stage of the development of the models. These are the problems to be addressed: the contradictory estimates of TCDD half lives from the available models and the possibility of a plateau in TCDD concentrations suggesting an ongoing source or an unaccounted for mechanism.

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Evaluating the Modeling Frameworks

June 30, 2008

I. Analysis of the Steady State Modeling Framework

The Empirical Mass Balance Model (EMB) is a one box steady state model of the lower eight miles of the Passaic River. It is based on a mass balance equation that relates the Be-7 bearing sediment concentration r_1 (ug/g) to the top 6 inch sediment concentrations $r_2(i)$ (ug/g) from the various sources ($i = 1,2...7$). An example is presented below

$r_2(i)$	Fraction Contributed	Cadmium	2,3,7,8-TCDD	Total PCB
1. Resuspension	0.461	2360	0.3740	620
2. Newark Bay	0.271	320	0.0210	150
3. Upper Passaic River	0.220	330	0.0004	100
4. Saddle River	0.024	10	0.0001	10
5. Third River	0.005	10	0.0000	1
6. Second River / SWO	0.013	20	0.0001	5
7. CSO	0.005	9	0.0000	1
r_1				
Predicted Target Area Concentration	1.000	3060	0.3956	890
Observed		3642	0.3713	1201

The idea is that the recently deposited sediment (r_1) is composed of sources (r_2) and the source fractions $f(i)$ can be deduced from the observed concentrations.

One way to think about the Be-7 bearing particles is that they are what would be collected from the water column by filtering a sample or what would be retrieved using a sediment trap. The idea is that any particle that has been in the water column is irreversibly tagged with Be-7 and since it has a relatively short half life, it must have been in the water column recently; hence the notation r_1 where the subscript 1 refers to the water column. Note that this association with the water column particles requires that Be-7 binds rapidly and *irreversibly* with solids, and in the water column only. The half life of Be-7 roughly corresponds to the average sampling time associated with the sample.

The mass balance equation for the EMB is

$$r_1 = \sum_{i=1}^7 f(i)r_2(i) \quad (1)$$

where $f(i)$ is the fraction of the i^{th} source. It must be true that $1 > f(i) > 0$, i.e. the fraction is less than one, positive and that

$$\sum_{i=1}^7 f(i) = 1 \quad (2)$$

i.e. everything has to come from somewhere.

One important point to note: For equation (1) to be a correct explanation of the data, it must be true that at least one r_2 (a source) must be larger than r_1 (the result), since all the fractions must be less than 1 so that equation (2) is satisfied. The physical explanation is that the water column particles are comprised of less contaminated particles (from upstream and Newark Bay) and more contaminated sediment particles with legacy contamination.

The sediment data are presented in Pages 1-5 of the Figures. The blue diamonds are r_2 the resuspended sediment and the gold dashes are r_1 the Be-7 bearing particles. Cd, Cu, Pb, Hg and TCDD are presented. Both sets of data are quite scattered, especially r_2 . As a consequence there is quite a lot of uncertainty in the fractions that are estimated from the model as shown below.

Estimation of sources

The source fractions $f(i)$ in the EMB are estimated from a linear regression

$$r_1(k) = \sum_{i=1}^7 f(i)r_2(i,k) + \varepsilon(k) \quad (3)$$

where $k = 1, 2, \dots, N$ are the different substances (Cd, Cu, etc) that are used in the analysis and $\varepsilon(k)$ is the random error associated with r_1 . The standard assumptions for applying linear regression is that the r_2 's are known exactly. Since this is clearly not the case (Pages 1-5) the proper random model for this situation is

$$r_1(k) = \sum_{i=1}^7 f(i)(r_2(i,k) + \eta(i,k)) + \varepsilon(k) \quad (4)$$

where $\eta(i,k)$ are the random errors associated with the r_2 's. This is a much more difficult model to analyze properly and it is well known that linear regression does a poor job of it in this situation.

Uncertainty of the Estimates

One way of estimating the uncertainty is to perform various analyses with slightly different r 's and see the results. This still does not answer the question of what the result of a proper analysis of eq (4) would produce but at least it gives an indication of what to expect. A sample of

the results are shown in Pages 6 (base case from the report using only the average metal concentrations) 7 (using averages of all variables) 8 (using medians of all the variables). The variations in $f(i)$ are shown in Page 9. The resuspension fraction is approximately 0.4 to 0.5. However, depending on whether metals only or all the variables are used, the fraction of r_1 coming from Newark Bay is 0.1 or 0.4 with the remainder coming from the Upper Passaic. Clearly the model is not capable of deciding where the non-resuspension contamination is coming from. The sensitivity of the calculations to small variations can be seen by comparing the all variable computations using average (purple) and medians (teal). The variation in f 's are approximately 50% whereas the variations in averages relative to medians (Page 10) is 10-15%.

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II. Analysis of the Time Variable Model

The response to be expected from either natural attenuation or the dredging alternative is estimated in the CSM using the assumption that natural attenuation produces exponentially decreasing concentrations. The high resolution dated cores are the raw data. The data being analyzed is the "excess concentration" see page 20-8 of the report. Although it is not clear just what the correction being applied is attempting to do, for the case of TCDD the excess concentration is essentially the same as the raw data.

The semi-log plot of the TCDD data from the CSM report is shown on Page 11. Note the significant scatter. I have repeated the analysis using the same model (Eq. 20-1) as in the CSM report and obtain a half life of approx 25 yrs (Page 12). The individual data from each core are plotted together with the exponential fit on Pages 13-15. Note the lack of fit. Specifically there appears to be a flattening out of the concentrations, whereas the forced exponential continues to decline.

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Suppose, however, that the decline is bi-phasic. For example, suppose the response is composed of the sum of two exponentials: a more rapidly and less rapidly declining components with half lives τ_1 and τ_2 respectively:

$$c_k(t) = c_{k,1}(0) \exp(-t / \tau_1) + c_{k,2}(0) \exp(-t / \tau_2) \quad (5)$$

where k indexes the cores and $t = 0$ corresponds to 1977, the beginning of the record. Page 16 lists the results of fitting eq (5) to the TCDD data. A rapid half life of approximately 6 years is predicted for the rapidly decreasing component, and then an essentially constant concentration for the rest. Pages 17-19 show the comparison.

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The same analysis is presented for total PCB. Page 20 shows the CSM analysis with a 20 yr half life. Page 21 is my repeat of the analysis which gives a smaller half life (15 yr). The

plateaus are less dramatic but still suggestive especially Page 24. The bi-phasic analysis (Page 25) results in a fast (5 yr) and slow (35 yr) half life with a much better fit of the data.

Commentary

This bi-phasic analysis is not meant to be a definitive resolution of the problem but rather a cautionary tale. It is clear that something is going on in addition to simple first order decay. The matter is serious enough to warrant a careful investigation. The implications for TCDD are significant. The slow decline may suggest a source that is not accounted for, or a mechanism that is not yet understood. Clearly the model – a first order decay – is not appropriate and should be abandoned.

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III. Analysis of the CARP Model

The Contamination Assessment & Reduction Project (CARP) produced a model of the New York Harbor complex that includes the Passaic River and Newark Bay as well as the rest of the harbor. This section compares the CSM and CARP model predictions of the effects of various remediation options. The CSM predictions are shown in Pages 29 (TCDD) and 30 (PCB). The predictions reflect the 20-25 yr half lives for PCB and TCDD.

The CARP model grid (Pages 31) and expanded views of the Inner Harbor (Page 32) and the Newark Bay (Page 33) regions illustrate level of detail of the model segmentation. In particular the Passaic River (Page 33) is rather crudely segmented with only one segment across the river. It is for this reason, apparently, that the results from this model were not considered in the CSM. Nevertheless, it is certainly a better model than the steady state one segment EMB or the single exponential time variable model.

The result of a TCDD No Action scenario are shown for the water column and sediments for lower Passaic (Page 34). The response is considerably faster than the CSM estimates with a half life of approximately 10 yrs in the sediment. The CARP model is consistent with the CSM in having no other significant source other than legacy sediments. Page 35 presents the results for other regions in the harbor. The rather rapid decline, if this is indeed a reliable prediction, suggests that natural recovery will happen much more quickly than the CSM predicts. The effects of the two dredging alternatives – the lower and entire river - are shown on Page 36. A more detailed presentation is available in the CARP report.

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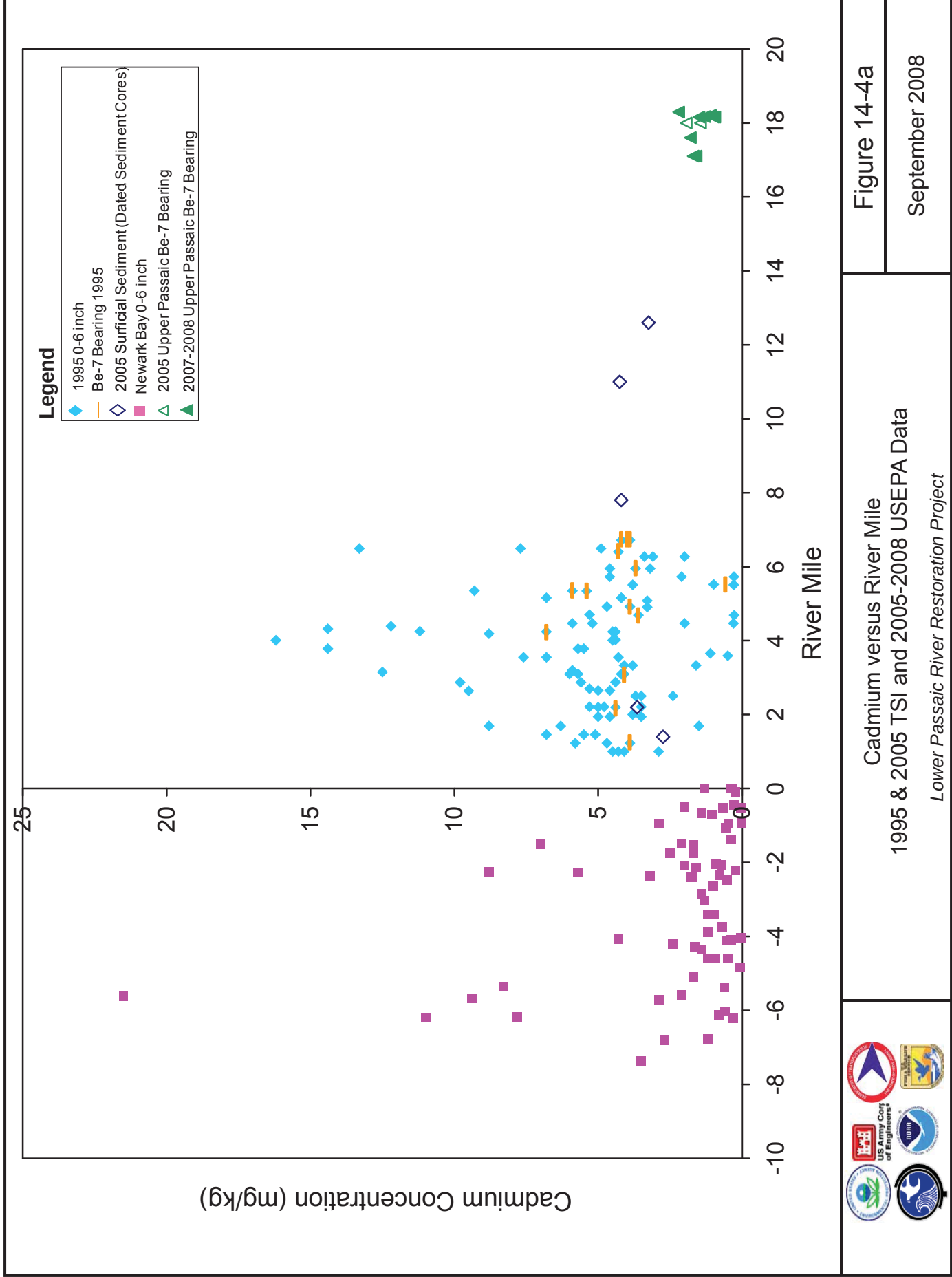
Hind casts and the Validation of the Model

There is little reason to trust the long term predictions – tens of years – of any model without a calibration/validation that spans a comparable time. The CARP model has been used to make Cs¹³⁷ hind cast. Cesium is an ideal tracer for this exercise since the loading to the harbor is well known. Pages 37-41 present the results. The model predicts a relatively rapid response that is reflected in the Cs data. Unfortunately there are no data compared to the computations in the Passaic River. It would be a very interesting exercise to do the comparison using the high resolution cores.

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A TCDD hind cast has also been conducted. A rapid response is predicted. This hind cast is somewhat of a circular exercise since the loading is deduced from the core records which in turn supply the data for comparison. However, that the overall picture is in reasonable agreement with the computations suggests that the CARP model's prediction of a short half life (~ 10 yr) is reasonable. However, the plateau deduced from the core data, presented above (Pages 17-19) suggests that the CARP model needs to be reconciled with those data as well. In any case, a more detailed segmentation is clearly warranted for more detailed analysis.

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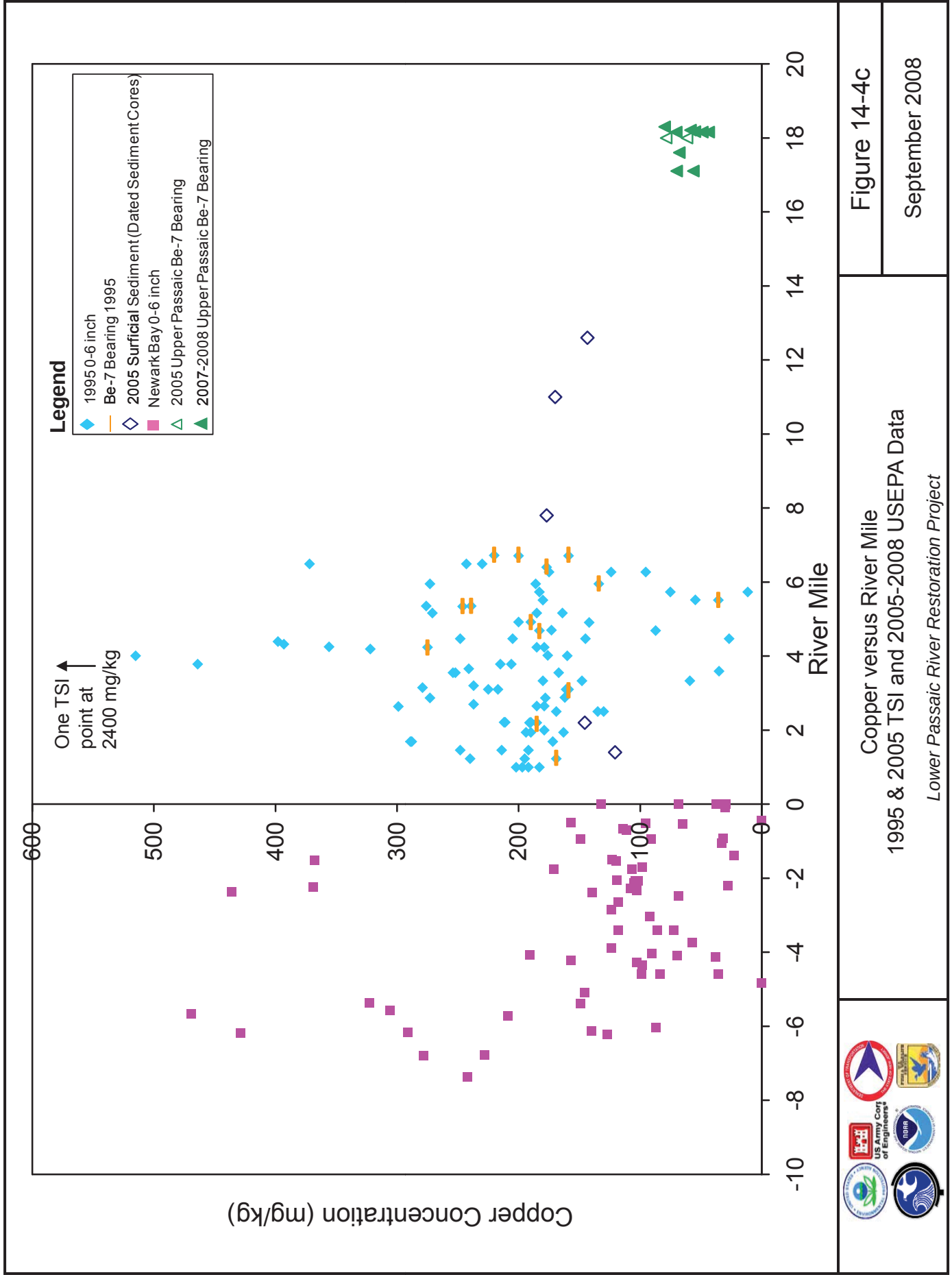


Figure 14-4c

Copper versus River Mile

1995 & 2005 TSI and 2005-2008 USEPA Data

Lower Passaic River Restoration Project

September 2008

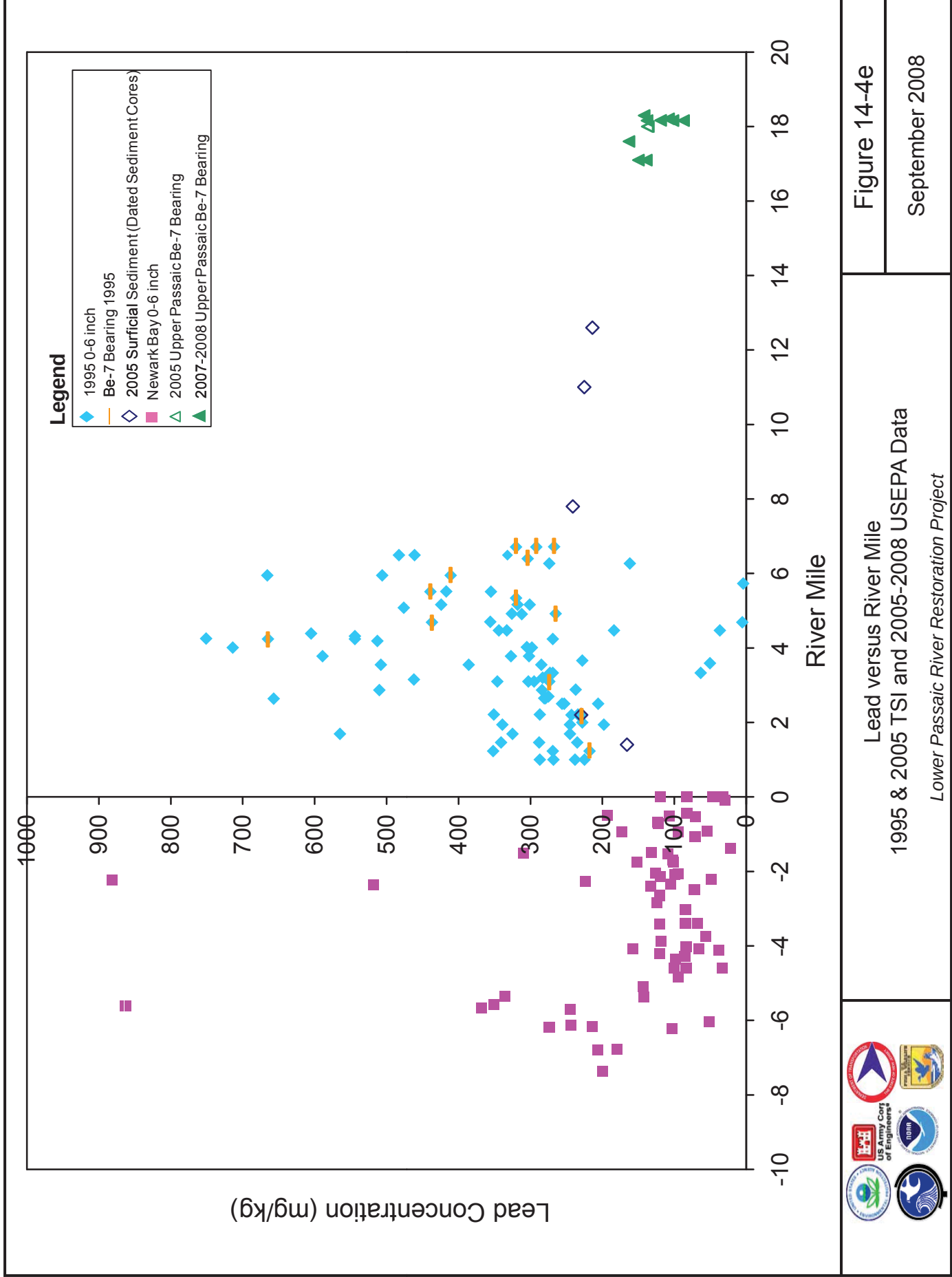
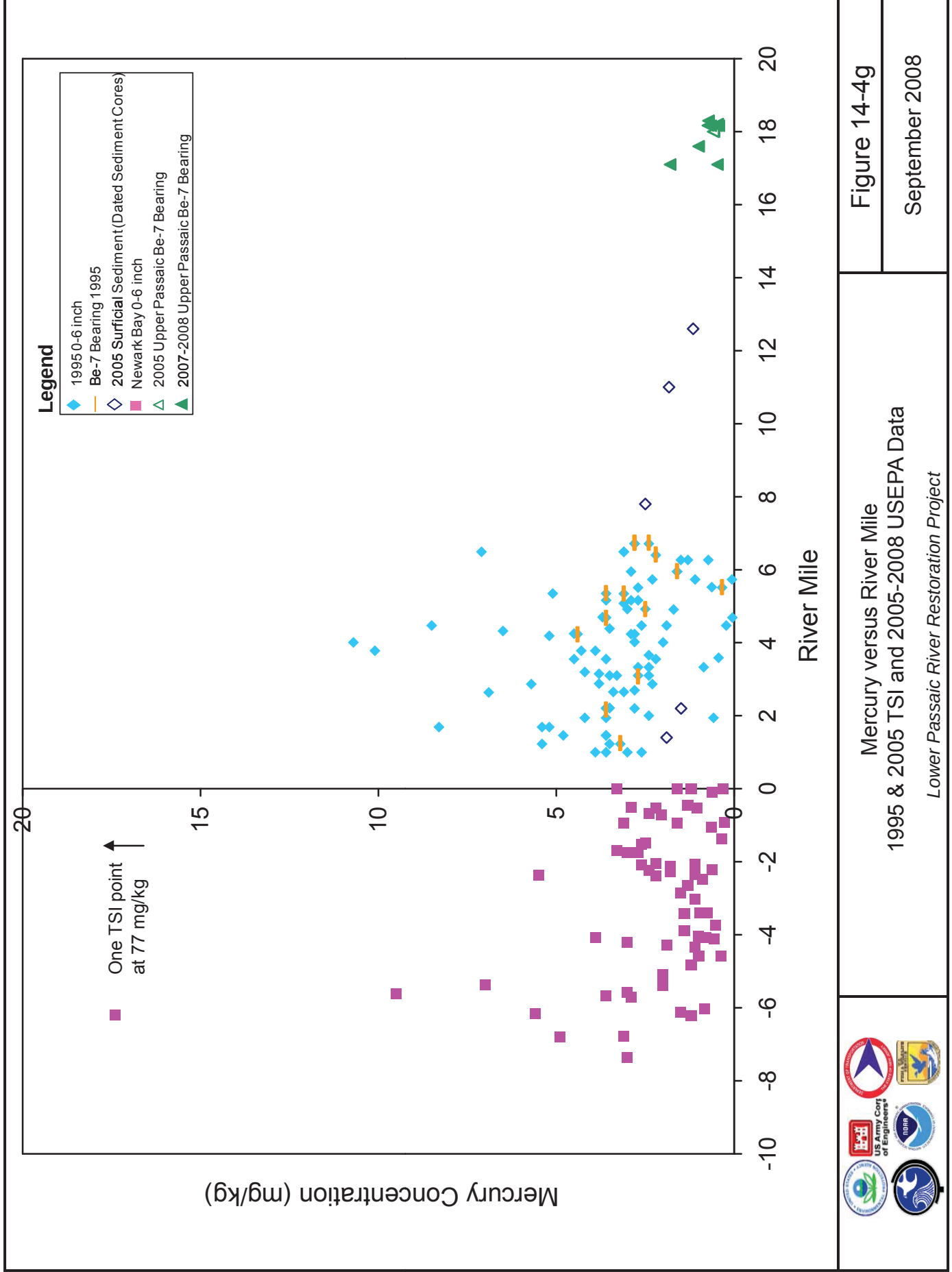
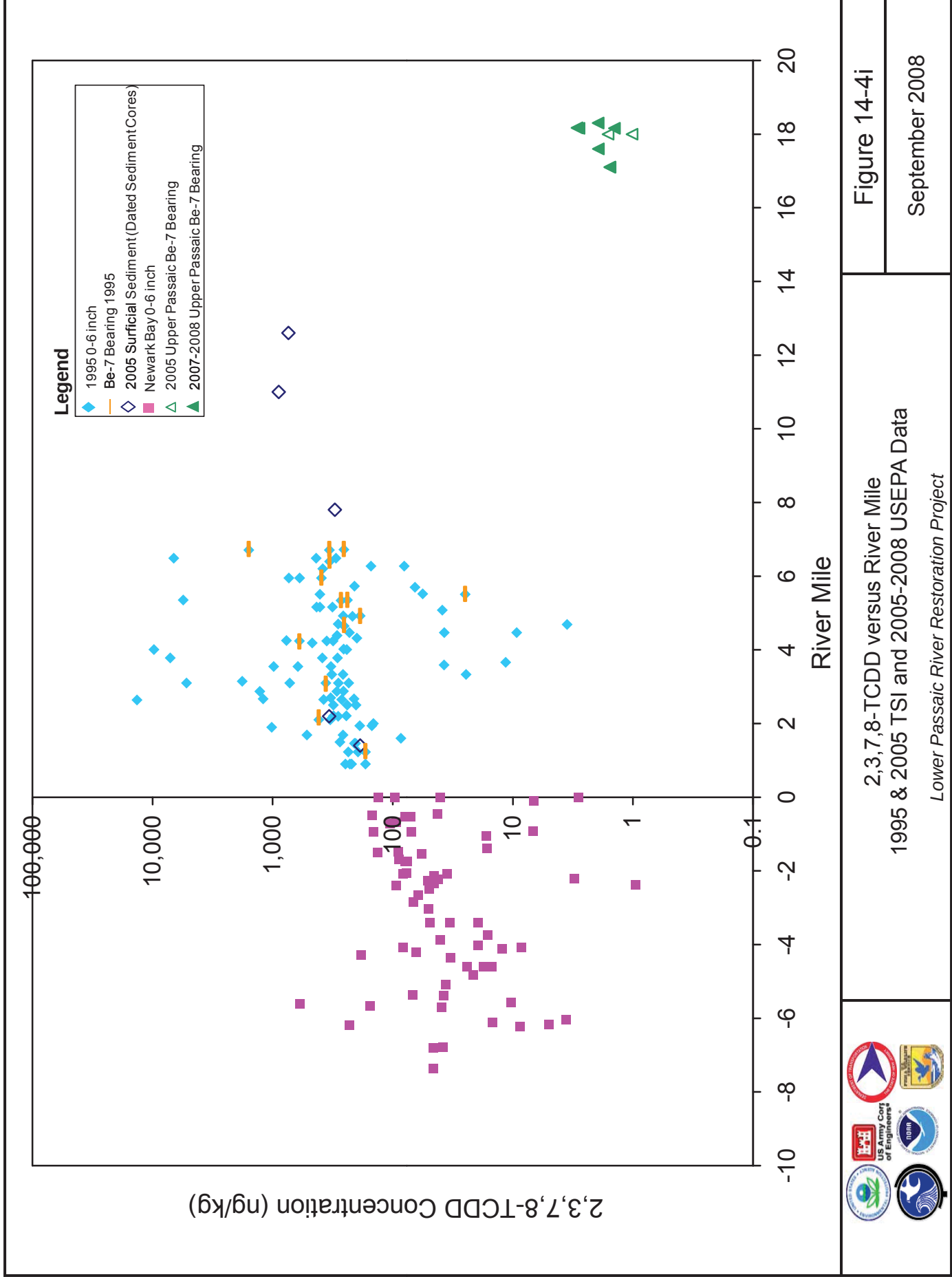


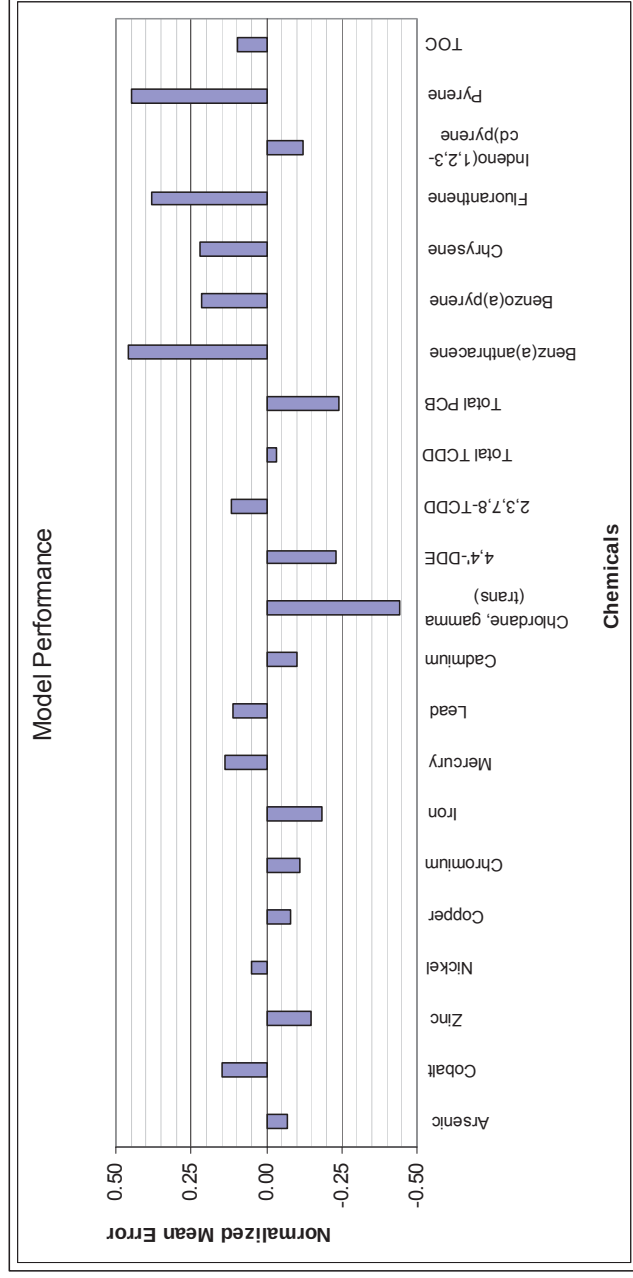
Figure 14-4e

September 2008





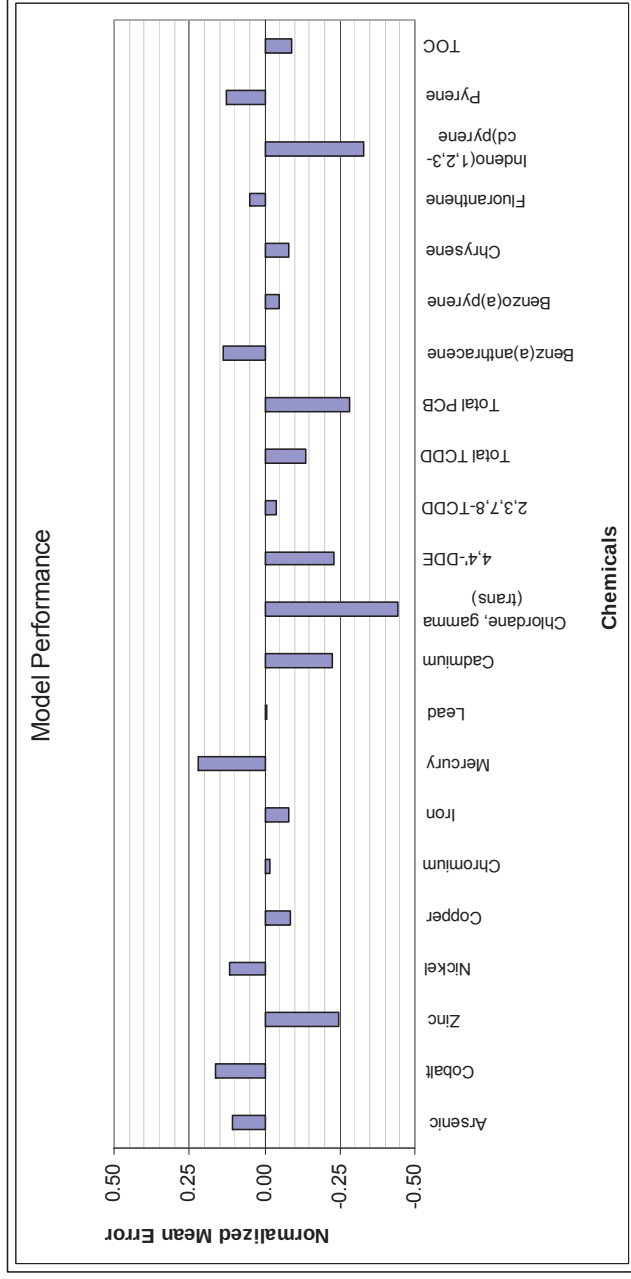
Base Case



Resuspension	0.461
Newark Bay	0.271
Upper Passaic River	0.220
Saddle River	0.024
Third River	0.005
Second River / SWO	0.013
CSO	0.005

II

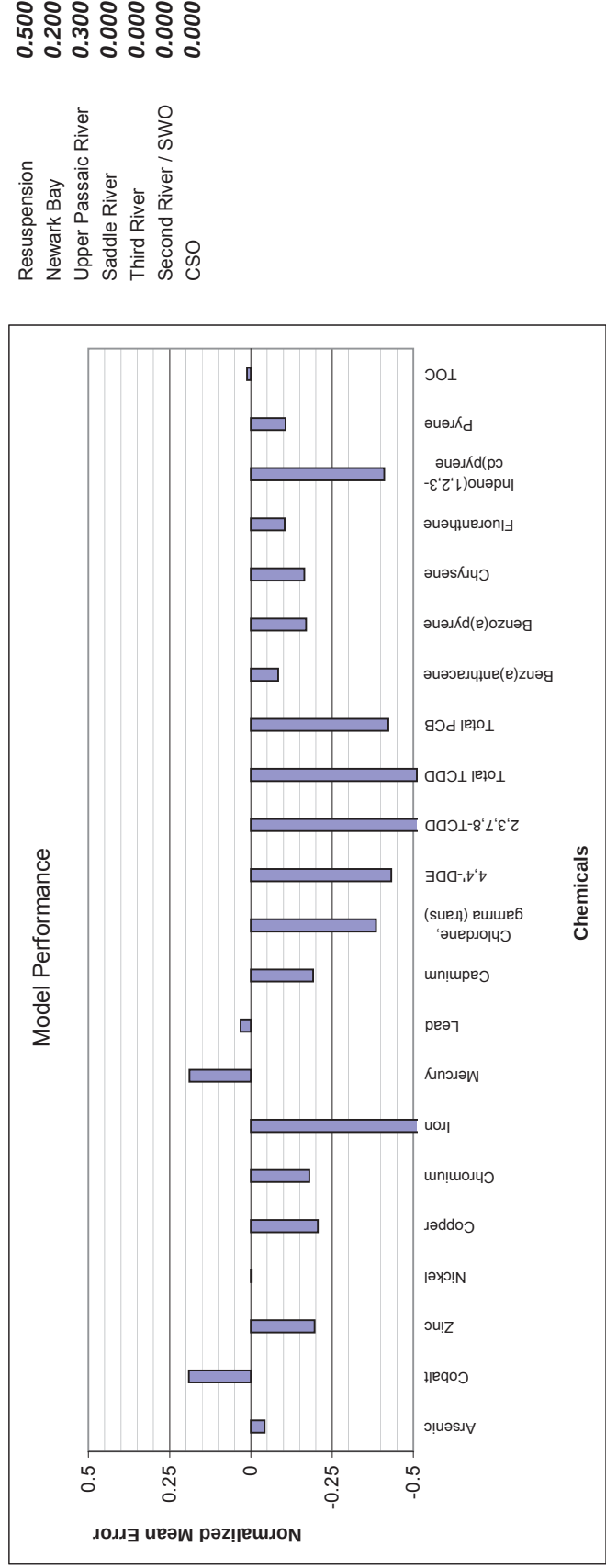
All Variables



Resuspension
Newark Bay
Upper Passaic River
Saddle River
Third River
Second River / SWO
CSO

0.400
0.400
0.200
0.000
0.000
0.000
0.000

All Variables using Median Concentrations



Metals only All Variable Base Case All Variables using Median Concentrations

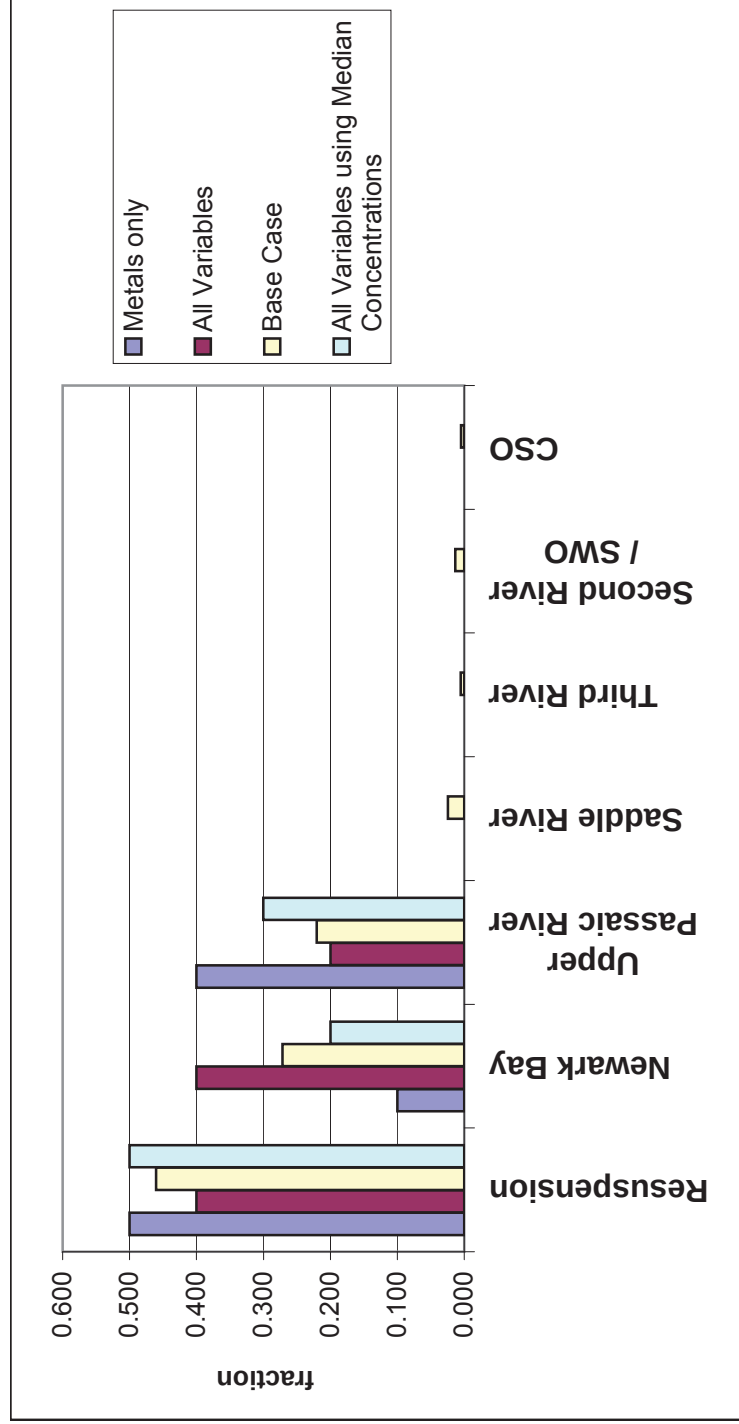
Resuspension
Newark Bay
Upper Passaic River
Saddle River
Third River
Second River / SWO
CSO

