

# HUDSON RIVER PCBs SITE

## Peer Review of Phase 1 Dredging

### Final Report

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### **Note**

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## EXECUTIVE SUMMARY

The Peer Review Panel (Panel) reviewed the considerable volume of data and reporting from the Phase 1 sediment remediation at the Hudson River PCBs Site to address 4 charge questions about the project. It was clear to the Panel that both the U.S. Environmental Protection Agency (EPA) and General Electric Company (GE) are committed to the success of the project and expended considerable effort to comply with the 2004 Engineering Performance Standards (EPS) during Phase 1. The Panel commends both parties for their extensive efforts to evaluate and report on the information generated during Phase 1 and the effort they expended in responding to the Panel's many requests for additional information and analyses.

Phase 1 showed that the 2004 EPS for Resuspension, Residuals, and Productivity were not met individually or simultaneously during Phase 1 and cannot be met under Phase 2 without substantive changes. EPA and GE proposed changes to the EPS but the Panel finds that the new proposed standards from either party would not contribute to the successful execution of Phase 2. However, Phase 2 can remove the bulk of the polychlorinated biphenyl (PCB) inventory if coring data and the resulting depth of contamination (DoC) model results are improved and focus is placed on quick closure of certification units (CU). The Panel developed an approach along with modified EPS to maximize removal of the PCB inventory in a careful balance with resuspension and residuals goals, while achieving an acceptable level of productivity.

The Panel also recommends building upon the adaptive practices and approaches that have been employed to date by developing a more comprehensive and formalized adaptive management approach to all EPS that includes the annual reassessment of the EPS based on each prior year's data. The challenges encountered during Phase 1, and the adaptations employed by EPA and GE to address those challenges, demonstrate the need for flexibility during Phase 2. This was evidenced in the records of the management meetings to achieve CU closure during Phase 1, and especially by the commitment to this Peer Review process, seeking to refine and improve the EPS and in-field practices. During Year 1 of Phase 2, the Panel recommends collecting additional data to support the further refinement of relevant performance standards to be applied for the remainder of the project's duration. Additional review between Years 1 and 2 of Phase 2, and each subsequent year of the project, should allow for ongoing modification of the EPS to optimize remedial operations while limiting unintended consequences and adverse environmental impacts from these operations.

Phase 1 demonstrated that the Residuals EPS had a substantial impact on the operational success of the project as well as the tangible interaction that exists between Productivity, Resuspension, and Residuals processes and their respective EPS. A key obstacle to simultaneously achieving the performance standards involved incomplete, inaccurate, and imprecise DoC characterization combined with disagreement on how to interpret and attain target levels. This directly affected both the Resuspension and Productivity EPS. The repeated dredge passes and prolonged exposure of sediments in the CUs resulted in increased PCB resuspension and release. The unexpected increase in inventory due to incomplete DoC characterization had the greatest effect on the Productivity EPS in terms of numbers of CUs remediated. The Panel presents revised EPS that accelerate CU closure by establishing an elevation-focused dredge design paradigm, thereby effectively managing residuals, reducing resuspension, and

accelerating productivity without compromising the goals of the Record of Decision (ROD) with respect to overall recovery of the river.

The Panel proposes an elevation-focused dredge prism design that builds on accurate, high-precision characterization of the DoC elevation, a 4-inch overdredge based on vertical tolerance of the dredge and precision of the DoC that ensures rapid achievement of the target elevation (i.e., the elevation of the DoC not including the overdredge) across at least 95 percent of the CU area or subunit area, verification of the target elevation based on high-precision bathymetry, and rapid closure of CU or subunit areas following EPA validation of confirmed elevations.

This approach does not involve redredging to remove dredge-generated residuals or address redefined inventory based on post-dredge confirmation sampling. The CU would be closed based on the results of the residuals sampling results. The CU (or sub-CU) should be backfilled if the average residuals concentration is less than or equal to 3 mg/kg Tri+PCBs and capped if the average residuals concentration is greater than 3 mg/kg Tri+PCBs.

This revised removal and closure approach is the first step toward integrating the Residuals, Resuspension, and Productivity EPS. Through better characterization of the DoC and establishing an elevation-based dredging prism design, Resuspension and Productivity EPS also can be revised to be consistent with the updated dredge depths and volumes. For Year 1 of Phase 2, the Panel proposes Resuspension and Productivity EPS based on metrics consistent with Phase 1: for resuspension, target levels are 2 percent and 1 percent of the dredged PCB mass, measured at Thompson Island Pool (TIP) and Waterford, respectively; for productivity, target volumes are 350,000 cubic yard (CY) per year. Both of these targets (i.e., for resuspension and productivity) should help guide Best Management Practices (BMP), but should not lead to shutting down operations. In other words, the Panel does not recommend interrupting dredging activities if the targets are not achieved during Year 1 of Phase 2; the goal of the interim standards is to establish baseline targets during Year 1 of Phase 2 and to allow dredging to recommence in 2011, while near-field and far-field data are collected.

Based on the results of Year 1 of Phase 2, combined with the Phase 1 results, EPA and GE should refine the performance criteria to establish practicable targets that can be achieved for all 3 EPS. In addition to evaluating the performance of the modified Residuals EPS, the focus between Years 1 and 2 of Phase 2 should be the Resuspension EPS to manage near-field and far-field resuspension, release, and deposition processes, based on an understanding of whether there are increased risks associated with surface sediment deposits containing PCBs released during dredging. The Productivity EPS should also be updated based on a revised volume estimate derived from the elevation-based dredging paradigm. In addition to an annual volume productivity standard, the Panel advances an additional EPS metric: annual areas to be remediated. Area remediated reflects a substantial measure of environmental benefit and could be expressed as a specified number of CUs to close each year. Tracking of total volume and mass of PCBs removed should continue, but the environmental benefit accrued should be based both on mass removal and area remediated. Eventually, an area-based standard could supplant the volume-based productivity standard, if appropriately tied to the elevation-based design.

The Panel found that the models used to develop the 2004 Resuspension EPS cannot be used to adapt revised standards for moving forward. The Panel believes that to do so requires a new model that must be developed collectively by EPA and GE. The GE model may be a useful foundation for this model, and

both model structure and parameters must be agreed upon by EPA and GE. The model must be peer reviewed by an expert panel once EPA and GE complete its development. Similar arrangements have been established at other Superfund Sites, including the Passaic River, the Lower Duwamish Waterway (WA), and the Lower Willamette River (OR). The fate, transport, and risk model must enable EPA and GE to understand the implications of operational changes on long-term recovery rates to support EPA and GE in making appropriate and meaningful risk management decisions about dredging productivity, BMPs, and the long-term fate and transport of PCB residuals and resuspension and release.

The Panel evaluated the results from Phase 1 in order to assess a practicable annual production rate. The evaluation included a detailed review of peak monthly output for each component of the remedial action (i.e., dredging, processing, transportation), dredging and removal output (i.e., numbers and cycle times for dredges and barges), and shipping output to the landfill. The Panel did not discover any single factor that could be adjusted to significantly increase overall productivity. For example, neither increasing the number of barges in service nor increasing the offload rate at the processing facility provided a substantive increase in productivity. Rather, the Panel found multiple lines of evidence supporting 350,000 cy/yr as a reasonable annual productivity estimate for the start of Phase 2. The Panel also found that the productivity schedule should be subordinated to the Resuspension EPS and Residuals EPS. Consequently the 5-year productivity criterion should be dropped to provide more flexibility to complete the work in a manner that protects the integrity of the project and its risk reduction objectives.

### Charge Question 1

The experience in Phase 1 does not show that each of the Phase 1 EPS can be consistently met individually and simultaneously. None of the Phase 1 EPS were consistently met during Phase 1. EPA and GE evaluations of the Phase 1 experience do not provide evidence that the EPS could be met consistently and simultaneously if applied without modification during Phase 2.

The Resuspension EPS was not achieved in Phase 1. Resuspension criteria were exceeded, including total PCB concentrations and total and Tri+PCB loads; suspended solids concentration requirements were not exceeded, but alone provide an insufficient basis for understanding PCB resuspension and release. PCB release is the result of a complex set of processes, and, based on Phase 1 results, Total Suspended Solids (TSS) could not be used to predict PCB resuspension and release at this site. Resuspension was due in part to the dredging activities themselves, but was magnified by CUs being left open for extended periods.

The Residuals EPS was not achieved in Phase 1. Residuals management required multiple production passes (not anticipated in the EPS) and the CUs were open longer than intended. The Residuals EPS was not truly tested as envisioned in Phase 1, mainly because inventory was improperly characterized and the EPS assumed that all inventory would be removed with a maximum of 2 passes, followed by additional passes to remove dredge-generated residuals. The incomplete characterization of inventory was attributed primarily to problems with the delineation of the DoC in much of the river, which was rooted in problems with sediment core data, including lack of absolute vertical control on the DoC, poor core recoveries, and inability to characterize the entire soft sediment column by coring to till. Consequently, core sample results fed into the Terrain Model provided inadequate representation of the DoC, and dredging to the Terrain Model DoC fell short in all CUs.

The Productivity EPS was not achieved in Phase 1. None of the 4 numerical productivity criteria (i.e., minimum removal, target removal, maximum monthly rate, and transportation of all material off site by the end of the year) was achieved. The goal of transportation and disposal of all Phase 1 dewatered sediment by the end of 2009 was not accomplished. Ramping up unit processes is possible, but the project cannot be scaled up to meet the anticipated inventory using the current design data.

### Charge Question 2

Both EPA and GE proposed changes to the EPS. The Panel finds neither proposal to be adequate, because neither adequately integrates the EPS so that all three EPS can be met individually and simultaneously.

EPA's proposal attempts to simplify the process, but it still relies too heavily on redredging and a complex decision process for closing CUs. Furthermore, EPA's recommended modifications to the Resuspension EPS do not support determination of whether released PCBs increase downstream risk to fish by creating unacceptable levels of surface sediment contamination outside of the remedial footprint. EPA's recommended annual productivity rates are much higher than can practicably be achieved.

GE's recommendations are tied to limiting downstream loading. Their assertion is that loading is tied directly to removal. The Panel finds that delayed closure of CUs is a major contributor to downstream loading. GE strongly recommends closing CUs with single-pass dredging in high-confidence areas and 2-pass dredging in low-confidence areas, while limiting the mass of PCBs removed. The Panel supports an approach that minimizes dredge passes and provides for quick CU closure. However, the Panel does not support placing an absolute limit on the mass of PCBs to be removed, because the mass of PCBs to be removed is unknown and such a limit appears contrary to the ROD.

### Charge Question 3

The EPS can be modified for successful completion of the project. However, in addition to revising the performance criteria, changes are needed in the overall management of the project and its objectives. Namely, focus needs to be placed on achieving rapid CU closure to limit resuspension and release, while productivity needs to be measured with regard to the remediated footprint (i.e., equal focus on the area remediated as well as inventory removed), and there should be a more immediate application of backfill or cap based on the residual concentration of PCBs. This can be achieved by proactively determining the DoC, using updated DoC information to establish Design Dredge Elevations that more accurately capture the target inventory, and dredging the inventory based on updated Design Dredge Elevations for each CU and not based on residuals chemistry.

The following steps should be taken to establish an accurate and useful picture of DoC that can drive dredging plans and residuals management:

- **Coring Program.** Perform recoring of all low-confidence samples. Samples now designated as high-confidence should be verified as high-confidence with respect to the DoC elevation or re-sampled. All sampling must be performed to attain at least 80 percent recoveries of all soft sediments either to bedrock or Glacial Lake Albany Clay (GLAC). Further sediment layers must be reported as actual elevations rather than depth below the mudline, including the existing and future high-confidence core areas. All cores should be analyzed until 2 6-inch layers have Total PCBs below 1 ppm.



- **DoC Elevation.** Remodel the DoC based on the 1 ppm Total PCBs cleanup level using all high-confidence elevation-based cores to establish the topography of the DoC throughout each CU, referred to as the DoC Elevation. Thus, the DoC Elevation is a modeled elevation based on the sediment core DoC values to ensure that the inventory is captured by the Design Dredge Elevation with an acceptable level of certainty.
- **Design Dredge Elevation.** Establish the Design Dredge Elevation based on the remodeled DoC Elevation. Set the Design Dredge Elevation initially to 4 inches below the modeled DoC Elevation to account for the vertical accuracy of the dredge, referred to as dredge tolerance. The goal is for dredging to achieve the DoC Elevation in 95 percent or more of the dredged area after a single pass (i.e., at least 95 percent of the dredged area should be at or below the DoC Elevation). Incorporating a factor for dredge tolerance in the Design Dredge Elevation ensures that the dredger attains the DoC Elevations as quickly as practicable (i.e., in a single pass). If the dredger can easily achieve the DoC Elevation quickly and efficiently, the dredge tolerance can be relaxed. If the dredger has trouble achieving this in a single pass, the dredge tolerance should be increased.
- **Confirmation Sampling.** Perform confirmation composite sampling of surface sediments in each 1-acre CU subunit as soon as possible after attainment of the DoC Elevation in 95 percent or more of the area is confirmed by EPA.
- **Sand Cover.** Place a 3 to 6-inch sand cover over the CU subunit as soon as possible after confirmation samples are collected (before PCB analytical results are obtained). No verification of placement thickness is required at this time.
- **Backfill or Cap.** Use PCB analytical results from the composite samples to determine whether area will be backfilled or capped. Then install appropriate final layers. Do not redredge to capture residuals.

#### Charge Question 4

Both EPA and GE proposed changes to the EPS with concurrent changes to the monitoring and sampling program for Phase 2. However, the Panel finds that it will not be practicable to consistently and simultaneously meet the EPS being proposed by either party and, thus, cannot make a cogent finding regarding the monitoring and sampling programs relative to these proposed standards. Rather, the Panel has addressed this question relative to the modified EPS and processes recommended by the Panel in response to Charge Question 3.

Achieving all 3 EPS in Phase 2 requires an accurate determination of the DoC for all CUs, single-pass dredging to the DoC with a dredge tolerance, post-removal composite sampling to determine whether the CU requires backfilling or a cap, immediate placement of 3 to 6 inches of cover material, and placement of backfilling or cap after the composite sediment sample analysis.

The potential for recontamination of off site areas is not sufficiently addressed in the current monitoring program. While to date there is insufficient information to demonstrate that transported PCB load outside the currently planned CUs in the Upper and Lower Hudson is causing increased PCB concentrations in bedded-sediment concentrations, the Panel believes that expected benefits of the removal action must be demonstrated in the off site areas. If significant increases are occurring that compromise the expected risk reductions, further changes to the removal program would be warranted.

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## 1 INTRODUCTION

This report summarizes the independent peer review of the U.S. Environmental Protection Agency (EPA) Phase 1 Evaluation Report, the General Electric Company (GE) Phase 1 Evaluation Report, and supporting information. The Phase 1 Evaluation Reports presented EPA and GE's evaluation of the experience of the Phase 1 removal actions with respect to the Phase 1 Engineering Performance Standards (EPS) and set forth EPA and GE's proposed changes to the Phase 1 EPS, respectively. The reports and supporting information were reviewed by a panel of seven independent experts (the Peer Review Panel) in accordance with the terms of the Consent Decree under which Phase 1 of the cleanup was performed.

The Engineering Performance Standards address resuspension, polychlorinated biphenyls (PCB) residuals, and productivity associated with the removal of sediments contaminated with PCBs in the Upper Hudson River, New York. The purpose of the peer review was to consider the implications of the experience gained during the Phase 1 removal actions, as described in the EPA and GE Evaluation Reports and other evidence before the Panel, regarding EPS for subsequent planned removal of PCBs in the Upper Hudson River.

The peer review process included independent review by the individual Panel members, discussions and deliberations among the Panel members, public Peer Review Meetings that took place from May 4, 2010 to May 6, 2010, in Glens Falls, New York, and preparation of this Peer Review Report. SRA International, Inc. (SRA), under contract to EPA, organized and implemented the peer review according to procedures for a "contractor-run peer review," as outlined in EPA's "Peer Review Handbook" (EPA 2000).

This report summarizes the findings of the Peer Review Panel. The findings and discussions presented in Sections 2 through 7 of this report were written by the members of the Peer Review Panel and have been edited only for readability. The remainder of this introductory section provides background information regarding the Hudson River PCBs site (Section 1.1), reference to the EPA and GE Phase 1 evaluation reports (Section 1.2), a description of the peer review process (Section 1.3), and a roadmap to the remainder of the report (Section 1.4).

### 1.1 Background

#### 1.1.1 Site and Regulatory/Enforcement History

In 1984, EPA classified approximately 200 miles of the Hudson River in the state of New York—from Hudson Falls to New York City—as a Superfund Site, based on PCB contamination of river sediments. This site traditionally has been divided into the "Upper Hudson River," which flows from Hudson Falls downstream to the Federal Dam at Troy, and the "Lower Hudson River," which flows from the Federal Dam downstream to New York City. The sediments were contaminated with PCBs predominantly by discharges from 2 capacitor manufacturing facilities owned by GE. In 1984, EPA issued a Record of Decision (ROD) for the Hudson River PCBs Site, which included, among other things, an interim No Action decision regarding the contaminated sediments.