0.500
0.100
0.400
0.000
0.000
0.000
0.000

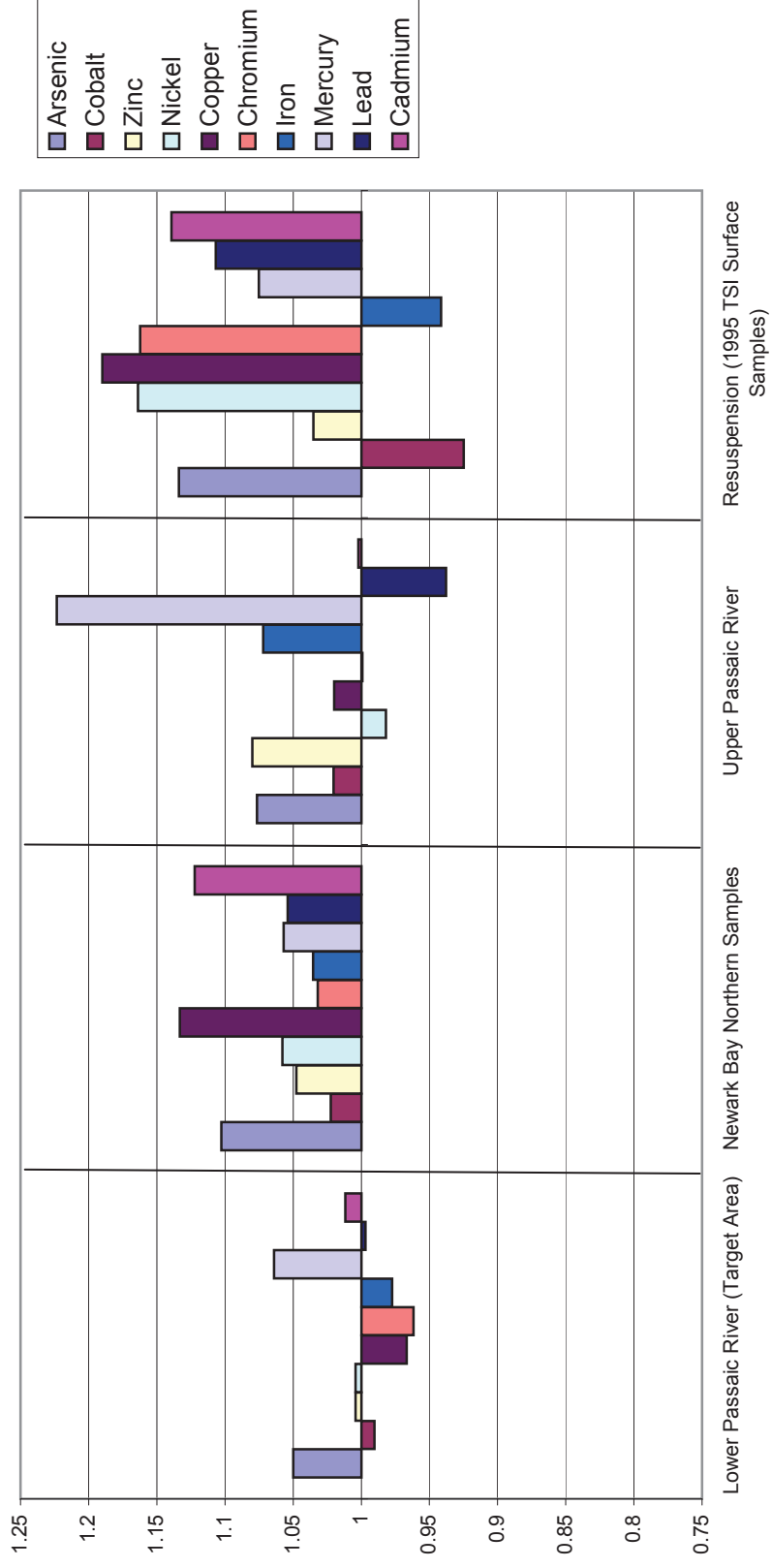
0.400
0.400
0.200
0.000
0.000
0.000
0.000

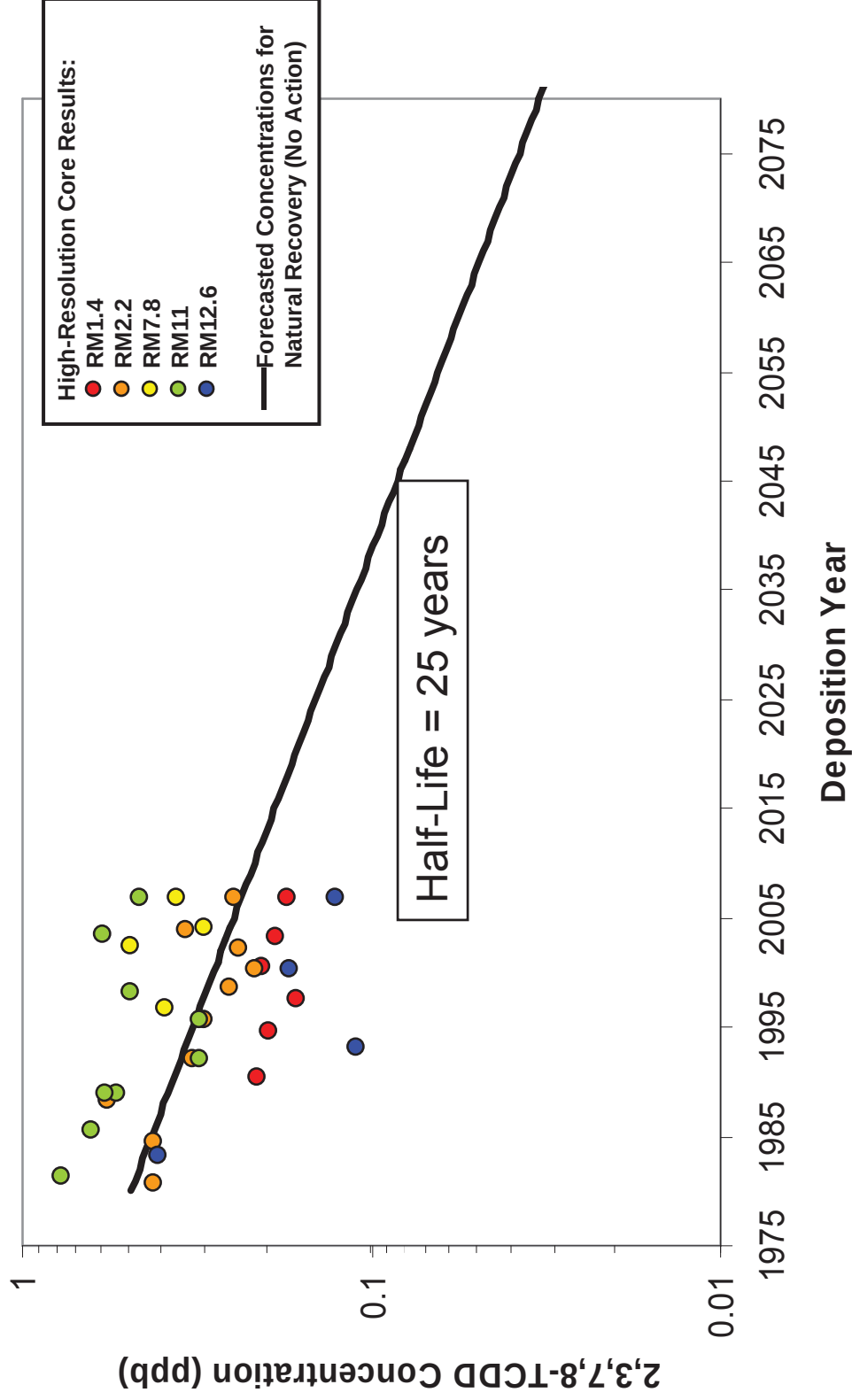
0.461
0.271
0.220
0.024
0.005
0.013
0.005

0.5
0.2
0.3
0
0
0
0



Ratio of Average to Median Concentrations



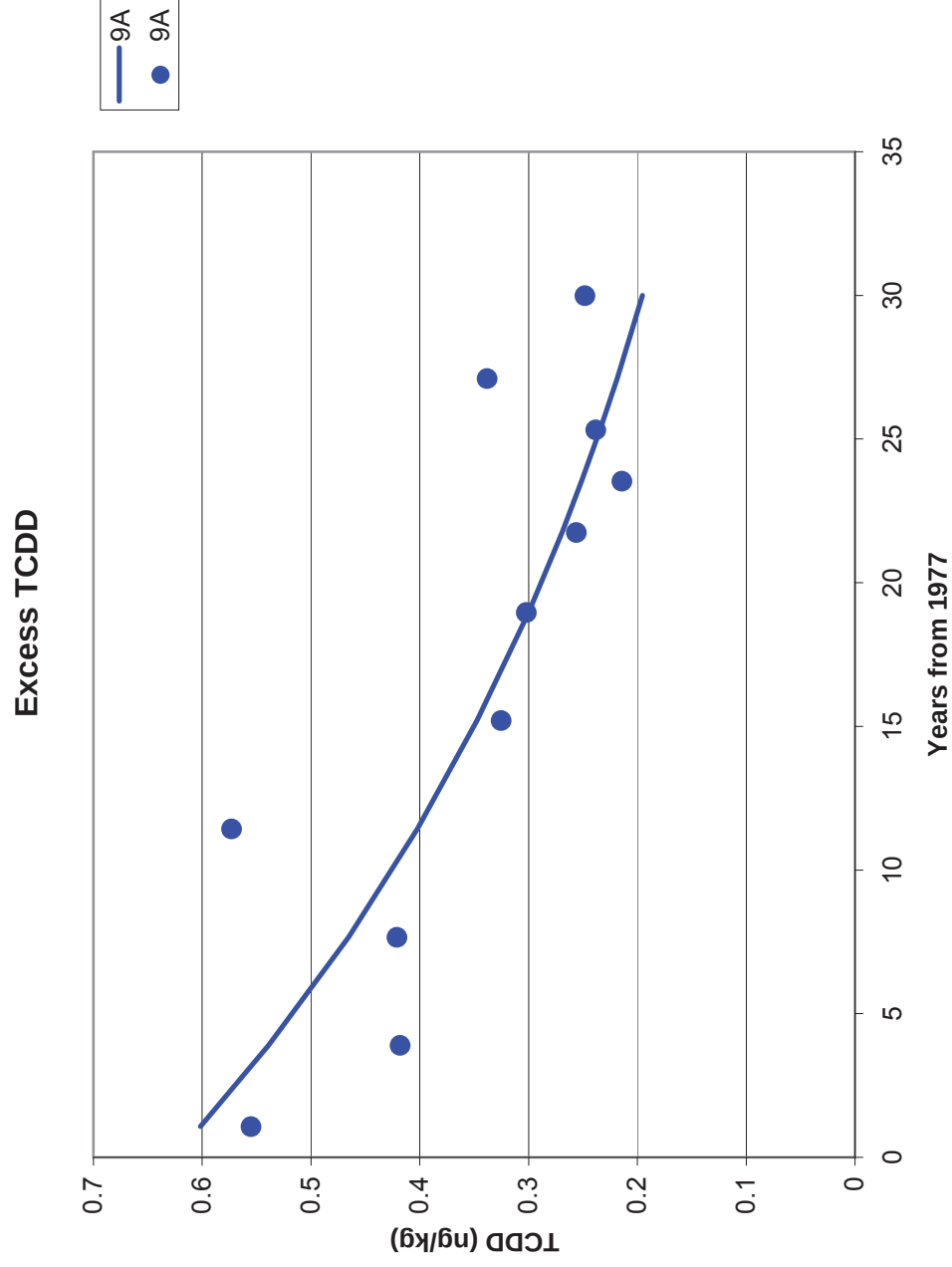


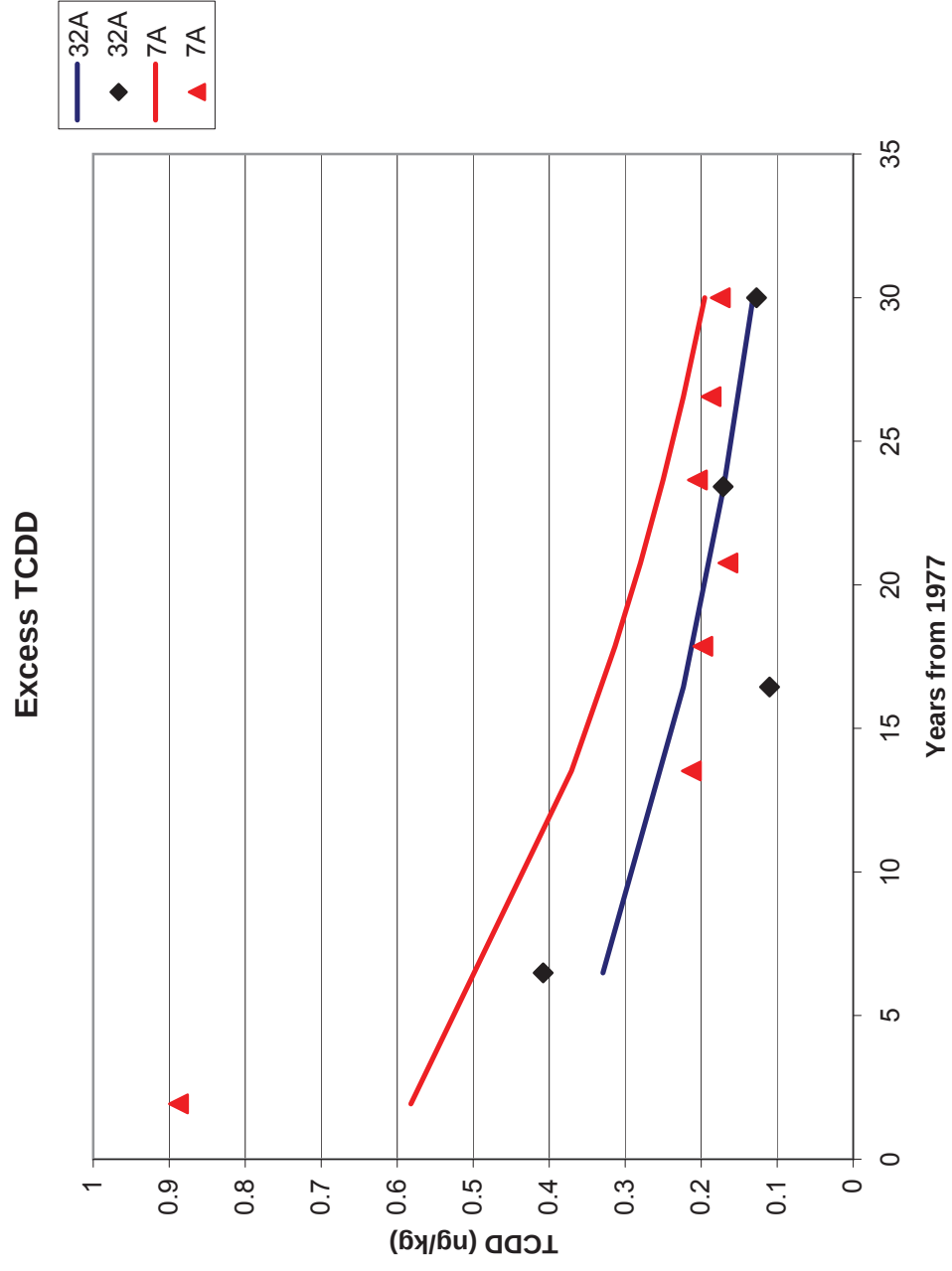
2,3,7,8-TCDD Concentrations in Recently Deposited (Be-7 Bearing) Sediments – Measured and Predicted
Lower Passaic River Restoration Project

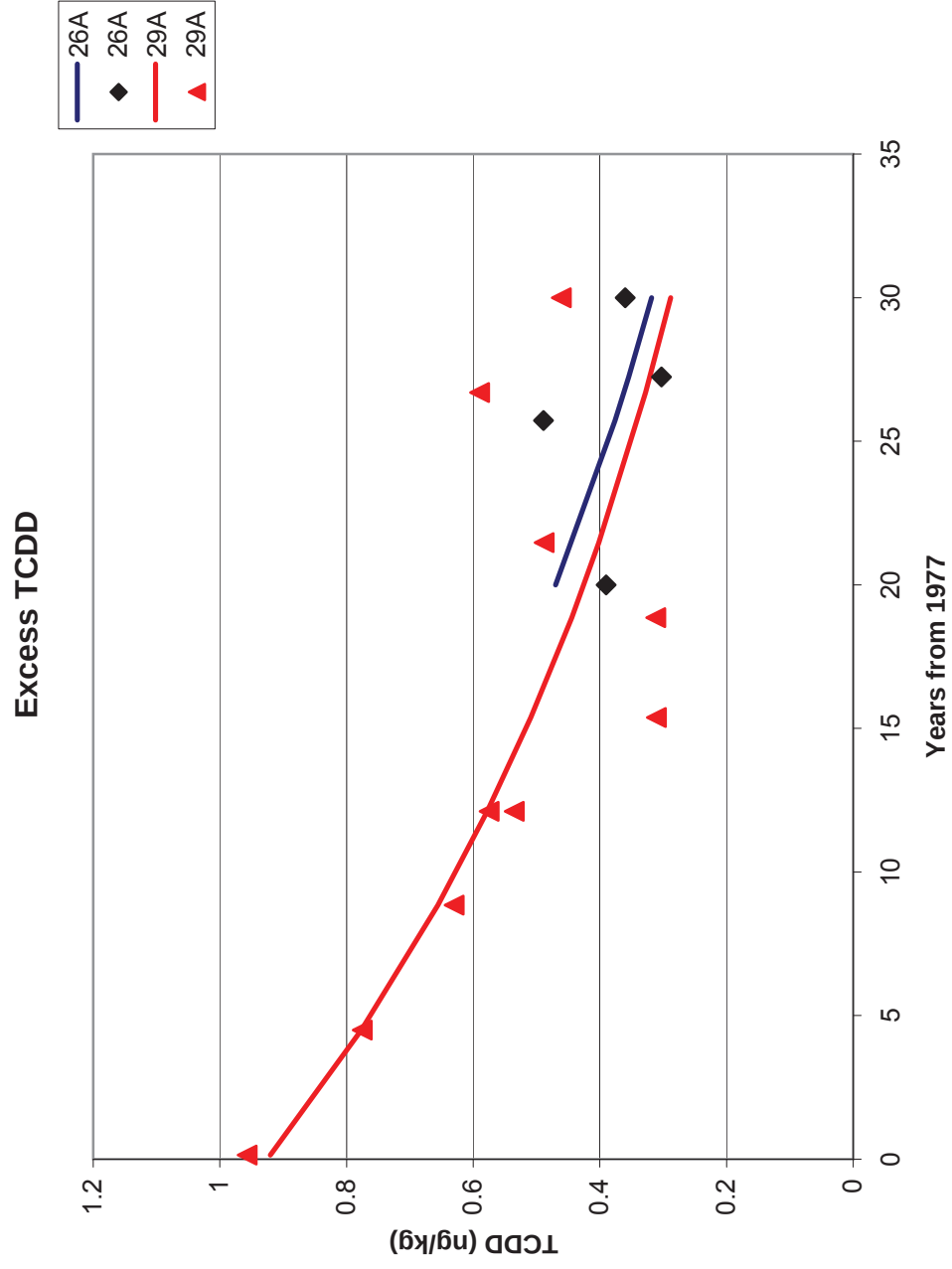
Figure 20-11

September 2008

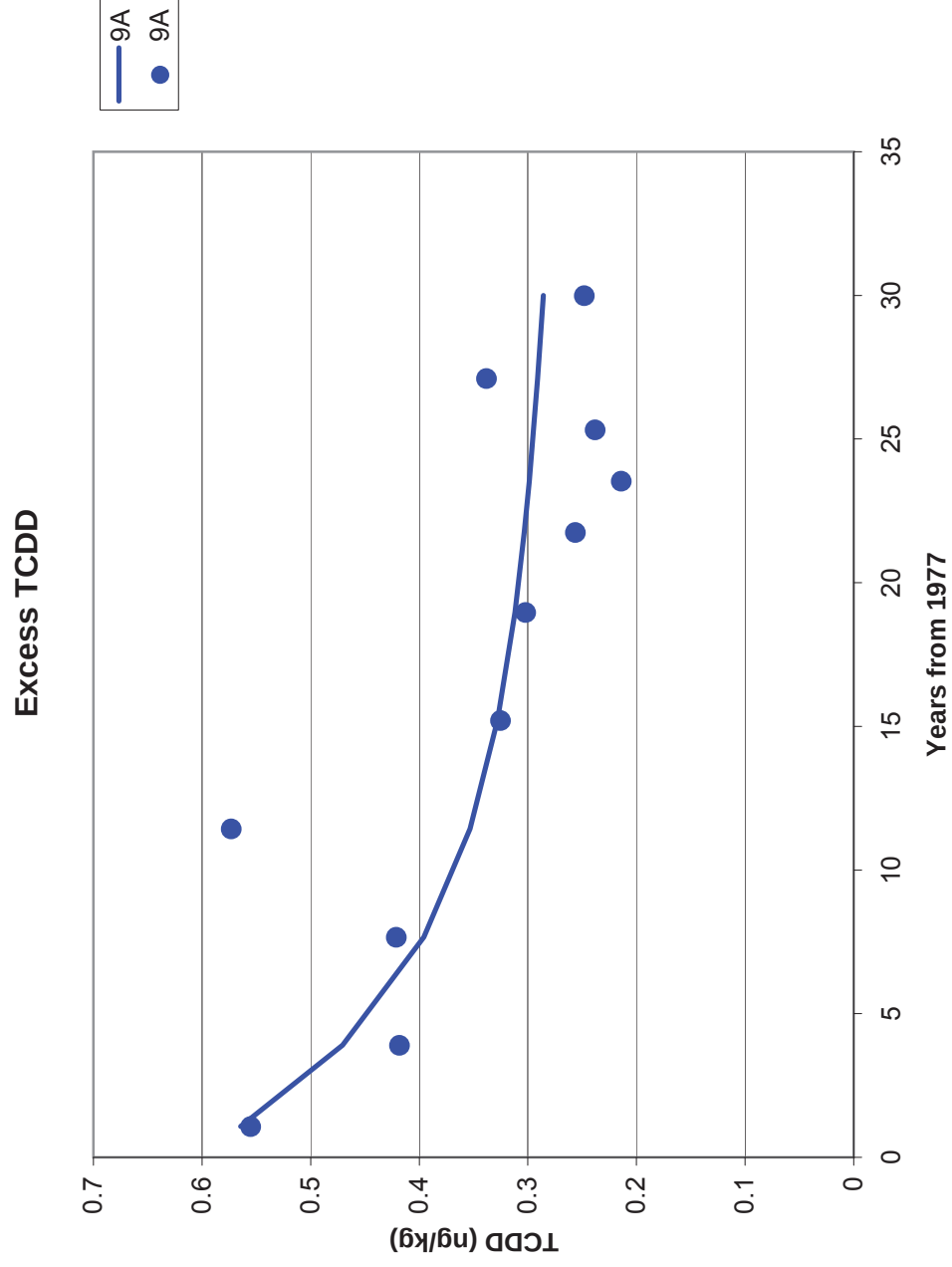
High Resolution Core Data Used for Calculating Half-Life										half life
Core ID	River Mile	Estimated Year of Deposition	Slice Concentration (ug/kg)	Upper Passaic Fractional Mass Load	Excess Concentration (ug/kg)	Natural Log of Excess Concentration	yr from 1977	c(0)	predicted	error
26A	7.8	1997.00	0.39	0.0000	0.390	-0.942	20	1.022517	0.469769	0.006363
26A	7.8	2002.72	0.489	0.0000	0.489	-0.715	26		0.376035	0.012761
26A	7.8	2004.24	0.303	0.0000	0.303	-1.194	27		0.354478	0.00265
26A	7.8	2007.00	0.36	0.0000	0.360	-1.022	30		0.318413	0.001729
29A	11	1977.15	0.957	0.0000	0.957	-0.044	0	0.925412	0.920206	0.001354
29A	11	1981.50	0.775	0.0000	0.775	-0.255	4		0.776921	3.69E-06
29A	11	1985.85	0.63	0.0000	0.630	-0.462	9		0.655948	0.000673
29A	11	1989.11	0.535	0.0000	0.535	-0.625	12		0.577748	0.001827
29A	11	1989.11	0.575	0.0000	0.575	-0.553	12		0.577748	7.55E-06
29A	11	1992.38	0.311	0.0000	0.311	-1.168	15		0.508871	0.039153
29A	11	1995.86	0.312	0.0000	0.312	-1.165	19		0.444428	0.017537
29A	11	1998.47	0.488	0.0000	0.488	-0.717	21		0.40151	0.007481
29A	11	2003.69	0.59	0.0000	0.590	-0.528	27		0.327708	0.068797
29A	11	2007.00	0.461	0.0000	0.461	-0.774	30		0.288175	0.029869
32A	12.6	1983.49	0.41	0.0000	0.408	-0.896	6	0.42374	0.329244	0.006203
32A	12.6	1993.45	0.110	0.0000	0.110	-2.207	16		0.223516	0.012886
32A	12.6	2000.42	0.171	0.0000	0.171	-1.766	23		0.170436	3.18E-07
32A	12.6	2007.00	0.127	0.0000	0.127	-2.064	30		0.131953	2.45E-05
7A	1.4	1978.93	0.888	0.0000	0.888	-0.119	2	0.627303	0.581921	0.093685
7A	1.4	1990.52	0.213	0.0000	0.213	-1.546	14		0.370835	0.024912
7A	1.4	1994.86	0.198	0.0000	0.198	-1.619	18		0.313184	0.013267
7A	1.4	1997.76	0.165	0.0000	0.165	-1.802	21		0.27982	0.013184
7A	1.4	2000.66	0.205	0.0000	0.205	-1.585	24		0.25001	0.002026
7A	1.4	2003.55	0.187	0.0000	0.187	-1.677	27		0.223376	0.001323
7A	1.4	2007.00	0.175	0.0000	0.175	-1.743	30		0.195343	0.000414
9A	2.2	1978.07	0.555	0.0000	0.555	-0.589	1		0.601634	0.002175
9A	2.2	1980.90	0.418	0.0000	0.418	-0.872	4		0.539008	0.014643
9A	2.2	1984.67	0.421	0.0000	0.421	-0.865	8		0.465529	0.001983
9A	2.2	1988.44	0.573	0.0000	0.573	-0.557	11		0.402066	0.029218
9A	2.2	1992.21	0.325	0.0000	0.325	-1.124	15		0.347255	0.000495
9A	2.2	1995.98	0.302	0.0000	0.302	-1.197	19		0.299916	4.34E-06
9A	2.2	1998.75	0.256	0.0000	0.256	-1.363	22		0.269216	0.000175
9A	2.2	2000.54	0.214	0.0000	0.214	-1.542	24		0.25116	0.001381
9A	2.2	2002.32	0.238	0.0000	0.238	-1.435	25		0.234316	1.36E-05
9A	2.2	2004.11	0.338	0.0000	0.338	-1.085	27		0.218601	0.014256
9A	2.2	2007.00	0.248	0.0000	0.248	-1.394	30		0.195343	0.002773
sum										0.425246

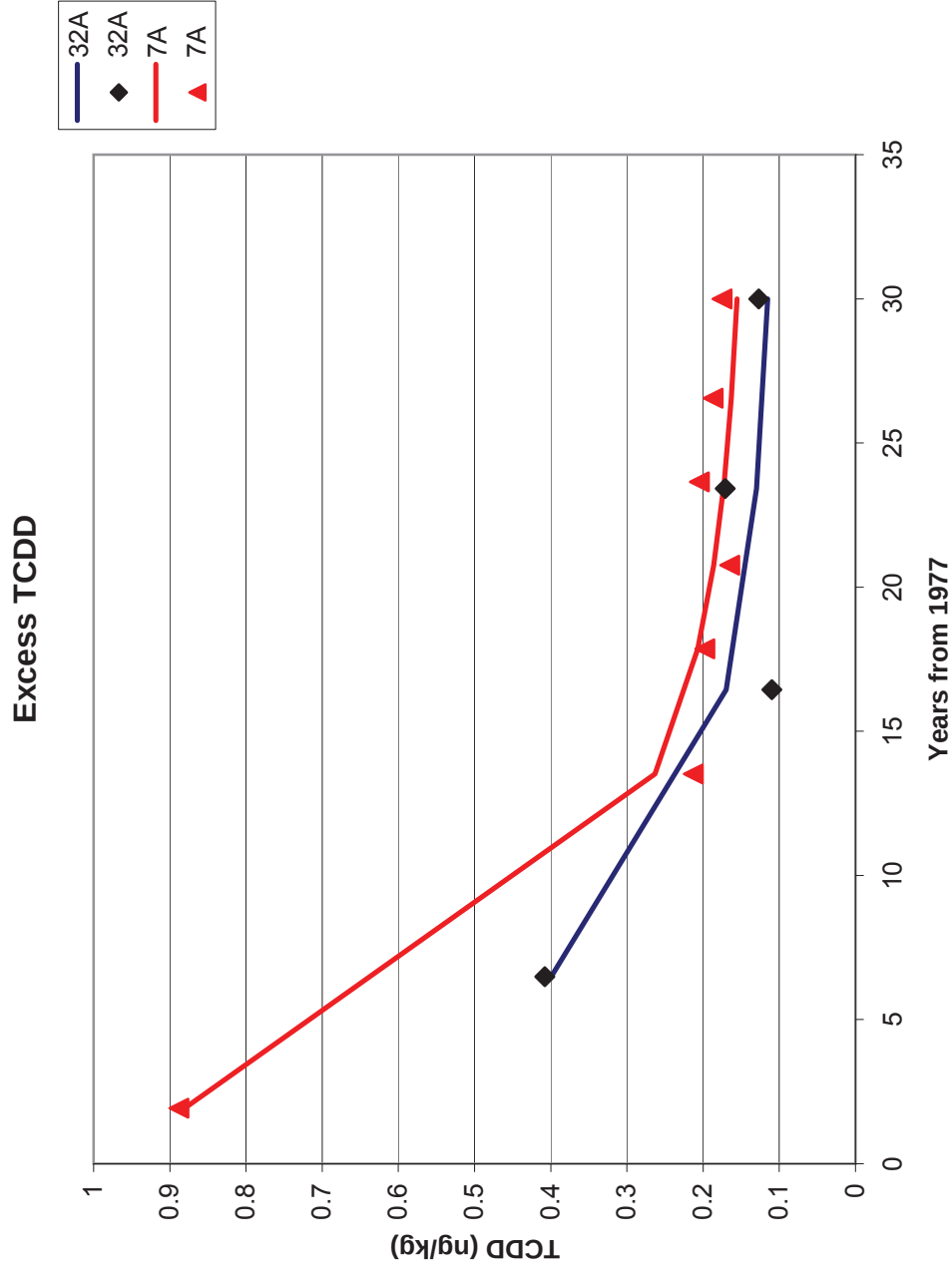


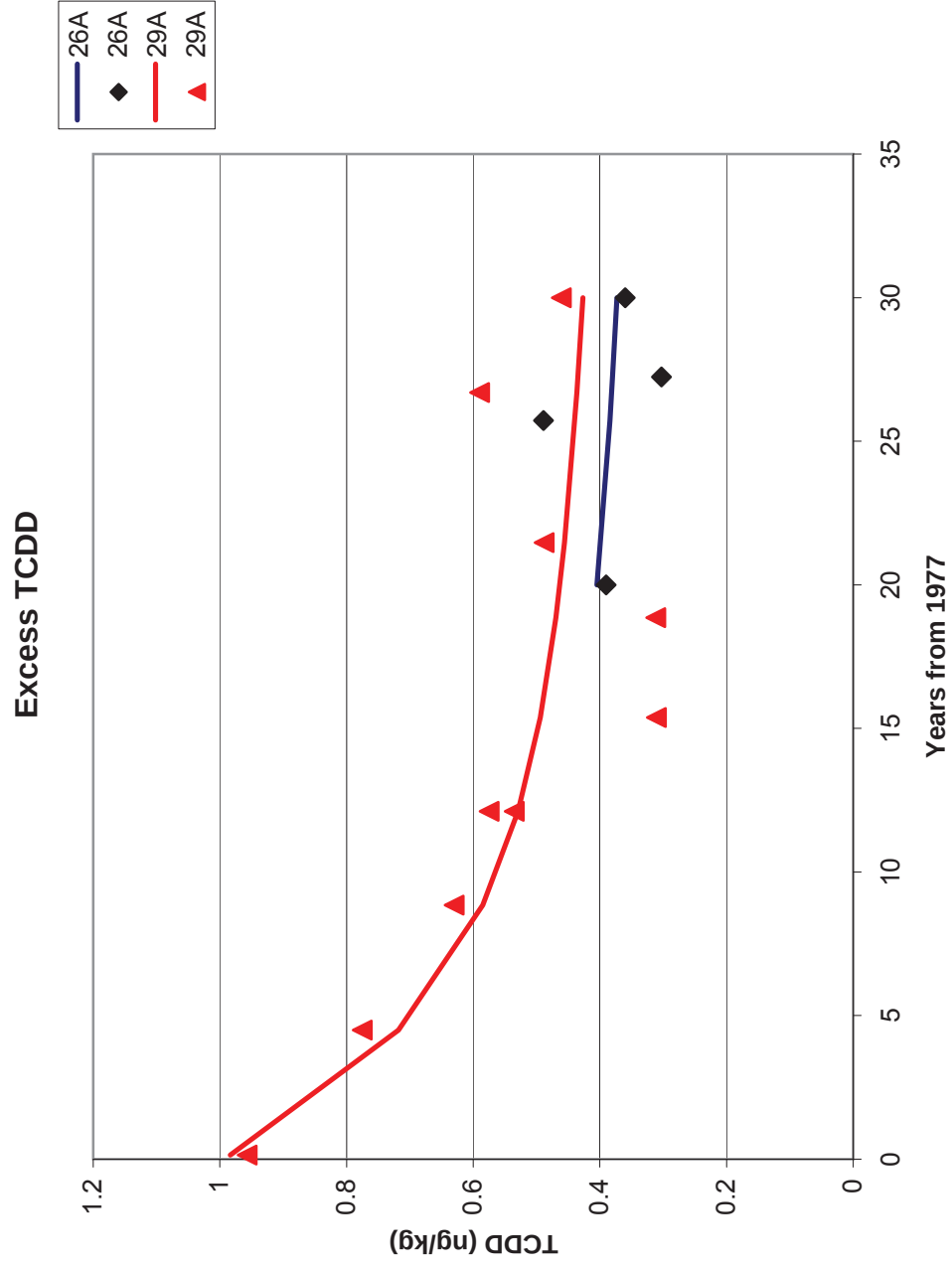


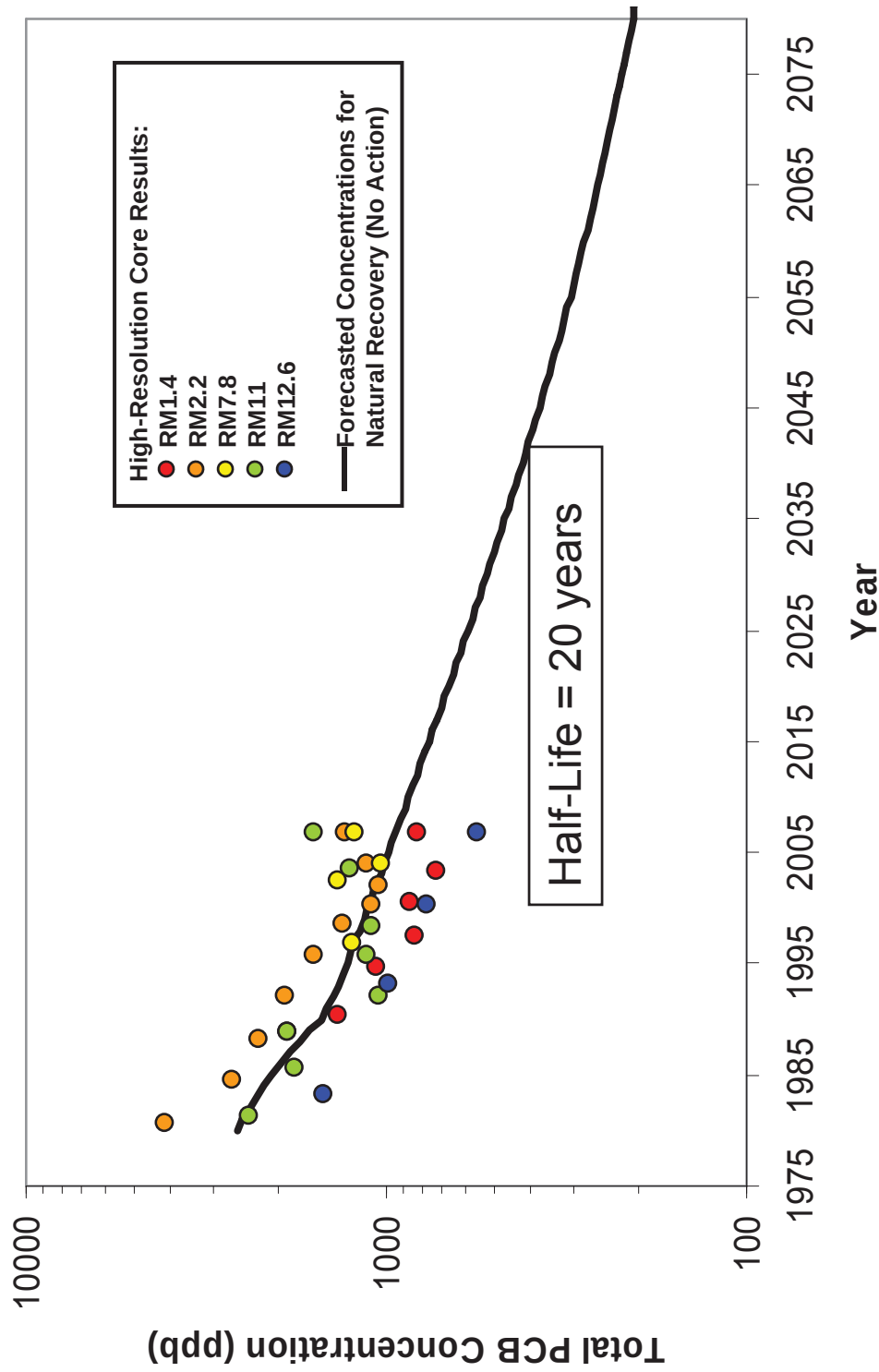


High Resolution Core Data Used for Calculating Half-Life							half life (yr half life (yr)			
Core ID	River Mile	Estimated Year of Deposition	Slice Concentration (ug/kg)	Upper Passaic Fractional Mass Load	Excess Concentration (ug/kg)	Natural Log of Excess Concentration	yr from 1977	c(0)	predicted	error
26A	7.8	1997.00	0.39	0.0000	0.390	-0.942	20	0.435552	0.404697	0.000216
26A	7.8	2002.72	0.489	0.0000	0.489	-0.715	26	0.430729	0.38431	0.01096
26A	7.8	2004.24	0.303	0.0000	0.303	-1.194	27		0.380132	0.005949
26A	7.8	2007.00	0.36	0.0000	0.360	-1.022	30		0.373299	0.000177
							5.953148 199.0886			
							Solver estimated			
29A	11	1977.15	0.957	0.0000	0.957	-0.044	0	0.503431	0.983592	0.000707
29A	11	1981.50	0.775	0.0000	0.775	-0.255	4	0.492641	0.718144	0.003233
29A	11	1985.85	0.63	0.0000	0.630	-0.462	9		0.585072	0.002019
29A	11	1989.11	0.535	0.0000	0.535	-0.625	12		0.529354	3.19E-05
29A	11	1989.11	0.575	0.0000	0.575	-0.553	12		0.529354	0.002084
29A	11	1992.38	0.311	0.0000	0.311	-1.168	15		0.494045	0.033505
29A	11	1995.86	0.312	0.0000	0.312	-1.165	19		0.4693	0.024743
29A	11	1998.47	0.488	0.0000	0.488	-0.717	21		0.455938	0.001028
29A	11	2003.69	0.59	0.0000	0.590	-0.528	27		0.436505	0.023561
29A	11	2007.00	0.461	0.0000	0.461	-0.774	30		0.42699	0.001157
32A	12.6	1983.49	0.41	0.0000	0.408	-0.896	6	0.819409	0.399437	7.33E-05
32A	12.6	1993.45	0.110	0.0000	0.110	-2.207	16	0.128011	0.169573	0.003549
32A	12.6	2000.42	0.171	0.0000	0.171	-1.766	23		0.129837	0.001694
32A	12.6	2007.00	0.127	0.0000	0.127	-2.064	30		0.115412	0.000134
7A	1.4	1978.93	0.888	0.0000	0.888	-0.119	2	0.980903	0.880729	5.29E-05
7A	1.4	1990.52	0.213	0.0000	0.213	-1.546	14	0.173226	0.263133	0.002513
7A	1.4	1994.86	0.198	0.0000	0.198	-1.619	18		0.207176	8.42E-05
7A	1.4	1997.76	0.165	0.0000	0.165	-1.802	21		0.186082	0.000444
7A	1.4	2000.66	0.205	0.0000	0.205	-1.585	24		0.172267	0.001071
7A	1.4	2003.55	0.187	0.0000	0.187	-1.677	27		0.162938	0.000579
7A	1.4	2007.00	0.175	0.0000	0.175	-1.743	30		0.155349	0.000386
9A	2.2	1978.07	0.555	0.0000	0.555	-0.589	1	0.282631	0.564386	8.81E-05
9A	2.2	1980.90	0.418	0.0000	0.418	-0.872	4	0.330201	0.470567	0.002763
9A	2.2	1984.67	0.421	0.0000	0.421	-0.865	8		0.395656	0.000642
9A	2.2	1988.44	0.573	0.0000	0.573	-0.573	11		0.353146	0.048336
9A	2.2	1992.21	0.325	0.0000	0.325	-1.124	15		0.327891	8.36E-06
9A	2.2	1995.98	0.302	0.0000	0.302	-1.197	19		0.31185	9.7E-05
9A	2.2	1998.75	0.256	0.0000	0.256	-1.363	22		0.303343	0.002241
9A	2.2	2000.54	0.214	0.0000	0.214	-1.542	24		0.298804	0.007192
9A	2.2	2002.32	0.238	0.0000	0.238	-1.435	25		0.294781	0.003224
9A	2.2	2004.11	0.338	0.0000	0.338	-1.085	27		0.291145	0.002195
9A	2.2	2007.00	0.248	0.0000	0.248	-1.394	30		0.285843	0.001432
							sum			0.188172