Between 1990 and 2000, EPA reassessed its earlier decision with respect to the contaminated sediments of the Upper Hudson River to determine whether a different course of action was needed. The reassessment involved compiling and analyzing existing data, collecting additional data, using models to

evaluate human health and ecological risk, and studying the feasibility of various remedial alternatives. In 2002, after completing the reassessment, EPA issued a ROD that calls for, among other actions, targeted removal of approximately 2.65 million cubic yards of contaminated sediments from the Hudson River PCBs site (EPA 2002). Readers should refer to the ROD for further details on the site history, the remedial action objectives, and other aspects of the selected remedy.

EPA and GE entered into Administrative Orders on Consent (AOC) for sampling, analysis, and geophysical characterization of sediments (July 2002) and for remedy design (August 2003). In October 2005, the Justice Department and EPA reached an agreement with GE for GE to construct sediment transfer/processing facilities and conduct dredging according to the ROD and design plans developed under the 2003 AOC. The U.S. District Court approved the Consent Decree documenting this agreement in November 2006.

### 1.1.2 Phase 1 Engineering Performance Standards

In addition to specifying the selected remedy, the ROD requires EPA to develop engineering performance standards that “promote accountability and ensure that the cleanup meets the human health and environmental protection objectives of the ROD” (EPA 2002). The ROD specifies the requirement for independent external peer review of reports prepared at the end of the first phase of the remediation to evaluate the removal action with respect to the engineering performance standards. The Consent Decree approved in November 2006 specifies process requirements for the peer review of the engineering performance standards.

EPA published an initial draft of the engineering performance standards in 2003, addressing resuspension, residuals, productivity, and quality of life standards associated with the planned removal of PCBs from the Upper Hudson River. A panel of 9 independent experts reviewed the EPS in accordance with the requirements of the Consent Decree. A public peer review meeting was held on January 27–29, 2004, in Saratoga Springs, New York. Based on input from the Peer Review Panel, EPA modified the EPS and published final EPS in the 5-volume document, “Engineering Performance Standards, Hudson River PCBs Superfund Site” (Malcolm Pirnie and Earth Tech, 2004).

## 1.2 EPA and GE Findings from Phase 1

Both EPA and GE prepared Hudson River Dredging Phase 1 Evaluation Reports that were completed and submitted to the Peer Review Panel on March 8, 2010. Both EPA and GE evaluated information gathered from Phase 1 and the outcomes of the removal work, and both EPA and GE proposed modifications to the EPS. Findings and proposed modifications to the EPS are documented in the EPA and GE Phase 1 evaluation reports and associated addenda (EPA 2010a, EPA 2010b, GE 2010).

## 1.3 Peer Review process

### 1.3.1 Peer Review Charge

The November 2006 Consent Decree specified the process for the peer review of the EPS. The Consent Decree presented 4 charge questions as well as general direction for conduct of the peer review process. The language from the Consent Decree, including the 4 charge questions, is presented in Figure 1.

### “14. Peer Review

- a. The Peer Review will evaluate the Phase 1 Evaluation Reports. The Peer Review will be conducted in accordance with EPA’s Science Policy Council Handbook: Peer Review (December 2000), or any applicable updates thereto; the Office of Management and Budget’s *Final Information Quality Bulletin for Peer Review* (December 16, 2004), or any applicable updates thereto; and the provisions of this Paragraph.
- b. The Peer Review panel shall, at a minimum, address the issues raised by the following questions:
- (1) Does the experience in Phase 1 show that each of the Phase 1 Engineering Performance Standards can consistently be met individually and simultaneously?
  - (2) If not, and if EPA and/or Settling Defendant has proposed modified Engineering Performance Standards, does the experience in Phase 1 and any other evidence before the panel show that it will be practicable to consistently and simultaneously meet the Engineering Performance Standards that are being proposed for Phase 2?
  - (3) If the experience in Phase 1 and other evidence before the panel does not show that it will be practicable to consistently and simultaneously meet the Engineering Performance Standards that are being proposed for Phase 2, can the Phase 1 Engineering Performance Standards be modified so that they could consistently be met in Phase 2, and, if so, how?
  - (4) If EPA and/or Settling Defendant has proposed modifications to the monitoring and sampling program for Phase 2, are the proposed modifications adequate and practicable for determining whether the Phase 2 Engineering Performance Standards will be met?
- d. The Peer Review panel will not evaluate whether the Remedial Action will, or may, achieve the human health and/or environmental objectives of the ROD, nor will the Peer Review panel evaluate whether Phase 2 should be implemented.”

*Figure 1: Excerpts from the 2006 Consent Decree Specifying the Peer Review Charge*

### 1.3.2 Peer Review Panel Selection Process

Paragraph 14c of the Consent Decree specified the process for selecting a Peer Review Panel to evaluate the Phase 1 evaluation reports and address the charge. Within this framework, EPA and GE established an agreed-upon process for selecting the Peer Review Panel. The process called for SRA to select a neutral Peer Review Panel selector, jointly approved by EPA and GE, who would have the authority to identify and select Panel members, provided that the candidates recommended by the Peer Review Panel selector had no personal or organizational conflicts of interest with respect to the Panel’s charge. SRA identified Gregory Hartman of Dalton, Olmsted & Fuglevand as a candidate for Peer Review Selector, and in June 2009, EPA and GE agreed to name Mr. Hartman Peer Review Selector.

Per the Consent Decree, both EPA and GE identified collaboratively the appropriate areas of expertise to be included on the Peer Review Panel as follows:

- Monitoring: Panel members who are selected as monitoring experts will be knowledgeable in PCBs in aquatic media (water and sediments)
- Dredging production, operations, and equipment (including accuracy in dredge cuts and bathymetry)
- Residuals
- Sediment resuspension including knowledge of fate and transport
- Capping including accurate placement of backfill

EPA and GE were afforded the opportunity to recommend to the Peer Review Selector potential members for the Panel. EPA sent SRA a candidate list jointly developed by EPA and GE in August 2009.

SRA developed a conflict of interest (COI) analysis of all candidates and sent it to the EPA project team who then shared the list with GE for review. No COI concerns were raised and the final composition of the Peer Review Panel was determined in September 2009. The following experts were selected as the Peer Review Panel:

- Todd Bridges, U.S. Army Corps of Engineers, Engineer Research and Development Center
- Richard Fox, Natural Resource Technology, Inc.
- Paul Fuglevand, Dalton, Olmsted & Fuglevand, Inc.
- Gregory Hartman, Dalton, Olmsted & Fuglevand, Inc.
- Victor Magar, ENVIRON International Corporation
- Paul Schroeder, U.S. Army Corps of Engineers, Engineer Research and Development Center
- Timothy Thompson, Science and Engineering for the Environment, LLC.

### 1.3.3 Information Provided to the Panel

Both EPA and GE sent all necessary peer review documentation to SRA who distributed the information to the Peer Review Panel members. The Peer Review Panel was provided documentation to be reviewed both electronically on CD-ROM and through a secure online SharePoint site. Information included the EPA and GE Phase 1 Evaluation Reports and all supplemental information, the EPA Phase 1 Evaluation Report Addendum, and all public comments. SRA forwarded hard copies as appropriate and when requested by Panel members. Documents provided included:

- EPA and GE Background documents (January 2010)
- EPA and GE Items Provided Independent of Panel Requests from the February 17-18 Introductory Session (includes Addendum to the Phase 1 Evaluation Report)
- EPA and GE Items Provided in Response to Panel Supplemental Information Requests following February 17-18 Introductory Session (submitted to EPA March 2, 2010 and forwarded by EPA to GE March 10, 2010)
- EPA and GE Information Provide to the Panel in Response to Information Requests following the May 4-6 Peer Review Panel Meeting

The Peer Review Panel did not review subsequent modeling runs completed by GE that occurred after the May 4-6, 2010 public meeting. A comprehensive list of documents provided to the Peer Review Panel is attached to this report as an Appendix.

### 1.3.4 Peer Review process

On October 1, 2009, the Panel was requested to visit the Hudson River PCBs Superfund Site to observe high-volume Phase 1 removal actions in progress. Six of the seven members of the Panel traveled to the site to participate in a boat tour, the purpose of which was to provide the Peer Review Panel members with factual information pertaining to the site. Following the tour, the Panel and SRA gathered in a GE

conference room with members of the EPA and GE site teams for an informal question and answer session regarding the general charge of the Panel, the schedule for the peer review, and some of the technical challenges encountered during the Phase 1 activities. The meeting did not include any discussions pertaining to the GE Phase 1 Data Compilation or the EPA or GE Phase 1 Evaluation Reports, nor did it involve any interpretation of data that were collected in connection with the Phase 1 removal actions.

A collaborative approach was implemented throughout the peer review process. SRA organized frequent internal conference calls with the Peer Review Panel members to discuss status of the review and administrative and logistical issues. SRA served as a liaison between the Panel and EPA and GE helping to address Panel member concerns, additional information requests, and technical documentation needs. Any information requests from the Panel were presented to SRA then forwarded to EPA; EPA and GE worked together to provide the appropriate information to the Panel.

The Peer Review Panel members attended 2 meetings held in New York. The first was the Introductory Session held February 17-18, 2010 in Saratoga Springs, New York where EPA and GE presented the data and issues presented in their respective Phase 1 Evaluation Reports. The second was the Peer Review Public Meeting held May 4-6, 2010 in Glens Falls, New York where EPA and GE presented findings and the Peer Review Panel deliberated on issues raised according to the charge questions provided in Section 1.3.1 of this report. There was also a public comment period during each of these meetings providing the public an opportunity to present comments to the Peer Review Panel members. Public comments were provided to the Peer Review Panel electronically and in hard copy as requested.

Subsequent to all public peer review meetings, the Peer Review Panel worked collaboratively to develop this Peer Review Report.

### **1.4 Organization of Report**

The Peer Review Panel findings are presented in the remainder of this report. Section 2 of the report presents an overview of the Panel's findings. Sections 3, 4, and 5 present the Panel's findings for each charge question for each the 3 Engineering Performance Standards, respectively: Resuspension, Residuals, and Productivity. Section 6 provides a summary of these findings organized by charge question, and Section 7 presents concluding remarks of the Panel.

## 2 OVERVIEW OF THE PANEL FINDINGS

### 2.1 Overview

The Panel reviewed the considerable volume of data and reporting from the Phase 1 sediment remediation at the Hudson River PCBs Site to address 4 charge questions about the project. It was clear to the Panel that both EPA and GE are committed to the success of the project and expended considerable effort to comply with the 2004 EPS during Phase 1. The Panel recognizes their extensive efforts to evaluate and report on the information generated during Phase 1 and the effort expended in responding to the Panel's requests for additional information and analyses.

The Panel also recognizes that during Phase 1, the project encountered challenges in the implementation of the remedy and the use of the EPS to guide these efforts. In this way, Phase 1 did achieve a critical outcome, in that it elucidated the strengths and weaknesses of the EPS and provided important lessons regarding the design and implementation of the EPS going forward. If these lessons are heeded and incorporated into a modified set of EPS, it is expected that the project will more effectively achieve the desired outcomes.

Phase 1 showed that the 2004 EPS for Resuspension, Residuals, and Productivity were not met individually or simultaneously during Phase 1 and cannot be met under Phase 2 without substantive changes. The Panel recognizes the considerable efforts expended by EPA and GE in developing proposed changes to the EPS based on the lessons learned from Phase 1. However, the Panel finds that neither the EPA proposed modified EPS nor the GE proposed modified EPS would support the successful execution of Phase 2. Consequently, in response to Charge Questions 3 and 4, the Panel has developed and is recommending the implementation of modified EPS and Best Management Practices (BMP).

Phase 1 demonstrated that the Residuals EPS had a substantial impact on project success and on the interaction with the Resuspension EPS and the Productivity EPS. A key obstacle to simultaneously achieving the performance standards involved incomplete depth of contamination (DoC) characterization combined with adherence to the 2004 EPS residual target levels. This directly affected both the Resuspension and Productivity EPS. The repeated dredge passes and prolonged exposure of sediments in the certification units (CU) resulted in increased PCB resuspension and release. The unexpected increase in inventory due to incomplete DoC characterization had the greatest effect on the Productivity EPS in terms of numbers of CUs remediated.

The Panel's proposed modifications are predicated on the Panel's belief—based on our evaluation of the Phase 1 information and our collective experience—that if the DoC is better characterized and a focus is placed on quick closure of CUs, the bulk of PCB inventory can be removed during Phase 2. The Panel proposes revising the Residuals EPS to accelerate CU closure by establishing an elevation-focused dredge design paradigm, thereby reducing resuspension, effectively managing residuals, and improving productivity without sacrificing goals of the ROD with respect to overall recovery of the river.

More importantly, the revised EPS must be designed with the recognition that the tensions created by trying to achieve all 3 standards simultaneously can lead to unanticipated and unacceptable environmental consequences, such as increased resuspension and residuals due to prolonged CU dredging, or reduced productivity due to resuspension and residuals management to meet the EPS.



These tensions should be recognized before entering Phase 2, while seeking to resolve them through adaptive management that involves routine reassessment of dredging operations, BMPs, and dredging performance with regard to the EPS.

Toward this end, the Panel has developed an approach along with proposed modified EPS to maximize removal of PCB inventory in a careful balance with resuspension and residuals goals, while achieving an acceptable level of productivity. Further, the proposed approach and EPS incorporate adaptive management principles and build upon the commitment to these principles demonstrated by EPA and GE during Phase 1.

The Phase 1 Hudson River EPS Peer Review represents the intensely collaborative product of a group of 7 senior sediment remediation experts with diverse and complementary expertise across all of issues involved in remediation of the Hudson River. The Panel's findings reflect an integrated understanding of the contemporary challenges, limitations, and opportunities associated with environmental dredging and sediment remediation and provide a solid foundation to improve the outcome of Phase 2. The Panel has concluded that its findings will not be effective if taken piecemeal, but require an integrated application to provide benefit to Phase 2.

### **2.2 Structure of Response to Charge Questions**

Sections 3 through 5 of this document present the Panel's detailed review of the charge questions. Each section is devoted to a different EPS – Section 3 addresses the Resuspension standard, Section 4 addresses the Residuals standard, and Section 5 addresses the Productivity standard. Each section addresses the four charge questions as they relate to their respective EPS. Section 6 reorganizes the presentation by charge question, presenting a synopsis of the detailed findings presented in Sections 3 through 5 for each of the charge questions.

The charge questions follow a logical line of inquiry. Question 1 lays the foundation for the review, addressing the question of whether the 2004 EPS were met in Phase 1. The response to Question 2 is predicated on the response to Question 1, and the responses to Questions 3 and 4 are predicated on the response to Question 2. During deliberations, the Panel decided that the clearest approach for communicating findings would be to address this logical series of questions for each EPS, rather than proceed question-by-question.

However, the Panel recognizes that the EPS should work together and cannot be addressed independently. Where these inter-connections are particularly relevant to a finding, the detailed responses presented in Sections 3 through 5 address them. This interconnectivity is further addressed in Section 6.

### 3 RESUSPENSION

CHARGE QUESTION 1. Does the experience in Phase 1 show that each of the Phase 1 Engineering Performance Standards can consistently be met individually and simultaneously?

***Finding Rsp.1: The Phase 1 Resuspension Engineering Performance Standard (EPS) could not be consistently met individually during Phase 1, nor could the Resuspension EPS be met simultaneously with the other EPS, and the Resuspension EPS must be revised for Phase 2.***

Phase 1 experience clearly indicates that the 2004 Resuspension EPS was not consistently met (Table 1). All criteria set for PCBs were exceeded in Phase 1. The resuspension criteria include total PCB concentration, total and Tri+PCB load, and suspended solids concentration thresholds. The Resuspension EPS requires that the criteria be met at all far-field stations; defined as at least 1 mile downstream of dredging operations.

Both EPA and GE reported that the PCB-related criteria within the Resuspension EPS were not met during Phase 1. On the other hand, the Total Suspended Solids (TSS) near-field and far-field criteria were not exceeded during Phase 1; however, the relation of these measurements to release of PCBs is not evident in the Phase 1 monitoring data.

The failure to meet the Resuspension EPS for PCBs during Phase 1 was caused by multiple factors, including:

- The conceptual model did not account for all potential release mechanisms associated with dredging-related activities (i.e., not just dredge-induced sediment resuspension), therefore data were insufficient to support analysis of activities not directly related to dredging.
- Lack of recognition that suspended solids alone provide an insufficient basis for predicting PCB release rates.
- Underestimates of the total volume and PCB mass dredged during Phase 1.
- Underestimate of the PCB release rate (i.e., the release rate as a percentage of PCB mass dredged).
- Underestimate the downstream cumulative PCB loading rate and its contribution to monitored natural recovery (MNR).
- The rate and magnitude of PCB deposition in the upper and lower river was unaccounted for and not monitored.