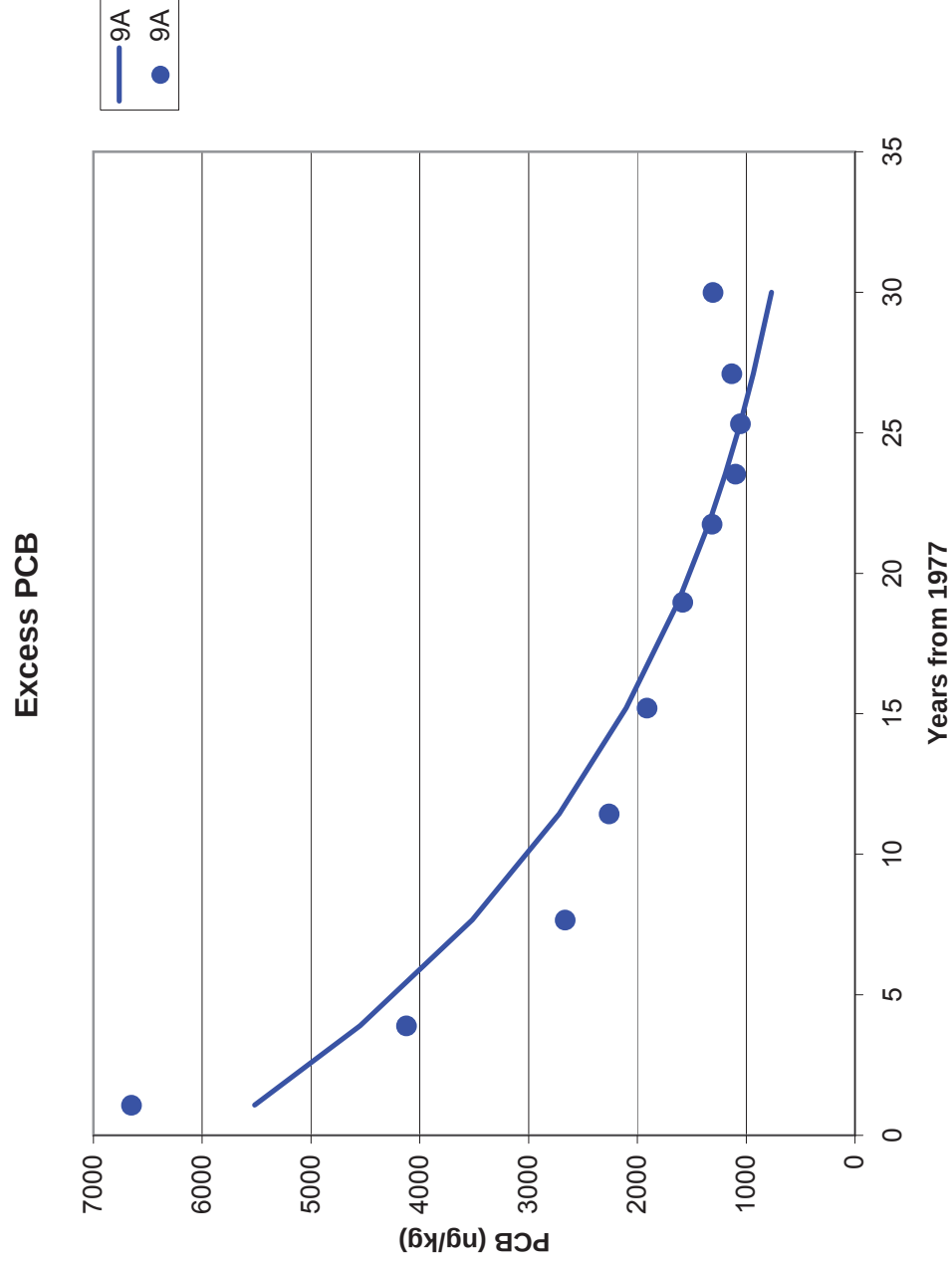


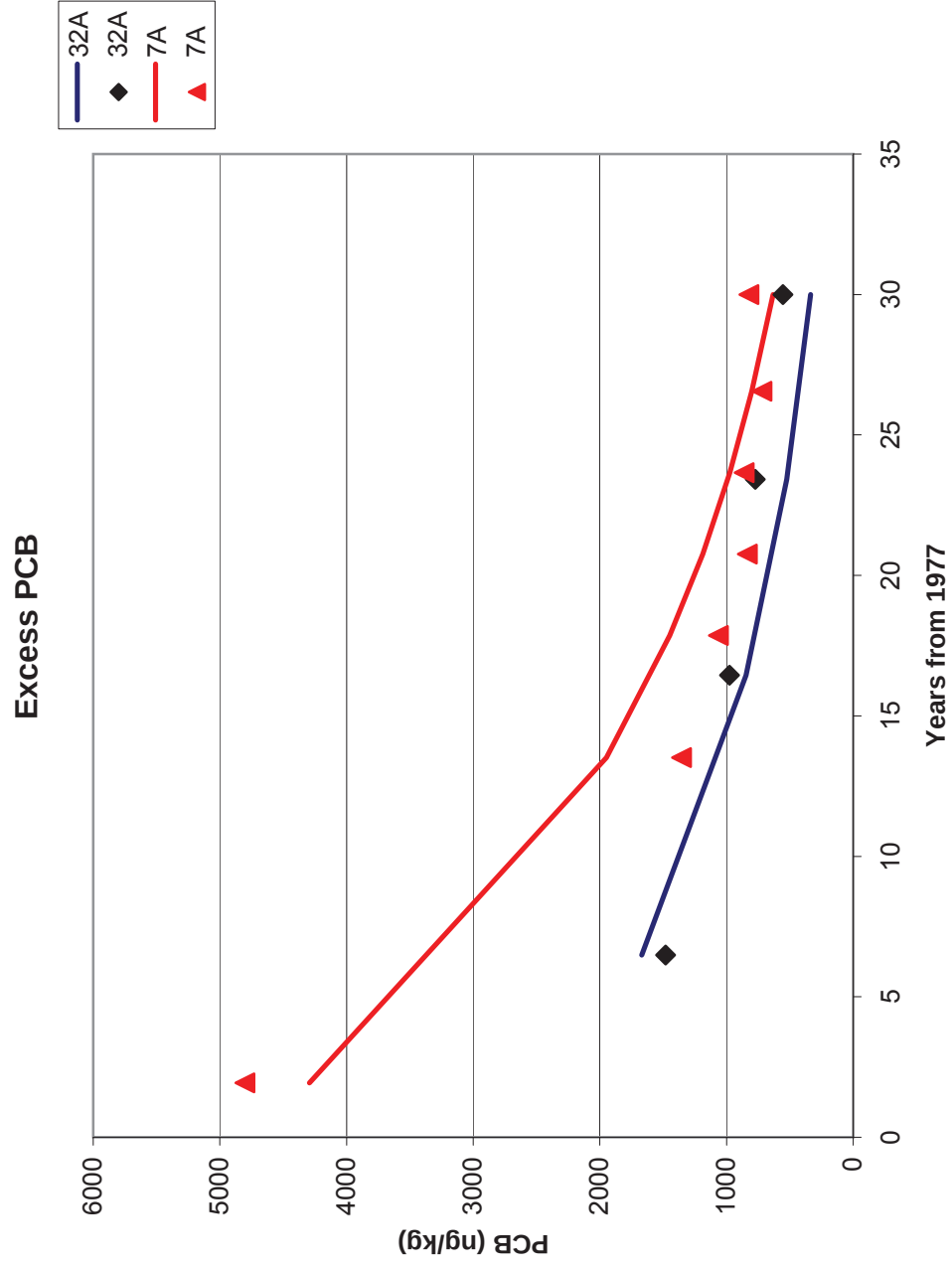
Total PCB Concentrations in Recently Deposited (Be-7 Bearing) Sediments – Measured and Predicted
Lower Passaic River Restoration Project

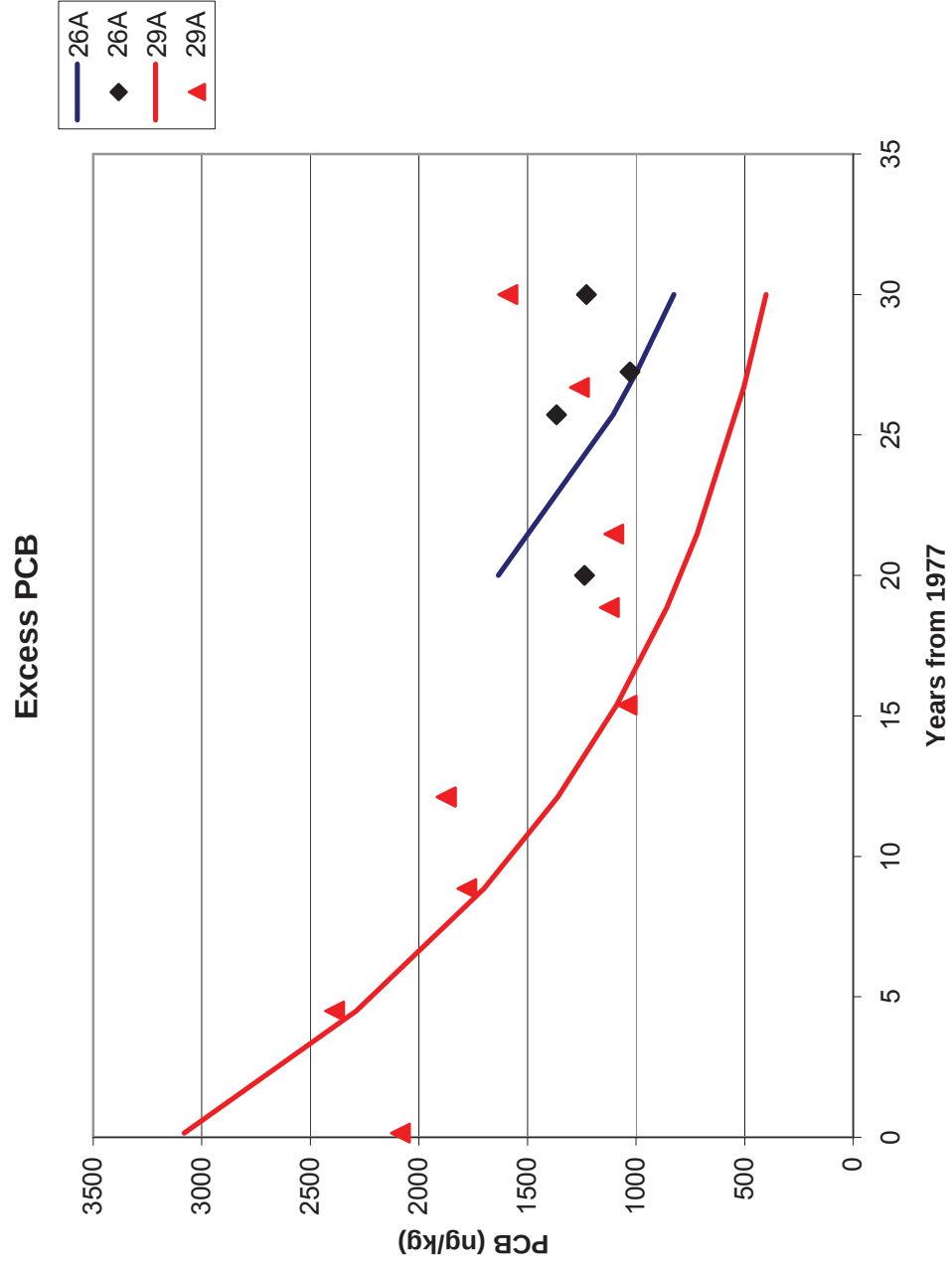
Figure 20-18

September 2008

High Resolution Core Data Used for Calculating Half-Life										half life
Core ID	River Mile	Estimated Year of Deposition	Slice Concentration (ug/kg)	Upper Passaic Fractional Mass Load	Excess Concentration (ug/kg)	Natural Log of Excess Concentration	yr from 1977	c(0)	predicted	error
26A	7.8	1997	1237.039	0.0000	1237.039	7.120	20	6401.752	1634.736	158163.2
26A	7.8	2003	1366.146	0.0000	1366.146	7.220	26		1106.131	67607.82
26A	7.8	2004	1027.705	0.0000	1027.705	6.935	27		997.2568	927.0831
26A	7.8	2007	1228.172	0.0000	1228.172	7.113	30		826.08	161678
29A	11	1977	2084.722	0.0000	2084.722	7.642	0	3111.442	3080.784	992139.9
29A	11	1981	2388.979	0.0000	2388.979	7.779	4		2289.006	9994.585
29A	11	1986	1778.705	0.0000	1778.705	7.484	9		1700.72	6081.635
29A	11	1989	1875.003	0.0000	1875.003	7.536	12		1361.044	264153.5
29A	11	1989	1875.003	0.0000	1875.003	7.536	12		1361.044	264153.5
29A	11	1992	1040.572	0.0000	1040.572	6.948	15		1089.209	2365.645
29A	11	1996	1122.540	0.0000	1122.540	7.023	19		858.8158	69550.24
29A	11	1998	1102.412	0.0000	1102.412	7.005	21		718.6071	147306.2
29A	11	2004	1260.822	0.0000	1260.822	7.140	27		503.1233	574106.6
29A	11	2007	1591.094	0.0000	1591.094	7.372	30		401.4995	1415135
32A	12.6	1983	1480.33	0.0000	1480.332	7.300	6	2598.919	1669.033	35608.05
32A	12.6	1993	977.711	0.0000	977.711	6.885	16		845.7424	17415.7
32A	12.6	2000	772.398	0.0000	772.398	6.649	23		525.508	60954.65
32A	12.6	2007	554.82	0.0000	554.820	6.319	30		335.3637	48161.06
7A	1.4	1979	4801.597	0.0000	4801.597	8.477	2	4898.978	4294.026	257628.8
7A	1.4	1991	1354.677	0.0000	1354.677	7.211	14		1947.242	351133
7A	1.4	1995	1064.606	0.0000	1064.606	6.970	18		1447.532	146631.7
7A	1.4	1998	836.385	0.0000	836.385	6.729	21		1187.864	123537.7
7A	1.4	2001	861.8293	0.0000	861.829	6.759	24		974.7778	12757.37
7A	1.4	2004	719.5541	0.0000	719.554	6.579	27		799.9161	6458.048
7A	1.4	2007	822.841	0.0000	822.841	6.713	30		632.1625	36358.3
9A	2.2	1978	6649.364	0.0000	6649.364	8.802	1	5936.493	5516.741	1282835
9A	2.2	1981	4120.727	0.0000	4120.727	8.324	4		4548.828	183270.3
9A	2.2	1985	2662.661	0.0000	2662.661	7.887	8		3517.132	730120.7
9A	2.2	1988	2259.219	0.0000	2259.219	7.723	11		2719.43	211794.3
9A	2.2	1992	1908.458	0.0000	1908.458	7.554	15		2102.65	37710.73
9A	2.2	1996	1581.644	0.0000	1581.644	7.366	19		1625.759	1946.215
9A	2.2	1999	1311.672	0.0000	1311.672	7.179	22		1345.064	1115.044
9A	2.2	2001	1096.409	0.0000	1096.409	7.000	24		1190.769	8903.824
9A	2.2	2002	1052.001	0.0000	1052.001	6.958	25		1054.173	4.717856
9A	2.2	2004	1129.499	0.0000	1129.499	7.030	27		933.246	38515.19
9A	2.2	2007	1304.208	0.0000	1304.208	7.173	30		766.0431	289621.4
sum										8015845

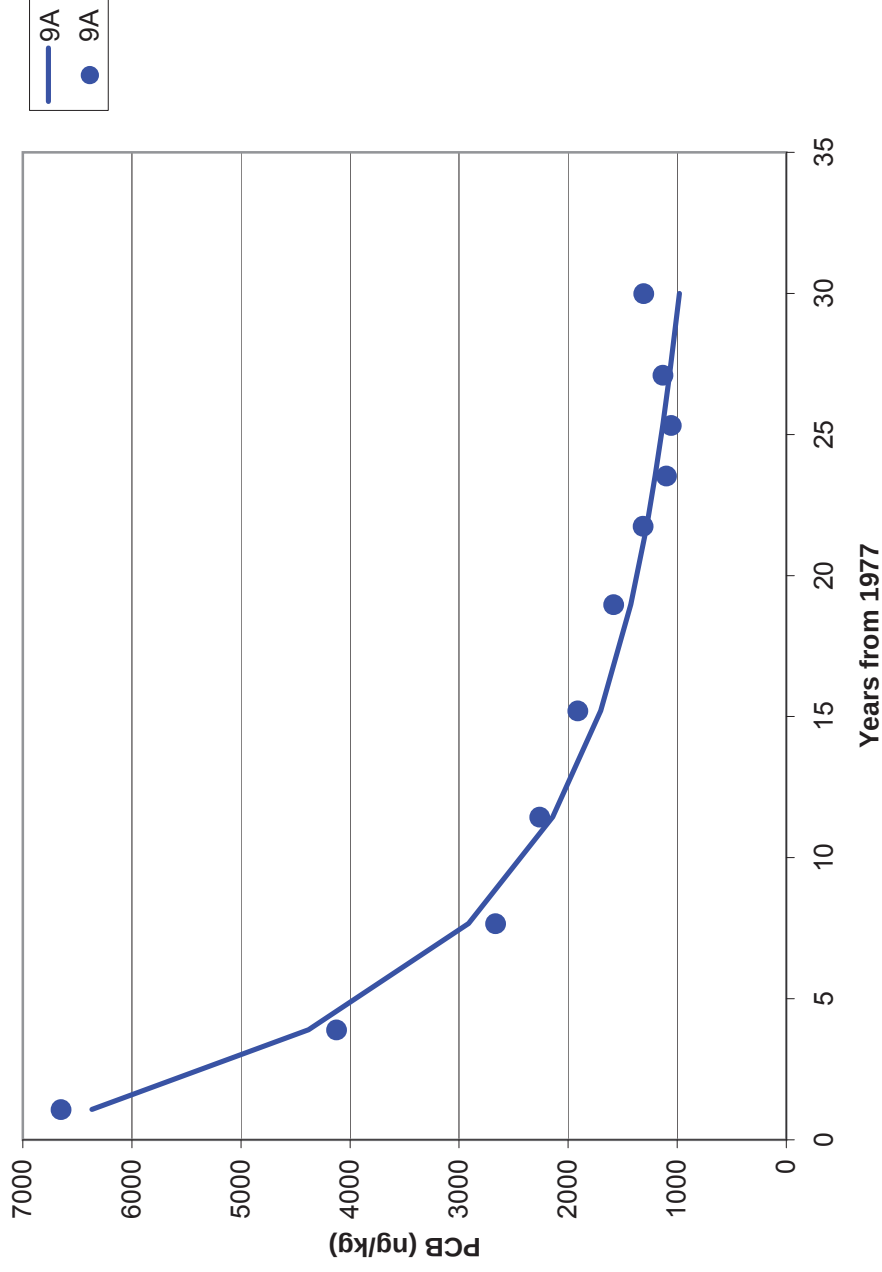


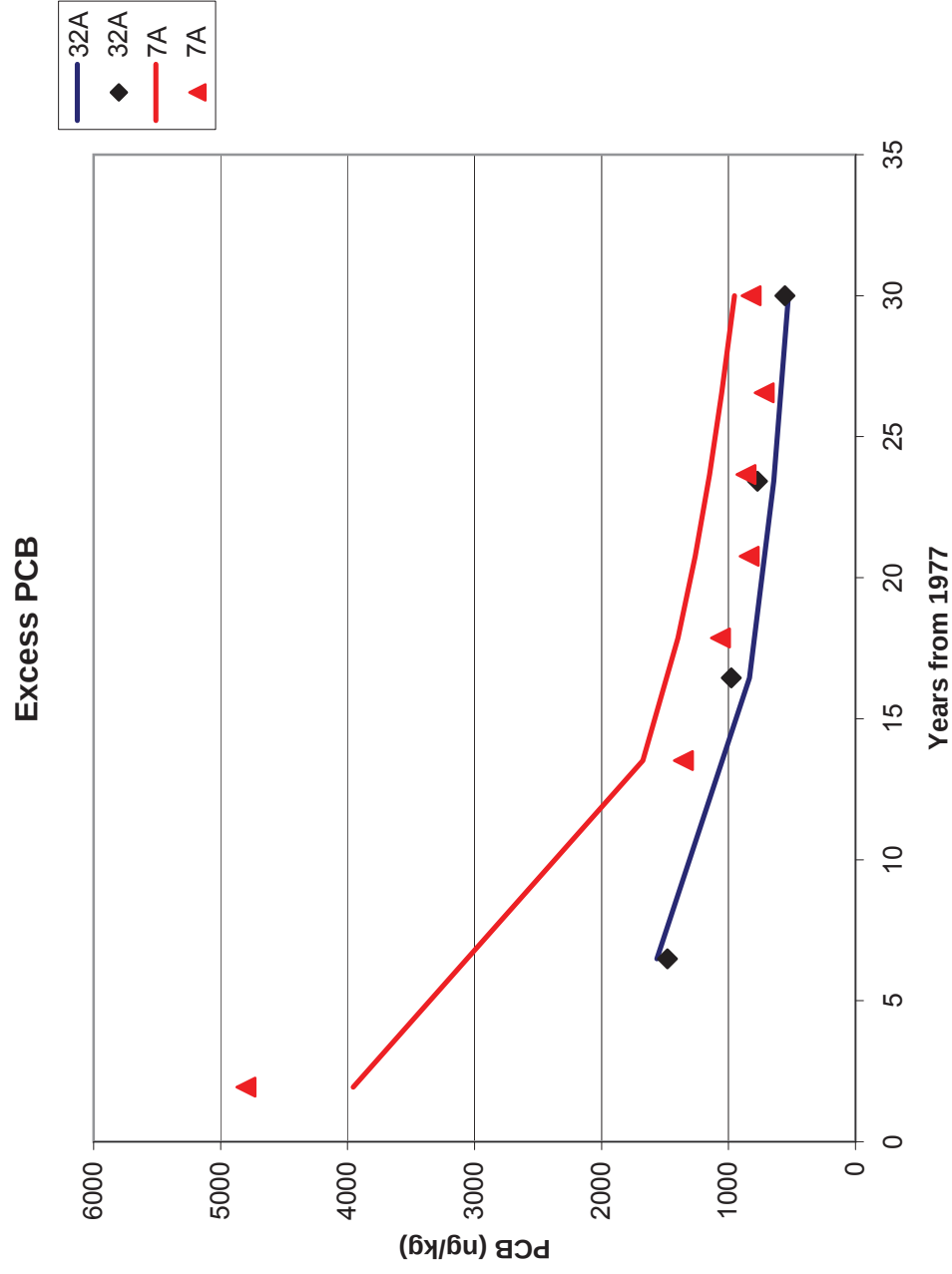


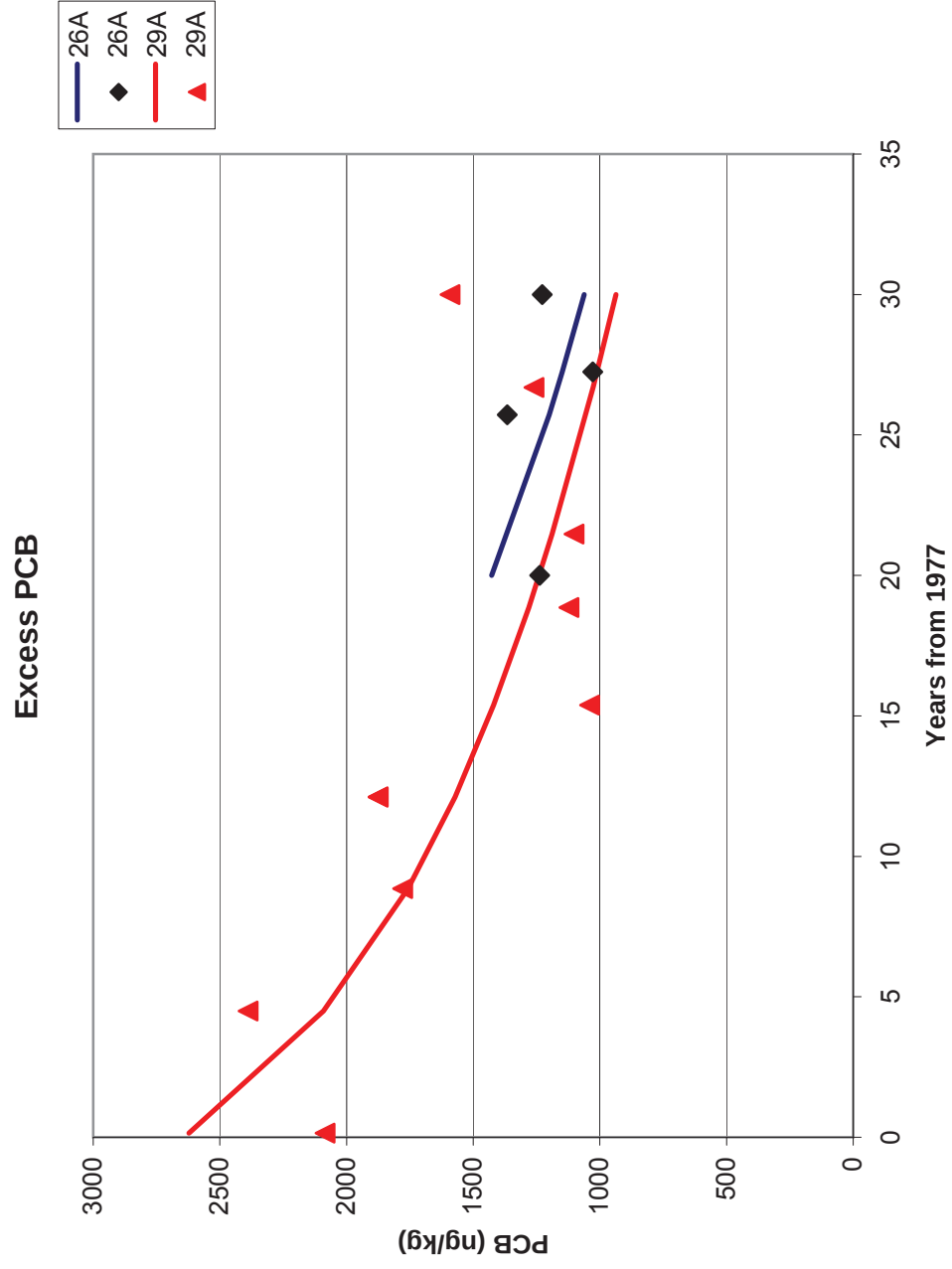


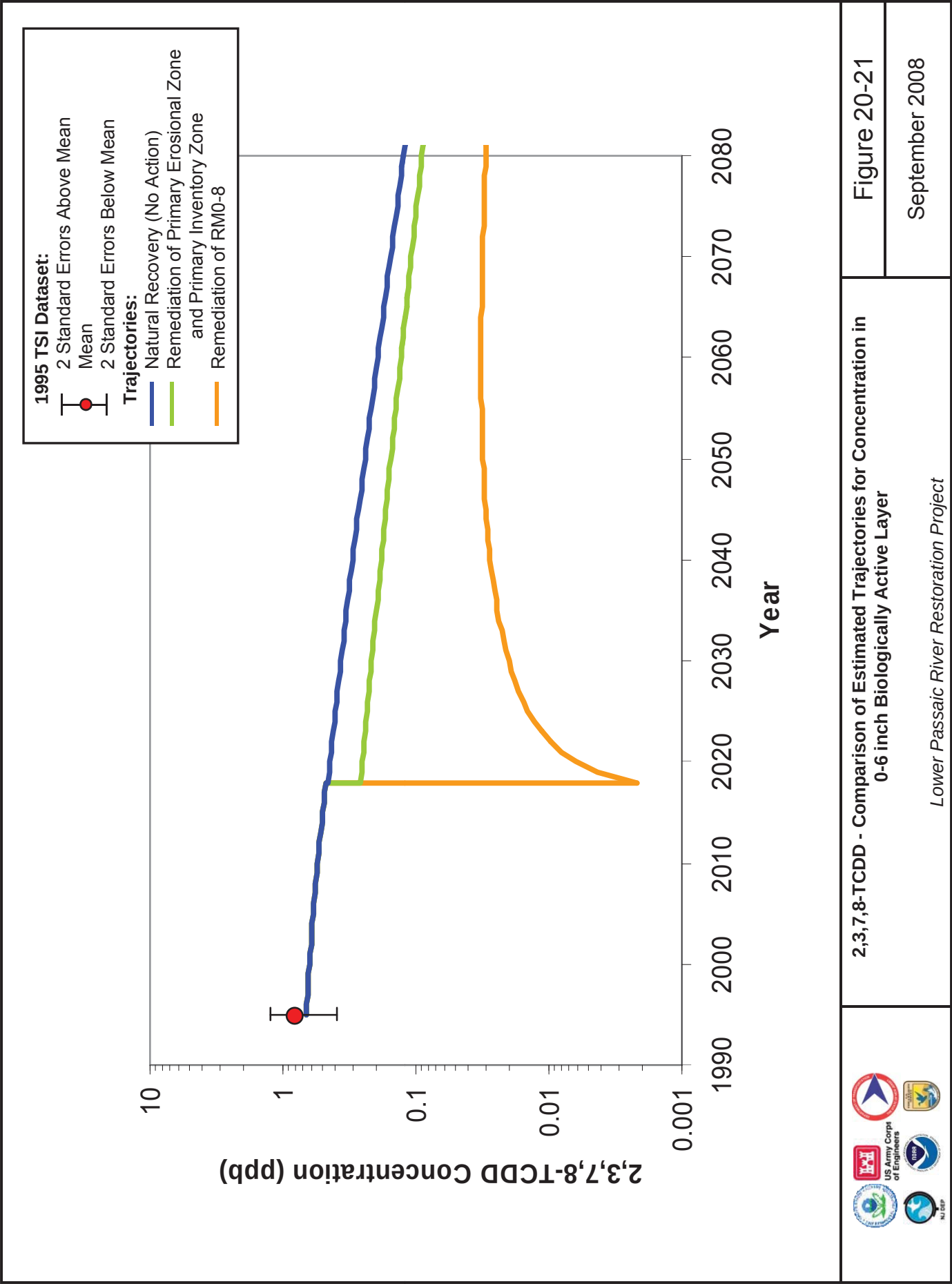
High Resolution Core Data Used for Calculating Half-Life							half life (yr)		half life (yr)	
Core ID	River Mile	Estimated Year of Deposition	Slice Concentration (ug/kg)	Upper Passaic Fractional Mass Load	Excess Concentration (ug/kg)	Natural Log of Excess Concentration	yr from 1977	c(0)	predicted	error
26A	7.8	1997	1237.039	0.0000	1237.039	7.120	20	2005.387	1427.233	36173.8
26A	7.8	2003	1366.146	0.0000	1366.146	7.220	26	2402.763	1200.679	27379.17
26A	7.8	2004	1027.705	0.0000	1027.705	6.935	27		1149.253	14774.02
26A	7.8	2007	1228.172	0.0000	1228.172	7.113	30		1062.676	27388.78
29A	11	1977	2084.722	0.0000	2084.722	7.642	0	519.3753	2621.452	288079.6
29A	11	1981	2388.979	0.0000	2388.979	7.779	4	2125.338	2090.739	88947.45
29A	11	1986	1778.705	0.0000	1778.705	7.484	9		1757	471.108
29A	11	1989	1875.003	0.0000	1875.003	7.536	12		1572.05	91780
29A	11	1989	1875.003	0.0000	1875.003	7.536	12		1572.05	91780
29A	11	1992	1040.572	0.0000	1040.572	6.948	15		1419.613	143672.7
29A	11	1996	1122.540	0.0000	1122.540	7.023	19		1280.795	25044.62
29A	11	1998	1102.412	0.0000	1102.412	7.005	21		1188.459	7404.161
29A	11	2004	1260.822	0.0000	1260.822	7.140	27		1026.598	54860.74
29A	11	2007	1591.094	0.0000	1591.094	7.372	30		936.8569	428026.1
32A	12.6	1983	1480.33	0.0000	1480.332	7.300	6	2089.534	1565.015	7171.168
32A	12.6	1993	977.711	0.0000	977.711	6.885	16	1186.678	834.808	20421.28
32A	12.6	2000	772.398	0.0000	772.398	6.649	23		644.7553	16292.67
32A	12.6	2007	554.82	0.0000	554.820	6.319	30		527.5707	742.5261
7A	1.4	1979	4801.597	0.0000	4801.597	8.477	2	2822.355	3956.539	714123.2
7A	1.4	1991	1354.677	0.0000	1354.677	7.211	14	2148.417	1673.776	101824.4
7A	1.4	1995	1064.606	0.0000	1064.606	6.970	18		1397.551	110851.9
7A	1.4	1998	836.385	0.0000	836.385	6.729	21		1262.232	181345.5
7A	1.4	2001	861.8293	0.0000	861.829	6.759	24		1149.909	82989.77
7A	1.4	2004	719.5541	0.0000	719.554	6.579	27		1053.253	111355.1
7A	1.4	2007	822.841	0.0000	822.841	6.713	30		952.7477	16875.74
9A	2.2	1978	6649.364	0.0000	6649.364	8.802	1	5244.281	6365.105	80803.28
9A	2.2	1981	4120.727	0.0000	4120.727	8.324	4	2197.893	4380.33	67393.76
9A	2.2	1985	2662.661	0.0000	2662.661	7.887	8		2914.316	63330.18
9A	2.2	1988	2259.219	0.0000	2259.219	7.723	11		2140.615	14066.96
9A	2.2	1992	1908.458	0.0000	1908.458	7.554	15		1701.059	43014.34
9A	2.2	1996	1581.644	0.0000	1581.644	7.366	19		1426.206	24160.67
9A	2.2	1999	1311.672	0.0000	1311.672	7.179	22		1280.197	990.6785
9A	2.2	2001	1096.409	0.0000	1096.409	7.000	24		1202.064	11163.08
9A	2.2	2002	1052.001	0.0000	1052.001	6.958	25		1132.794	6527.605
9A	2.2	2004	1129.499	0.0000	1129.499	7.030	27		1070.423	3489.982
9A	2.2	2007	1304.208	0.0000	1304.208	7.173	30		980.5543	104751.7
							sum			3109468

Excess PCB









2,3,7,8-TCDD - Comparison of Estimated Trajectories for Concentration in 0-6 inch Biologically Active Layer

Lower Passaic River Restoration Project

Figure 20-21

September 2008

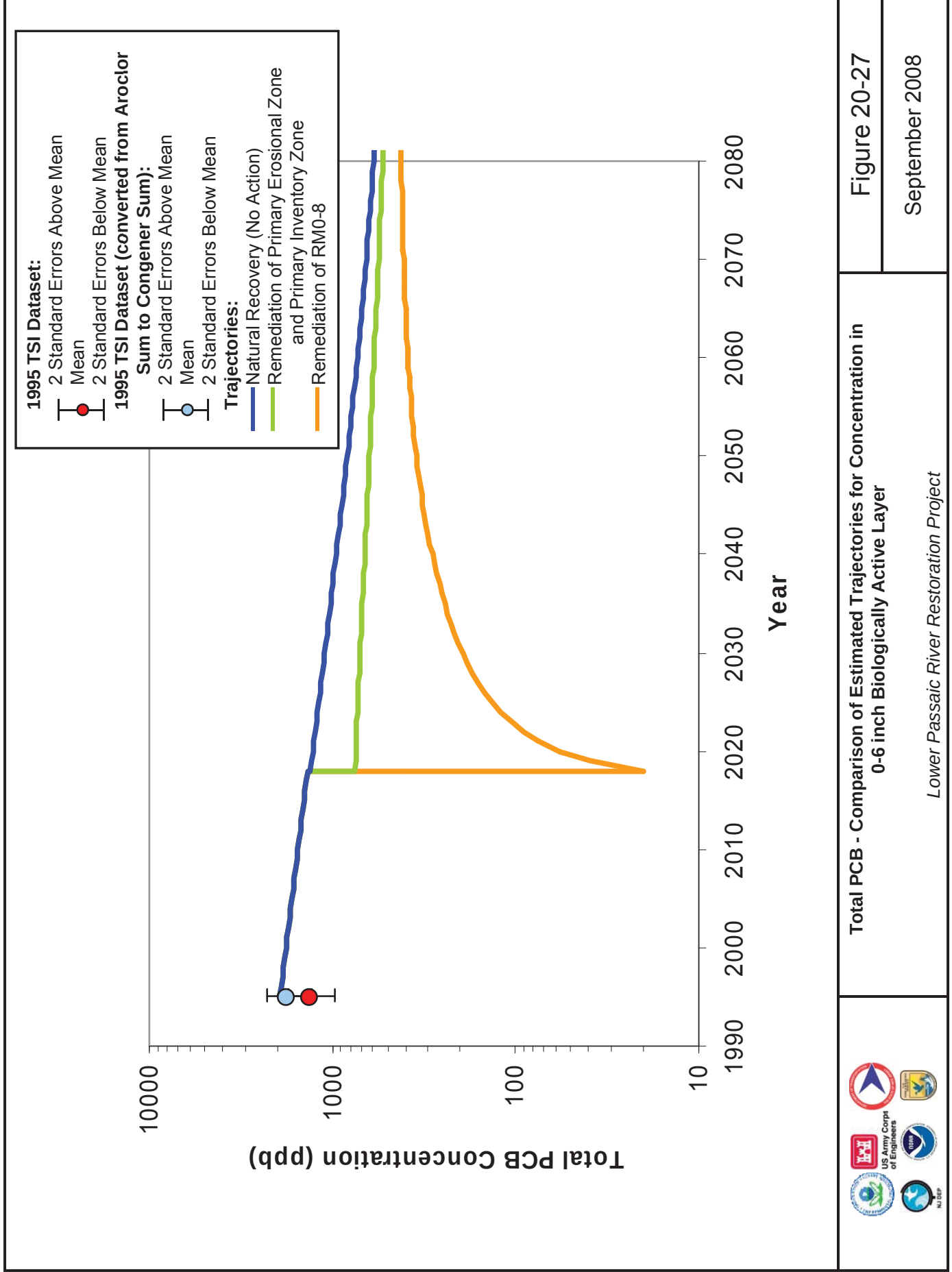
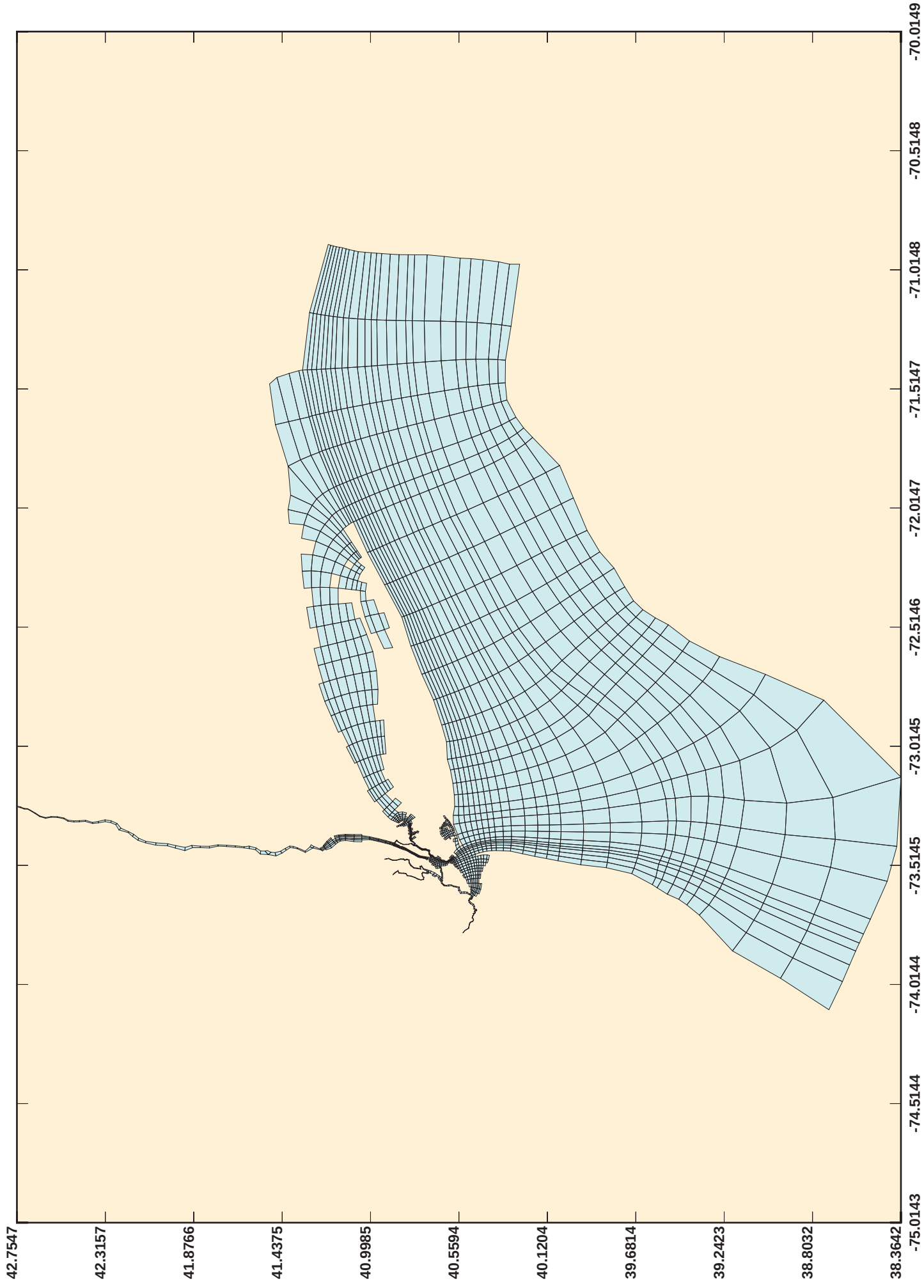
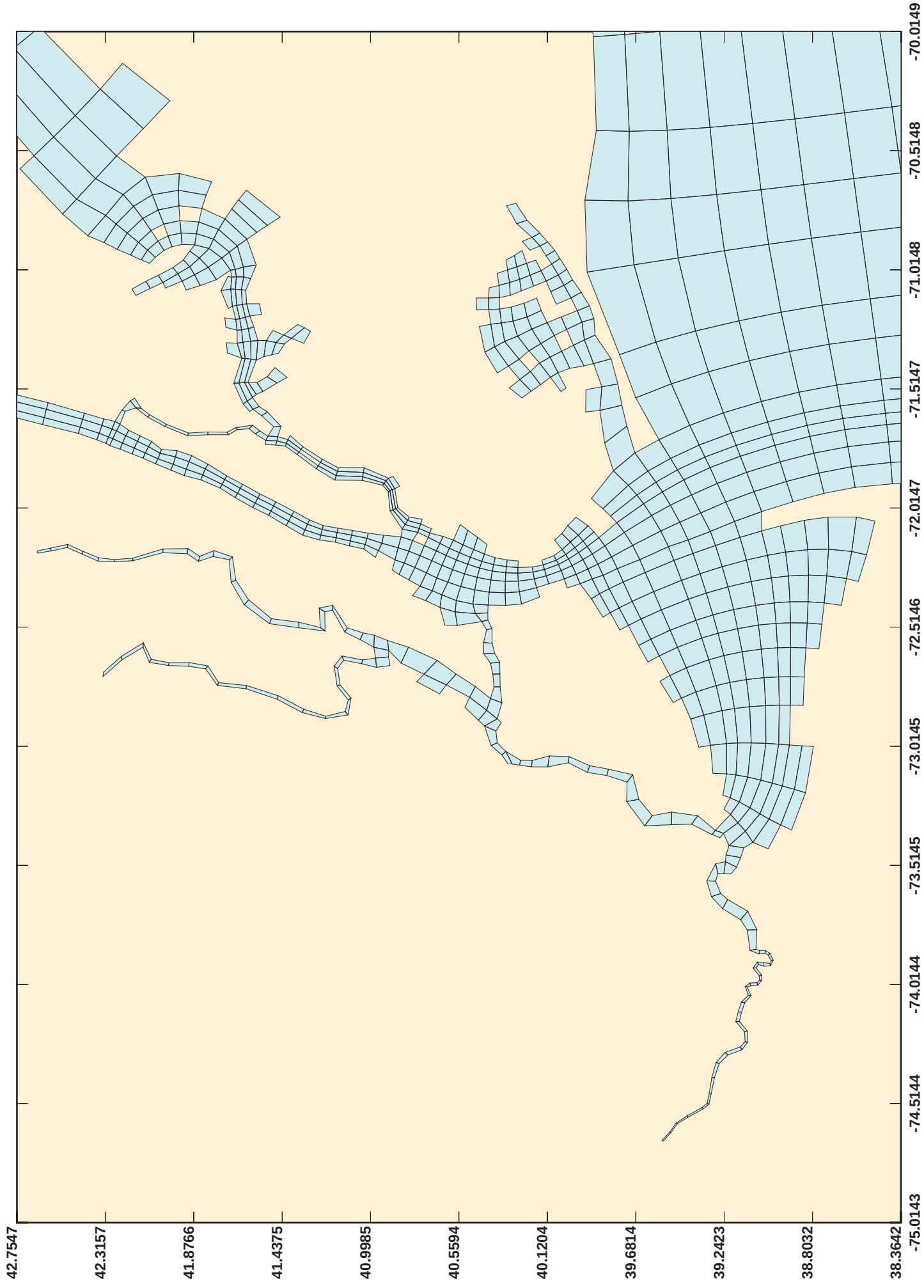