The 2004 Resuspension EPS could not have been met because it is based upon the unsubstantiated premise that PCB release and transport are closely and simply related to the rate of sediment particulate resuspension and that a reliable relationship existed between total PCBs and sediment particulates as measured by TSS and/or turbidity. As indicated by the 2004 EPS Peer Review Report, the accumulated body of evidence in dredging studies demonstrates that the resuspension and release of PCBs during dredging cannot be predicted simply by measuring suspended solids and without accounting for dissolved PCB release and transport (Bridges et al. 2008). There are a number of release mechanisms/pathways for PCBs in addition to the release of suspended solids during dredging, including dredging induced release of porewater, dredging induced release of PCB oils, flux from exposed sediment surfaces, resuspension of sediments from exposed surfaces, as well as partitioning from

resuspended particles. Phase 1 demonstrate that there is no reliable relationship between total PCBs and sediment particulates as measured by TSS and/or turbidity; that is, measured TSS and PCB transport from removal operations were not statistically correlated during Phase 1.

The EPS for resuspension was set too low to be met in Phase 1 or Phase 2 without flow and traffic control in the Hudson River. The EPS was based on the premise that resuspension of solids and release of PCBs during dredging could be held to less than 1 percent of the total dredged mass. The experience in the dredging literature shows that resuspension by the dredge can generally be limited to a 1 percent loss (Hayes and Wu 2001, Pennekamp et al. 1996, Palermo et al. 2009); however, this resuspension does not represent the total loss of solids and PCBs. Additional losses occur from debris removal, and erosion of generated/disturbed residuals by high flow events and prop wash. Generated/disturbed residuals typically represents 2 to 9 percent of the total dredge mass of the final pass (Patmont and Palermo 2007). In a riverine system with currents as high as present in the Hudson River during higher flow periods, much of the generated residuals will be lost if the residuals are not covered. Therefore, typical PCB losses in riverine systems such as the Fox River (Steuer 2000) and Grasse River (Connolly et al. 2006) are reported to be in 2 to 3 percent of the mass dredged. These typical results encompassing all sources of losses are consistent with the losses observed in Phase 1. Therefore, setting the EPS for resuspension to achieve losses less than 2 percent without flow and traffic control are unrealistic and not practicable.

Table 1: Comparison of resuspension results to the EPS

Parameter*		Evaluation Level		Control Level		Standard Level		Finding	Was the 2004 EPS met?
		Limit	Duration	Limit	Duration	Limit	Duration		
Far-Field PCB Concentration	Total PCBs		---	350 ng/L	7-day running average	500 ng/L	Confirmed Occurrence	Total PCB Standard of 500 ng/L at Thompson Island Station was exceeded on 3 to 10 occasions. The Control Level was exceeded 4 times (as a 7-day average) at the TIP, but not at Lock 5 (Schuylerville).	No
	Tri+PCBs								
Far-Field Net PCB Load	Total PCBs		---	117 kg/yr	Dredging Season	---		Total PCBs transport was 437 kg (500 kg GE estimate) past the TIP, and 151 kg (200 kg GE estimated) to Waterford. Tri+ levels were 123 kg past Lock 5, and 61 kg past Waterford.	No
	Tri+PCBs			39 kg/yr					
	Total PCBs	541 g/day	7-day running average	1080 g/day	7-day running average				
	Tri+PCBs	180 g/day		361 g/day					
Far-Field Net Suspended Solids Concentration	TSS	12 mg/L	24 hrs.-average	24 mg/L	24 hrs.-average	---	Average TSS concentrations at near-field monitoring stations were well below the evaluation criteria of 700 mg/L at 100 m and 100 mg/L at 300 m downstream of the dredging operations.	Yes	
Near-Field (300 m) Net Suspended Solids Concentration	TSS	100 mg/L	6-hr average net increase over ambient	100 mg/L	6-hr average net increase over ambient	---		Yes	
Near-Field (100 m and Channel-Side) Net Suspended Solids Concentration	TSS	700 mg/L	Calculated from discrete turbidity measurements made in 2 sampling events per day	---	---	---		Yes	

\* Sources for this data include Table I-1-1 from EPA Phase 1 Evaluation Report 1, and Phase 1 Performance Standards Compliance Plan, May 2009, Table 2-1. See also Tables I-1-2 through I-1-6 and I-2-1 through I-2-3

**Finding Rsp.1-1: The far-field PCB concentration limit was exceeded repeatedly.**

The PCB concentration standard and control level was exceeded during Phase 1 at the Thompson Island Pool (TIP) and Lock 5 far-field monitoring stations. The Standard Level of 500 ng/L total PCBs, set to protect drinking water supplies at Waterford Station, was exceeded on 3 or 10 occasions (EPA reported 3, whereas GE reported 10 exceedances at Thompson Island; the difference depends on the interpretation of analytical results for certain co-eluting congeners). GE reported that the Control Level of the 7-day running average of 350 ng/L was exceeded during 4 periods at the Thompson Island monitoring station; July 18-22, 2009; July 31-August 10, 2009; September 15-16, 2009; and October 12-21, 2009. EPA acknowledges the Control Level was exceeded at the Thompson Island station; from EPA's Figure I-3-4b this appears to have occurred between July 28 and August 9. Notably, by EPA's measures, the 7-day average total PCB concentrations did not exceed the Control Level of 350 ng/L at the Lock 5 (Schuylerville) monitoring station, but there was 1 exceedance of the 500 ng/L level Resuspension Standard.

**Finding Rsp.1-2: The net PCB load criterion was exceeded at far-field stations.**

All PCB loading criteria were exceeded at the far-field stations in Phase 1 (Table 1). This includes both the evaluation and control levels as either 7-day running average or as the total mass for the Phase 1 dredging season. The Panel understands that while the loadings were adjusted in the Phase 1 Performance Standards Compliance Plan (GE 2009) based upon the estimated Phase 1 mass, even adjusting again for the actual mass removed, the far-field net PCB load criteria were exceeded (Table 2). Both the EPA and GE reports acknowledge this fact.

**Table 2. Estimated and actual PCB transport losses from Phase 1**

	Document					
	ROD <sup>1</sup>	EPS Phase 1 <sup>2</sup>	Phase 1 Design <sup>3</sup>	PSCP <sup>4</sup>	EPA Phase Report <sup>5</sup>	GE Phase 1 Report <sup>6</sup>
Total Mass TPCB (kg)	69,800	6,980	10,000	12,564	20,000	16,320
Estimated TPCB Loss (kg)	90.74	65	30 - 59	117	437 past TI 151 to Waterford	500 kg past TI 200 kg to Waterford
Estimated Tri+PCB Loss (kg)	---	---	---	39	123 past Lock 5 61 past Waterford	---
Percent Loss	0.13%	1%	0.3%	0.93%	2.2%	3.1%
	---	---	0.6%	---	0.8%	1.2%
<b>Notes:</b>						
1. Record of Decision, Table 3-1 and Page 69 which stated a 0.13% loss due to resuspension						
2. EPS (2004) Pages 16 and Pages 95 - 97.						
3. Phase 1 Design Report, F.6, Page 6-1. Modeled loss of 0.35% (30 kg) and 0.65% (59 kg) of mass removed.						
4. Phase 1 Performance Standard Compliance Plan, pages 13 and 21. Control level criteria adjusted to 117 kg/yr total PCBs; 39 kg Tri+PCB						
5. EPA Phase 1 Report, Page I-3.						
6. GE Phase 1 Report, page 77 and Table 4.2-3						

--- Indicates no value was reported

For the annual load limit, EPA reports 437 kg transported past Thompson Island, while GE reports about 500 kg. The 2 parties report total PCBs of 151 kg and 200 kg, respectively, past Waterford. EPA reports Tri+ levels were 123 kg past Lock 5, and 61 kg past Waterford; GE does not report the Tri+ loads past Lock 5 or Waterford.

Using EPA's 437 kg value, the average daily release rate is 2,497 g/day for the 175-day production period from May 14 through November 4, 2009. Thus, PCB loading exceeded all of the criteria, including the 1,600 g/day criterion deemed unacceptable by EPA in the 2004 Resuspension EPS.

While the Total PCB (TPCB) and Tri+PCB 7-day running average net load at Thompson Island exceeded the Phase 1 Control Levels (1,080 g/day and 361 g/day, respectively) throughout most of the project, the TPCB loads at Lock 5 and Waterford were significantly less than those observed passing the Thompson Island Dam. At Waterford, the 7-day average load was less than the Evaluation Level about 50 percent of the time and only exceeded the Control Level 20 percent of the time.