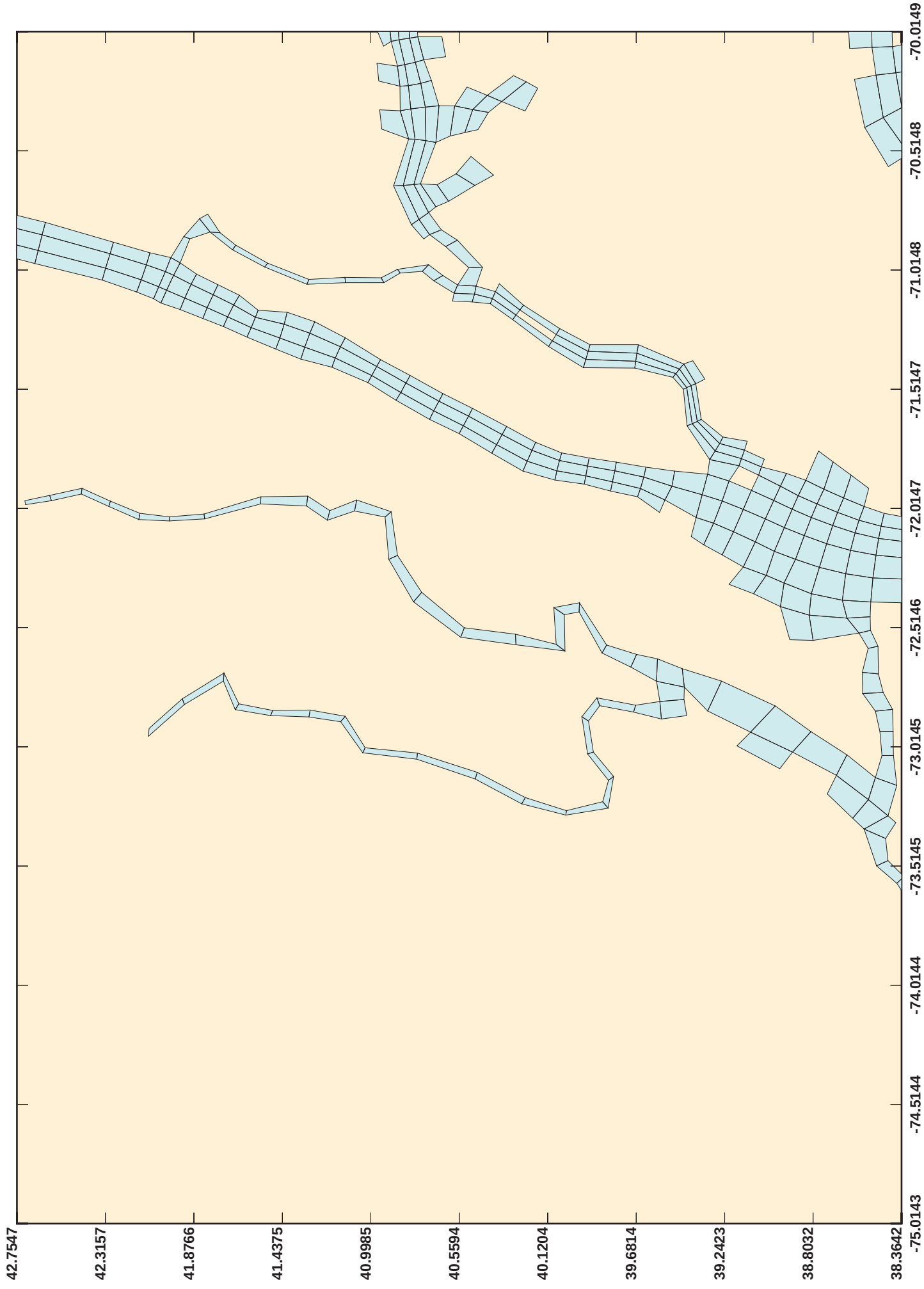
Figure 20-27
September 2008

Total PCB - Comparison of Estimated Trajectories for Concentration in
0-6 inch Biologically Active Layer
Lower Passaic River Restoration Project

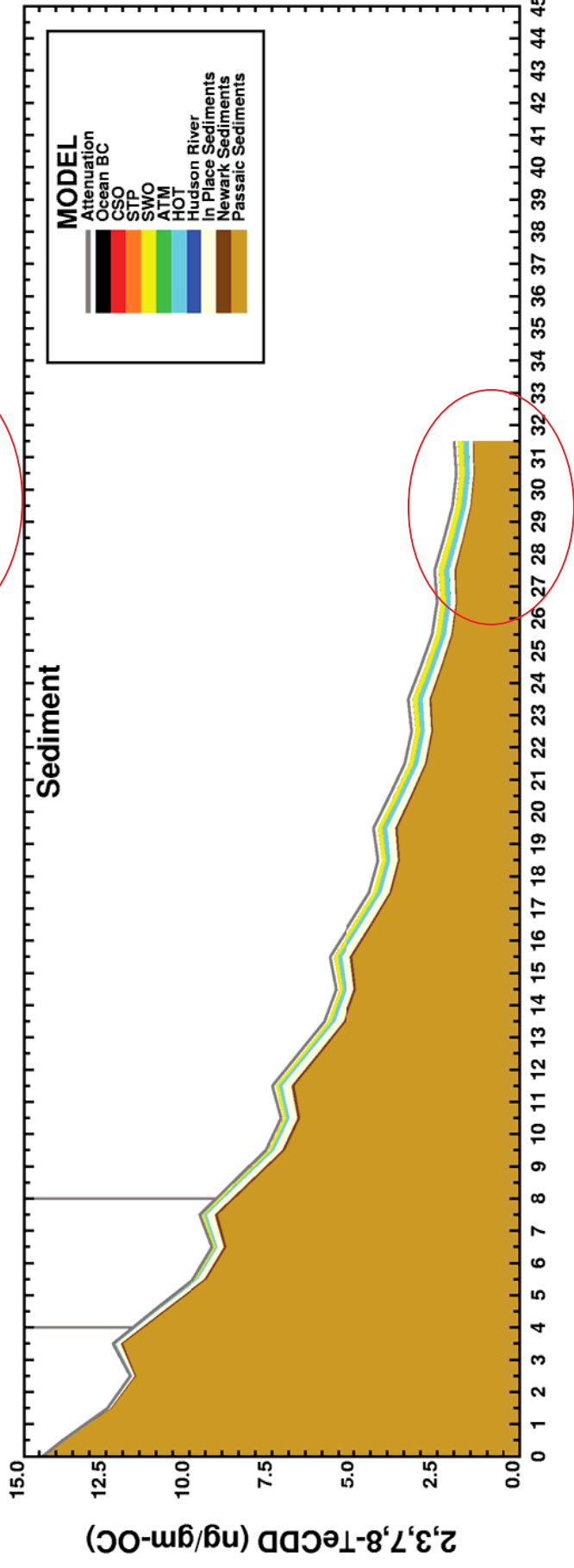
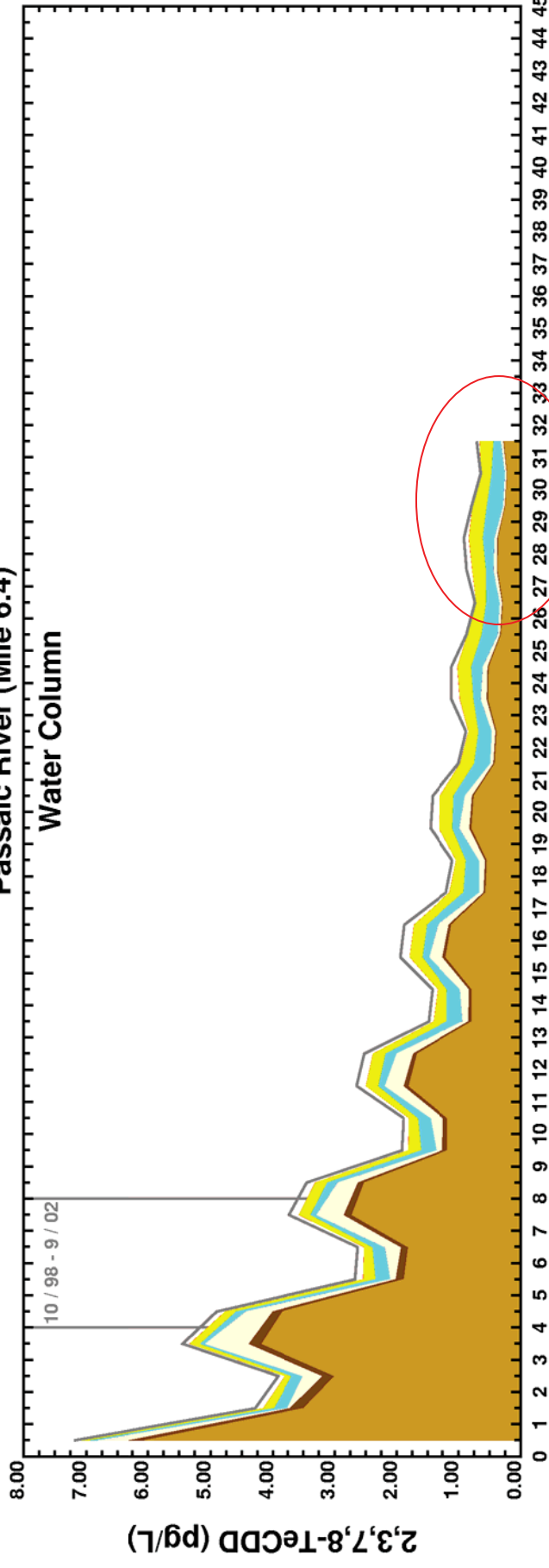


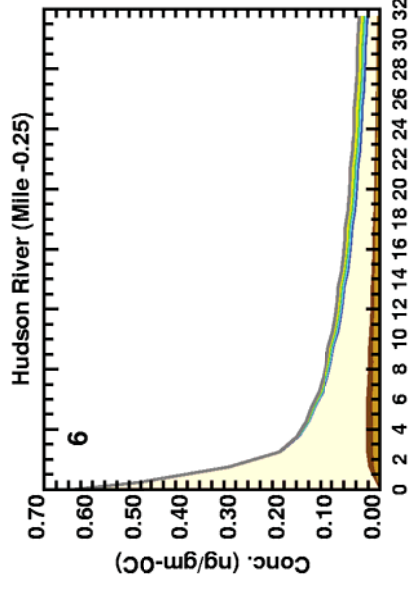
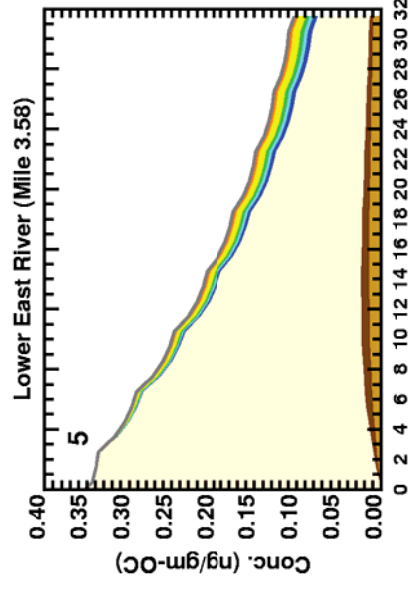
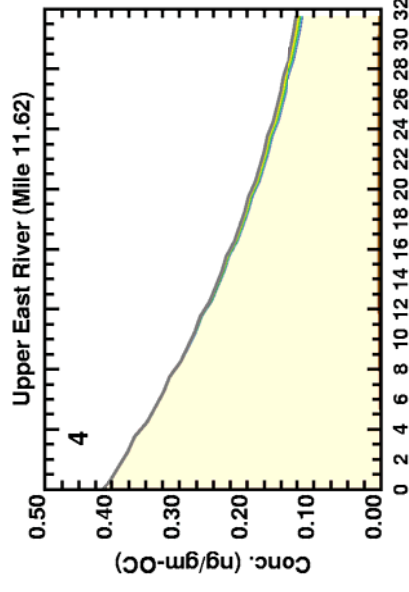
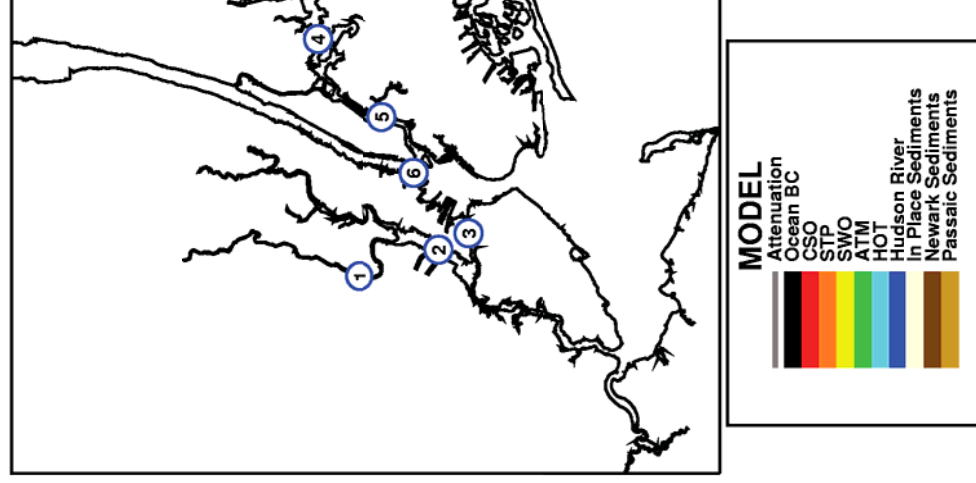
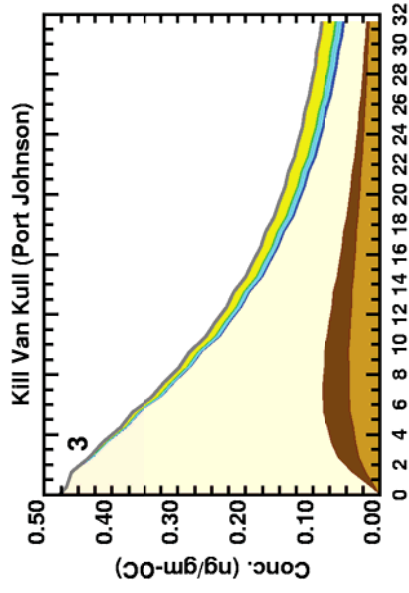
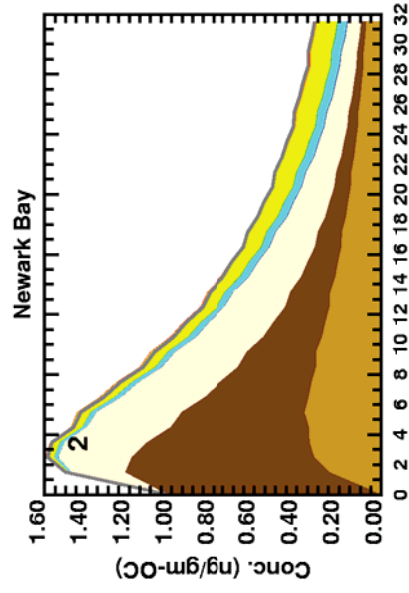
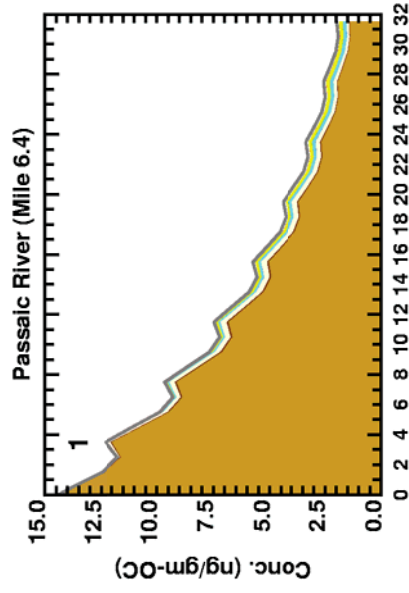




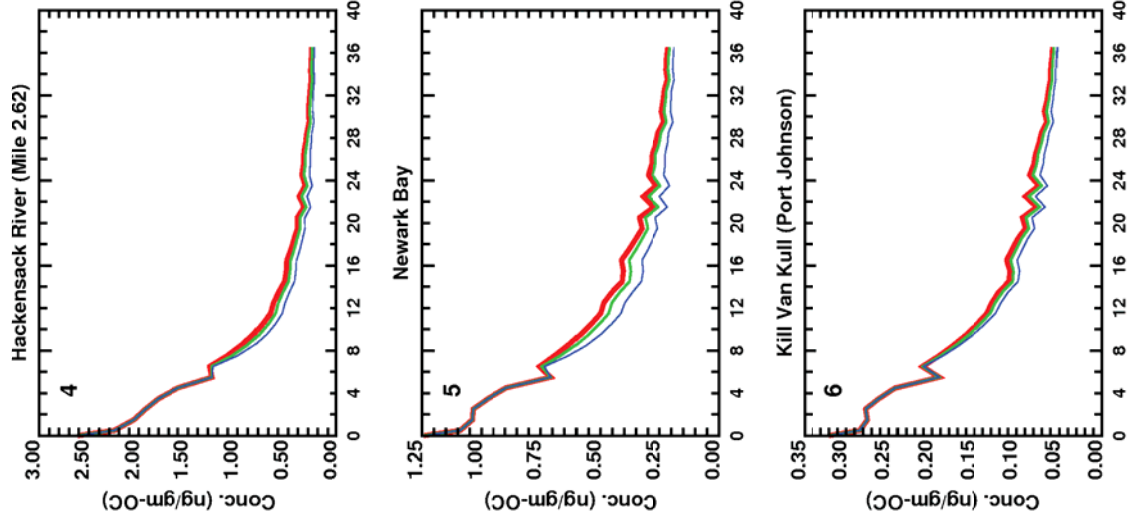
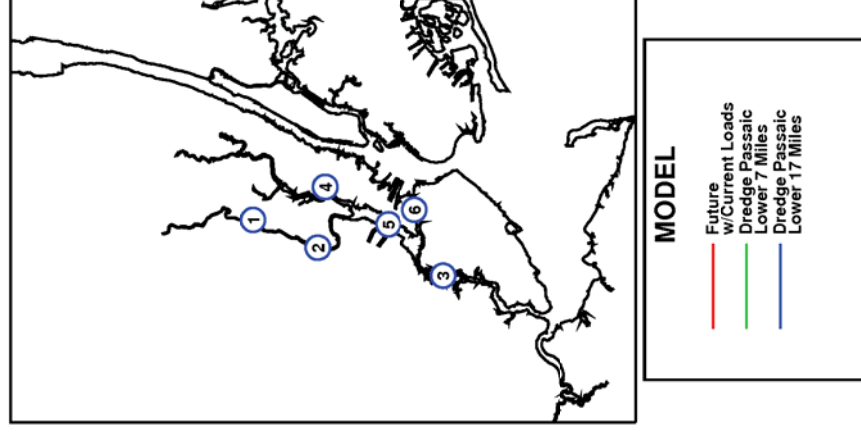
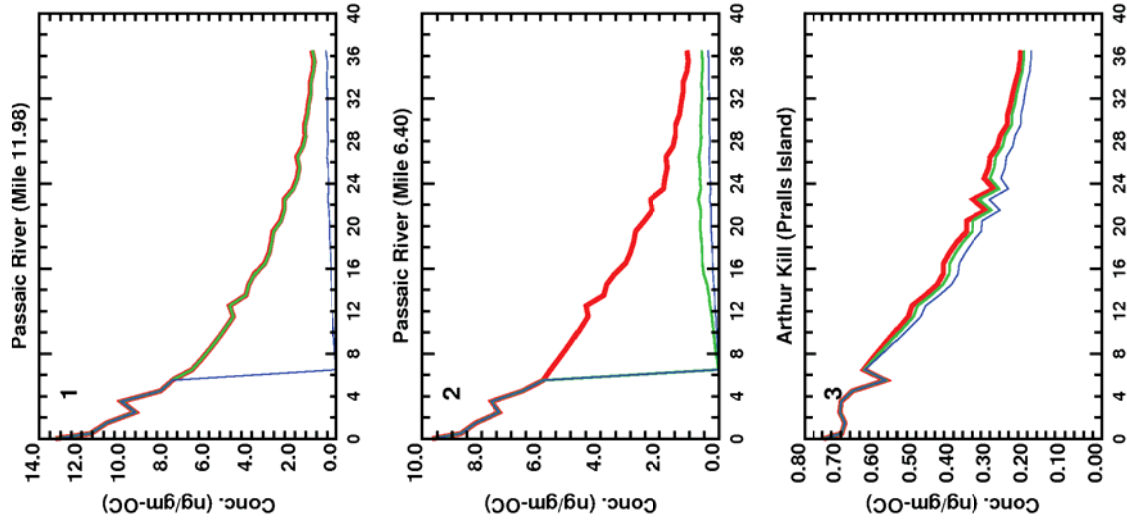


Passaic River (Mile 6.4)



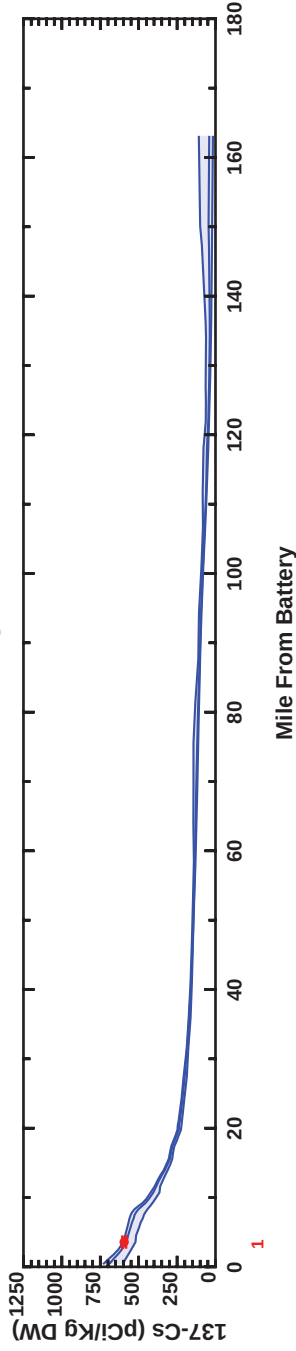


Component Run Sediment Time Series for 2,3,7,8-TeCDD (ng/gm-OC)

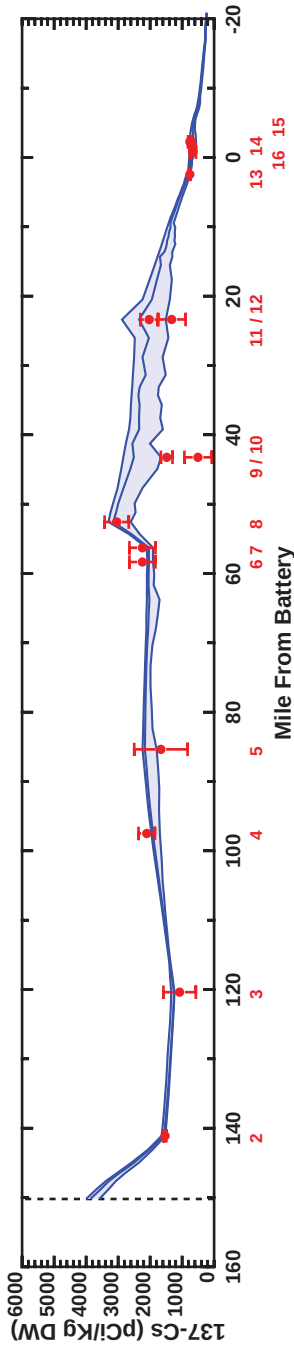


Projection Run, Sediment, Time Series for 2,3,7,8-TeCDD (ng/gm-OC)

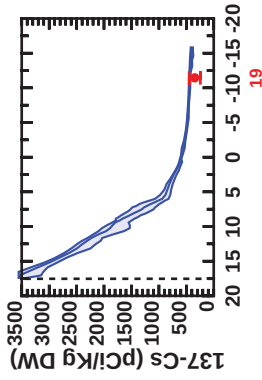
East River and Long Island Sound



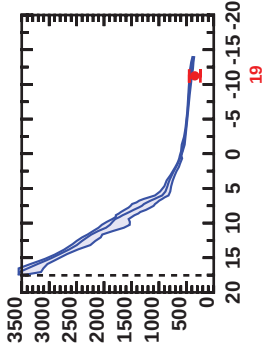
Hudson River, Upper and Lower Bay, Ocean



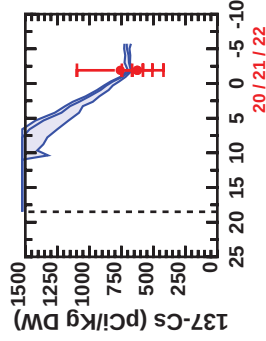
Raritan River and North Shore of Raritan Bay



Raritan River and South Shore of Raritan Bay



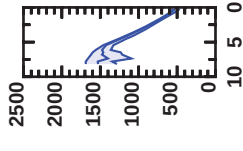
Hackensack River and Newark Bay



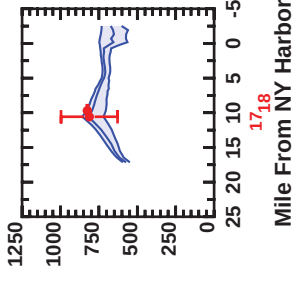
Mile From Mouth Raritan River

HRCORES	BOPP / CHAKY / LAMONT-DOHERTY
1) HR-005	7) MP59.551 - CN2182
2) HR-011	12) HAST - R1472
3) HR-014	16) MP-1.7 - CN1472
4) HR-013	17) KILL14 - CN1730
5) HR-010	18) KILL21 - R1091
6) HR-009	19) RB17 - CN1533
8) HR-008	20) NB13 - CN1964
9) HR-007	21) NB20 - CN1998
10) HR-006	22) NB13B - CN2251
11) HR-001	23) JB13 - CN2057
13) HR-004	
14) HR-002	
15) HR-003	

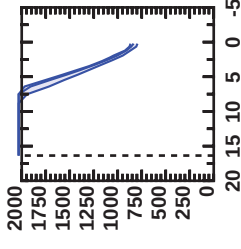
Harlem River



Arthur Kill and Kill Van Kull



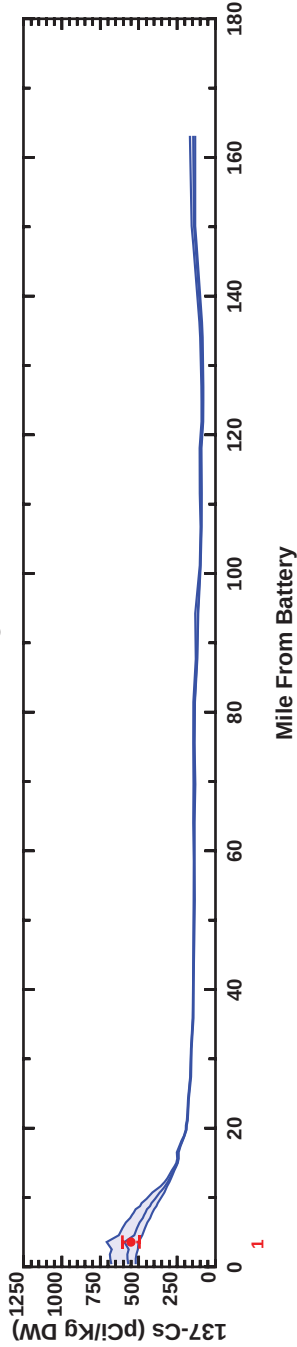
Passaic River



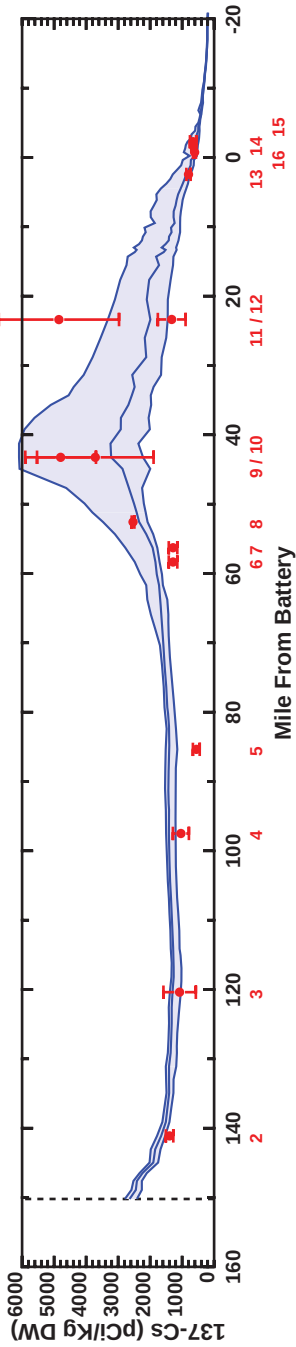
MODEL

MODEL	Annual Maximum	Annual Average	Annual Minimum

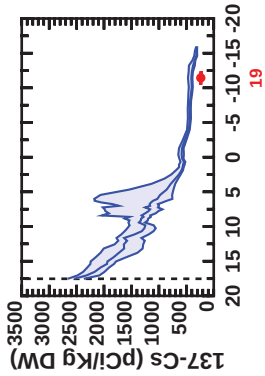
East River and Long Island Sound



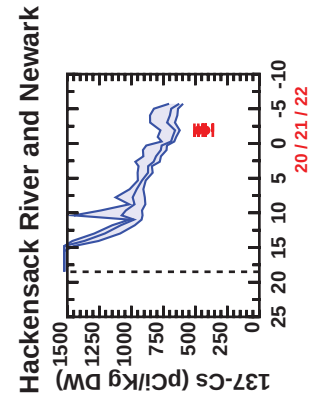
Hudson River, Upper and Lower Bay, Ocean



Raritan River and North Shore of Raritan Bay

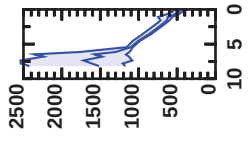


Hackensack River and Newark Bay

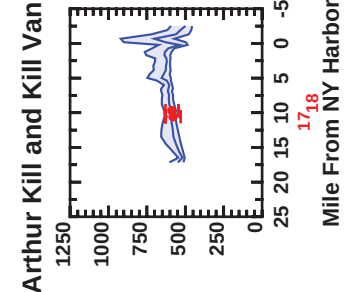


Mile From Mouth Hackensack River

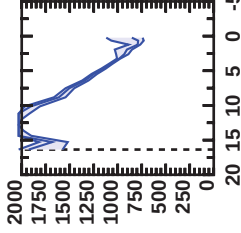
Harlem River



Arthur Kill and Kill Van Kull



Passaic River



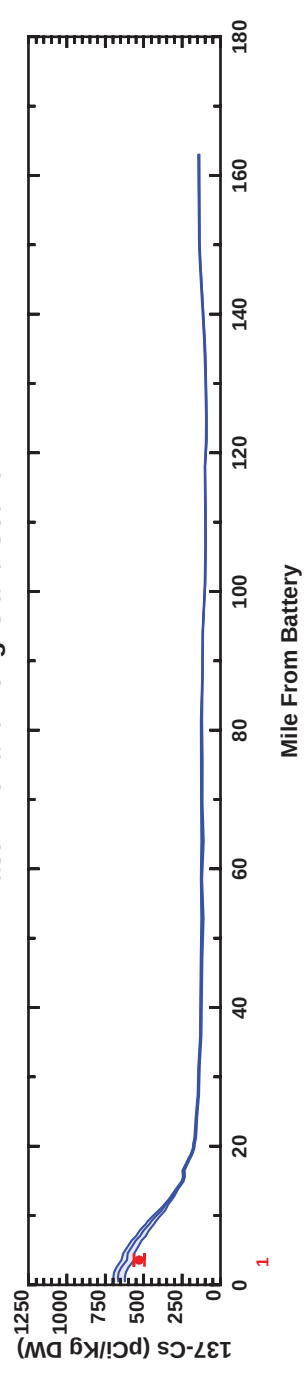
Mile From Mouth Passaic River

DATA 137-Cs Cores	
HRCORES	BOPP / CHAKY / LAMONT-DOHERTY
1) HR-005	7) MP59.551 - CN2182
2) HR-011	12) HAST - R1472
3) HR-014	16) MP-1.7 - CN1472
4) HR-013	17) KILL14 - CN1730
5) HR-010	18) KILL21 - R1091
6) HR-009	19) RB17 - CN1533
8) HR-008	20) NB13 - CN1964
9) HR-007	21) NB20 - CN1998
10) HR-006	22) NB13B - CN2251
11) HR-001	23) JB13 - CN2057
13) HR-004	
14) HR-002	
15) HR-003	

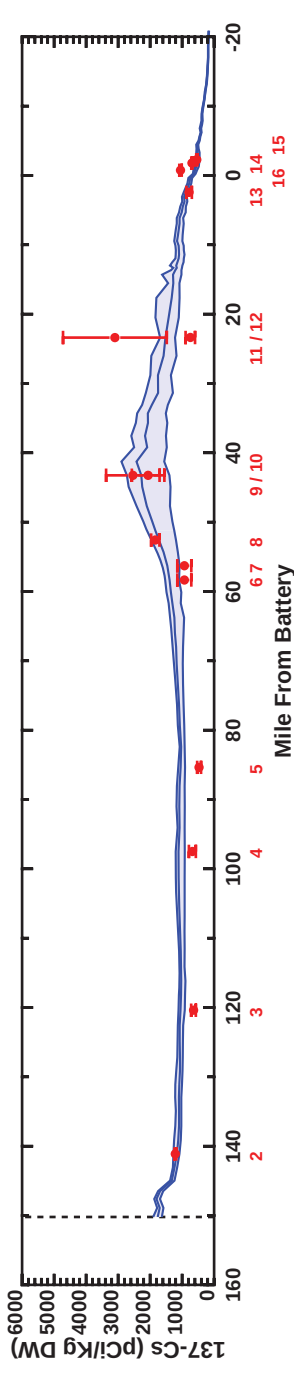
MODEL

Annual Maximum
Annual Average
Annual Minimum

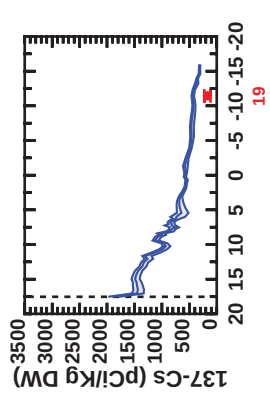
East River and Long Island Sound



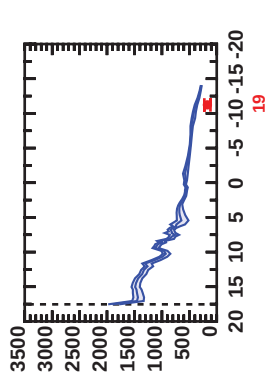
Hudson River, Upper and Lower Bay, Ocean



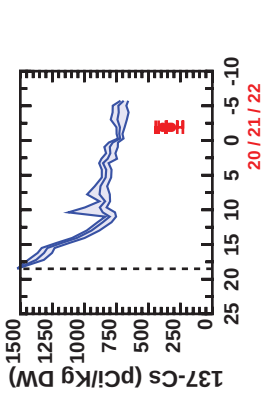
Raritan River and North Shore of Raritan Bay



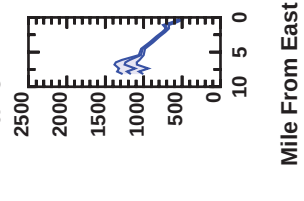
Raritan River and South Shore of Raritan Bay



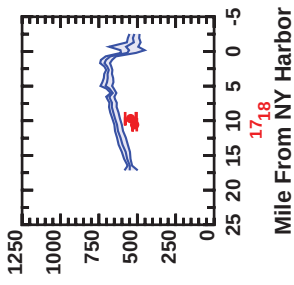
Hackensack River and Newark Bay



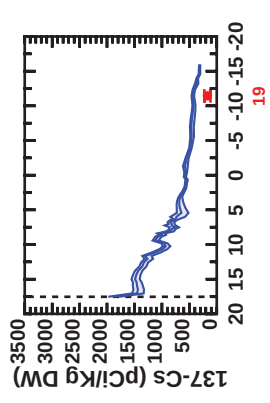
Harlem River



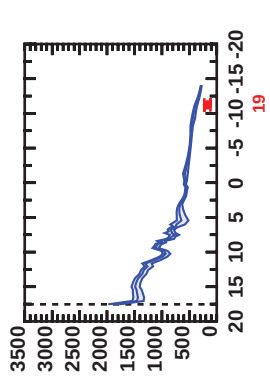
Arthur Kill and Kill Van Kull



Raritan River and North Shore of Raritan Bay



Raritan River and South Shore of Raritan Bay

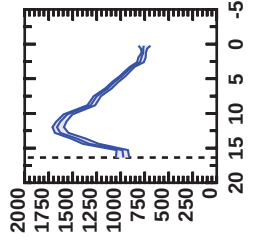


Mile from Mouth Raritan River

Mile From Mouth Raritan River

Mile From Mouth Passaic River

Passaic River



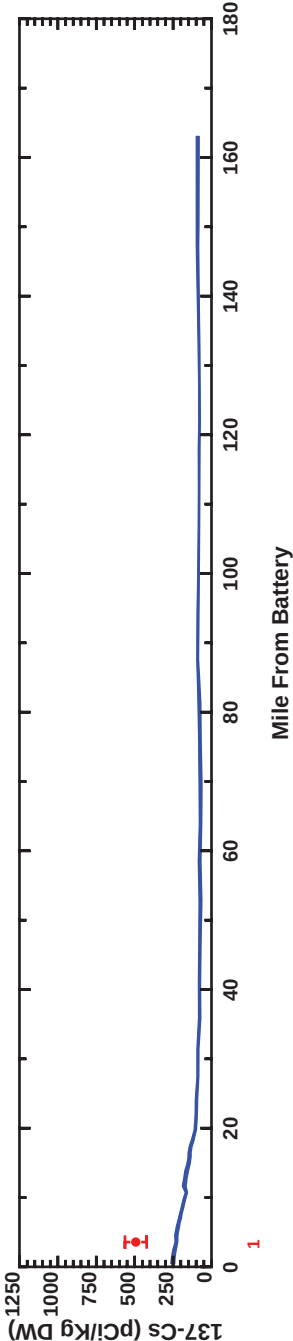
DATA 137-Cs Cores

HRCORES	BOPP / CHAKY / LAMONT-DOHERTY
1) HR-005	7) MP59.551 - CN2182
2) HR-011	12) HAST - R1472
3) HR-014	16) MP-1.7 - CN1472
4) HR-013	17) KILL14 - CN1730
5) HR-010	18) KILL21 - R1091
6) HR-009	19) RB17 - CN1533
8) HR-008	20) NB13 - CN1964
9) HR-007	21) NB20 - CN1998
10) HR-006	22) NB13B - CN2251
11) HR-001	23) JB13 - CN2057
13) HR-004	
14) HR-002	
15) HR-003	