EPA states in its Phase 1 Report that "EPA's goal of a maximum 1 percent loss rate to the Lower Hudson River was achieved." While this is true, the 2004 Resuspension EPS is very clear in stating that the standard is applicable to all far-field stations, which are defined in the 2004 EPS as stations that are 1 mile or more below the dredging area. A revised Far-Field Net PCB Load standard should be applied to all far-field stations in Phase 2 in order to ensure that the objectives motivating the use of the load standard are met for the upper and lower portions of the river.

That the net PCB loads exceeded the 2004 Resuspension EPS is singularly troubling. The Panel disagrees with EPA's contention that the "Data do not support the notion that settling of PCB-contaminated sediment was a significant contributor to resuspension and recontamination of non-dredged areas." In fact, limited data collected on the net load deposition downstream of the TIP dam make it impossible to substantiate this observation. The incompleteness of the conceptual model in regard to PCB release and deposition mechanisms, and the incompleteness of the monitoring data relative to those release mechanisms, prevents the Panel from reaching credible conclusions about the nature and fate of the PCB releases—the origin of the releases, the long-term consequences of those releases, and what management actions should be taken to reduce or control those releases.

***Finding Rsp.1-3: The Total Suspended Solids (TSS) standard was met, but the basis for the standard is invalid.***

As pointed out by the 2004 Peer Review, the scientific literature demonstrates the TSS cannot be used as a predictor of PCB release during dredging operations. The Phase 1 data also show that TSS is not a sufficient predictor of PCB release.

***Finding Rsp.1-4: Modeling and data collection gaps limit the usefulness of MNR comparisons.***

The 2004 Resuspension EPS used HUDTOX and FISHRAND models to simulate water column, sediment, and fish Tri+PCB concentrations as a result of dredging operations. Modeled export loads and potential impacts to the public water supply were written into specific criteria; however, this effort also examined the potential effects of changes to fish tissue concentrations.

A conclusion in the 2004 EPS is that resuspension of PCBs in compliance with the standard would have a negligible adverse effect on Tri+PCB concentrations in Hudson River fish, as compared to a scenario with non-dredging-related PCB releases. The EPS defined a negligible effect as a predicted Tri+PCB

concentration in Upper Hudson fish of 0.5 mg/kg or less, and in Lower Hudson River fish of 0.05 mg/kg or less, within 5 years after the completion of dredging in the Upper Hudson. These results could not be substantiated based on the Phase 1 data.

The 2004 EPS clearly, and repeatedly, references monitored natural attenuation (MNA) as a basis for establishing the upper bound of an acceptable level of sediment release (emphasis added).

“The cumulative Tri+PCB load at Waterford as forecasted by HUDTOX was used to determine what would be considered a significant release (i.e., resuspension export rate) from the dredging operation...The lower bound will be the ideal conditions of dredging, where there are no sediments being spilled (no resuspension) and ***the upper bound will be the MNA scenario.***”

While a comparison to MNA or MNR conditions is worthwhile, the usefulness of the modeling effort has been limited by the following:

- Fish tissue monitoring results have been insufficient to determine the net effect on short- and long-term PCB bioaccumulation downstream of the dredging footprint (see following discussion).
- HUDTOX/FISHRAND models are outdated and inadequate to accurately project MNR and post-dredge fish recovery rates.
- Neither EPA nor GE has sufficient data or a credible tool to project recovery.
- The MNR analysis is incomplete, insofar as it relies on a single line of evidence (namely, comparison of MNR vs dredge-related far-field PCB sediment loads) to evaluate and compare dredge-related releases to MNR releases.

The incomplete analysis done for the 2004 EPS does not consider near-field and far-field PCB deposition rates on the sediment bed surface; accelerated recovery potential in the areas targeted for dredging, primarily due to post-removal backfill and capping, natural sedimentation, and surface sediment mixing; and volatilization that can influence human exposures. An analysis based solely on cumulative loads to compare MNR and dredging is incomplete. A more relevant analysis would measure and predict changes in surface sediment chemical concentrations due to dredging and long-term changes in fish recovery rates to compare the time required for long-term recovery after dredging with the time required for long-term recovery under MNR.

Results of fish tissue monitoring offered limited projections on long-term fish concentrations relative to the no dredging-related PCB releases (i.e., MNR alternative). The fish concentration data collected during and after 2009 dredging operations are a measure of short-term, transient exposures due to water column PCB concentrations produced as a result of dredging. More substantial impact is likely to occur via long-term exposures due to increased surface sediment PCB concentrations resulting from the release, deposition and flux of PCBs into the sediment bed in the upper and lower river. Factors that must be considered in evaluating existing and future fish tissue data include:

- Black bass, bullhead, and yellow perch were sampled in June 2009, before most of the removal activity occurred. If these species were sampled again in June 2010, the results would be relevant to developing projections regarding long-term recovery.

- The forage fish sampling protocol results in limited statistical power due to limited replication.
- The most useful of the existing fish tissue monitoring data sets is the pumpkinseed data. However, pumpkinseed are not a “worst case” species with respect to bioaccumulation potential, as they are neither top predators, directly associated with bedded sediments, nor particularly high in lipid content.
- PCB concentrations in fish take time to equilibrate and may have continued to increase after water and sediment concentrations began to stabilize.



CHARGE QUESTION 2. If not, and if EPA and/or GE has proposed modified Engineering Performance Standards, does the experience in Phase 1 and any other evidence before the panel show that it will be practicable to consistently and simultaneously meet the Engineering Performance Standards that are being proposed for Phase 2?

***Finding Rsp.2: It is not practicable to consistently and simultaneously meet the Resuspension EPS proposed by either GE or EPA for Phase 2.***

Both EPA and GE provided tables of their proposed changes for Phase 2 to the Resuspension EPS at the May 2010 Peer Review meeting in Glens Falls, New York. Those are shown in Table 3 and Table 4, respectively, along with the Panel's response to each of those proposed revisions. In general, the Panel found that neither party proposed changes that can be supported at this time for Phase 2. The Panel specifically finds that (1) the far-field net PCB loads cannot be solely applicable to the Lower Hudson; (2) while load criteria are needed for Phase 2, neither the tools nor data necessary for setting them are available from Phase 1; (3) there is no need to revise the TSS standard, but the rationale for setting that standard should be examined as it is no longer valid; and (4) the far-field PCB concentration standard of 500 ng/L should be maintained.

EPA articulated a broad set of goals in the 2004 EPS to protect human health and the environment, and designed the resuspension standard to avoid disturbing near-field and far-field conditions relative to an MNR trajectory modeled for the ROD. It is both reasonable and important to comprehensively evaluate the long-term effects of planned remedial actions, and to adjust plans and operational practices so as to limit the unintended and undesirable environmental consequences associated with remedial activities. However, EPA's proposed revision to the resuspension standard does not adequately address how the removal action in the river could positively or negatively affect environmental conditions between the TIP and Waterford. As GE has indicated, unrestricted release of PCBs from the removal action could exacerbate risks to both near-field and far-field receptors. However, the Panel was not provided with sufficient evidence to evaluate the environmental consequences of increased mass transport observed in Phase 1, and predicted for Phase 2.

Neither EPA nor GE has proposed scientifically supportable standards. EPA's load analysis, presented in the 2004 EPS and Phase 1 reports, is based on HUDTOX/FISHRAND model projections, which are not reliable for evaluating and setting release loads. GE did not provide the Panel with sufficient detail and explanation supporting their proposed standard change based on new modeling results; therefore the Panel was not able to evaluate the calculations, assumptions, or conclusions of their effort. However, regardless of the modeling details, the Panel believes that the data collected during the 2009 dredging season are unlikely to provide a sufficient basis for a definitive modeling effort concerning PCB releases and their consequences. In this regard, defensible data on near-field resuspension release rates are needed. It is also not acceptable, nor is it consistent with the ROD or 2004 EPS, to constrain the consideration of long-term consequences of release to the Lower Hudson. Consistent with the 2004 EPS definition of far-field, an understanding of the loading to the Hudson River between the TIP Dam and Waterford is required.

HUDTOX is not a proper basis upon which to derive dredging criteria for Phase 1, and cannot be relied upon to derive criteria for Phase 2. In addition to HUDTOX not being built to model dissolved PCB losses,

the key assumption in that model is that losses are from dredging resuspension alone. The model was not constructed in a manner that considered other contributing factors such as debris removal, prop wash from scows and tugs associated with the dredging, prop wash from other vessels in the river, and hydrodynamic scour due to (a) the dredging configuration, and (b) the time newly exposed dredge surfaces were left open. Furthermore, HUDTOX is not capable of evaluating dredge-related or localized resuspension scenarios; it requires input of PCBs as a specific load rate (EPS Volume 1, Section 2.6).