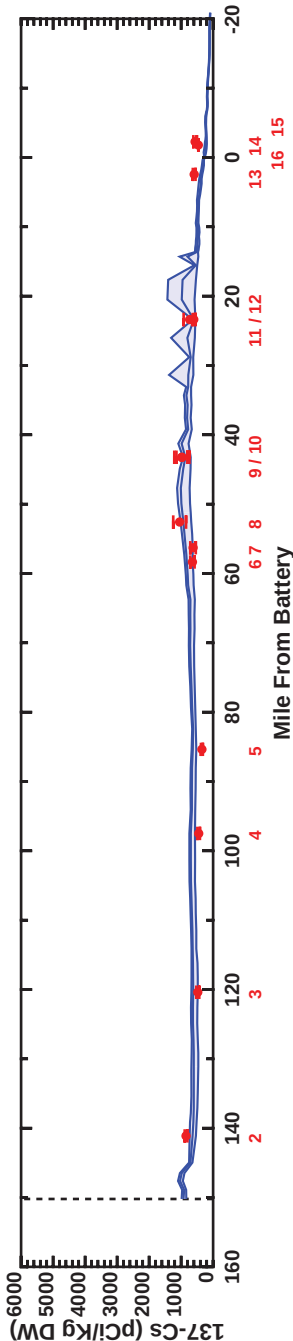
MODEL

Annual Maximum
Annual Average
Annual Minimum

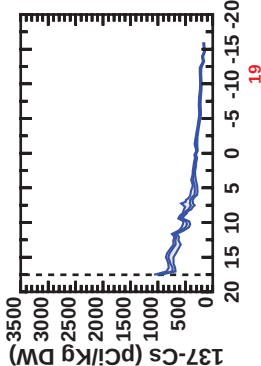
East River and Long Island Sound



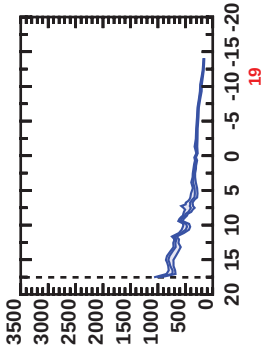
Hudson River, Upper and Lower Bay, Ocean



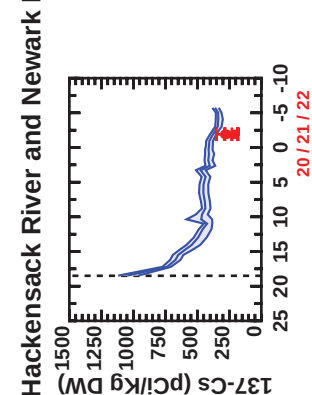
Raritan River and North Shore of Raritan Bay



Raritan River and South Shore of Raritan Bay



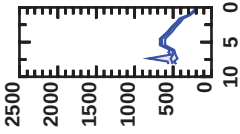
Hackensack River and Newark Bay



Mile From Mouth Raritan River

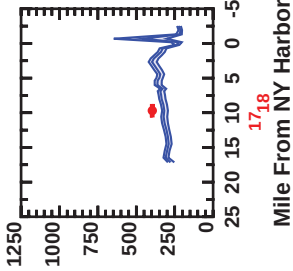
DATA 137-Cs Cores	
HRCORES	BOPP / CHAKY / LAMONT-DOHERTY
1) HR-005	7) MP59.551 - CN2182
2) HR-011	12) HAST - R1472
3) HR-014	16) MP-1.7 - CN1472
4) HR-013	17) KILL14 - CN1730
5) HR-010	18) KILL21 - R1091
6) HR-009	19) RB17 - CN1533
8) HR-008	20) NB13 - CN1964
9) HR-007	21) NB20 - CN1998
10) HR-006	22) NB13B - CN2251
11) HR-001	23) JB13 - CN2057
13) HR-004	
14) HR-002	
15) HR-003	

Harlem River



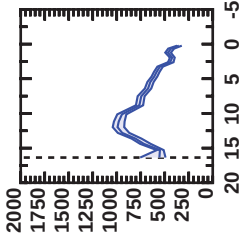
Mile From East River

Arthur Kill and Kill Van Kull



Mile From Mouth Raritan River

Passaic River

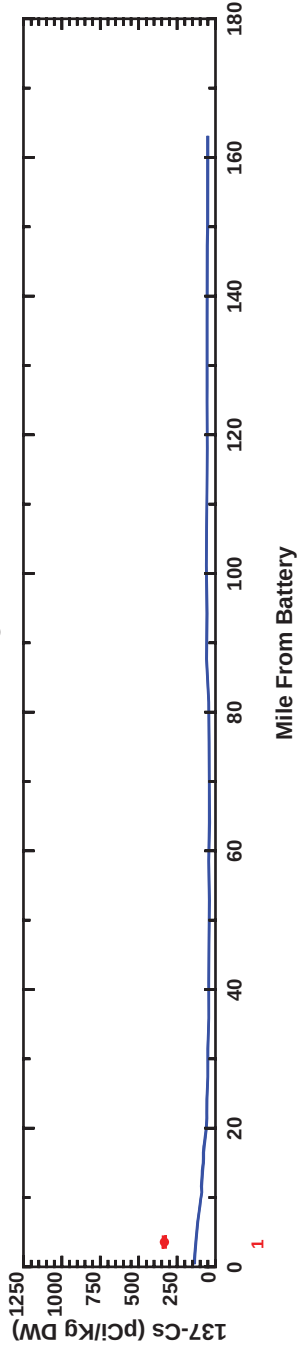


Mile From Mouth Passaic River

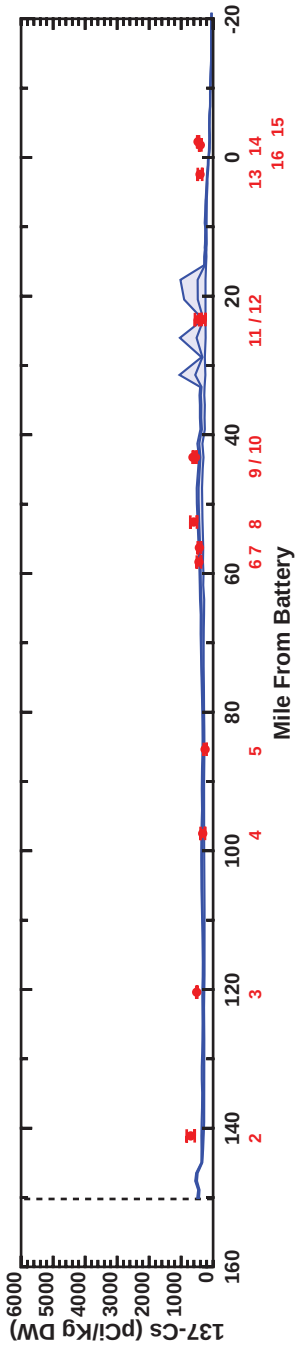
MODEL

MODEL
Annual Maximum
Annual Average
Annual Minimum

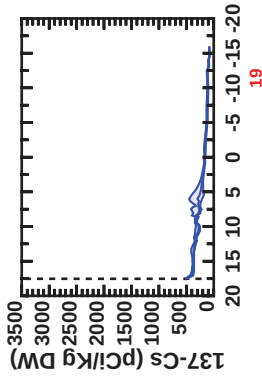
East River and Long Island Sound



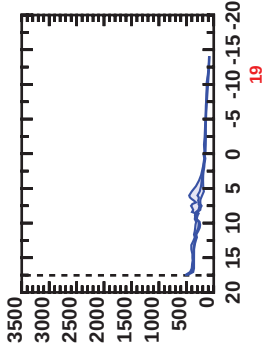
Hudson River, Upper and Lower Bay, Ocean



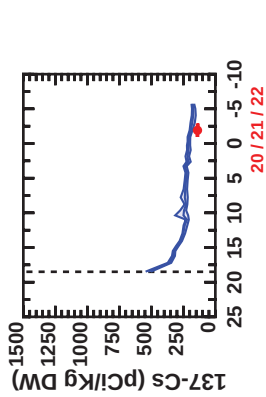
Raritan River and North Shore of Raritan Bay



Raritan River and South Shore of Raritan Bay



Hackensack River and Newark Bay



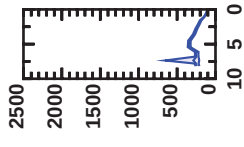
Mile from Mouth Raritan River

Mile From Mouth Raritan River

DATA 137-Cs Cores

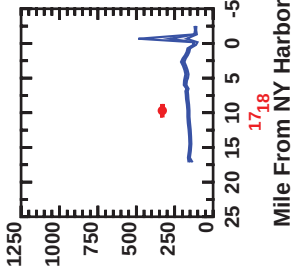
HRCORES	BOPP / CHAKY / LAMONT-DOHERTY
1) HR-005	7) MP59.55i - CN2182
2) HR-011	12) HAST - R1472
3) HR-014	16) MP-1.7 - CN1472
4) HR-013	17) KILL14 - CN1730
5) HR-010	18) KILL21 - R1091
6) HR-009	19) RB17 - CN1533
8) HR-008	20) NB13 - CN1964
9) HR-007	21) NB20 - CN1998
10) HR-006	22) NB13B - CN2251
11) HR-001	23) JB13 - CN2057
13) HR-004	
14) HR-002	
15) HR-003	

Harlem River

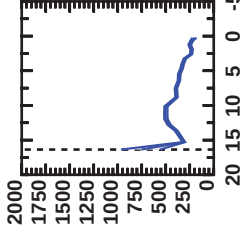


Mile From East River

Arthur Kill and Kill Van Kull



Passaic River



Mile From Mouth Passaic River

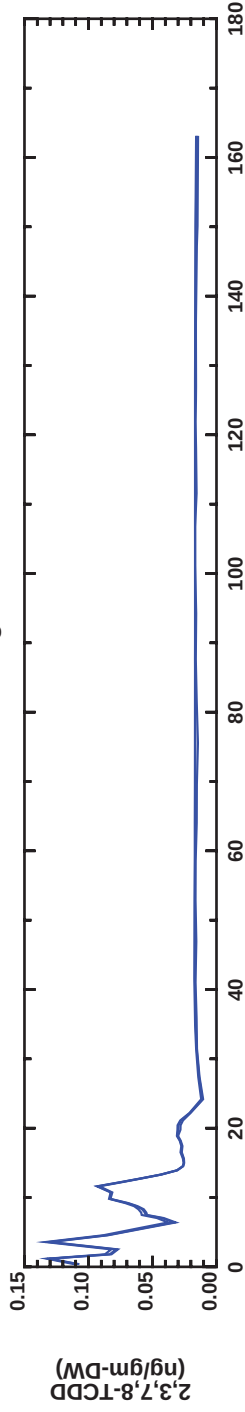
MODEL

Annual Maximum

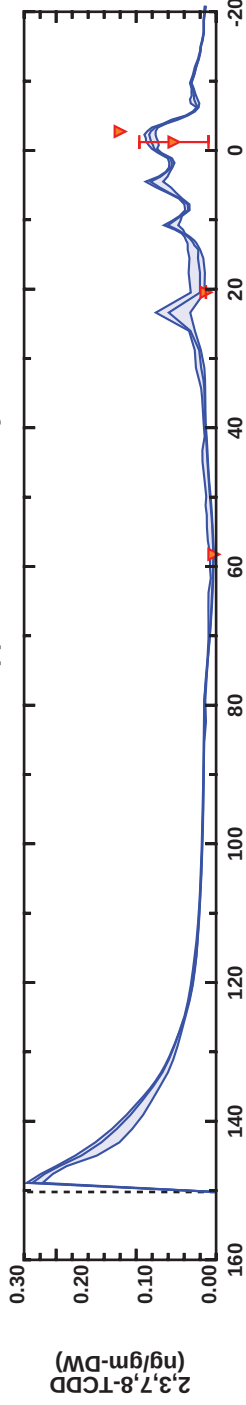
Annual Average

Annual Minimum

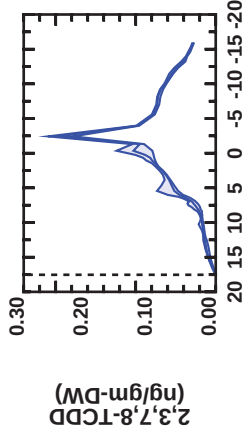
East River and Long Island Sound



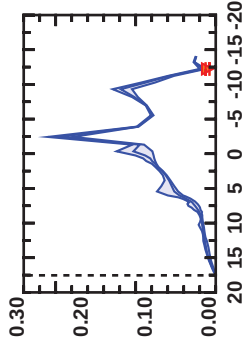
Hudson River, Upper and Lower Bay, Ocean



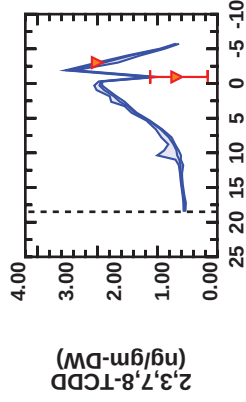
Raritan River and North Shore of Raritan Bay



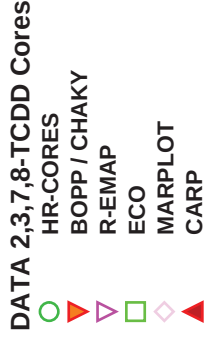
Raritan River and South Shore of Raritan Bay



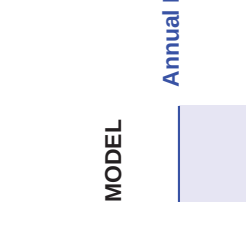
Hackensack River and Newark Bay



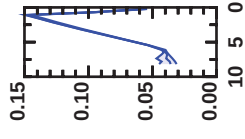
Mile From Mouth Raritan River



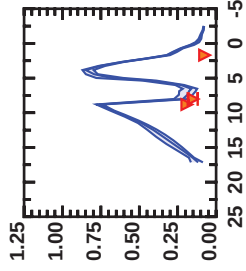
Mile From Mouth Passaic River



Harlem River

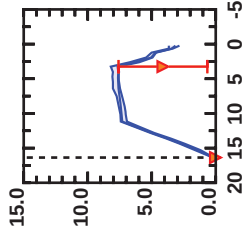


Arthur Kill and Kill Van Kull

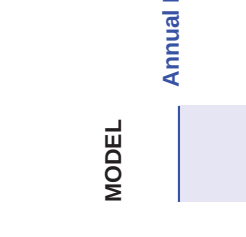


Mile From NY Harbor

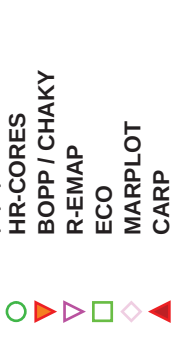
Passaic River



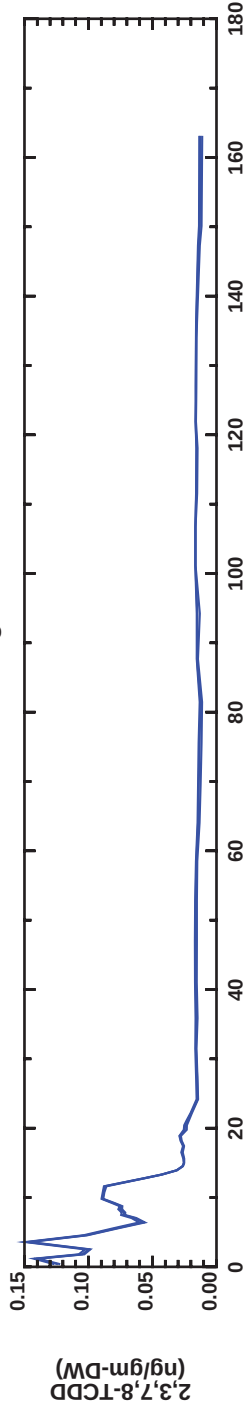
Mile From Mouth Passaic River



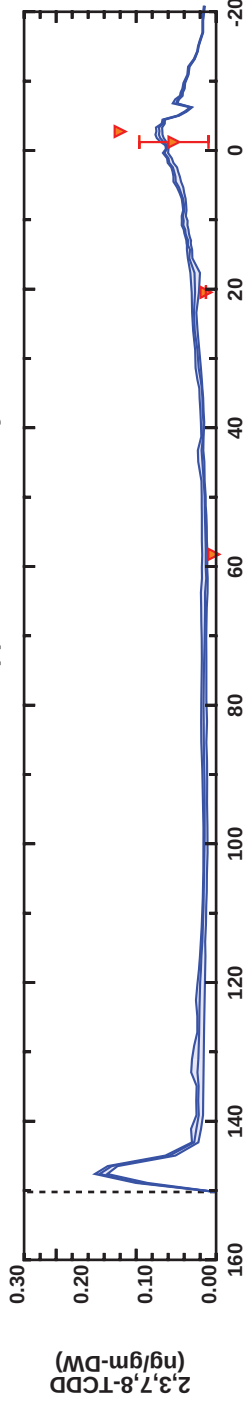
MODEL



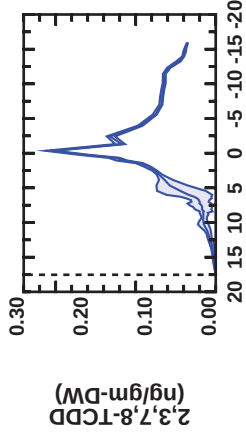
East River and Long Island Sound



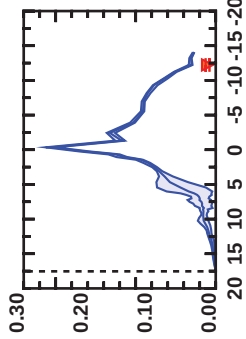
Hudson River, Upper and Lower Bay, Ocean



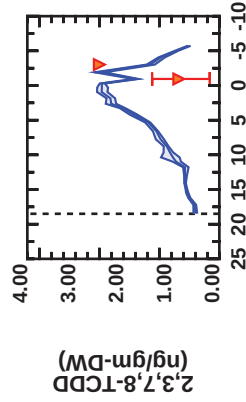
Raritan River and North Shore of Raritan Bay



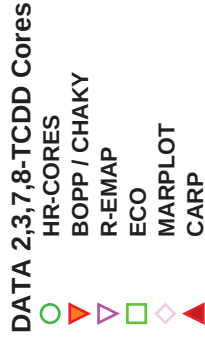
Raritan River and South Shore of Raritan Bay



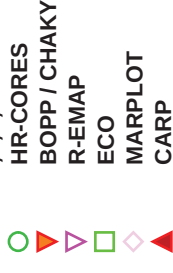
Hackensack River and Newark Bay



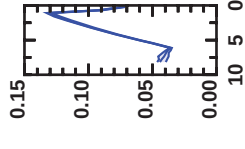
Mile From Mouth Raritan River



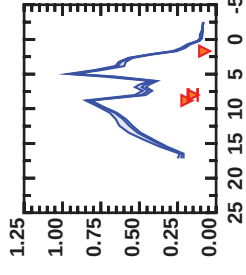
DATA 2,3,7,8-TCDD Cores



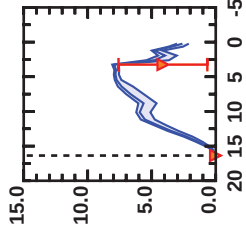
Harlem River



Arthur Kill and Kill Van Kull



Passaic River



MODEL

Annual Maximum

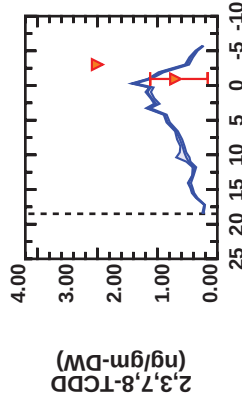
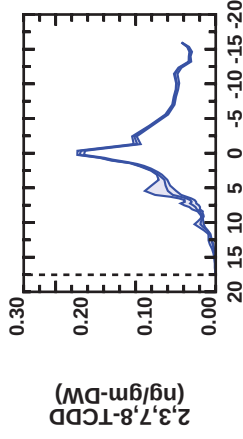
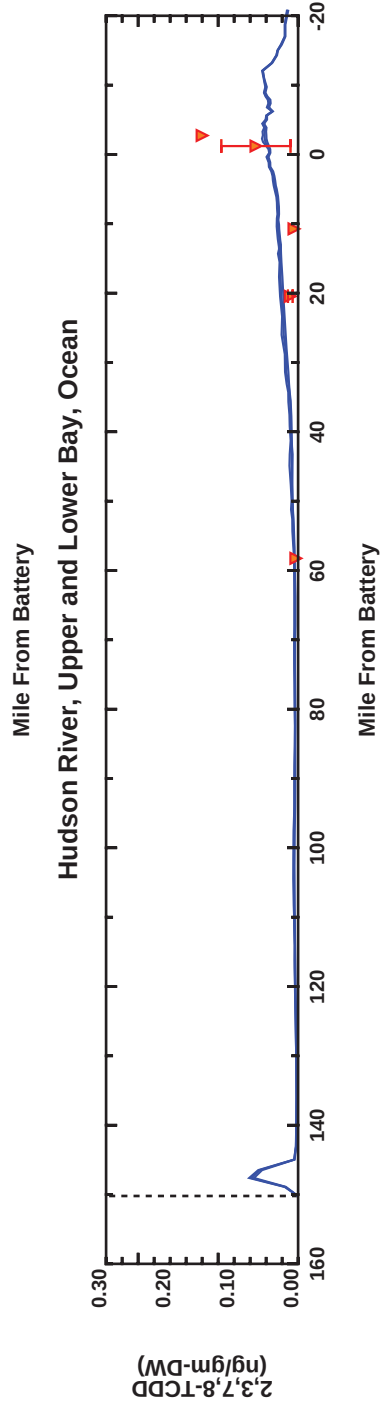
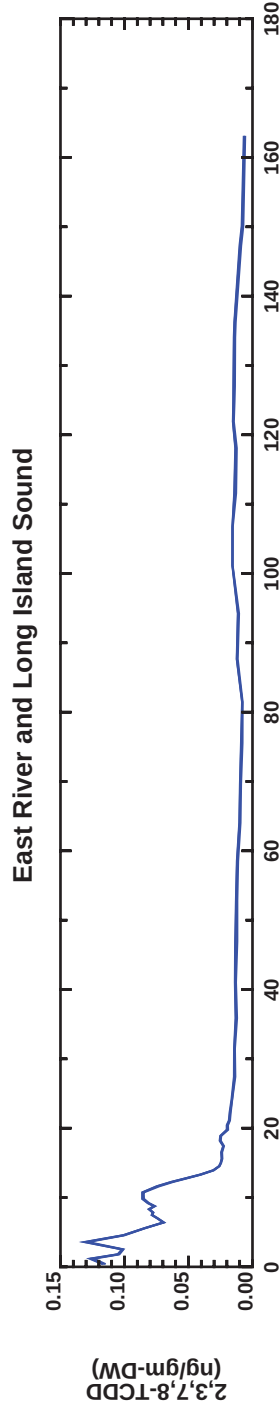
Annual Average

Annual Minimum

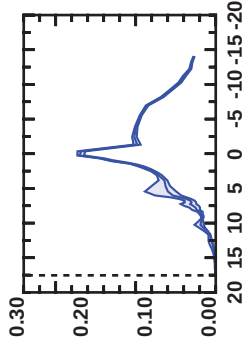
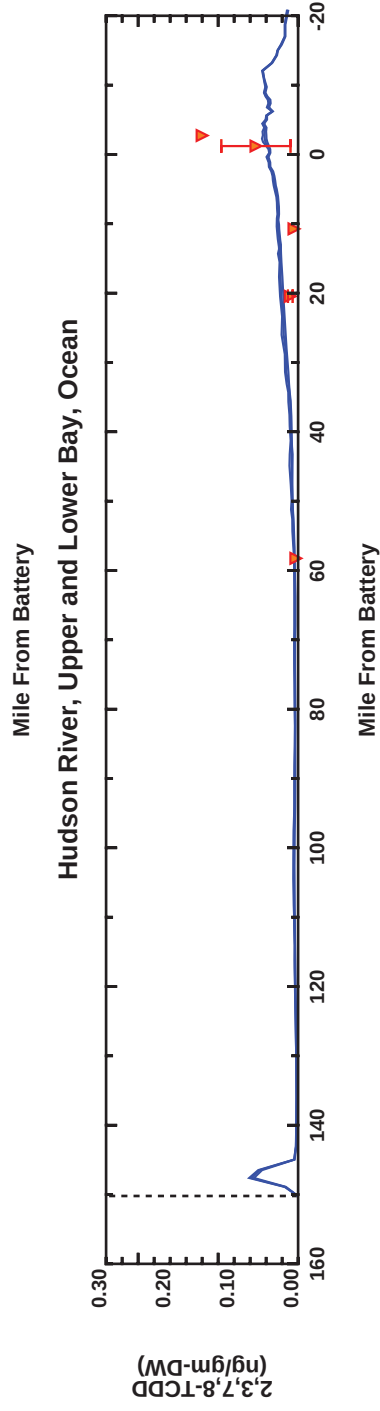
Annual Maximum

Annual Average

Annual Minimum

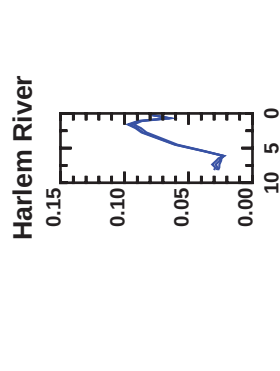
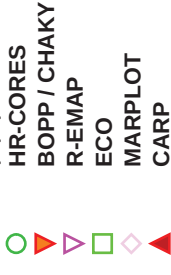


Mile From Mouth Hackensack River

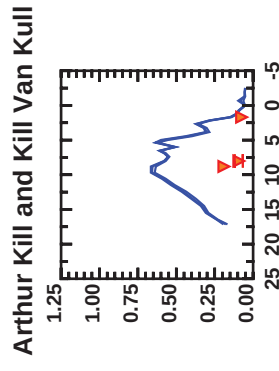


Mile From Mouth Raritan River

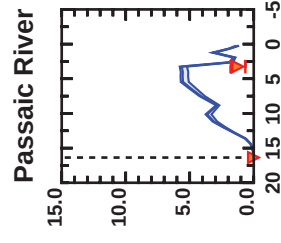
DATA 2,3,7,8-TCDD Cores



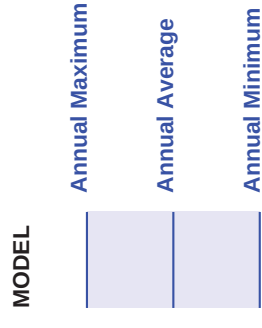
Mile From East River

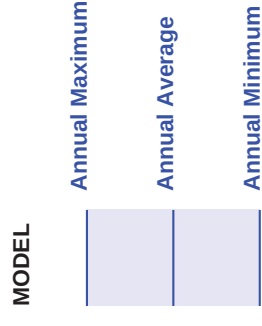
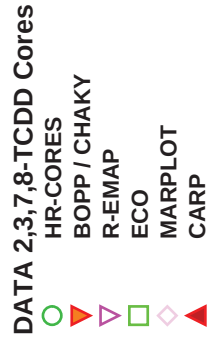
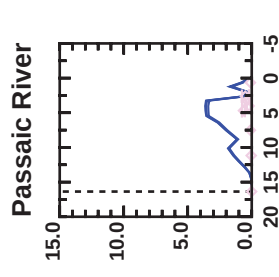
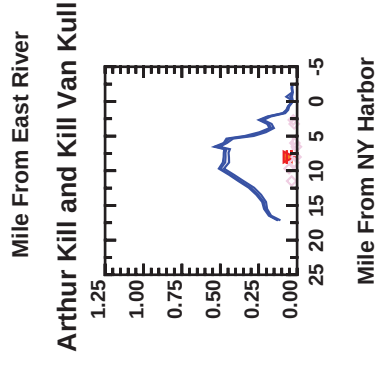
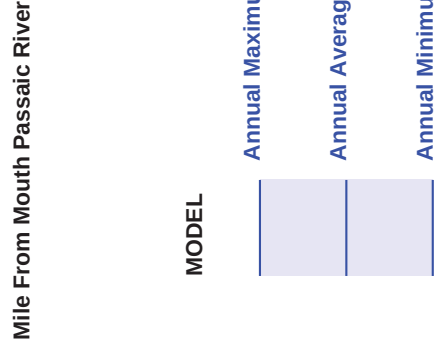
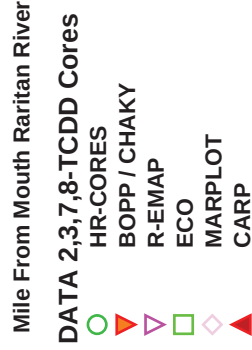
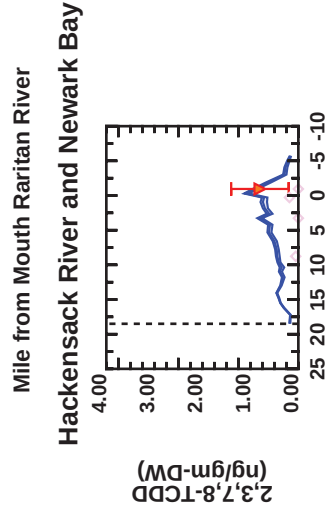
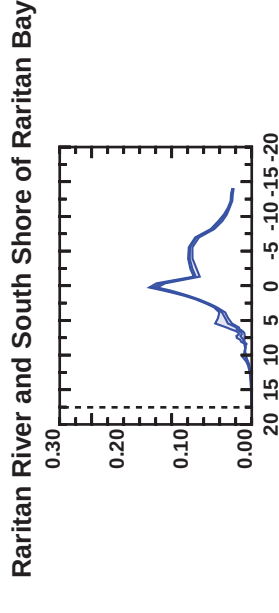
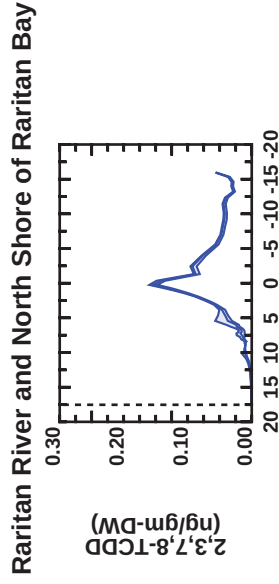
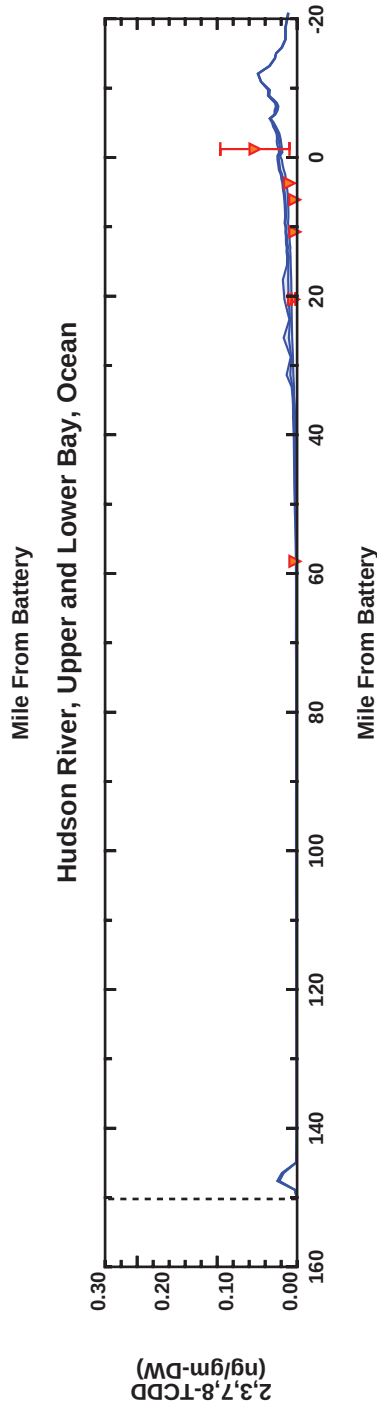
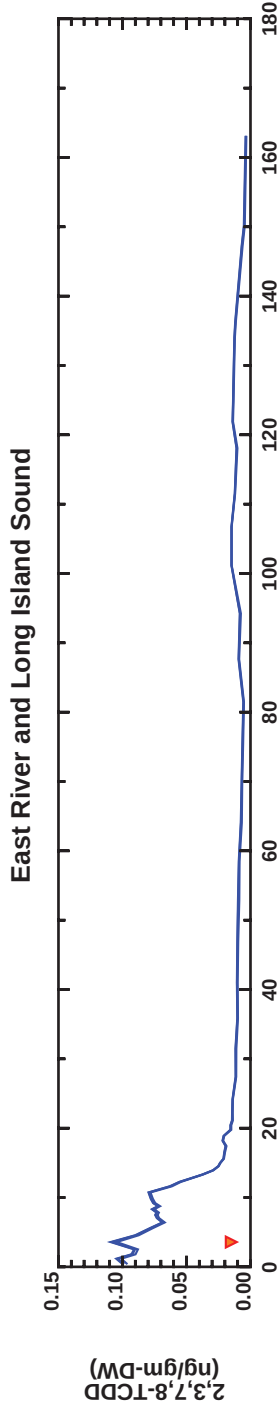


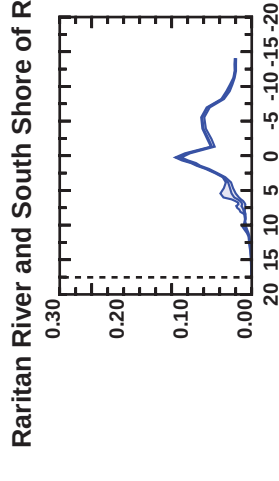
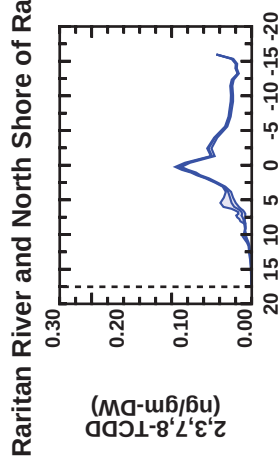
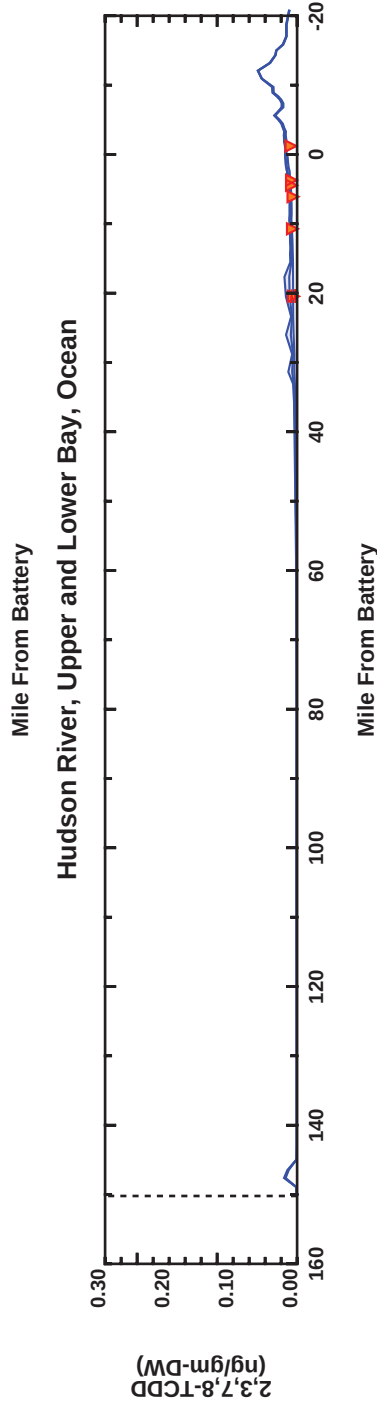
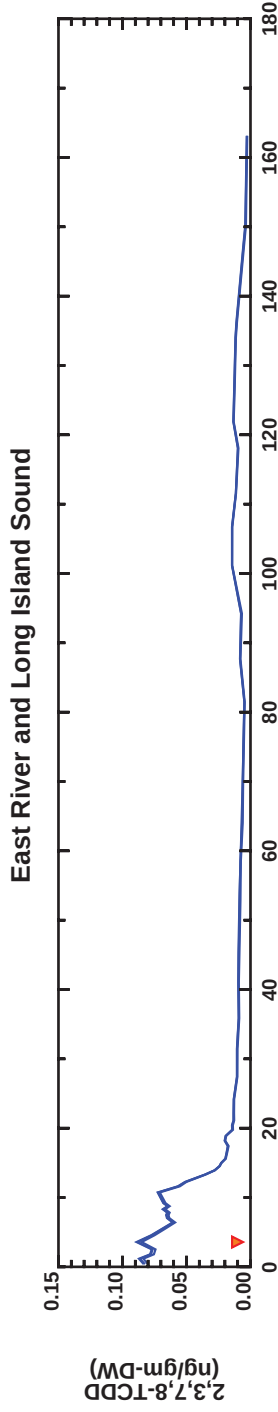
Mile From NY Harbor



Mile From Mouth Passaic River

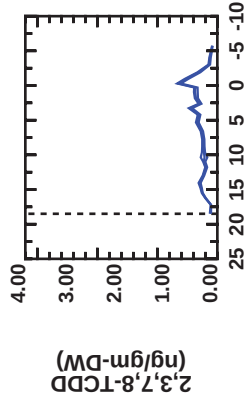




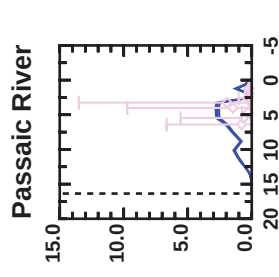
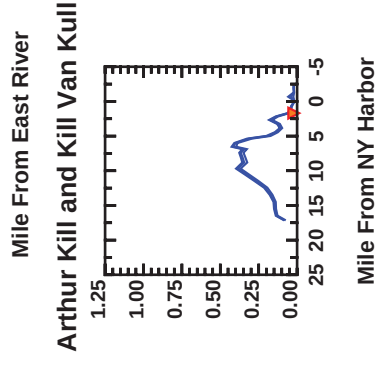
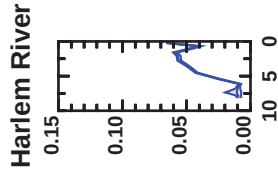