Attachment F of the 2006 Phase 1 Final Design Report included dredge resuspension modeling. The dredge resuspension simulated is only that sediment resuspended in the water column from direct dredge operations, and does not include other dredge-related sources of resuspension such as debris removal, installation and removal of sheet piling, silt curtains, and barge movement. High-flow / event resuspension (erosion) was not considered because dredging activities were not expected to take place during such river conditions (ref. p. 1-4 of Attachment F of the 2006 Phase 1 Final Design Report).

While there is a very real need to set far-field PCB load criteria, neither the data nor the tool(s) presented to the Panel are adequate for setting a revised standard. Additional data will be needed on near-field PCB releases, continued near-field and far-field measures of PCBs (total and dissolved), formulation of a conceptual site model that encompasses all the mechanisms for PCB release, and the development of a new or updated model that can be used to project PCB fate and effects with a higher degree of confidence than is currently available.

**Table 3. Summary of EPA’s proposed modifications to the Resuspension EPS**

EPA Proposed Modifications to Resuspension EPS				Panel Finding	
Standard	Proposed Change	Proposed Numerical Criteria	Rationale	Accept Proposed Change?	Rationale
<b>Far-Field Net PCB Load</b>	Adjust the far-field net PCB load standard; adjust the seasonal load and corresponding daily evaluation and control level loads upwards.	<p>The Control Level for cumulative Tri+PCB load due to the project: 1% of the estimated Tri+PCB inventory. Based on the current best estimate of the PCB mass to be removed, 1% is 670 kg Tri+PCB; the corresponding daily load Control Level is 680 g/day based on a 7-day running average.</p> <p>The Evaluation Level will be 500 kg Tri+PCB. The daily load equivalents will be 490 g/day, based on a 7-day running average.</p> <p>The daily load for the Control and Evaluation Levels will also be prorated to reflect the annual Productivity EPS schedule and the estimated mass of PCBs to be removed in the given year.</p>	Based on new model analysis, a total project net PCB load of 670 kg Tri+PCBs +/- 25% was shown to have only a negligible impact on the Lower Hudson. Evaluation of potential effects of various Tri+PCB loads on Lower Hudson River fish tissue concentrations indicates that a 670 kg project load will yield a similar rate of recovery to 2004 model simulations.	No	The Panel agrees in concept with the need to re-evaluate the numerical load criteria for both the Upper and Lower Hudson River. However, because EPA could not adequately define the environmental consequences of near-field and far-field resuspension and release loads, the Panel maintains that there is insufficient information available to establish revised numerical criteria for the Resuspension EPS. Insufficient Phase 1 data specific to near-field PCB releases exist to support the development of a revised Resuspension EPS.

EPA Proposed Modifications to Resuspension EPS				Panel Finding	
Standard	Proposed Change	Proposed Numerical Criteria	Rationale	Accept Proposed Change?	Rationale
	Revise the station of compliance for load to Waterford, exclusively.	N/A	<p>Waterborne PCB concentrations decrease with distance from dredging. The focus of the load analysis in the 2004 Resuspension EPS documents was loads that would be released to the Lower Hudson; such loads are best measured at Waterford. Thus, this change is consistent with the intent of the performance standard.</p> <p>Based on new model analysis, a total project net PCB load of 670 kg Tri+PCBs +/- 25% was shown to have only a negligible impact on the Lower Hudson. Additionally, a model simulation of the Upper Hudson showed that similar loads in the Stillwater/Waterford pool did not substantively impact this reach of the Upper Hudson.</p>	No	<p>The Panel agrees in concept with the need to re-evaluate the numerical load criteria for both the Upper and Lower Hudson River. However, because EPA could not adequately define the environmental consequences of near-field and far-field resuspension and release loads, the Panel maintains that there is insufficient information available to establish revised numerical criteria for the Resuspension EPS. Insufficient Phase 1 data specific to near-field PCB releases exist to support the development of a revised Resuspension EPS.</p>
<b>Near-Field Net Suspended Solids Concentration</b>	Reduce the near- field net suspended solids (TSS) levels for Phase 2.	<p>Net increase of 50 mg/L TSS above ambient (upstream) conditions at a location:</p> <ul style="list-style-type: none"> <li>◆ 300 m downstream of the dredging operation, or</li> <li>◆ 150 m downstream from any TSS control measure.</li> </ul>	<p>Conditions during Phase 1 showed that current suspended solids criteria are too high to be useful and lower criteria are achievable and needed to monitor solids transport and releases. Proposed levels are</p>	No	<p>The Panel does not agree with EPA's rationale for a reduced TSS standard. The 2004 EPS standards were achieved in Phase 1, and the data clearly showed that TSS is not a reliable predictor of</p>

EPA Proposed Modifications to Resuspension EPS				Panel Finding	
Standard	Proposed Change	Proposed Numerical Criteria	Rationale	Accept Proposed Change?	Rationale
		<p>Sustained TSS of 100 mg/L above ambient (upstream) conditions at near-field stations located:</p> <ul style="list-style-type: none"> <li>◆ to the side of dredging operations, or</li> <li>◆ 100 m downstream of dredging operations.</li> </ul>	<p>consistent with observations of suspended solids during Phase 1 and should not result in the need for more stringent practices than applied in Phase 1 with respect to suspended solids control.</p>		<p>PCB release. The Panel concluded that any further restriction on TSS loading unnecessarily burdens productivity. The 2004 TSS standard should be maintained.</p> <p>The Panel agrees with discontinuing the use of turbidity data for Phase 2. The collection of near-field TSS data should be continued at least through Year 1 of Phase 2 (along with near-field PCBs) to facilitate model calibration. However, the EPS should clarify how the TSS data will be used (to quantify near-field sediment deposition rates and chemical resuspension, near-field deposition, and far-field release rates). This assessment may be particularly relevant to non-PCB chemicals, such as metals.</p>

EPA Proposed Modifications to Resuspension EPS				Panel Finding	
Standard	Proposed Change	Proposed Numerical Criteria	Rationale	Accept Proposed Change?	Rationale
<b>Far-Field PCB Concentration</b>	Use the 500 ng/L threshold at Thompson Island as a trigger to require operational changes, but not necessarily an operational shutdown, at EPA's discretion.	N/A	The towns of Waterford and Halfmoon are not going to use the Hudson River as their source of potable water during the dredging period. For this reason, the drinking water quality basis for the 500 ng/L is alleviated. However, this level is still seen as important to control the mass loading to the Lower Hudson River and will be maintained to help EPA require operational changes when resuspension is elevated.	Yes	Far-Field EPS criteria for PCB concentration should be maintained and measured at all stations. However, because drinking water sources have been relocated to avoid drawing from the Hudson River during dredging, the Panel recommends that the 500 ng/L concentration limit be used operationally, to help manage dredging operations but not necessarily to shut down operations.
	Maintain the water column Control Level of 350 ng/L for discretionary use by EPA to require (as opposed to merely recommend) appropriate operational changes.	N/A	Using 350 ng/L as a Control Level will help ensure that resuspension does not exceed acceptable levels.	No	The 350 ng/L control level should be maintained as an advisory level only. To do otherwise would unnecessarily impact productivity.