Mile from Mouth Raritan River

Hackensack River and Newark Bay



Mile From Mouth Hackensack River



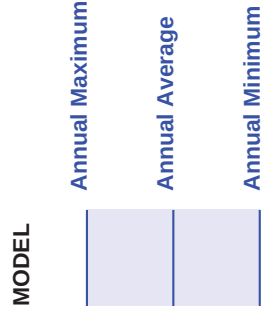
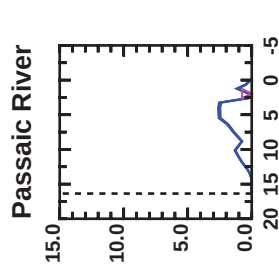
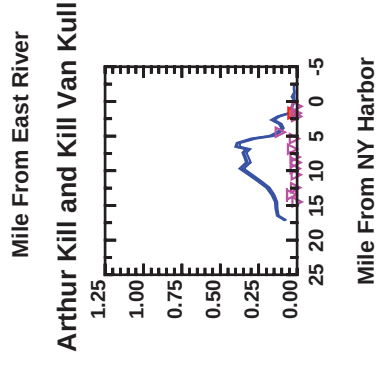
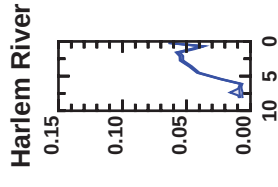
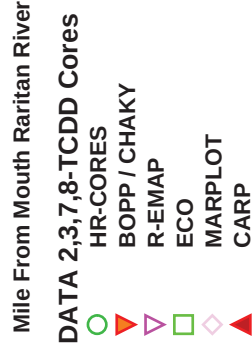
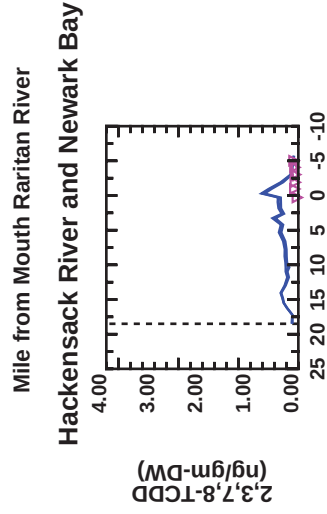
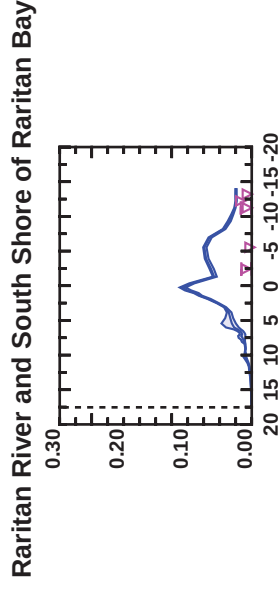
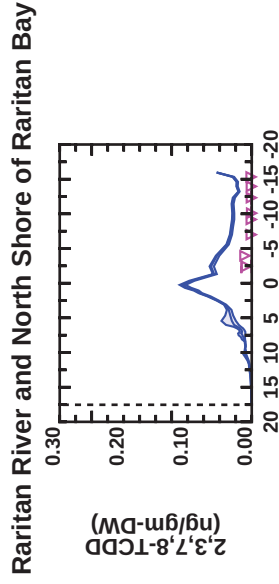
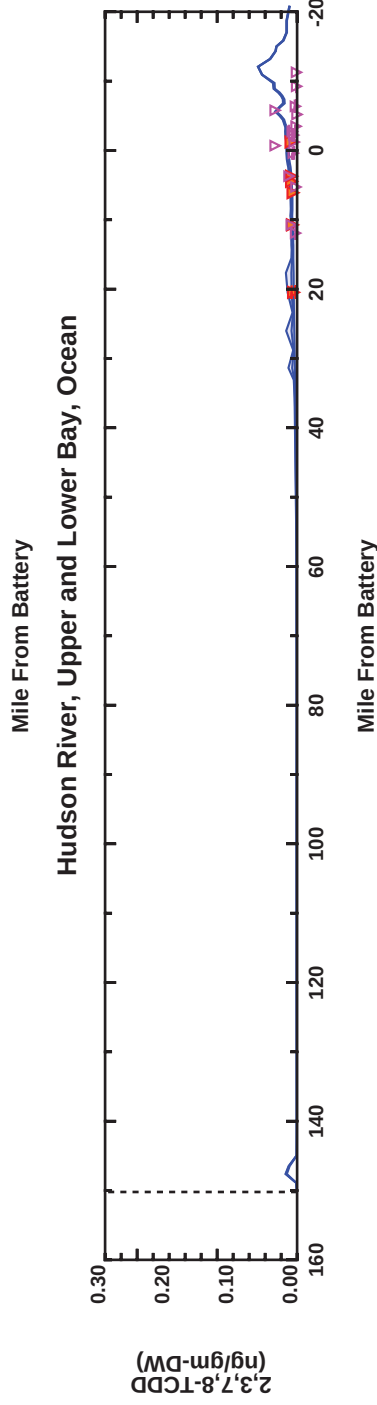
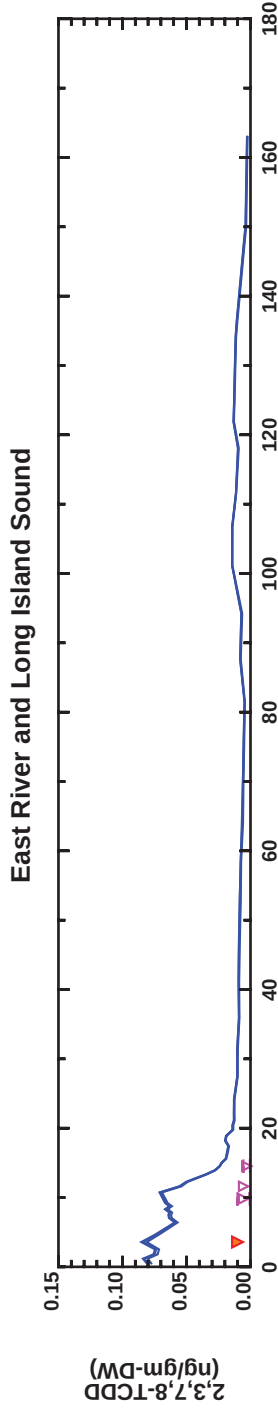
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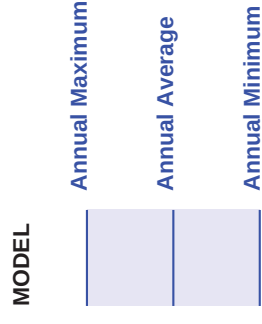
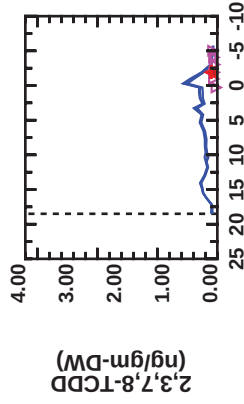
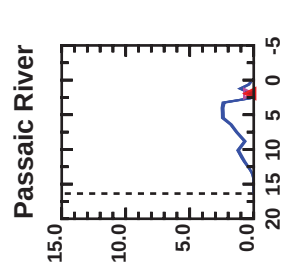
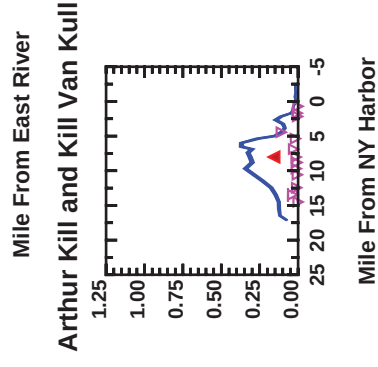
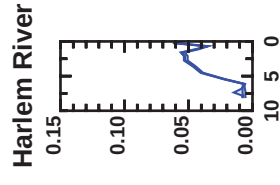
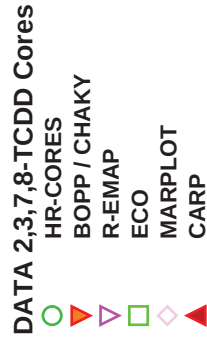
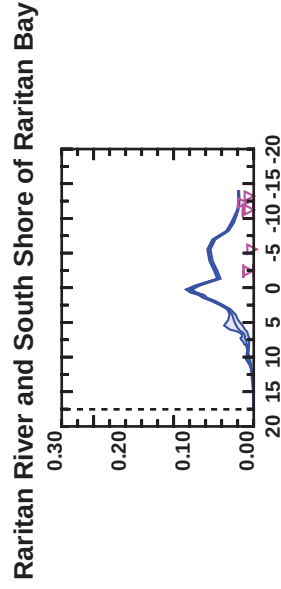
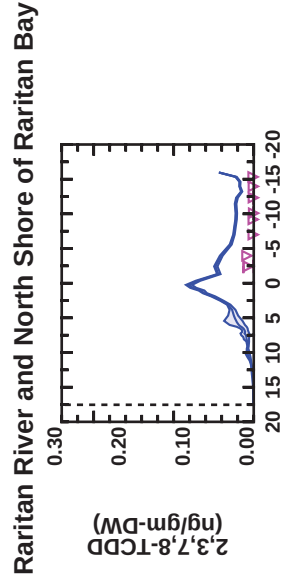
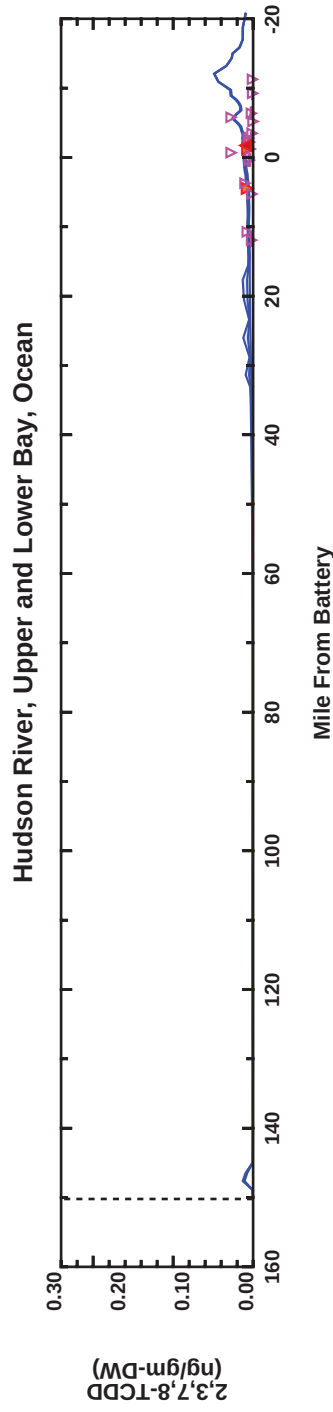
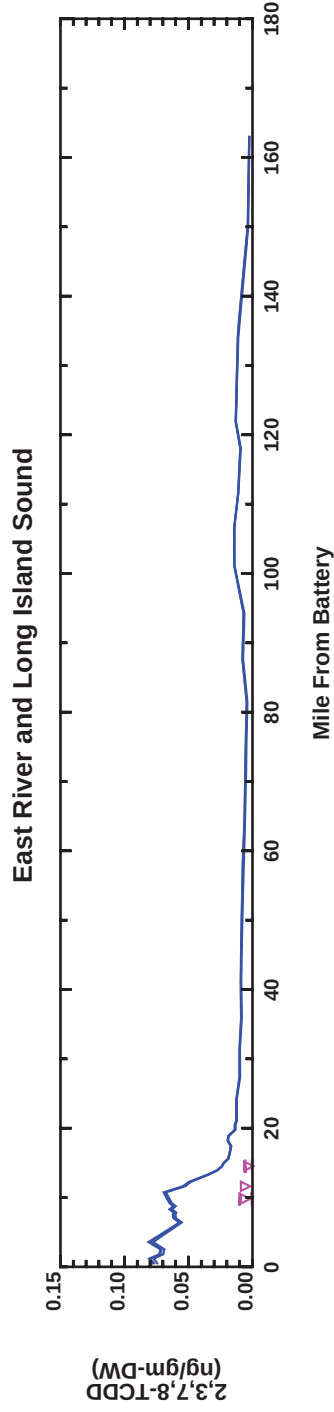
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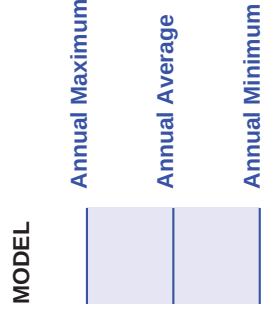
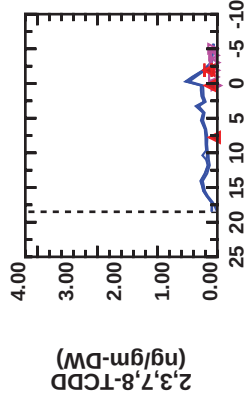
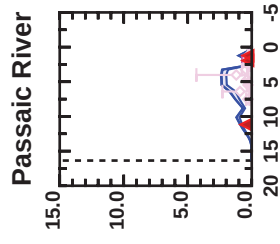
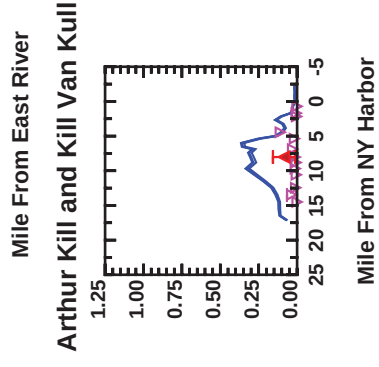
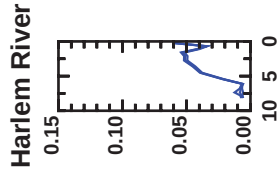
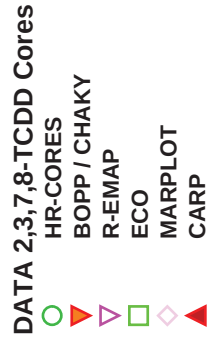
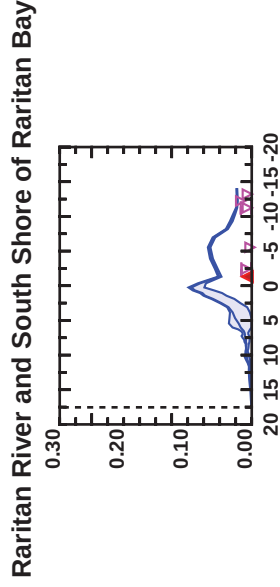
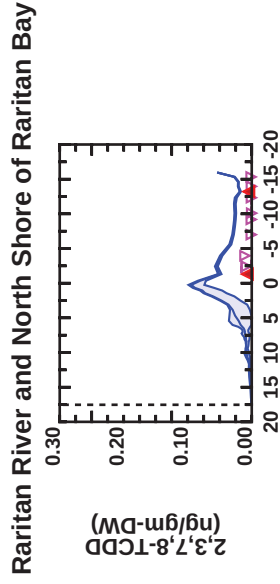
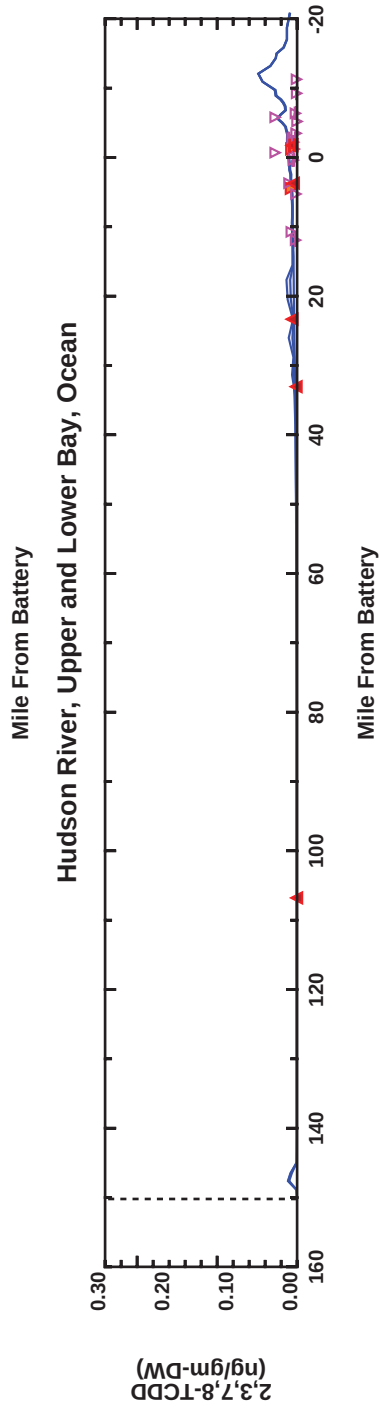
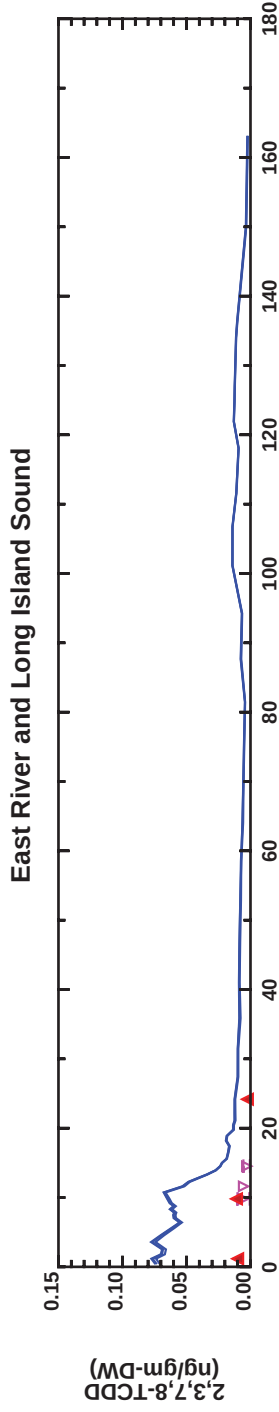
- HR-CORES
- △ BOPP / CHAKY
- ▽ R-EMAP
- ECO
- ◇ MARPLOT
- ▲ CARP

MODEL









COMMENTS ON LOWER PASSAIC RIVER RESTORATION PROJECT

Introduction

The description in the MP report of the horizontal mixing of sediments and contaminants in the Lower Passaic River (LPR) is somewhat misleading; for this reason, a few paragraphs describing this process are given first below. There are many serious errors in the EMBM. Some of these are described below. However, all of them are not given here. The reason is that there are fundamental questions of whether the accuracy of the EMBM predictions is sufficient for practical purposes; and whether the most significant predictions can be obtained without the use of the EMBM, i.e., is the EMBM necessary? The basic premise of the MP report is based on the remediation of the RM0 to RM8 area alone without any action, present or future, for the area of the LPR above RM8. This is incorrect as discussed below.

Attached are comments and an article on the well-mixed layer due to bioturbation which may be interesting and/or helpful.

Conceptual Site Model

Hydrodynamics and Sediment Transport

It can be shown that the sediment erosion due to tidal action alone is on the order of a few millimeters. As the tide comes in, the flow and shear stress increase, and a few millimeters of surficial sediments erode and are swept upstream. As the tide slows, these sediments more-or-less deposit. As the tide goes out, these same sediments are then resuspended and are swept downstream. As the tide subsequently slows, these same sediments more-or-less deposit. This cycle repeats. The net effect is that only a few millimeters of surficial sediments are disturbed by tidal action.

Superimposed on this motion is a gradual transport of a fraction of the suspended sediments into and from Newark Bay and a gradual transport of (cleaner) sediments from upstream (from above Dundee Dam) into the LPR.

If this were all, concentrations of hydrophobic chemicals in surficial sediments would decline rapidly due to burial of these sediments by deposition of cleaner sediments from upstream. But this doesn't happen. The reason is resuspension of sediments (and contaminants) in certain areas of the LPR due to highly-variable-in-time-and-space floods and wind-driven waves and currents. The areas of resuspension are probably mostly near

shore in RM0 to RM8 and are more widely distributed in RM8 to RM12.6 and possibly above RM12.6.

Critique of the Empirical Mass Balance Model.

There are many serious errors in the EMBM. The most fundamental and significant errors are described below.

Multiple solutions

An implicit assumption in one solution for the EMBM is that the 6-inch surficial sediments from the 1995 core are mixed with the 2005 Be-7 layer (say a thickness of 4 inches for convenience) along with sediments from above Dundee Dam (3 inches) and Newark Bay (3 inches). This implies that 16 inches or more of the surficial sediments in the LPR are now well-mixed. This occurs over some indeterminate time, but it must occur according to this solution for the EMBM.

Once this happens, additional sediments and contaminants are transported to and from the LPR. An additional layer similar to the surficial layer of the 1995 core must now be mixed into the 16-inch LPR layer in order to obtain the correct chemical concentrations in the surface LPR layer. When does this occur? And to what depth can this mixing penetrate?

This surface concentration in the LPR (the Be-7 layer) could also occur due to resuspension of some of the sediments in the LPR to deeper depths (smaller amounts but higher concentrations of dioxin) while other sediments were undisturbed or in depositional areas. This latter hypothesis is more probable since erosion/deposition are highly variable in space and time. In fact, MP illustrated this in their previous report where they produced multiple solutions (corresponding to erosion at and to different sediment depths) all of which satisfied the criteria for concentrations in the Be-7 layer. The original MP modeling suggestions can be expanded into an almost infinite number of non-unique, but mathematically possible solutions, some of which are obviously incorrect physically.

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In Fig. 19-3, the solids concentrations for the length-weighted-average scenario are presented. This is described in more detail in the earlier MP report but presumably is a legitimate solution to the EMBM. But it is hard to believe that all the sediments corresponding to this length-weighted-average (on the order of meters) are going to be resuspended and mixed with the surficial layer.

To be more succinct, the EMBM allows multiple solutions for the thicknesses and depths of resuspended sediments. Another way of saying this is that there is a large variability in the predictions of the depth of erodibility. From another point of view, DiToro also demonstrated the large variability in the solutions to the EMBM. These arguments are complementary and do not give confidence in the solution indicated in the report.

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Assumption of uniformity

In the EMBM, it is assumed that resuspension occurs uniformly over the entire RM0 to RM8 region. This is incorrect. Much of this area is depositional. Resuspension occurs non-uniformly over the area with some areas experiencing deep erosion while other areas have little or no erosion or even deposition. Areas where significant erosion occurs will erode sediments with higher chemical concentrations (since chemical concentrations increase with depth). A uniform erosion of a sediment layer of constant concentration is not reasonable.

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Because of this assumption of uniformity, MP predicts that remediation will be proportional to the amount of surficial sediment dredged and capped. This is incorrect. For example, dredging and capping sediments in a depositional area will do little to reduce contamination in the LPR.

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Remediation area

MP proposes to remediate (dredge and cap) RM0 to RM8 only. If this is done, contaminated sediments from above RM8 will be resuspended during storms and floods and expose further contaminants above RM8; but more importantly the resuspended contaminated sediments will deposit in the RM0 to RM8 area, an area which is mostly depositional. The result will be that the surface layers in the LPR will be essentially contaminated the same as before.

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Contamination in surface waters is essentially a problem of the chemical concentrations in surficial sediments. Buried contaminants are irrelevant unless they are resuspended. Contaminated sediments in depositional areas are only a short-term problem if they will be covered by clean sediments and not exposed.

Chemical desorption

MP ignores the desorption of hydrophobic chemicals. As a first approximation for highly hydrophobic chemicals (e.g., dioxin and high K_p PCBs), this is probably a good approximation. However, for low K_p PCBs, PAHs, and other chemicals, this may cause serious errors. The statistical analyses are therefore in question. Actually, if desorption rates which depend on K_p are considered, this will help explain the fact that the ratio of high K_p to low K_p PCBs changes from above Dundee Dam to the LPR.

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Upstream source

The sources of chemicals above Dundee Dam are assumed to be characterized by core(s) from a depositional zone. By definition, these sediments are non-erosional and therefore are not characteristic of sediments which have eroded from above Dundee Dam. The eroded sediments probably have higher chemical concentrations indicative of past contamination as compared with sediments that have been recently deposited.

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Proposed Remediation and Required Analyses

Dioxin is the main toxin. The emphasis of remediation and modeling should be on this chemical.

1. Use hydrodynamic (ECOM) and sediment transport (SEDZLJ) models to calculate potentially erodible areas in the entire LPR for a wide range of hydrodynamic conditions, e.g., high flows, high tides, especially conditions after low flow periods during which sediments can deposit and accumulate. Finer grid sizes than now used across the river are probably necessary to delineate erosion/deposition areas more accurately so as to guide dredging/capping. 182
2. Dredge and cap all potentially erodible areas throughout the LPR. This is the best that can be done unless upstream areas are also remediated. (Potentially erodible areas means all areas that can be significantly eroded in storms/floods/tides up to and including a 100 year event.) Do not dredge and cap depositional areas. This would be an enormous waste of time and money. 184
3. No other modeling is necessary. As far as chemical concentrations in organisms are concerned, these concentrations will decrease proportional to the decrease in chemical concentrations in surface sediments. For example, if chemical concentrations in surface sediments are reduced by 50%, chemical concentrations in organisms will also reduce by 50%. There will be a time lag in this decrease, but this time lag is less than the time for dredging and capping, approximately 10 years, and can therefore be ignored. 183
4. A reasonably early action should, and can, be based on hydrodynamics and sediment and contaminant transport alone. 181

Concluding Remarks

1. The MP report recommends remediation of RM0 to RM8 alone without any action, present or future, for the area in the LPR above RM8. If this is done, contaminated sediments from erodible areas from above RM8 will be eroded during storms and floods; this erosion will expose deeper contaminants in this area, and most importantly the eroded sediments will deposit in the RM0 to RM8 area, an area which has already been remediated but much of which is depositional. The result will be that the surface layers in the LPR will be essentially contaminated as before. Details of remediation should be investigated as described above.
2. Because of the inherent variability in the solutions to the EMBM and basic errors in the formulation of the EMBM, there is little of use in the predictions by the EMBM.
 - a. Dioxin is the most significant toxin and is the only chemical which can be significantly remediated by action in the LPR. This conclusion does not depend on the EMBM. 185
 - b. Dioxin has no significant sources above Dundee Dam, from Newark Bay, or from any tributaries. The presence of dioxin in surface layers is almost 186

entirely due to resuspension of older, contaminated sediments. This conclusion also does not depend on the EMBM.

- c. Although all other chemicals need not be considered, the quantitative prediction of their sources by EMBM is too variable and unreliable for practical purposes.
- d. If all potentially erodible areas in the LPR are dredged and capped, the remediation time will be primarily that due to the time required for dredging and capping, on the order of 10 years. The time lag for the decrease of chemical concentrations in organisms is less than this and is probably almost negligible by comparison.

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The Elusive Well-Mixed Layer

During the conference call on June 18, there was discussion and several questions about the thickness of the well-mixed layer due to bioturbation on the Passaic. The existence and especially the thickness of this layer are important in many water quality models since the thickness determines the remediation time (or chemical concentration half-lives or decay times).

Because of its importance, I carefully examined the high resolution cores from the Passaic (Chapter 13). I saw no evidence for a well-mixed layer due to bioturbation and, of course, I could not determine any thickness for this layer except that, if it did exist, it was less than 2 cm.

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I have previously examined cores from the Housatonic River. I saw no evidence for a well-mixed layer due to bioturbation in that river.

Over the last 10 years in our work with Sedflume on field cores (on the order of 200 cores), we have measured sediment properties as a function of depth; we have especially measured density profiles using the attenuation of electromagnetic radiation (accuracy of 0.01 g/cm³ and resolution of 0.1 to 1.0 cm). These cores were from the Great Lakes and rivers in the Great Lakes area. We have never observed a well-mixed layer due to bioturbation in these cores.

However, we have observed very distinct sedimentary layers of constant density and constant sediment and chemical composition. These layers were almost certainly due to large erosion/deposition events caused by storms and/or floods. Additional evidence for this is from Kersten et al. 2005. These layers are sometimes mistaken for bioturbated layers, but they are distinctly different.

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The sediment-water flux of HCB due to bioturbation by three different organisms has been studied in detail in the laboratory and by theoretical modeling (Luo et al. 2006). Experiments lasted up to 96 days. Vertical profiles of HCB at different intervals of time were measured. By 96 days, no significant evidence for a well-mixed layer had developed. The theoretical model, which was based on the experiments, predicted that a well-mixed layer would develop for *Lumbriculus*, but only after several years.

In the field, densities and types of organisms are not constant over periods of years, but fluctuate locally in space and time depending on the season, big events such as floods and storms, and ecological succession after big events. Because of this, the formation and maintenance of extensive and distinct well-mixed layers due to organisms probably does not occur very often.

A more detailed discussion of the evidence (or non-evidence) for a well-mixed layer due to bioturbation is given in the attached paper (Lick 2006). Conclusion: There is no direct

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evidence for a well-mixed layer due to bioturbation. I know this concept is dear to the hearts of many people, but please read the paper before responding.

In the Passaic, remediation after dredging and capping all erosional areas will be primarily due to deposition of clean sediments from upstream. This deposition is on the order of 2 inches/year and is much greater than the potential effects of organisms and molecular diffusion. This indicates remediation after dredging and capping will be on the order of a year or a few years at most. But since dredging and capping will take on the order of 10 years, this remediation time is almost negligible by comparison.

ATTACHMENT B

Peer Review Comment Table with Responses

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
60	Adequacy and Use of Data	1	The general conclusions of the CSM are adequately supported by the data.	No response required.
63	Adequacy and Use of Data	1	The CSM does provide a reasonably conclusive argument that the major contaminant sources are known and correctly identified.	
9	Adequacy and Use of Data	1	In general, the reviewer agrees that there are sufficiently robust data of appropriate kinds to characterize the contaminant loads that enter the lower eight miles. Certainly for in stream sediments above RM8 and current inputs from tributaries (the suspended matter samples). While a more comprehensive sampling of CSOs and SWOs would have been nice, the available data are “sufficiently robust” in light of their small relative contributions to contaminant loadings. I do have reservations about the Newark Bay sampling, especially as the overall project proceeds to a consideration of that waterway and contiguous systems. A focus on dated sediment cores (see Bopp et al., ES&T, 1991) and greater attention to and consistency in collecting Be-7 bearing surface sediments should be part of any future sampling.	This recommendation will be forwarded to the Newark Bay study team.
141	Adequacy and Use of Data	1	The adequacy of the data can only be judged in comparison to the model being employed. Since the models are completely inadequate ..., the question as it stands cannot be answered. The data certainly will be useful if a mechanistic model is employed to predict the consequences of various remedial actions.	This was the opinion of a single peer reviewer. We respectfully disagree with it. It ignores numerous analyses and findings presented in the CSM which were developed separate from the models, and in many cases, were more detailed than any mechanistic model (e.g. the bathymetric analyses or the dioxin ratio fingerprinting). Regardless of this difference in opinion, we are implementing one major recommendation of the peer reviewers, which is to use a mechanistic model developed for the NY/NJ Harbor (CARP) to confirm the future trajectories calculated by the single-layer box model associated with the EMB. The CARP model will be updated with recent data, including the high resolution cores.
61	Adequacy and Use of Data	1	Sediment sample results are used appropriately.	No response required.
142	Adequacy and Use of Data	1	The surface sediment data is used to compute averages and other statistics for the EMB. For this purpose they are adequate.	
120	Adequacy and Use of Data	1	There is clearly a great deal of heterogeneity with respect to erosion and deposition, see Figs 11-7 – 11-9. In addition to sediment cores from depositional areas there should be some measurements of pollutant concentrations of eroded, upstream sediment.	A set of low resolution cores was collected above RM8 as part of the 2008 sampling event to address this data gap (see Chapters 14 and 16 in the CSM).
44	Adequacy and Use of Data	1	There are enough high TCDD surface sediment concentrations reported for the document to provide more about these potential source areas and geological settings where these hotspots occur, as related to where the most important contaminant erosion occurs/will occur. There is not enough insight or analysis of the nature of the resuspension sources or their controls. Ex: RM8.5-10.4 have lower long-term deposition rates, so, on average, TCDD maximas are nearer the surface and less erosion can expose hot spots.	Because of the high degree of spatial and temporal variability of erosion and deposition, we do not believe that a closely detailed examination of potential resuspension sources will identify uniquely important areas. Furthermore, even if hotspots could be identified, other areas with surface sediment contamination at levels that cause 10^{-2} human health cancer risk would still need to be remediated.
43	Adequacy and Use of Data	1	The depth of contamination in the LPR sediments is not addressed, as related to whether a 100-year storm could resuspend highly contaminated sediments and whether changes in bathymetry due to dredging would change hydrology and sediment transport.	The reviewer has correctly noted that the depth of contamination is not very well known in many areas. This has been discussed in Chapter 16. Note that all alternatives being evaluated in the Focused Feasibility Study include capping or backfill, so that contamination at depth would not be left exposed.
46	Adequacy and Use of Data	1	Creation and interpretation of maps depicting the best estimates of 3-D distributions of COPCs should be extremely valuable.	There is a 3D map (Figure 5-9) in the Geochemical Step 2 report (2006), but it is not especially useful because many of the cores do not go deep enough to capture all of the contamination. Also, the heterogeneity and constant changing of erosional and depositional areas make traditional interpolation techniques less useful.
45	Adequacy and Use of Data	1	Consider relationships between surface concentrations, sediment profile distributions, penetration of COPC, measured sediment properties (texture), estimates of deposition and sediment type.	

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
8	Adequacy and Use of Data	1	Based on decades of work in the Hudson, and depositional zones in rivers - Dundee "Lake" is as much a river (i.e. a relatively narrow and continuously flowing water body that happens to be located behind a dam) as a lake - remove and store a sample of the suspended matter as the vast majority moves by and is transported downstream, in this case to the Lower Passaic. Some of the best recent description of such behavior can be found in Chilrud et al. (Chemical Geology 199, 53-70, 2003 and Water, Air and Soil Pollution: Focus 4, 469-482, 2004) where historical levels of several contaminants in a series of dated cores from depositional areas along the Hudson are explained in terms of levels at the farthest upstream site "diluted" by relatively clean inputs of particles from intervening tributaries. The cores from above Dundee Dam are the two "best dated" cores in the CSM and additional work involving Damon Chaky and Steve Chilrud is currently underway to further interpret the dating information, relate historical contaminant levels to those observed in the lower Passaic, and certify that the analyses of dried samples from these cores can be compared directly to the "wet" analyses carried out on all the samples collected in the lower Passaic River and Dundee Lake by Malcolm Pirnie. This additional work will also investigate another factor related to the "appropriateness" of these cores as indicators of "background loading levels" which I interpret as loadings from the Upper Passaic basin. That factor is grain size. Our field and lab notebooks related to the collection and processing of these cores noted that the upper few sections, while dominantly fine-grained, were relatively sandy. This could be a reflection of the influence of ongoing construction/development observed along the shore near the sampling site. The surface section of these cores did contain detectable levels of Be-7 and there are several other Be-7 bearing surface grabs from Dundee Lake collected by Malcolm Pirnie that will be compared with Be-7 bearing samples from the lower Passaic in our evaluation.	We have acknowledged the value of the cores above Dundee Dam by making extensive use of them in delineating the Upper Passaic source term (Chapter 5). This information forms a major component of the interpretation of the cores in the Lower Passaic River.
1	Adequacy and Use of Data	1	In general, the sediment sample results collected in the lower eight miles are used appropriately except for DDT-related compounds and the limited suite of PAHs.	Refer to responses to Comments 3 and 4.
3	Adequacy and Use of Data	1	While DDT-related compounds would not be at the top of the list of COCs, a large amount of DDT was manufactured at the 80 Lister Avenue Site and with a most unusual history. Consequently, the levels and geographic distribution of DDT-related compounds have significant potential as a lower Passaic River source tracer (see Bopp et al., ES&T, 1991). I have brought up this point previously and the "problems" experienced with the DDT analyses of these samples have been discussed directly with Ed Garvey and other Malcolm Pirnie personnel.	We recognize the value of applying DDT as an additional tracer and have been able to confirm two separate sources of 2,3,7,8-TCDD as a result of its application.
4	Adequacy and Use of Data	1	With respect to PAHs, the attempts at "source characterization" employing normalization to dieldrin (or is it benzo [a] anthracene??, Figure 6-8) could certainly have been improved with more extensive (and expensive) analyses of PAH and related compounds.	In response to previous input by Dr. Bopp, the recent sampling events (2007-2008) included some of the more detailed chemical analyses of PAHs as represented in Yan's thesis (2004). However, resource allocation did not allow for the analysis of the entire suite of PAHs as developed by Yan.

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
2	Adequacy and Use of Data	1	The reviewer has addressed the adequacy and use of data with respect to sediment sample results collected in the lower twelve miles, instead of the lower eight miles specified in the charge question.	We understand the reviewer's concern with the lower 12 miles; however, the CSM shows that fine-grained sediments below RM8 are the single-most important source of contaminants to the Lower Passaic River. The area of fine grained sediments above RM8 is substantially smaller than below RM 8 expressed on an absolute basis and on a percentage of the river bottom. About 86% of the fine-grained sediment surface area is located below RM8 and only 6% of the fine grained area is located between RM8 and RM12. Even if the contaminant concentrations in surficial sediments between RM8 and RM12 were twice as high as those in the lower 8 miles, the flux from the sediments below RM8 would still be seven times greater than the flux originating in RM8-12, assuming that the rate of fine-grained sediment resuspension is proportional to the fine-grained sediment surface area. In addition, EPA will be using the sediment transport model SEDZLJ to evaluate whether a remediation should start in RM0-8 or RM8-12.
7	Adequacy and Use of Data	1	The reviewer stated that the results of the high resolution cores collected above Dundee Dam are sufficient to represent background loading levels for the system. He disagreed strongly with comment 180.	The reviewer's disagreement with Comment 180 is supported by the results of field work performed by Malcolm Pirnie in 2007-08: contaminant concentrations in the sediment traps immediately below Dundee Dam and in the core tops above the Dam were similar and contaminant concentrations in sediment traps and in core tops in the Saddle and Third Rivers were similar as well.
180	Adequacy and Use of Data	2	The sources of chemicals above Dundee Dam are assumed to be characterized by core(s) from a depositional zone. By definition, these sediments are non-erosional and therefore are not characteristic of sediments which have eroded from above Dundee Dam. The eroded sediments probably have higher chemical concentrations indicative of past contamination as compared with sediments that have been recently deposited.	See response to Comment 7.
62	Adequacy and Use of Data	1	Although one could wish for more data, these samples (dated cores and fine-grained surface sediment) are sufficient to represent the pollutant concentrations in depositing sediments above the dam. Whether they are adequate to represent upstream loads is less certain. Solids that move across the dam during major flow events could well differ from those solids retained in consistently depositional areas above the dam. Unfortunately, no direct evidence on this point seems to be available and I believe the use of the available depositional sediment data is adequate for the purposes of the CSM.	
122	Adequacy and Use of Data	1	For Dundee Dam, are the upstream eroded sediment carried downstream similar to the concentrations observed above the Dam?	
49	Adequacy and Use of Data	1	Estimates of resuspended sediment volume could have larger error than suggested, because they are based on the Dundee Dam flux measurements, which are tough to obtain for high flow events.	
50	Adequacy and Use of Data	1	Estimates of resuspended sediment volume seem to assume that little of the sediment from the Upper Passaic River escape the Lower Passaic River and that the sediment which does escape to Newark Bay, comes back. Is this reasonable?	The CSM does not make this assumption. Our basic conceptual idea of sediment movement in the system is that sediment from the Upper Passaic River flows over Dundee Dam and mixes with Lower Passaic River sediments. At the same time, these sediments are being mixed with Newark Bay sediments brought upriver on incoming tides. The sediment is sufficiently mixed that most contaminants exhibit little gradient between RM2 and RM12. The outgoing flows move this mixed sediment out into Newark Bay. On average, the LPR is a sink for sediment, gaining approximately 0.25 inch of sediment each year. The text will be revisited to assure clarity.

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
98	Adequacy and Use of Data	1	The Upper Passaic (above Dundee Dam) is described as an important source of total PCBs to the Lower Passaic, but the fraction of highly chlorinated PCBs above Dundee Dam is much greater than seen in the Lower Passaic. This suggests a situation in which PCBs in the Dundee pool are being dechlorinated, with preferential transport (perhaps in DOC-sorbed form) of the lighter congeners into the Lower Passaic.	Our analysis to date indicates that the PCB congener shift is not due to dechlorination. This is based on the absence of congeners indicative of the dechlorination process as well as the presence throughout much of the estuary of salt water, which tends to curtail PCB dechlorination. We believe that eliminating PCBs lighter than BZ52 from the EMB calculations has eliminated the concern about dissolved-phase PCB transport.
143	Adequacy and Use of Data	1	It appears that the high resolution cores from Dundee Lake represent the only data available. It would be much better if actual data were collected from the inflow to the Passaic River to confirm the conclusions made from the analysis of the cores.	Section 14.5 describes the analyses used to prove that suspended sediments are similar to recently deposited sediments. Therefore, we can infer that the high resolution cores in Dundee Lake are a historical record of the suspended sediment passing over Dundee Dam. Because the data from Little Falls shows little or no correlation between flow and suspended sediment (see Section 18.2.2 of the CSM), the program being suggested in this comment would require many years to collect a reliable data set. We have used an integrated sampling program (including high resolution cores, core tops, sediment surface samples and sediment traps) to make the same estimate in a shorter period of time.
57	Adequacy and Use of Data	1	If I thought these sources (CSOs & SWOs) could be at all important in the system, I would be more concerned about the incredibly low CVs associated with measurements used for these inputs.	The low variability of these data results from filtering of the samples. We have collected two additional rounds of data not included in the draft CSM submitted for peer review and they corroborate the results of the first round. Those data will be incorporated into the final CSM.
69	Adequacy and Use of Data	1	The delivered loading rates for Saddle River do appear reasonable, but are clearly less than near-source literature values for solids loading from urban sources. Because individual storm water drainage basins generally have higher sediment delivery ratios, resultant load rates can be significantly higher than those derived from near-source literature.	Most of the stormwater drainage is captured by the monitored tributaries. While the comment may be correct that SWOs yield a greater percentage of solids per unit area, the low level of contamination observed on these solids indicates that, even if the loads were greater, they would not represent a significant contribution for most contaminants, dioxin in particular.
71	Adequacy and Use of Data	1	The reviewer agrees that CSO/SWO input is likely a minor fraction of the total pollutant mass balance; but states insufficient data exists to characterize CSO/SWO inputs to the lower river.	The method used to estimate loads from CSO/SWO sources is documented in the CSM, Sections 18.2.2 and 20.1. In general, the chemical signatures of sources and a watershed area approach were used to infer solids loads.
72	Adequacy and Use of Data	1	Long-term solids loads from CSO/SWO sources are basically unknown, and the method of estimating same is undocumented. This may introduce bias into the sediment load calculations due to the strong correlation between flow and load.	Both the sediment loads and the contaminant ratios indicate the insignificance of the contributions of the SWOs and tributaries. In particular, the Second River and Third River are situated entirely in urban settings and therefore, are little more than glorified SWOs. There is very little overland runoff reaching these tributaries; their flow is almost entirely due to capture of stormwater runoff from impervious surfaces through catch basins. For the main contaminants of concern, even if these tributaries and SWOs contributed an order of magnitude greater solids load than estimated, their contribution to the contaminant load would still be minor compared to other sources.
65	Adequacy and Use of Data	1	It is possible that SWO/CSO sources could include non-aqueous phase loads of hydrophobic contaminants from industrial sources not associated with sediment loads. As such, it is possible that that CSO/SWO solids load may be significantly underestimated, and storm water contributions from individual source areas could be significant to the lower river mass balance.	We believe that the probability for this scenario is extremely low. In order for NAPL to enter the river unassociated with solids loads, it would have to enter above the monitoring locations, not contaminate any solids in the CSO/SWOs, circumvent the sediment traps, and then immediately sorb to solids in the river. Although hypothetically this might happen, it cannot be a significant source of contaminant to the Lower Passaic River.

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
144	Adequacy and Use of Data	1	The only really convincing data are actual measurements of the sources. There appears to be little of this actual data available. In the light of the plateau behavior of the TCDD (Pages 17-19), a concerted effort to make real loading estimates would be very useful. Toward this end, the CARP data should be the starting point.	The dataset presented is robust (see response to Comment 10). The sample set includes core tops, sediment traps, water column samples from each of the sources and high resolution cores. Other than the instantaneous water column samples, the other methods represent larger periods of time and can be used to estimate time-integrated loads. (As an example, core tops represent 6 months, sediment traps represent 2 weeks, while water column samples represent 2 hours.) For this reason, these time-integrated samples are much more powerful than low-frequency instantaneous sampling.
10	Adequacy and Use of Data	1	The reviewer is convinced that the available data are adequate to verify that there are no important ongoing, unquantified sources.	Other than a single short-term dioxin release near RM11 (discussed in Section 15.7) the ongoing source of TCDD is likely resuspension of old sediments in the upper reaches of the Lower Passaic River.
64	Adequacy and Use of Data	1	Locally important, ongoing sources may be present. The concentration gradient observed in longitudinal TCDD profiles downstream of RM12 suggests that a possible ongoing load source may exist from a former facility identified in that area.	
145	Adequacy and Use of Data	1	The plateau behavior (Pages 17-19) suggests that there may be such a source or sources. It is imperative that this issue be settled before any remediation is commenced.	
166	Adequacy and Use of Data	1	The lingering TCDD concentrations suggest a continuing source.	
124	Adequacy and Use of Data	1	With regard to the pollutants investigated, the available data shows that there are likely no on-going, unquantified sources. However, as far as other pollutants are concerned, we don't know. For example, brominated flame retardants such as polybrominated diphenyl ethers (PBDEs) are not considered here, probably because they are not known to be a environmental threat in this area. However, the question of other pollutants, including those that are not especially particle reactive such as atrazine merits some consideration.	Concentrations of PDBE and atrazine have not been measured in the historical and recent sampling events associated with the Passaic River or in the Newark Bay samples. Thus, there is no basis for an evaluation of the risk they might pose.
5	Adequacy and Use of Data	1	I was amazed at the lack of description of "point" sources. Is this "typical" of a CSM? I prepared a summary of the 80 Lister Avenue Site (2,3,7,8-TCDD and DDT) and its fairly well-known history of operations in the late 1980s (see file 80 Lister Ave RFB.pdf).	The focus of the CSM was to identify the relative impacts of all of the external and internal sources to the sediments of the river, in order to help EPA decide on which remedial actions, if any, to take on the sediments of the river. It was less important to identify historical point sources than to describe current sources that could be remediated. In a separate enforcement process, EPA will further investigate the presence of the historical sources to the river to identify potentially responsible parties.
6	Adequacy and Use of Data	1	The CSM contains the briefest mention of a second source of 2,3,7,8-TCDD in the vicinity of RM 11 (p. 13-6). The importance of such information to an informed peer-review was demonstrated by the fact that one of the other reviewers specifically brought up the question of other 2,3,7,8-TCDD sources in the midpoint conference call. A scan of the classic dioxin reference (Hay, The Chemical Scythe, 1982) and information available on the web indicates that manufacture of hexachlorophene at a Givaudan plant near the confluence of the Third and Passaic Rivers is the likely source. A NIOSH/CDC report (Piacetelli et al., 1990) available on the web provides the following details related to 2,3,7,8-TCDD - i. Givaudan manufactured 2,4,5-trichlorophenol (2,4,5-TCP) (the source of 2,3,7,8-TCDD) as a starting material for synthesis of hexachlorophene (HCP) from 1945 through 1949. ii. Between 1949 and 1984, they purchased "purified" 2,4,5-TCP from several suppliers, mainly Hooker and Dow Chemical. iii. Between 1947 and 1984, HCP production at the plant ranged from 17,000 to 3.5 million 'pounds per year. iv. From 1970-1972 HCP production was increased by "adding a building," but in 1972, the building was devoted to "non-HCP" processes. Some very approximate calculations I have done suggest that discharges from the plant could account for on the order of a kilogram of 2,3,7,8-TCDD – highly uncertain, potentially significant.	
56	Adequacy and Use of Data	1	The document does not interpret the high variability in small fish and crab TCDD. This is probably the result of exposure to varying and patchy sediment concentrations.	
				We agree with this comment and will alter the text to reflect this suggestion.

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
55	Adequacy and Use of Data	1	Interpretation of 7-Be distributions do a great job of explaining transport of resuspended sediments and contaminants. With respect to bioaccumulation, careful analysis would show that the available data are insufficient to test this question (use of upper 6 inches for biota exposure) with sufficient accuracy.	The comments are correct in noting that the depth of bioturbation is not well known. The 6-inch mixed layer is based on SPI camera results, which identify a zone of approximately 6 inches of sediment which appear well-mixed. The SPI results also suggest that bioturbation is slow compared to hydrodynamic mixing. The bathymetric analysis shows that more than 6 inches of sediment movement occurs routinely due to tidal effects. Knowing the exact depth of bioturbation is not important if the upper layers of sediment are well-mixed and the bioturbation depth is less than 6 inches. The text in Chapter 11, which presents these analyses will be clarified.
119	Adequacy and Use of Data	1	It is stated that the biologically active (mixing) layer is 0- 6 in. How accurate is that number?	
170	Adequacy and Use of Data	1	The reviewer finds no direct evidence for a bioturbation layer under freshwater/estuarine settings, which is a point of basis for the model forecasts.	
171	Adequacy and Use of Data	1	The reviewer indicates that any homogeneous surficial thickness is due to the impacts of storms, floods and other events where large volumes of sediment are transported about.	
118	Adequacy and Use of Data	1	The reviewer did not find suspended solids concentration for the water column which can be an alternate way of estimating resuspension.	This comment is correct in noting that there is not a lot of suspended solids data for the Passaic River. The lack of data reflects the knowledge that this system is extremely dynamic and thus, establishing typical suspended solids data would require many months or years of data collection. Instead, our approach uses time-integrated samples (e.g. Be-7 bearing sediment samples) to approximate the suspended sediment concentrations in the river. Some suspended solids data do exist, but they are not sufficient to do a mass balance on the suspended sediment.
123	Adequacy and Use of Data	1	One wonders about the variability of the contaminant concentrations of suspended solids from external sources, in stream sediments above RM8 and from Newark Bay. The higher the variability, the more data are required for a reliable analysis. High SWO 2008 concentrations around RM 10 of BaP (Fig. 14-13a), mercury (Fig. 14-10l), cadmium (Fig. 14-10c), and lead (Fig. 10j) point to the possibility of having best management practices (BMPs) in place in order to reduce the concentrations of these pollutants before they reach the estuary.	Additional work on the EMB (Monte Carlo analysis) is planned which will help determine the effect of data variability on the conclusions. Note that most of the SWO samples from the 2007-08 sampling event were collected too close to the river and were therefore affected by the tidal exchange, which transported river sediments into the SWP sampling locations at high tide, when SWO discharges were occurring.
30	Adequacy and Use of Data	2	The reviewer calls attention to the constant, precise trans chlordane levels in slices dated between 1982 and 1988.	Comment noted.
11	Adequacy and Use of Data	2	The reviewer is most familiar with the use and interpretation of Be-7 data in sediments. Based on comment at the midpoint conference call and the central role of Be-7 bearing samples in data interpretation, I would suggest further explanation focusing on the role of sediment mixing and a discussion of absolute activities of this nuclide.	Additional discussion will be added to the CSM to clarify these concerns and questions.
73	Adequacy and Use of Data	2	The description of the utility of data from Be-7 bearing sediments is sufficiently explained in its implications for assessing fate and transport.	
125	Adequacy and Use of Data	2	Be-7 is cosmogenic with a half-life of 53 days. One should realize that what is recent is really a matter of definition. Sediment that has been added 6 months ago may be recent in a sense, yet it may have lost most of its Be-7 radioactivity.	
146	Adequacy and Use of Data	2	Explanation is not sufficient, and it should be. I have attempted an analogy using sediment trap data as the equivalent in Evaluating the Modeling Frameworks. However, there are issues to be settled. Is Be-7 irreversibly sorbed? I doubt it. Can legacy particles become contaminated in the sediment without exposure to the water column? Probably not but it should be addressed. What is the magnitude of the partition coefficient? The modeling of 137Cs requires a partition coefficient to account for the dissolved concentrations. Why not 7Be? In fact it is not clear to me that the use of Be-7 as an absolute marker of recently deposited sediments is as fool proof as the analysis in the CSM assumes.	
147	Adequacy and Use of Data	2	What happens if Be-7 tagged sediments are mixed with untagged sediment particles by sediment mixing? Do the untagged particles become tagged, and are therefore mistakenly labeled as “recently deposited?” This seems to me to be a serious problem that needs addressing. The whole rationale in the CSM depends on the absolute unambiguous tagging via Be-7.	

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
168	Adequacy and Use of Data	2	The CARP model was used to hindcast Ce-137 in the estuary. There were no data for the Passaic River. Comparison to high resolution cores would be interesting.	As recommended by the peer reviewers, the CARP model is being updated with Passaic River-specific data and parameterization, so that it can be run to confirm the future projections calculated by the EMB. CARP model results will be compared to the high-resolution core results.
67	Explanation of Assumptions and Uncertainties	3	Statistically significant differences between 2007-08 CSO/SWO samples and the CARP CSO/SWO data are not adequately explained.	The analysis in the CSM already indicates that no significant differences exist between the data sets at the 95 percent confidence level. The high level of variability in these data is consistent with the highly variable flow regimes associated with such systems.
76	Explanation of Assumptions and Uncertainties	3	The EMBM adds lines of evidence to support the geochemical interpretation of the CSM, but given the levels of uncertainty, the EMBM should be regarded as more qualitative than quantitative. The qualitative confirmation of the CSM is a useful result of the EMBM.	We agree with the reviewer that the EMB is one component of our understanding of the Lower Passaic River and that it is not highly quantitative in all aspects. We plan to further refine its quantitative results through the use of a Monte Carlo analysis. In addition, as recommended by the peer reviewers, the CARP mechanistic model will be run to confirm the future projections calculated by the EMB. The CARP model will be updated with recent data, including the high resolution cores.
174	Explanation of Assumptions and Uncertainties	3	The EMBM can be expanded into an almost infinite number of non-unique, but mathematically possible solutions, some of which are obviously incorrect physically.	Although the EMB may have more than one mathematically-possible solution, the CSM uses other lines of evidence, such as the magnitude of solids resuspension as calculated from bathymetric changes, to constrain the EMB to a physically-correct solution. We are planning to improve our understanding of the uncertainty in the EMB solution through a Monte Carlo analysis.
90	Explanation of Assumptions and Uncertainties	3	The spatial variation problem is acute with the key internal resuspension source; with coefficients of variation in excess of 200% for 2,3,7,8-TCDD and total TCDDs.	See response to Comment 154.
91	Explanation of Assumptions and Uncertainties	3	The TCDD longitudinal profiles show that spatial gradients in surface sediment concentrations are indeed present in the Lower Passaic. The implicit assumption that all "1995" sediments are equally likely to contribute to resuspension is unlikely to be true in practice.	We agree that this "implicit assumption" is unlikely to be true; however, we believe that the average concentration from the 1995 dataset is close to the average concentration on resuspending sediments. Based on the results of the bathymetric analysis (Chapter 11), we believe that nearly all areas of the river have a reasonable probability of contributing to resuspension as part of the annual reworking of the sediment bed. Based on the geochemical balance and the bathymetric evidence, the process of resuspension combines a volume of resuspended sediments (whose average concentrations are similar to the 1995 0-6 inch layer) with an approximately equal volume of sediments generated by the Upper Passaic River and Newark Bay. In addition, based on the recommendation of the peer reviewers, the CARP model, with a more finely segmented Lower Passaic River, is being run to confirm the future projections calculated by the EMB. The CARP model will be updated with recent data, including the high resolution cores.
175	Explanation of Assumptions and Uncertainties	3	The EMBM allows multiple solutions for the thicknesses and depths of resuspended sediments. Another way of saying this is that there is a large variability in the predictions of the depth of erodibility.	We agree that the EMB alone permits multiple solutions. However, the bathymetric analyses in the CSM constrain the EMB to a physically-realistic solution. See responses to Comments 91 and 174.
92	Explanation of Assumptions and Uncertainties	3	The constraint that the source fractions sum to 1 is not necessarily appropriate, given uncertainty in the regressors, and some variability about a sum of 1 should be allowed.	

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
121	Explanation of Assumptions and Uncertainties	3	In the version of EMB considered here where the sum of the solids fractions f_j equals one, the assumption is that the particle size distribution is similar at different sample sites. This is not necessarily the case, however.	Many of the EMB runs were set up using iron-normalized concentrations in an effort to account for particle size differences among the sources. The sensitivity analysis showed little effect of iron-normalization vs. non-normalization, indicating that particle size differences are not important to the final result and f_j can be set to one. The planned Monte Carlo analysis will address some of the uncertainty issues raised here.
132	Explanation of Assumptions and Uncertainties	7	The requirement that the sum of source contribution factors f_j should equal one is not necessary in general; only if the particle size distribution is the same for all sources and the receptor. If large particles, containing only small amount of contaminants, are settled out before reaching the receptor, this sum is greater than one (Christensen et al 1997).	
161	Explanation of Assumptions and Uncertainties	3	The variability in the source terms, specifically 1995 surface sediment data, used in the EMB necessitate an additional term in the EMB equation to account for this uncertainty. This makes the calculation much more difficult.	
70	Explanation of Assumptions and Uncertainties	3	The constraints on relative proportions of solids appear reasonable, except that the range may be too small for the CSO and SWO sources; and some such constraints are likely required to obtain a physically meaningful fit in the face of multicollinearity.	We agree with the reviewer that the uncertainty in the EMB has not been sufficiently characterized. As recommended by Ogura (2005) we plan to address this uncertainty by running a Monte Carlo analysis, instead of adding the uncertainty term suggested by this reviewer.
68	Explanation of Assumptions and Uncertainties	3	Of possible greater concern than solids contribution is the unknown nature of pollutant concentrations in CSOs/SWOs. It is possible that watershed area constraints on CSO/SWO loads employed in the EMBM are too restrictive.	
66	Explanation of Assumptions and Uncertainties	3	The calculations to support the argument that SWO loads are a small percentage of the lower river mass balance are not documented in the report.	
176	Explanation of Assumptions and Uncertainties	3	The EMBM assumes that resuspension occurs uniformly over the entire RM0 to RM8 region. This is incorrect. Much of this area is depositional. Resuspension occurs non-uniformly over the area with some areas experiencing deep erosion while other areas have little or no erosion or even deposition. Areas where significant erosion occurs will erode sediments with higher chemical concentrations (since chemical concentrations increase with depth). A uniform erosion of a sediment layer of constant concentration is not reasonable.	The discussion of these calculations in the CSM will be clarified.
74	Explanation of Assumptions and Uncertainties	3	Uncertainties are adequately described throughout the CSM chapters.	The EMB does not assume uniform resuspension. It assumes a high degree of mixing of resuspended sediment (wherever it may originate) with the sediment originating at other source locations (tributaries, CSO/SWOs, Upper Passaic River, Newark Bay) before deposition. See response to Comment 91.
75	Explanation of Assumptions and Uncertainties	3	The impacts of the uncertainties outlined in the CSM on EMBM conclusions are not sufficiently acknowledged.	
78	Explanation of Assumptions and Uncertainties	3	The EMBM adds to our understanding of pollutant dynamics in the Lower Passaic and reinforces many of the conclusions from the CSM. The EMBM forecasts provide a useful basis for bounding the remediation problem. They do not, however, provide sufficient power or precision to serve as the primary basis for the design and implementation of a costly remediation plan.	
83	Explanation of Assumptions and Uncertainties	3	The uncertainties associated with the forecast evaluations of remedial alternatives are not adequately described. This is especially true for all statements that depend on predicted time to reach a target or asymptote, which in many cases provide a single quantitative statement of number of years despite the fact that these calculations depend on estimated half lives that are highly uncertain.	
				No response required
				The uncertainties inherent in the EMB and the forecast trajectories will be addressed

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
84	Explanation of Assumptions and Uncertainties	3	Chapter 20 and the summary in the report should both provide additional discussion of the uncertainties associated with the forecasts and the potential impacts of such uncertainties on remedial decision making.	through a Monte Carlo analysis. The final CSM text will more fully describe the uncertainties. In addition, as recommended by the peer reviewers, the CARP model will be run to confirm the future projections calculated by the EMB. The CARP model will be updated with recent data, including the high resolution cores.
148	Explanation of Assumptions and Uncertainties	3	The uncertainties are clearly large and not accounted for in the modeling. An incorrect statistical model is applied to estimating the fractional contributions. Further it is clear that the computation is very sensitive to small errors in the concentrations used (e.g. averages or medians). Therefore, where approximately ~50% of the recently deposited particles are coming from, Upper Passaic River or Newark Bay, is unclear (Page 9).	A Monte Carlo analysis of the EMB and trajectory forecasts is planned to quantify uncertainty and revisit the statistical model
187	Explanation of Assumptions and Uncertainties	3	Although all other chemicals need not be considered, the quantitative prediction of their sources by EMBM is too variable and unreliable for practical purposes.	Additional work is planned for the EMB (a Monte Carlo analysis), which will help quantify the uncertainty in the results. Specifically, a Monte Carlo analysis will be conducted using the estimated variability of the input terms and, subsequently, the results of the EMB will be validated by examining mass balances for constituents not included in the EMB using the solids balance from the EMB.
89	Explanation of Assumptions and Uncertainties	3	The EMBM assumes that the source profiles are known. The profiles are highly uncertain and considerable lumping was done to identify the number of sources.	We respectfully disagree for the major solids sources. The profiles for the Upper Passaic River and Newark Bay are very well defined. The resuspension volume is based on the results of the bathymetric analysis (Chapter 11). Other source profiles are less well-known, but constitute a small part of the entire contaminant load.
162	Explanation of Assumptions and Uncertainties	3	One way of estimating the uncertainty is to perform various analyses with slightly different inputs. To illustrate the uncertainty in the analysis and the model's sensitivity to changes in source term variables, example calculations indicate that 15% changes in variables (mean vs. median) results in about 50% change in model result.	This issue will be addressed as part of the planned Monte Carlo analysis.
12	Explanation of Assumptions and Uncertainties	3	Future predictions depend on the dating assignments of the five high resolution cores. As a group, the Cs-137 profiles on which the dating is based (Figures 13-2 and 13-3) are by no means "ideal". The activities do not in general define a single peak (1963 horizon) and little consideration is given to absolute activities (the activity in the section assigned to the 1963 time horizon in the RM 11 core is approximately double that in the RM 12.6 core (?)).	
13	Explanation of Assumptions and Uncertainties	3	To be fair, these are perhaps the best profiles that could be expected in such a dynamic sedimentary environment as documented by the historic bottom profiling analysis (Chapter 11). The dating assignments do, however lead to significant inconsistencies in the contaminant chronologies (for example, factor of 2 to 5 differences in 2,3,7,8-TCDD concentrations at the same assigned time horizons between the cores at RM 1.4 and 2.2 (Figure 13-4)) which necessarily lead to uncertainties (largely unexplored) in the Natural Recovery (No Action) projections of the EMB.	

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
15	Explanation of Assumptions and Uncertainties	3	Of considerable concern is the lack of any significant discussion/consideration of the 1984 high flow event in the Passaic River. The Figure 4-4 from a draft of the EMB apparently failed to make the final cut for inclusion in the CSM. The event of April 1984 was the most intense high flow event recorded by the USGS at Little Falls since 1936. The only recent event that approaches its magnitude occurred from April 17-19, 2007 which is more recent than the relevant sediment core collections. Deposition associated with the 1984 event has been noted in Dundee Lake, Lower Passaic River and Newark Bay cores (Bopp et al., ES&T, 1991) and as I recall, there are accounts of flooding at the 80 Lister Avenue site in April of 1984. Given the evidence of complex, relatively unpredictable patterns of deposition and erosion presented in Chapter 11, it is difficult for me to imagine that such an event had little effect on the profiles observed in the high resolution cores (as is assumed by the dating assignments) and that the possibility that some of the sites may have experienced significant erosion during that event was not considered/discussed.	While the core dating is not ideal, the dating represents the best profiles to be expected in this type of dynamic environment. Despite the possible limitations, the cores are dated well enough to give a good history of the last 20 years. In response to these comments, we will perform an extensive Monte Carlo analysis of uncertainties.
160	Explanation of Assumptions and Uncertainties	3	The reviewer would not endorse any remediation plan based on the present stage of the development of the models. These are the problems to be addressed: the contradictory estimates of TCDD half lives from the available models and the possibility of a plateau in TCDD concentrations suggesting an ongoing source or an unaccounted for mechanism.	See responses to Comments 163 through 165 and 167/169.
163	Explanation of Assumptions and Uncertainties	3	There is a lack of fit between the projections used to calculate half lives and the data. The data suggest a flattening not accounted for in the projection.	The flattening or biphasic behavior of the high resolution core data was noted. However, the use of a simpler exponential curve fit was deemed more conservative since it causes the natural reduction in concentration to be greater, reducing the effect of remediation on the sediment concentrations. By using the exponential equation, we avoid over-selling the remediation strategies. That the forecasts show such significant improvements in many contaminants (even with the more conservative trend line) highlights the advantages of remediation (which must be greater than that seen in the plots).
164	Explanation of Assumptions and Uncertainties	3	A bi-phasic projection fits the data better, so that TCDD has an early 6-year half life and a later flat period, and total PCB has a fast (5yr) and slow (35 yr) half life.	
165	Explanation of Assumptions and Uncertainties	3	The fit of the bi-phasic curves suggest that there is a more complex system than can be accommodated with the first-order exponential, so it should be abandoned as insufficient.	
167	Explanation of Assumptions and Uncertainties	3	The CARP model predicts that sediments should recover much more quickly than predicted by the CSM. The Half life of TCDD predicted by CARP is 10 years.	In response to this comment, we plan to refine the EMB and its uncertainty using a Monte Carlo analysis. Also, in response to the recommendation from the peer reviewers, we are updating the CARP model with Passaic-River-specific data and parameterization, and running it to confirm the future projections calculated by the EMB. The CARP model will be updated with recent data, including the high resolution cores.
169	Explanation of Assumptions and Uncertainties	3	CARP predicted a 10-year half life for TCDD. This needs to be reconciled with the plateauing observed in the high resolution core data.	
29	Explanation of Assumptions and Uncertainties	3	The reviewer indicates that an "evolution of exponentials" has taken place in the analysis of persistent contaminants and radionuclide tracers. The half-lives have been increasing. The reviewer provides data from the Hudson River basin to support this statement.	
31	Explanation of Assumptions and Uncertainties	3	The reviewer indicates that the section of the time trend referred to by Dominic DiToro as an "early, more rapidly declining" section, includes the high flow event of 1984 that was not mentioned in the CSM.	

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
32	Explanation of Assumptions and Uncertainties	3	The reviewer calls attention to conflicts in comments made by Dominic DiToro's discussion of the half-lives presented in the CSM for dioxin (2,3,7,8-TCDD). At some points he suggests a larger half-life for dioxin to account for an unknown source, but at other points, he suggests a 10-year half-life which will cause a faster decline. Reviewer asks how CARP results can be reconciled with high resolution core data/observations.	We concur with these observations. In accordance with the recommendation of the peer reviewers, we are updating the CARP model with Passaic-River-specific data and parameterization, and running it to confirm the future projections calculated by the EMB. CARP results will be reconciled with the data provided by the high resolution cores.
172	Explanation of Assumptions and Uncertainties	3	There is no direct evidence for a well-mixed layer due to bioturbation. In the Passaic, remediation after dredging and capping all erosional areas will be primarily due to deposition of clean sediments from upstream. This deposition is on the order of 2 inches/year and is much greater than the potential effects of organisms and molecular diffusion. This indicates remediation after dredging and capping will be on the order of a year or a few years at most. But since dredging and capping will take on the order of 10 years, this remediation time is almost negligible by comparison.	The reviewer questions the existence of a well-mixed layer due to inferred absence of efficiently robust biological processes. In contrast, in this analysis, a mixed layer construct was used to represent the hydrodynamically-driven movement of the active inventory of sediments in the river (i.e., due to physical not biological processes). It is the movement of this active inventory (depicted by the dynamics seen in bathymetric change analysis) that determines the rate of the recovery from legacy contamination. Because erosional areas based on bathymetric change analysis were randomly distributed and occurred at various locations over time, representing this active inventory as a mixed layer was the only way to perform the analysis within this modeling framework. Note also that the reviewer's description of deposition on the order of 2 inches/year only applies to RM0-2, as shown in the CSM.
80	Explanation of Assumptions and Uncertainties	3	Uncertainty in the EMBM propagates into the forecast concentration through estimation of the mixing depth. Bioturbation alone cannot provide a mixing mechanism to a depth of 6 inches. Hydrodynamic scour and redeposition are likely experienced to a greater depth in most areas. Even so, a smaller mixed depth (not to be called bioturbation depth) should be used for the forecasts. The effect of reducing the mixed depth is to make both remediated and unremediated areas asymptote more quickly to the current year estimate of total loads.	In reality, reducing the thickness of the bioturbation/hydrodynamically mixed layer serves to recreate a contaminated surface layer in much less time. This is because the upper layer of the cap serves as a diluent for recently deposited material that still bears some dioxin contamination from above RM8.
177	Explanation of Assumptions and Uncertainties	3	Model forecasts predict that remediation will be proportional to the amount of surficial sediment dredged and capped. This is incorrect. For example, dredging and capping sediments in a depositional area will do little to reduce contamination in the LPR.	Because multiple bathymetric studies show that depositional and erosional areas are neither stable nor static from year to year, it would be impossible to find a discrete depositional (or erosional) area to remediate. Therefore, all alternatives evaluated in the Focused Feasibility Study are based on remediation of the sediments of the entire lower eight miles of the river.
14	Explanation of Assumptions and Uncertainties	3	2,3,7,8 TCDD is arguably the contaminant of greatest concern. The "exponential trend line" from 1980 to 2006 shows a best fit half life of 25 years. To my eye, the data could be reasonably "fit" with half lives between 10 and about 40 years (!?). Where is the uncertainty estimation? Furthermore, it seems clear from that figure that the RM 11 and 7.8 points tend to fall above the plotted "exponential trend line" while the RM 1.4 and 12.6 points tend to fall below. This pattern is not particularly consistent among contaminants (although the RM 12.6 points are generally relatively low), but it does seem to warrant further consideration/explanation as a source of uncertainty.	

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
82	Explanation of Assumptions and Uncertainties	3	Uncertainty in the EMBM propagates into the forecast concentration through estimation of half lives. The comparison between remedial options depends critically on the estimated half life. It is therefore somewhat disturbing to see the high levels of uncertainty present in the half-life estimates. In particular, for 2,3,7,8-TCDD, which is the major contributor to risk, the R2 value cited for the half-life regression is only 0.19, and values for several other compounds are not much better. The relatively poor fit appears to be a direct result of the simplifying assumption that concentrations are longitudinally mixed throughout the Lower Passaic below RM 12. But the cores do not represent longitudinally constant conditions, and lumping the different cores together obscures the underlying trend in individual cores. An analysis of core trajectories suggests that the assumption of a single half-life across the entire Lower Passaic may not be reasonable.	Using the uncertainty output from the statistical analysis which resulted in the half-life, we plan to apply a distribution to the half-life in a Monte Carlo analysis of the forecasts. This will compensate for some of the scatter in the data and will quantify the uncertainty in the half-life calculations and show their effect on the results.
81	Explanation of Assumptions and Uncertainties	3	The half-lives are based on logarithmic regression through dated core segments (after 1980 only) in the Lower Passaic, after correction for the estimated portion of the load due to external sources. Source concentrations in Northern Newark Bay (which lacks recent high resolution cores) are assumed to decline at the same rate as the resuspension source in the Lower Passaic River – an assumption that is cited as “rational, and perhaps conservative.” I am not sure the selection is rational, as the Northern Newark Bay source is conceived of as active surface sediments, while the Lower Passaic River resuspension source is supposed to represent buried legacy contaminant mass in place since ca. 1995, but there do not seem to be data to support an alternative.	We agree with the point made by the reviewer. The assumption made is the best option given the available information; no alternative constructs are reasonably arrived at.
38	Explanation of Assumptions and Uncertainties	3	The forecast trajectory assumption that "the impact of any remedy on resuspension is proportional to the fraction of fine-grained area impacted by the remediation scenario" is not clear to the reviewer.	Additional discussion to the CSM will be added to clarify the forecast assumptions
39	Explanation of Assumptions and Uncertainties	3	It is unreasonable to assume no future changes to sedimentation rates (forecast trajectory assumption). A more detailed sediment transport model might be needed to address this issue.	We agree with the reviewer. In all likelihood, any active remediation scenario will include deepening of the river to allow for sufficient flood-carrying capacity or for reasonably-anticipated future navigational use. This would increase sedimentation rates and specifically increase the amount of solids captured from external loads. Thus, the future trajectories forecast by the EMB likely underestimate the rate of recovery due to active remediation for contaminants dominated by resuspension of legacy sediments (e.g., 2,3,7,8-TCDD and total PCBs). A detailed sediment transport model has been developed and calibrated for the Lower Passaic River and Newark Bay. It is being incorporated in the CARP model that is being run to confirm the future projections of the EMB. The CARP model will be updated with recent data, including the high resolution cores.
40	Explanation of Assumptions and Uncertainties	3	The reviewer questions the assumption that "following remediation, surface sediment concentrations in unremediated areas will continue to decline exponentially with the same half life values from 2018 onward." There is no reason to remediate if the benefits of remediation don't extend outside the immediate area.	We believe that this was a conservative assumption. Without any way to estimate the change in resuspension source term above RM8, we did assume that the source would continue to decline along the same trajectory. However, the unremediated areas do receive a benefit from the remediation in the calculation of the 0-6 inch layer concentration. Thus, the benefits of the remedy are propagated above RM8, although in a conservative fashion.
41	Explanation of Assumptions and Uncertainties	3	The assumption that resuspension from the cap will initially be zero and then linearly increase until it matches the resuspension rate from non-remediated areas is tenuous and difficult to follow. Does this mean there will be resuspension from depositional areas?	Based on our bathymetric analysis (Chapter 11), we have not been able to identify any large areas that are exclusively depositional. This comment refers to the assumption that after the 6-inch mixed layer has been deposited, resuspension per unit area will be the same in remediated and unremediated areas. We will clarify the explanation in the final CSM.

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
42	Explanation of Assumptions and Uncertainties	3	It is too conservative to assume there will be no improvements in the source concentrations. Remediation will affect the resuspension concentrations above RM8 and Newark Bay sediments will be diluted by the Kills.	We agree with the premise of this comment that the approach in the EMB is conservative. While we may have been able to speculate for more rapid rates of recovery for the various end members, we felt that this speculation would not be defensible and that this conservative approach would avoid over-selling the remedy. In response to the recommendation of the peer reviewers, we are using the CARP model to confirm the future projections of the EMB. As a mechanistic model, CARP incorporates specific physical processes to simulate the effect of the remediation on resuspension concentrations above RM8 and in Newark Bay as diluted by the Kills.
16	Explanation of Assumptions and Uncertainties	3	The “best fit” half times for Natural Recovery (No Action) determined from the EMB are highly uncertain. However, the general conclusion that levels of all contaminants (except perhaps dieldrin) are decreasing rather slowly over time is very well supported by the data analysis and consistent with expectations based on particle and contaminant source analysis.	No response required.
17	Explanation of Assumptions and Uncertainties	3	The general projections of surface sediment trends following remediation portrayed in the figures in Chapter 20 (i.e. dramatic initial improvement followed by some degradation as a result of sources uncontrolled by the remedial efforts) is most likely and highly defensible on the basis of simple, rational analysis of the generally excellent data that was collected on a well-chosen suite of samples.	
77	Explanation of Assumptions and Uncertainties	3	In general, the EMBM forecasts appear fairly robust to the effects of altered source fractions or recalculated half life, while the mixing depth assumption primarily impacts the partial remediation scenario.	
18	Explanation of Assumptions and Uncertainties	4	Most importantly from the reviewer's perspective, the very well documented complex nature of sedimentation along the lower 12 miles of the Passaic compounded by our inability to reliably predict the occurrence and/or effect of major high flow events such as those in 1984 and 2007, makes it highly unlikely that additional efforts at complex modeling (either extending or refining the EMB or invoking more complex models such as CARP) would be particularly useful.	We appreciate the perspective of this reviewer. However, based on the recommendation of all of the other peer reviewers, we plan to use the CARP model as another line of evidence to confirm the future projections calculated by the EMB.
99	Explanation of Assumptions and Uncertainties	4	The general use of a receptor model to evaluate source contributions as one among multiple lines of evidence is sufficiently justified in the report. However, too much precision has been attributed to the results of the EMBM application and uncertainties associated with EMBM forecasts have not been fully acknowledged.	The final CSM will include additional discussion of the EMB uncertainties and will present the results of a Monte Carlo analysis of the EMB.
149	Explanation of Assumptions and Uncertainties	4	No. The reviewer is mystified by the neglect of the CARP model. At least it is mechanistic and it is calibrated using long term hind casts (Pages 37-49). The two models used in the CSM, the one segment steady state EMB and the single exponential, are simply too crude and unconvincing to be of any real use.	Based on the recommendation of the peer reviewers, we are updating the CARP model with Passaic-River-specific data and parameterization, and running it to confirm the future projections calculated by the EMB. The CARP model will be updated with recent data, including the high resolution cores.
33	Explanation of Assumptions and Uncertainties	4	The reviewer indicates that the CARP hindcast may not be useful for the purposes of this CSM. The input for Cs-137 is dominantly to drainage basin soils, while many of the COCs are input directly to the river. Thus Cs-137 is not an ideal tracer for the Passaic contaminants.	
34	Explanation of Assumptions and Uncertainties	4	The reviewer indicates that he was not happy with the CARP Cs-137 hindcast results. At his request a more detailed CARP hindcast was performed, but two additional suggestions for additional hindcasting were not acted upon.	
35	Explanation of Assumptions and Uncertainties	4	The reviewer disputes Dominic DiToro's observation that the CARP model predicts a relatively rapid response that is reflected in the Cs data. The reviewer indicates that the half-life of Cs-137 has been increasing. The reviewer presents Cs-137 data from NY Harbor and indicates that this should not be projected forward using a rapid response (half-life of about 10 years).	

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
182	Explanation of Assumptions and Uncertainties	4	Use hydrodynamic (ECOM) and sediment transport (SEDZLJ) models to calculate potentially erodible areas in the entire LPR for a wide range of hydrodynamic conditions, e.g., high flows, high tides, especially conditions after low flow periods during which sediments can deposit and accumulate. Finer grid sizes than now used across the river are probably necessary to delineate erosion/deposition areas more accurately so as to guide dredging/capping.	A fine-grid sediment transport model based on SEDZLJ was developed and calibrated for the Lower Passaic River-Newark Bay. It is being used to evaluate various remediation options in the Focused Feasibility Study, including surgical capping of discrete erosional areas, application of a thin layer cap and short-term dredging impacts among others.
129	Explanation of Assumptions and Uncertainties	4	The use of a receptor model in this system such as the EMB with modifications is fine as long as there are some alternate evaluations of contributions of contaminants from these sources. These alternate estimates can be simple products of flow and concentrations of contaminants and suspended solids. The reviewer looked for suspended solids concentrations in the water column but couldn't find any.	We recognize the value in this suggestion, but we feel that we have addressed this by using integrating samples that represent long-term averages rather than building up a database of many short-term samples to accomplish the same end.
100	Explanation of Assumptions and Uncertainties	5	The premise that atmospheric deposition and groundwater flux (separate from resuspension) are negligible contributors to the total mass balance of most pollutants under current conditions is generally credible.	No response required.
150	Explanation of Assumptions and Uncertainties	5	<On premise that loads from atmospheric deposition and groundwater can be considered negligible>: This is the common assumption but I did not see any direct evidence. This is a difficult issue. The plateau in TCDD concentration is suggestive of something like a diffuse, continuous source.	The evidence for this inference is found in Chapter 9. We will revisit this chapter to ensure that the evidence is clearly presented.
79	Explanation of Assumptions and Uncertainties	5	Atmospheric deposition is not the major source of many of the contaminants in the Lower Passaic – but this does not mean that it does not play a role in the mass balance of contaminants, particularly in the evaluation of future conditions as in situ regeneration of loads declines. Near-field combustion sources of PAHs via atmospheric deposition might be of particular importance, but are not discussed here, despite the fact that PAHs are included in the EMBM fit.	Even if the river is cleaned up to the point where atmospheric deposition is the greatest source of PAH (or another contaminant), the area of the river is still insignificant compared to the area of the watershed. Thus the majority of the atmospheric deposition would still reach the river through runoff (SWOs and tributaries) not through direct deposition. These SWOs and tributary inputs capture the atmospheric deposition to the watershed as a whole. Only the atmospheric deposition directly to the river surface itself was considered negligible in the CSM.
101	Explanation of Assumptions and Uncertainties	5	Additional discussion should be provided as to why atmospheric deposition can continue to be considered negligible in the lower-loading conditions after remediation.	
54	Explanation of Assumptions and Uncertainties	5	I am not worried by uncertainties surrounding external sources from storm/waste water/atmosphere and groundwater. The advective term (in groundwater) is trivial, especially in the face of high deposition. Diffusive fluxes would be much more significant using most model formulations, but the depositional nature of this system, combined with the obvious utility of the EMB suggests that in the lower Passaic it may not be serious to neglect it.	The Reible model, which was used to analyze the possible contribution of pore water to contamination in the Lower Passaic River, included advective and diffusive flux. Because the pore water seepage velocity was so large (conservative), advective flux was found to be more important than the diffusive flux. In any case, the combined impact of advective and diffusive flux was found to be negligible compared to other sources of contamination to the river.
110	Explanation of Assumptions and Uncertainties	5	The discussion of the pore water boundary contribution in Chapter 9, using the Reible model, concludes that this is not a major source of contaminant flux to the river. The conclusion appears reasonable; however, there are problems with the way the argument is made. The Reible approach evaluates equilibrium partitioning between sediment and pore water, then uses the pore water velocity and sediment area to calculate load to the water column. The seepage velocity is a key parameter here. Apparently areal groundwater discharge rates were estimated by base flow separation, then applied to the Passaic River direct drainage (the calculations are not given in detail). It seems clear that this approach will drastically overestimate seepage velocity through contaminated fine-grained sediments, because (1) groundwater discharge will occur predominantly through coarse-grained sand lenses, and (2) a significant portion of the total groundwater discharge from the direct drainage is likely intercepted by the storm water conveyance system in this relatively flat topography.	Additional discussion will be added to the CSM to clarify this issue. The calculation of the seepage velocity will also be presented. The calculation of the seepage velocity included weighting values to account for the fact that much of the seepage will be through the coarse-grained sediments, which are not expected to be contaminated. Further, the base flow was estimated using a nearby watershed (Elizabeth River) which is expected to have a similar proportion of its recharge intercepted by storm water conveyance. This same base flow (calculated as a depth) was applied to the LPR watershed as a depth and then converted to a volume using the area of the LPR watershed. Thus the loss due to storm water system is accounted for. However, we agree that the seepage velocity is likely to be overestimated. The model results indicate a miniscule portion of the contamination coming from pore water even with the highly conservative input parameters. Thus, we conclude that pore water is not important to the overall mass balance.

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
130	Explanation of Assumptions and Uncertainties	5	I believe the atmospheric input is negligible. During combined sewer overflows in Milwaukee, we found that up to 8 % of the flow came from groundwater.	Our calculations indicate that while a portion of the flow may come from groundwater, most of the groundwater will pass through coarse-grained lenses, where it cannot pick up contamination. Despite the results in Milwaukee, our calculations and modeling presented in Chapter 9 indicate no effect of groundwater on the contamination level in this river.
102	Explanation of Assumptions and Uncertainties	6	The receptor model approach assumes that the different source area profiles are independent of one another. This is commonly stated as a requirement for receptor models, as correlation between profiles can interfere with solution of the inverse problem, and may refer to either time series inputs or pollutant spectra. In the case of the Passaic the receptor model application is steady state, so the potential issue is correlation among the pollutant spectra. For example, the mercury concentration in one source should not be fully predictable from the TCDD concentration and the relationship between TCDD and mercury in another source. In fact, complete independence of source profiles is not required to solve such problems; rather, they must not be exactly correlated, as that would cause a situation in which the inverse problem does not have a unique solution (because the transfer matrix cannot be inverted). Presence of partial correlation will cause problems, but not preclude a solution.	We agree with the reviewer. While complete independence is not feasible, the analysis conducted to select the chemicals included in the EMB was intended to minimize the amount of correlation in the source profiles, and allow for a stable solution of the regression problem.
131	Explanation of Assumptions and Uncertainties	6	It is difficult to judge the independence assumption based on Tables 18-6 – 18-8. For example, PCB concentrations do seem higher in Saddle River than in Third and Second Rivers. A sensitivity analysis using Monte Carlo variations of each profile would help answer this question. Also you should compare the source profiles in linear or log plots.	A Monte Carlo analysis of the EMB is planned.
151	Explanation of Assumptions and Uncertainties	6	The reviewer is not sure what “independent” means. The use of sediment cores to infer loadings is sometimes necessary for historical loadings. However they are no substitute for actual loading measurements.	"Independence" was used to describe the analysis conducted to select the chemicals included in the EMB such that the correlation in the source profiles was minimized to allow for a stable solution of the regression problem (see also response to comment 102). The CSM explains how dated cores are used to infer historical loadings (see Chapter 13 of Comprehensive CSM). Sediment cores were used to provide a record of loadings over the past several decades, because actual loading measurements in those same past decades were not available.
106	Explanation of Assumptions and Uncertainties	7	The Base Case EMBM results reported in Table 19-2 do not appear to be correct and do not entirely match the electronic file. Table 19-2 indicates fractions that sum to 97.1%. Also, the ratio of CSO to Dundee Dam (Upper Passaic) is 0.0136, which violates the constraint stated in Equation 18-4d. The electronic file, which appears to match Figure 19-2 (but not Table 19-2), gives the fractions a bit differently – and does meet all the stated constraints. This set of parameters yields an objective function value of 0.385 (incorrectly labeled “Chi square”, as noted above). The Excel Solver will not improve the model from this point – but the supposed fit can readily be shown not to be a global minimum. Holding all but the first two components (resuspension and Dundee Dam) constant, a better fit, with objective function value of 0.371, is readily obtained with 43.5% resuspension and 29.% Newark Bay (Figure 1). All constraints stated in the text are met with this revised solution.	
107	Explanation of Assumptions and Uncertainties	7	Why the Crystal Ball application failed to find a better fit (at least as good as the one shown above) is unclear and needs to be explained.	

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
108	Explanation of Assumptions and Uncertainties	7	A fit to the same set of variables used in the base case that minimizes chi-square error (rather than mean-normalized error) while meeting the stated constraints yields rather different results, with 37.3% from resuspension, 37.1% from Newark Bay, and 20.9% from Upper Passaic River. As expected, this fit de-emphasizes TCDD (reviewer Figure 2). One way to evaluate the impacts of regressor uncertainty on the EMBM results would be to do a comprehensive Monte Carlo simulation, in which the regressor concentrations are either generated from statistical distributions or obtained by bootstrap resampling from the data.	A minor difference (rounded values) between the spreadsheet used to create Table 19-2 and the spreadsheet provided to the peer reviewers resulted in these differences. The 0.385 objective function value was based on an optimization using Excel SOLVER (which has been criticized for finding local minima). Using Crystal Ball (which has been found to be a more robust optimizer) the optimized solution (using the values in the spreadsheet provided to the peer reviewers) had an objective function value of 0.349, a significant improvement over the result presented by this reviewer. All constraints are met with this solution. Thus, there is no known issue with Crystal Ball's solution technique and the concerns raised here are caused by rounding errors. A Monte Carlo analysis is planned, which will help quantify the uncertainty in the model and the sensitivity of the output to changes in input parameters.
109	Explanation of Assumptions and Uncertainties	7	Exploration of the model response surface reveals a difficult optimization problem, in which the Excel Solver gradient approach tends to become trapped in local minima. In part, this may be due to the constraint that the sum of the factors exactly equal 1. Parameter uncertainty and correlation introduced by multicollinearity in the source data also likely plays a role.	
86	Explanation of Assumptions and Uncertainties	7	Consideration of a single receptor site is problematic because it is actually an average over 10 miles of river, with evident variability and spatial trends in the Lower Passaic.	The CSM presents the evidence that the variation in RM2-12 is minimal. The use of several cells in the single-layer box model associated with the EMB would increase significantly the degrees of freedom in the model, perhaps prohibitively. A Monte Carlo analysis of the EMB is planned, which will allow a better estimate of uncertainty in the model. In addition, in response to the recommendation of the peer reviewers, the CARP model is being run to confirm the future projections calculated by the EMB's box model. The CARP model divides the Lower Passaic River and Newark Bay into several cells laterally and longitudinally, allowing more than one receptor and source to be considered.
85	Explanation of Assumptions and Uncertainties	7	The definition of the key internal resuspension source is particularly uncertain. In fact, every deposition area within the Lower Passaic is a somewhat different receptor, and ever eroding hotspot is a separate source. Obviously, analytical complexity precludes distinguishing all these different receptors and sources; however, the analysis could have been done in a variety of different ways -- for instance by subsetting the length of the Lower Passaic into more than one receptor (and more than one source) and solving the model using a multivariate approach.	
94	Explanation of Assumptions and Uncertainties	7	Significant loads are most likely from areas that have recently shifted from a depositional to erosional status, perhaps from lateral migration of the channel thalweg. It seems likely that the major resuspension load source areas change over time, although the average rate of resuspension loading across the entire Lower Passaic River may be approximately constant. The spatially averaged EMBM approach is not capable of evaluating remedial options at a finer spatial scale than the entire length of the Lower Passaic below RM12 or some specified fraction of that reach based on the assumption of complete longitudinal mixing.	Multiple bathymetric surveys show that erosional and depositional areas shift unpredictably from year to year, so that it would be impossible to find a discrete erosional area to remediate. In addition, high concentrations of dioxin and other contaminants exist throughout the surface sediments of RM0-8, so that targeted remediation aimed at cutting off the source of contamination would fail to address the high levels of risk that exist throughout RM0-8. For this reason, the FFS evaluates remedial alternatives that encompass the sediments in RM0-8. However, as recommended by the peer reviewers, a fine-grid sediment transport model based on SEDZL-J is being run to investigate the possibility of focused remediation of discrete erosional areas
47	Explanation of Assumptions and Uncertainties	7	The assumption that all COPCs are perfectly conservative particle tracers is probably useful in this sediment transport dominated system for many of the contaminants -- best for TCDD, PAHs that are associated with particles in "resistant" phases or they would not be there or last, some more chlorinated PCBs, DDE or sum of DDT residues, and more particle reactive metals Pb, Cu and Hg being the best. The inclusion of Cd, Zn, As, Cr, Co in the EMB may not be a good idea because they can be more soluble depending on the chemistry of the water and the sediments (ex. Cd, Zn, As are primarily in the dissolved phase in sea water.) The fact that the EMB works so well with these metals may indicate poor constraints on the model. The bottom line is I do worry to an extent about neglecting the dissolved phase/particle-solution exchange may bias the EMB - but the calculations make reasonable sense and are constrained by other bathymetry and sediment load data. This approach (EMB) actually works better than what one would get in a model including exchange between particulate and dissolved/colloidal phases.	Of these metals, only chromium was used in the optimization routine of the EMB. The other metals cited were not used in the model solution, but their sources were estimated from the EMB results. Because these contaminants do not show gradients in the LPR and especially because their ratios to iron are constant, it would appear that their particle concentrations are largely independent of aqueous changes. This might suggest the presence of sulfide-bearing sediments, which would be consistent with the observations of the organic-rich, reducing conditions of the Lower Passaic River sediments.
48	Explanation of Assumptions and Uncertainties	7	What are the effects of TOC and Fe on the EMB results? More testing and refinement of the EMB would lend greater confidence in the results.	The planned Monte Carlo analysis of the EMB will help quantify the uncertainty and determine the effects of TOC and Fe on the results

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
88	Explanation of Assumptions and Uncertainties	7	Targets for the receptor analysis were selected via a cluster analysis to identify independent contaminants that “provide a relatively unique pattern for each of the various sources.” This is a necessary step to reduce multicollinearity, but also contains subjective components that may influence model results. In theory, the EMBM is predicting only solid-phase transport. One identified cluster of PAH compounds “was not included because it contained mostly 2- and 3-ring PAH compounds, which likely have significant dissolved phase concentrations.” Some other constituents may also have significant non-solids phases, such as mercury, TOC, and PBCs sorbed to DOC in the water column.	The EMB focused on contaminants that were highly particle-bound in aquatic systems, to serve as tracers for sediment transport. Although there is some dissolved phase for some of the constituents, this phase is assumed to be in equilibrium with concentrations on the particles, and it is likely not significant with respect to changing the particulate chemistry in the Lower Passaic River. The fact that the EMB can explain the mass balance of Hg and TOC, for example, within 20 percent, supports the inference that any dissolved phase transport is small and cannot substantively change the chemistry of the particles in the Lower Passaic River. Thus, the EMB formulation adequately describes gross particle behavior in the system.
126	Explanation of Assumptions and Uncertainties	7	The EMB as applied to the Lower Passaic River, the expression for the tracer concentration Y_i , eq. 18-2 should contain an error term e_i .	
127	Explanation of Assumptions and Uncertainties	7	For the EMB, the weighted variance expression, eq. 18-3 must reflect the errors of the source profiles X_{ij} where i and j represent the i th chemical and the j th source.	
87	Explanation of Assumptions and Uncertainties	7	Equation 18-2 presents the model as: ((SEE COMMENTS FOR EQUATION)) where Y_i is the receptor concentration of constituent i , f_j is the fraction contributed by the j th source, and X_{ij} is the concentration of constituent i in the j th source. This simplistic presentation ignores the presence of measurement uncertainty in both the Y and X . The uncertainty in the Y_i implies that the receptor model should properly be written with a disturbance term as ((SEE COMMENTS FOR EQUATION)), from which it is evident that the receptor model is actually a multiple linear regression problem – as is acknowledged through proposed use of a chi-square fit criterion in the parameter optimization.	
104	Explanation of Assumptions and Uncertainties	7	There are considerable uncertainties in the source (regressor) terms, the X_{ij} (refers to equations in Bu-28). Stochastic regressors can cause problems with chi-square optimization. In general, if the disturbances in the regressors are independent of the disturbances in the receptor measurements no bias is introduced; however, if the disturbances in the regressors are correlated with the disturbances in the receptor measurements the resulting fit may exhibit systematic biases, because some of the disturbance-generated variation of the dependent variable is incorrectly ‘credited’ to the regressor with which that disturbance is correlated. For example, if the estimated value of the receptor mean concentrations are overestimated relative to the true average (due to choice of sampling locations, for instance), then too much weight will be assigned to sources whose strength is also over-estimated.	
103	Explanation of Assumptions and Uncertainties	7	There are some significant potential problems with the mathematical implementation of the EMBM. Fitting is to mean-normalized squared errors, not chi-square as stated, which weights the fit to contaminants that have a low concentration instead of toward those with high precision. The solution presented does not appear to be the optimal solution, and model results are sensitive to small changes in assumptions.	

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105	Explanation of Assumptions and Uncertainties	7	Fitting of the EMBM is done through numerical optimization, rather than solution of normal equations for the regression problem, but is subject to the same problems: 1) high variability in source terms results in high uncertainty in estimated values of f; 2) solution may be impacted by heteroscedasticity. If the disturbances in measurements are positively scale-dependent, then a chi-square fitting procedure will tend to exaggerate the effect on the fit of disturbances in larger observed concentrations. A log transformation might improve the model fit approach. The approach on p.18-6 (implies that chi-square optimization was not used) is an incorrect response to this problem. Instead, suitable data transformations should have first been used to reduce the scale-dependence of the disturbance term. Each chi square term in the summation has been multiplied through by the square of the CV, as $CV = \sigma/\mu$. This has the effect of weighting the fit toward those constituents that have a lower concentration rather than lower variance. Approach taken leads one to suspect that fit was purposely weighted toward TCDD.	Our formulation method is from Ogura, 2005. It is planned to add the error term to the equation as suggested by the reviewer. A planned Monte Carlo analysis will address the uncertainty in the source terms.
128	Explanation of Assumptions and Uncertainties	7	In order to have a statistically valid solution one must require that the chi-squared value is comparable to the degrees of freedom df.	
152	Explanation of Assumptions and Uncertainties	7	The statistical formulation (Eq. 3 in Evaluating the Modeling Frameworks) is not appropriate. The Errors in Variables formulation (Eq. 4) is what is required. Furthermore, it is assumed that Be-7 containing particles can be treated as though they are water column particles. This needs to be justified by direct measurements. Finally the steady state assumption needs testing, as well as the implicit assumption of irreversible sorption.	The formulation of the equations comes from Ogura, 2005 See Section 14.5 for a rationale for the assumption that Be-7 sediments have concentrations similar to those found on the suspended sediment in the water column. The constant concentrations of almost all contaminants along the river's length as well as their constancy when normalized to iron indicates that the dissolved and sorbed portions of these contaminants are in equilibrium. Thus, dissolution does not remove contaminants from their sorbed state.
133	Explanation of Assumptions and Uncertainties	7	In applying the EMB to the Lower Passaic River, the reviewer questions the role of the suspended sediments (eq. 18-1). While the sources including the Upper Passaic River, Newark Bay, Saddle River, Third River, Second River and SWOs, and CSOs make sense, the reviewer believes that the suspended sediment category should belong to the surface sediment receptor category.	These comments reflect a misunderstanding relative to the EMB formulation, as acknowledged by Dr. Christensen during the 7/9/08 final conference call with the peer reviewers.
137	Explanation of Assumptions and Uncertainties	7	The resuspended sediment should be classified as a receptor not as a source.	
58	Clarity and Correctness of Data Evaluations	8	The EMB is sufficient for this purpose and done very well in a system that is especially amenable to this approach. The importance of internal cycling (resuspension term) of TCDD cannot be explained easily otherwise. Differences in the assumptions/parameters in the EMB and the resulting model fits would affect other conclusions but the very high percentage of TCDD load calculated to be from local sources is one prediction that is not at all sensitive to the calculation - without a missing higher concentration source - there can be no other result from this calculation.	No response required.
134	Clarity and Correctness of Data Evaluations	8	Surface sediment and suspended sediment should belong to the same category, that is the receptor. Regarding local variations, one should look for individual partially protected sites, if any, where pollution may be high due to former manufactured gas plants, certain industries, etc.	In general, we have observed very little evidence for partially protected sites, except for an area near two cores in the immediate vicinity of the 80 Lister Avenue site with extremely high dioxin concentrations at depth; sediments represented by these cores are being addressed as part of a non-time critical removal by Occidental Chemical Corp under a June 2008 Administrative Order on Consent.

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20	Clarity and Correctness of Data Evaluations	8	The reviewer finds the relevant plots (Figure 14-4) most convincing to an uncertainty of a factor of 2 or 3 (consistent with uncertainty in the EMB). Consequently, from a modeling and remediation perspective, he tends to agree (that recently deposited sediments from RM2-12 are sufficiently similar that they can be represented by an average concentration relative to external sources), however, from a geochemical perspective, he has several concerns. For example, the highest levels of dieldrin (by about a factor of 5) in the high resolution cores occur at RM 11 and 12.6 (although significantly “offset” in time based on current dating assignments) and do not appear to have “mixed” downstream. A similar situation exists for the “second source” 2,3,7,8-TCDD noted in the upper sections of those two cores (page 13-6) discussed above.	In 2007, surface sediments were collected at the high resolution core locations sampled in 2005, to update the core profiles with recent data. The 2007 surface sediments at RM11 and 12.6 show that sediments in those areas have returned or are on their way to returning to similar concentrations as observed in RM2-10. In addition, the CSM shows that the inventory of fine-grained sediments above RM8 is too small for recontamination to be a significant mechanism for transport of contaminants from RM8-17 to RM0-8, even if temporarily elevated concentrations are observed in RM8-17.
21	Clarity and Correctness of Data Evaluations	8	The salt-front penetration arguments for tidally driven upstream sediment transport and contaminant mixing (Chapter 10) is rather weak. If the extent of upstream particle transport/mixing is deemed to be critical information, the best approach would be additional exploitation of particle-reactive geochemical tracers. As discussed above, DDT-related compounds derived from production at 80 Lister Avenue have potential as tracers of at the “downstream end,” as does hexachlorobenzene (based on the PhD thesis of Damon Chaky that has been shared with Malcolm Pirnie). As tracers of “upstream” particles entering over the Dundee Dam, the composition of the persistent flame-retardant chemicals, PBDEs (PhD thesis and draft ms of Luci Benedict) and perhaps alkylphenol ethoxylates or other surfactant chemicals that Bruce Brownawell is working on have significant potential.	The extent of upstream sediment transport and mixing is being investigated using a fine-grid hydrodynamic and sediment transport model (based on SEDZL-J), as recommended by the peer reviewers.
111	Clarity and Correctness of Data Evaluations	8	Representation of recently deposited sediments between RM2 and RM12 as fully mixed is somewhat problematic as there do appear to be consistent spatial gradients. These internal gradients are sufficiently small relative to the external sources and end members that use of a receptor model, based on average concentrations, is acceptable as a means of investigating the overall mass balance of pollutants in the Lower Passaic. This simplification does create problems for evaluating and comparing remedial scenarios.	We concur with this statement, in general. However, we feel that the bathymetric evidence provides another line of support to the conclusion that no limited areal remediation would work. Specifically (as noted in response to comment 94), all areas have similar, but locally heterogeneous and temporally variable rates of erosion and deposition.
154	Clarity and Correctness of Data Evaluations	8	The top 6 inch data is highly variable. The Be-7 tagged TCDD concentrations are reasonably uniform. The model assumes that both are uniform. Is this reasonable? The reviewer thinks not. But why do it that way? Models that can actually take the spatial inhomogeneity into account are being developed. The CARP model is available now for use in at least exploring the consequences of varying concentrations.	Although there is high variability in the top 6 inch data, there are no discernable trends or hotspots in the river. Variation in the 6-inch data is expected because it covers a variety of erosional and depositional areas where sediments deposited in different eras are exposed. The EMB and forecasts are based on the idea that erosional areas cover a wide range of concentration levels and that as they deposit out of the water column, river sediments are mixed along the length. As recommended by the peer reviewers, the CARP model is being used to confirm the future projections calculated by the EMB. The CARP model grid is being refined to explore spatial heterogeneity in the Passaic River.
22	Clarity and Correctness of Data Evaluations	8	The reviewer finds this most important assertion to be very well supported by the data and analysis. [Assertion: Approximately 95% of the dioxin (NOTE: I assume that the assertion meant to say 2,3,7,8-TCDD) currently accumulating in the recently-deposited sediments on the river bottom is due to resuspension and subsequent deposition of the bedded legacy sediments; i.e. an internal source is driving the dioxin (2,3,7,8-TCDD) concentration in recently deposited sediments.]	No response required.
112	Clarity and Correctness of Data Evaluations	8	The finding that the majority of the dioxin currently accumulating in the recently-deposited sediments is derived from resuspension of legacy sediments is supported by multiple lines of evidence. Due to uncertainties in the EMBM formulation, the reviewer would characterize this as “90% or more” rather than “approximately 95%.”	Additional work (Monte Carlos analysis) will be done to quantify the uncertainty in the EMB results.
185	Clarity and Correctness of Data Evaluations	8	Dioxin is the most significant toxin and is the only chemical which can be significantly remediated by action in the LPR. This conclusion does not depend on the EMBM.	

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186	Clarity and Correctness of Data Evaluations	8	Dioxin has no significant sources above Dundee Dam, from Newark Bay, or from any tributaries. The presence of dioxin in surface layers is almost entirely due to resuspension of older, contaminated sediments. This conclusion also does not depend on the EMBM.	Agreed.
155	Clarity and Correctness of Data Evaluations	8	As the reviewer understands the EMB, 50% not 95% is from the lower eight miles. The rest is from either the Upper Passaic or Newark Bay. The reviewer perceives that this statement refers to all the within river sources.	We believe that the reviewer is confusing solids contributions from resuspension with dioxin contributions from resuspension. The EMB showed that nearly 50% of the solids in the LPR originated as resuspended legacy sediments. The other 50% came mostly from the UPR and Newark Bay. The dioxin contribution mentioned in this charge question is a mass load contribution, calculated by multiplying the average concentration on the solids at each source by the fractional solids contribution. For 2,3,7,8-TCDD, the concentration on the resuspended sediment is 2-3 orders of magnitude greater than the concentrations on the UPR sediments and those derived from minor sources and nearly 1 order of magnitude greater than that on the sediments from Newark Bay. Thus, as mass, 95% of the 2,3,7,8-TCDD in the Be-7 bearing sediments in the LPR originated from the 50% of the solids that were resuspended. Note: When this response was explained to the reviewer during the 7/9/08 final conference call with the peer reviewers, he understood and retracted the comment.
153	Clarity and Correctness of Data Evaluations	8	It's not data alone that is used to support predictions. It is models and data together and the models (EMB and the single exponential extrapolation) are simply not up to the task.	The uncertainties involved in these models (EMB and forecast) are well-known and acknowledged by the team. A Monte Carlo analysis will be done to better quantify the uncertainty. As recommended by the peer reviewers, the CARP model will also be used to confirm the future projections calculated by the EMB.
113	Clarity and Correctness of Data Evaluations	9	It is particularly appropriate for an Early Action decision to focus on the major sources of risk, which are particle-reactive and relatively conservative. A full analysis of site risks and responses to remedial options would require a more comprehensive examination that accounts for transport in the dissolved phase and the DOC-sorbed phase that can play an important role in the transport of hydrophobic contaminants.	No response required.
93	Clarity and Correctness of Data Evaluations	9	The report focuses on contaminants of potential concern (COPCs) on sediment, largely ignoring mass and transport in the dissolved phase or sorbed to dissolved or colloidal organic matter (both of which are in most cases analytically resolved as part of the dissolved phase). This is, in part, a function of the available data, as water column monitoring is sparse at best. It is also a reasonable approximation for hydrophobic contaminants that occur predominantly in particle-sorbed form. The approach also assumes that boundary condition concentrations on sediment are equivalent to concentrations on depositing sediment within the river, ignoring any transformations in the water column. However, these approximations may not be adequate for all COPCs, such as low molecular weight PAHs and mercury.	See responses to Comments 88 and 7.
136	Clarity and Correctness of Data Evaluations	9	The EMB should also look at more soluble low molecular weight compounds including PCBs and PAHs. Other compounds of interest is atrazine and MTBE, and personal care products and pharmaceuticals. In the category of particle associated compounds one could screen for PBDEs.	The CSM focused on particle reactive contaminants because they have been found to be the main drivers in the risk assessment. Remediation of the sediments is expected to have a marked effect on the contamination levels in the river. See also response to Comment 88.
179	Clarity and Correctness of Data Evaluations	9	EMBM ignores the desorption of hydrophobic chemicals. As a first approximation for highly hydrophobic chemicals (e.g., dioxin and high K _p PCBs), this is probably a good approximation. However, for low K _p PCBs, PAHs, and other chemicals, this may cause serious errors. The solids balance is potentially impacted by this error. Partitioning behavior will help explain the fact that the ratio of high K _p to low K _p PCBs changes from above Dundee Dam to the LPR.	

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156	Clarity and Correctness of Data Evaluations	9	All modern contaminant transport models consider both dissolved and particulate fractions. The proper modeling of 137Cs requires an explicit consideration of the dissolved component. It would be a simple exercise to run the CARP model with infinite partitioning and test the assumption.	The partitioning coefficient of Cs-137 is greater than 10^4 , meaning that it is highly particle-reactive and thus effectively used as a tracer of sediment dynamics. There is an extensive body of data collected with respect to atmospheric deposition and environmental fate of Cs-137 in the region (NOAA's environmental monitoring laboratory in Manhattan). Work conducted in the NY-NJ Harbor Estuary by Curt Olsen (1979, 1981 and 1984-85) and fate and transport analyses conducted by Steve Chilrud (1996) document the basis for using Cs-137 for core dating and, in fact, develop models of Cs-137 input to the watershed and behavior in the sediment. In the CSM, Cs-137 sediment data were used only to identify specific horizons in the cores for the purpose of dating the various intervals; Cs-137 was not used as a chemical parameter for modeling purposes.
114	Clarity and Correctness of Data Evaluations	10	The evidence for resuspension of legacy sediments does appear clear; what is less clear is whether this is a phenomenon that occurs throughout the Lower Passaic or is dominated by erosion of specific hotspots. The specific selection of the 1995 layer to represent this source appears somewhat arbitrary. Use of the 1995 core tops appears to provide a reasonable approximation of the ensemble behavior, but it should be recognized as a gross spatial approximation that obscures actual site processes. For this reason (among various others) the EMBM approach is not really competent to make distinctions more subtle than that between near total remediation and natural attenuation.	While the EMB may not provide spatial resolution to identify small areas for remediation, evidence suggests that for contaminants derived by resuspended sediments, the EMB does allow us to test the impact of a smaller remedy on the river as a whole. The properties of the Be-7 layer predicted by the EMB are related to the magnitude of the resuspension term. For those contaminants driven by resuspension, it follows logically that concentration in this layer can only decline in direct proportion to the amount of resuspension controlled by remediation. The relative improvement achieved by each remediation option can be directly related to the spatial extent of that option and the associated decrease in the resuspension term. For areas that remain unremediated, surface concentrations will recover no faster than this estimate for the annual Be-7 bearing layer. Also, following the recommendation of the peer reviewers, we are using the CARP model and a fine-grid sediment transport model based on SEDZL-J to investigate remediation of discrete areas of the river, among other scenarios.
157	Clarity and Correctness of Data Evaluations	10	There is probably not too much error in the approximately 50% resuspension fraction. However, this should be backed up with an actual sediment transport model, which is being constructed. The real question is: what is the source of the other 50% and is there an ongoing unknown source of TCDD.	This comment was clarified during the 7/9/08 final conference call with the peer reviewers. See response to Comment 155.
52	Appropriateness of Conclusions	11	There should be more statistical analysis of the historical data used to estimate the half lives. The rate of contaminant reduction generally tends to slow over time.	
116	Appropriateness of Conclusions	11	Model forecasts based on decay rates are highly problematic given the variability in the data used to estimate these rates, as discussed in Section 4 of these comments. The uncertainty in estimating decay rates has significant effects on the predicted ability of remedial actions to achieve goals; however, the effect on relative performance of the remedial alternatives and their comparison to natural attenuation is less severe. The EMBM approach is significantly limited in its ability to represent pre- and post-remediation conditions – and thus the potential for recontamination – due to its assumption of completely mixed, homogenous conditions between RM 2 and RM 12.	
158	Appropriateness of Conclusions	11	The reviewer is concerned about the plateau in the time course data for TCDD and the discrepancy between the various half life estimates: less than 10 yrs from the CARP model, 25 yrs from the exponential analysis, and a by-phasic behavior in the data suggesting a continuing source. Until this is sorted out, there is no strong reason for believing that we can forecast the outcome of remediation alternatives.	

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37	Appropriateness of Conclusions	11	Trajectory calculations ignore the dynamic nature of the system (where erosional areas are non-steady state; i.e., formerly deposited contaminants are exposed) and do not account for changes to the system caused by remediation or passage of time.	The reviewer is correct in noting that the trajectory calculations do not take changes in physical processes due to remediation into account. However, because any active remedial alternative includes deepening the river (to allow sufficient flood-carrying capacity or reasonably-anticipated future navigation use), the sedimentation rate will increase upon remediation, increasing the relative amounts of Newark Bay and Upper Passaic River sediments compared to the resuspension contribution, and decreasing the surface sediment concentrations. Thus, the trajectory forecasts for remediation presented in the CSM are conservative, upper-bound estimates of future conditions. In addition, as recommended by the peer reviewers, a fine-grid sediment transport model and CARP model that simulate the dynamic nature of the river bottom are being used to confirm the future projections calculated by the EMB.
138	Appropriateness of Conclusions	11	The empirical extrapolations used to evaluate the remediation scenarios are only valid if upstream pollution is curtailed significantly.	The upstream pollution was removed from the total concentration in the LPR before extrapolating a trajectory. Thus, they are unaffected by the upper Passaic River concentrations. The trajectories assume constant concentrations from 2004 to the future from the upper Passaic River. This is consistent with the Dundee Lake cores for most contaminants.
139	Appropriateness of Conclusions	11	With a mixed layer thickness of 6 in and a sedimentation rate in the RM0-8 stretch of 0.25 in/yr we obtain a half-life for cleanup of 17 years. The contribution of suspended sediment to this half-life is probably minor. At 20' water depth, 500 mg/l suspended solids concentration, and a sediment porosity of 0.6, the equivalent sediment thickness is only 0.3 cm compared to the 6 in = 15.2 cm.	We concur with the estimate of 17 years for the half-life if the settling sediment is clean of contaminant. It is not clear where the estimate of 500 mg/L TSS comes from.
183	Appropriateness of Conclusions	11	No other modeling is necessary. As far as chemical concentrations in organisms are concerned, these concentrations will decrease proportional to the decrease in chemical concentrations in surface sediments. For example, if chemical concentrations in surface sediments are reduced by 50%, chemical concentrations in organisms will also reduce by 50%. There will be a time lag in this decrease, but this time lag is less than the time for dredging and capping, approximately 10 years, and can therefore be ignored.	No response required.
19	Appropriateness of Conclusions	12	Rather than the current level of uncertainty limiting or delaying remedial options, I believe that a basic data analysis strongly supports a focused preliminary remedial effort.	Given that high concentrations of dioxins and other contaminants exist throughout the surface sediments of RM0-8, remediation in RM0-1 alone or above Dundee Dam will not address the high risks present in RM1-8. A sediment transport model has been run to design a cap with armor that will withstand large storm events. The future projections calculated by the single-layer box model associated with the EMB (and those to be calculated by the CARP model) take into account recontamination from external sources.
25	Appropriateness of Conclusions	12	Because the areas that supply the resuspension flux have not been located and may not be consistent over time, a preliminary remediation strategy that should be considered would involve dredging an area near the mouth of the Passaic. This could remove a large fraction of the contaminant inventory and significantly address the problem of 2,3,7,8-TCDD, arguably the contaminant of greatest concern.	
26	Appropriateness of Conclusions	12	Capping this area should not be considered as the "hole" would serve as a trap for sediments and associated contaminants both from Newark Bay and further upstream in the Passaic. Such an area would be expected to accumulate contaminated sediments at a rapid rate. Our one core from the lower Passaic from a recently dredged area (a marina near RM 8) had an estimated net accumulation rate based on the Be-7 profile of over a meter per year. Future dredging of the area would continue the remediation.	
27	Appropriateness of Conclusions	12	In general, the reviewer would be concerned about capping anywhere in the lower Passaic based on the unstable patterns of deposition and erosion and lack of information related to the effects of major high flow events.	
28	Appropriateness of Conclusions	12	A similar dredging operation in Dundee Lake as part of the preliminary remediation could be considered to significantly decrease future inputs of PAHs (Figures 19-7 and 19-8) and, to a somewhat lesser extent, total PCBs (Figure 19-6).	

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24	Appropriateness of Conclusions	12	While the reviewer is convinced of the importance/dominance of the resuspension source for most of the contaminants, he is concerned that the areas supplying the resuspended contaminated sediment have not been (and, given the convincing analysis of erosional and depositional regimes presented in Chapter 11 probably could not be) specified in space or time. It seems unlikely that further measurement/determination of current mixing depth or “erodibility” as a function of location would prove particularly useful. Indeed, it seems quite possible that the high flow event of April 2007 may have changed the sedimentary environment significantly at specific sites since samples were collected. Such considerations lead to the concern that any remedy other than large scale source removal will result in significant recontamination. To me this suggests a strategy based on dredging that maximizes inventory removal, enhances deposition in the remediated areas, and allows for future dredging following recontamination.	No response required.
115	Appropriateness of Conclusions	12	An optimal approach to remediation could well involve more focused (and less costly) remediation of specific high-risk source areas, but such scenarios cannot be evaluated within the current framework. If the EMBM forecasts are used as a basis for an Early Action decision, other lines of geochemical evidence need to be used to remediate the highest-risk locations first, with provisions for adaptive management to adjust the remedy as additional information is collected.	Multiple bathymetric surveys show that erosional and depositional areas shift unpredictably from year to year, so that it would be impossible to find a discrete erosional area to remediate. In addition, high concentrations of dioxin and other contaminants exist throughout the surface sediments of RM0-8, so that targeted remediation aimed at cutting off the source of contamination would fail to address the high levels of risk that exist throughout RM0-8. However, as recommended by the peer reviewers, a fine-grid sediment transport model based on SEDZL-J is being run to investigate the possibility of focused remediation of discrete erosional areas.
117	Appropriateness of Conclusions	12	It is clear, as stated (p. 11-40), that “much of the river bottom is subject to large movements of several inches of sediment, resulting in multiple layers of deposition of alternating silts and sands.” It does not necessarily follow from this observation that remedial alternatives must address the entire sediment bed of the lower eight miles of the river – although that is the only alternative that the EMBM approach is really capable of evaluating. Use of a detailed hydrodynamic and sediment erosion would obviously be useful to evaluate targeted remediation. The currently available data may provide some clues suitable for early action intervention. For instance, the bathymetric profiles could be reanalyzed to provide some indication of areas in which erosion is progressing into areas with significant stores of legacy contamination. Such areas would be natural high priority candidates for early action.	
135	Appropriateness of Conclusions	12	The reviewer has some reservation with the idea of only remediating fine grained depositing, but also resuspending, sediment in the RM0- 8 compartment. From Fig. 7-1 it is apparent that there is a significant dioxin source at RM11.5. Before remediating the RM0-8 stretch one should consider removing high dioxin sediment erosion source areas such as those around RM11.5.	The magnitude of the reservoir of material at RM11 is substantively smaller and less thick than the inventory below RM8. Based on the dated sediment cores, there was no measureable gradient between RM2.2 and RM11 in the decade prior to the circa 2000 release event. Additionally, about 86% of the fine-grained sediment surface area is located below RM8 and only 6% of the fine grained area is located between RM8 and RM12. Even if the dioxin concentrations in surficial sediments between RM8 and RM12 were twice as high as those in the lower 8 miles, the flux from the sediments below RM8 would still be seven times greater than the flux originating in RM8-12, assuming that the rate of fine-grained sediment resuspension is proportional to the fine-grained sediment surface area. Therefore, the fine-grained sediments below RM 8 remain the single-most important source of dioxin to the Lower Passaic River. Also, EPA will be using the sediment transport model SEDZLJ to evaluate whether a remediation should start in RM0-8 or RM8-12.
140	Appropriateness of Conclusions	12	Remediation should proceed in three stages: First remediate upstream hot points such as dioxin around RM11.5. Considering the heterogeneity of the RM0-8 stretch with respect to contaminant concentrations and sedimentation rates, I think one should next design a remediation plan for perhaps 20% of the RM0-8 stretch concentrating on sites with high contaminant concentrations that are likely to undergo resuspension frequently. The third step, if necessary, would be removal or capping of most of the remainder of the river stretch.	See response to Comment 135 on remediation above RM8. As to detailed procedures for remediation within RM0-8, the design of the remedy will take into consideration these types of concerns and is not part of the Focused Feasibility Study.

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
184	Appropriateness of Conclusions	12	Dredge and cap all potentially erodible areas throughout the LPR. This is the best that can be done unless upstream areas are also remediated. (Potentially erodible areas means all areas that can be significantly eroded in storms/floods/tides up to and including a 100 year event.) Do not dredge and cap depositional areas. This would be an enormous waste of time and money.	See responses to Comments 115 and 25.
23	Appropriateness of Conclusions	12	While clearly a geochemical question, the answer requires a risk assessment perspective that I do not possess. I did find the PRGs (Table 20-10) to be rather arbitrary and not particularly related to risk assessment (!?).	These PRGs were developed based on the Risk Assessment and are consistent with EPA guidance on background concentrations ("Role of Background in the CERCLA Cleanup Program", OSWER 9285.6-07P).
178	Appropriateness of Conclusions	12	If remediation is performed on RM0 to RM8 only, contaminated sediments from above RM8 will be resuspended during storms and floods and will deposit in the RM0 to RM8 area, an area which is mostly depositional. The result will be that the surface layers in the LPR will be essentially contaminated the same as before.	We agree that recontamination of remediated areas will occur from above RM8. However, because there is less fine-grained sediment above RM8, the recontamination will not be to the same levels as before remediation. This is explicitly calculated in the EMB model forecasts and is shown not to be a disproportionate problem. In particular, the forecasts indicate significant and sustained reduction in surface concentrations as a result of the remediation of the lower 8 miles. In addition, based on recommendations from the peer reviewers, the sediment transport model based on SEDZL-J is being run to investigate the extent of recontamination from RM8-17 onto any remediation of RM0-8. See also response to Comment 135.
159	Appropriateness of Conclusions	12	At this stage of analysis, the models are too crude and too uncertain, see the above comments and the analysis in Evaluating the Modeling Frameworks, to be able to discriminate between selective dredging or capping alternatives. Also, a detailed dredging or capping plan needs to look at the effects of large storms as well as the gradual effects of dilution by clean sediments. The present uncertainty of the source of sediments to the 8 mile reach: Newark Bay vs. Upper Passaic River, and the uncertainty of the future concentrations in these sediments makes the projections in the CSM very uncertain.	A Monte Carlo analysis of the EMB is planned. Also, based on the recommendation of the peer reviewers, the CARP model is being run to confirm the future projections calculated by the EMB.
59	Appropriateness of Conclusions	12	The reviewer's biggest concern involves the application of the EMB in its current state to project contamination in the future - the application of the EMB in Chapter 20 is neither well thought or described, nor is it reflective of the thought and good work that precedes it. It brings up the question of whether the type of large scale box model used (with many steady state assumptions) is/can be adequate for assessing or even defining alternative remedial action scenarios.	The CSM is used in combination with other lines of evidence (such as a robust bathymetric data set to evaluate sediment stability) to define alternative remedial alternatives. In addition, at the recommendation of the peer reviewers, the CARP model is being run to confirm the future projections calculated by the EMB as yet another line of evidence to assess the remedial alternatives.
181	Appropriateness of Conclusions	12	A reasonable early action should, and can, be based on hydrodynamics and sediment and contaminant transport alone.	We agree that mechanistic modeling is a useful tool. Based on recommendations from the peer reviewers, both the sediment transport model (SEDZL-J) and CARP model are being run to investigate various options for the Focused Feasibility Study, including capping of discrete erosional areas and other scenarios. However, EPA also believes empirical analyses can provide reliable lines of evidence to support remedial decisions.
96	Other	N/A	In the discussion of solids transport (Chapter 11), the apparent lack of strong correlation between depositional rate estimates from bathymetric surveys and core classification (p. 11-37) is disappointing, particularly as the reason is cited as "unknown." This calls into question whether the bathymetry is sufficiently accurate to establish sedimentation/erosion rates and/or whether the ¹³⁷ Cs data interpretations are valid. I suspect both analyses are valid (although you will need to support this in stronger terms) and that the lack of correlation is primarily due to scale issues, with a core representing only a 6" segment of the bottom. That, however, suggests that erosion and deposition in the Lower Passaic is extremely heterogeneous at a fine scale, making the identification of high-risk erosional hotspots problematic.	CSM discussion will be expanded to include these concerns
97	Other	N/A	The analysis assumes that one constant deposition rate applies prior to 1963, and another lower rate applies after 1963. If the decline in deposition rates is due to gradual filling of the dredged channel, wouldn't it be more appropriate to assume a deposition rate that declines exponentially over time, rather than imposing a step change?	These deposition rates (prior to 1963 and after 1963) are averages based on total depth deposited over a given period of time. We do not mean to imply that the depositional rate suddenly changed in 1963, but that the average before and after that date was different.

Comment No.	Charge Category	Charge Question	Comment Summary	Substance of Response
95	Other	N/A	The discussion of salinity data in the hydrodynamic evaluation notes problems with probes, attributed to “debris.” The observed problems with these data seem more likely to be due to biofilm development. The QC procedures cited in regard to the salinity data appear fairly arbitrary; there are no detailed notes on quality evaluation, and no discussion of drift correction. Analysis of fit of the hydrodynamic model to salt front position should ideally employ a harmonic analysis. These issues are, however, mitigated because the analysis of salt front position in the CSM is used only in a qualitative way to establish that the water between RM 2 and RM 12 is tidally mixed.	The text will be expanded to indicate the possibility of biofilm development. The section describing QC will be clarified.
36	Other	N/A	Figure 14-4i does not include all the high concentrations seen in Figure 14-1, 14-2 and 14-3.	Comment noted.
51	Other	N/A	Chapter 20 says that it would be most prudent to isolate the primary erosional zone. This neglects areas defined by bathymetry to be near neutral with respect to net deposition. There is no reason to neglect these areas.	The Primary Erosional Zone is a hypothetical construct and is not fixed at any specific location on the river bed. The associated trajectory forecast predicts the effects of any remediation scenario which reduces the resuspension term by 33%. Because the bathymetric change analysis indicates a dynamic system with erosion and deposition interchanging with time, this remedial scenario makes no distinction between erosional and neutral areas.
53	Other	N/A	The remedial scenarios are not sufficiently explained. Need more specifics of the remediation design or goals. Chapter 20 needs to better reference and be integrated with the sections in Chapter 11 about area and time dependent estimates of net deposition.	Detailed descriptions of the remediation scenarios and goals are provided in the FFS main text.
173	Other	N/A	Resuspension of sediments (and contaminants) in certain areas of the LPR is due to highly-variable-in-time-and-space floods and wind-driven waves and currents. The areas of resuspension are probably mostly near shore in RM0 to RM8 and are more widely distributed in RM8 to RM12.6 and possibly above RM12.6.	We agree with the first statement in this comment. However, we have not found any evidence to support the claim that resuspension is mostly near-shore. The data above RM8 are too limited in time to assess differences relative to below RM8.