**Table 4. Summary of GE's proposed modifications to the Resuspension EPS**

GE Proposed Modifications to the Resuspension EPS				Panel Finding	
Standard	Proposed Change	Proposed Numerical Criteria	Rationale	Accept Proposed Change?	Rationale
<b>Far-Field Net PCB Load</b>	<p>The load standard must be determined correctly. Correct numerical load criteria should be developed for the Upper and Lower Hudson. The standard for the Upper Hudson should be based on the benefits to Upper River fish. The standard for the Lower Hudson should be based on a comparison to the load that would occur from MNA.</p> <p>(from GE Report Section 9.1.2.1, page 177)</p> <p>The PCB fate and bioaccumulation models should be used to determine allowable loads for the Upper and Lower Hudson considering the full impact of resuspension, including redeposition. The numbers should be based on minimizing impacts to fish in the Upper Hudson and ensuring that dredging accrues a benefit in the Lower Hudson.</p>	<p>A firm, not to exceed 1,200 kg Total PCB limit, subject to downward adjustment based on redeposition.</p> <p>The net load should be assessed for the entire year, not just during the dredging season, to account for redeposition.</p> <p>The load standard must remain true to its original purpose, to ensure that dredging does not release more PCBs to the river than MNA. The load standard was not, and should not be, based on a percentage of the PCB mass encountered during dredging. A standard based on the percentage of PCB mass allows more PCB to be sent downriver than MNA, and thus eliminates the benefits of dredging originally projected by EPA. The load standard must be a hard cap. EPA originally set this standard as a fixed</p>	<p>New projections of PCB load for natural recovery and dredging that are made using an improved model that is not biased relative to the loads measured during the baseline monitoring program. From these new projections, a determination can be made of the maximum resuspension load that would allow dredging to achieve a net reduction in PCB load to the lower river within the next 20 or so years and preserve most of the benefits to Upper Hudson fish.</p>	No	<p>The Panel agrees in concept with the need to re-evaluate the numerical load standards for both the Upper and Lower Hudson River. The Panel was not provided the information necessary to evaluate the model(s) used by GE to propose these specific numbers. In addition, the Panel believes that there are insufficient Phase 1 data specific to near-field PCB releases to support appropriate calibration and validation of any model.</p>

GE Proposed Modifications to the Resuspension EPS				Panel Finding	
Standard	Proposed Change	Proposed Numerical Criteria	Rationale	Accept Proposed Change?	Rationale
		number, and it should remain fixed to ensure the remedy achieves its intended benefits.			
<b>Near-Field Net Suspended Solids Concentration</b>	<ul style="list-style-type: none"> <li>◆ Discontinue the use of near-real time turbidity data to estimate TSS concentrations using the TSS/turbidity relationship.</li> <li>◆ Discontinue TSS compliance monitoring in the near-field.</li> <li>◆ Limit TSS sample collection to 24-hour composite samples that accompany PCB samples.</li> </ul>	---	---	Yes	The Panel agrees with discontinuing the use of turbidity data for Phase 2. Near-field TSS should be continued at least through Year 1 of Phase 2 (along with near-field PCBs) in order to provide data for model calibration.
<b>Far-Field PCB Concentration</b>	GE does not propose any change to the 500 ng/L resuspension standard for PCB concentration in the water column. That standard is based on EPA’s drinking water standard for PCBs and should remain in place for Phase 2. (Page 178)	---	---	Yes	The Panel agrees that the PCB chemical concentration EPS should be maintained for all far-field stations.



CHARGE QUESTION 3. If the experience in Phase 1 and other evidence before the Panel does not show that it will be practicable to consistently and simultaneously meet the Engineering Performance Standards that are being proposed for Phase 2, can the Phase 1 Engineering Performance Standards be modified so that they could consistently be met in Phase 2, and, if so, how?

Phase 1 demonstrates that the resuspension and redeposition mechanisms operating at the site are not well understood. Further investigations are necessary to develop a Resuspension EPS that is protective of the resources identified in the ROD and EPS, and that can be consistently be met in Phase 2. This standard must address the influence of PCB resuspension and release on recovery in both the upper and lower portions of the river.

The Panel recommends an expanded adaptive management approach be applied to all EPS in order to achieve the expected benefits of the project in Year 2 and in subsequent years. The following standards apply to Year 1 of Phase 2. During Year 1, the Panel recommends collecting additional data to support the development of a meaningful and environmentally relevant Resuspension EPS that will be applied for the remainder of the project duration. The Panel also recommends that the expanded adaptive management approach allow for continuous modification of the EPS to optimize remedial operations and to limit unintended consequences and adverse environmental impacts from those operations. To achieve these goals, the Panel recommends the following:

- Establish a common method for analyzing and presenting PCB data. Tri+ is the PCB measurement basis used in the ROD; the Panel proposes that any future standard for resuspension be expressed as Tri+PCB, but that both total and Tri+PCBs be reported routinely. The exception is the far-field concentration of 500 ng/L TPCB.
- Collect additional near-field and far-field data in Year 1 of Phase 2 to relate operational activities to sediment resuspension and PCB release.
- Set an interim resuspension standard for Year 1 of Phase 2 that Tri+PCB release rates measured at the TIP Dam and Waterford to 2 percent and 1 percent, respectively, of the Tri+PCB mass removed.
- Develop, calibrate, and validate a project-specific fate and transport model to set near-field and far-field resuspension criteria.
- Adaptively manage all EPS to achieve the expected benefits of the project in Year 2. With respect to the Resuspension EPS, based on the Phase 2 Year 1 results, EPA should establish appropriate and achievable criteria that balance the benefits of reduced risks within the dredging footprint against the detriments of increased downstream transport and associated risks.
- Use the 500 ng/L total PCB threshold at the far-field monitoring stations as a trigger to consider operational changes, not operational shutdown. Drop the 350 ng/L Control Level.
- Continue use of near-field TSS compliance monitoring and levels at a minimum for completion of the Phase 1 CUs (9 - 16), and then re-evaluate the utility of TSS after Year 1 of Phase 2. Add PCB homolog measures to stations where TSS is being collected.
- Set allowable transport loads for Phase 2 based upon the findings from Year 1 of Phase 2.

***Finding Rsp.3: The Phase 1 Resuspension EPS can be modified to be consistently met in Phase 2; however, neither the data nor the tool(s) presented to the Panel are adequate for defining a practicable standard that meets risk reduction goals.***

The data presented to the Panel are insufficient for setting appropriate limits for resuspension and release that are protective of near-field and far-field habitat areas. The goal of a resuspension EPS should be to ensure that the dredging operation is performed as well as practicable, recognizing that any release of contaminants has the potential to cause short- and long-term environmental harm. If the environmental harm is unacceptable, then the environmental dredging protocols or remedial design must be changed. In the absence of additional BMPs, changes in dredging operations, and modification of the other EPS, the experience in Phase 1 provides relatively extensive far-field information; however, the data and tools are insufficient to determine the potential for short- and long-term environmental harm, as negligible information is provided regarding near-field and far-field PCB deposition. In addition, the data and tools are insufficient to determine what is practicable with additional BMPs, changes in dredging operations, and modification of the other EPS. To develop a useful resuspension standard, a single, defensible model is required. The Panel strongly recommends that EPA and GE work together to develop such a model to meet project needs.

The Panel does not have enough information to propose specific revisions to the Resuspension EPS, particularly for the portion of the river between the TIP Dam and Waterford. Given (1) the failure to achieve the 2004 EPS resuspension standard, (2) the absence of supportable projections by either party, and (3) the lack of near-field PCB data, the Panel has laid out a process that relies on interim performance standards to allow for additional data collection during Year 1 of Phase 2, followed by use of an adaptive management approach that includes updating the Resuspension EPS at the end of Year 1 of Phase 2 and for subsequent Phase 2 work. The goal is to produce a scientifically sound and environmentally protective Resuspension EPS that can be consistently met, simultaneously with the Residuals EPS and Productivity EPS. Thus, the Panel has defined an interim standard (to be used for 1 season) based upon observed PCB releases in Phase 1, and proposes that the Resuspension EPS be revised for Year 2 of Phase 2 based upon development of model-validated projections using the additional data to be collected in Year 1 of Phase 2. Further, the project should undergo annual review and should make use of an adaptive management approach that draws from the experience and data gained in each year's efforts to update the operational design and practice for the following year.

***Finding Rsp.3-1: Inconsistent data produced by EPA and GE creates obstacles to establishing the validity of scientific conclusions and makes it difficult or impossible for community stakeholders and other interested parties to understand the impact of remediation activities. Therefore, EPA and GE should establish a common method for analyzing and presenting PCB data.***

In the Phase 1 report, GE updated the correction factor used to adjust the PCB concentrations of some of the peaks measured by the modified Green Bay Method; EPA did not. The Panel had to expend considerable resources during the evaluation process to compare results between the 2 reports. Inconsistent expression of the Resuspension EPS (as Total PCB *and* Tri+PCBs) also made data analysis difficult. The ratio of Tri+PCBs to total PCBs is not consistent throughout the site, ranging from less than 20 percent to 35 percent Tri+PCB. Understanding the fraction of PCBs that are likely to be volatilized during near-field and far-field transport (i.e., primarily mono and di-PCBs) and the fraction that may potentially redeposit further downstream or that can potentially become available for bioaccumulation is critical to revising resuspension criteria to be protective of near-field and far-field receptors.

EPA and GE should come to an agreement as to the appropriate summation method for PCB data prior to undertaking Phase 2. The same method must be used for all data comparisons, whether they precede Phase 1 or are based on Phase 1 and 2 results.

The Panel also recommends that any future standard for resuspension be expressed as Tri+PCB, but that both total and Tri+PCBs also be reported routinely. One exception to this rule may be the reporting of far-field aqueous concentrations for comparison to the 500 ng/L TPCB water quality standard, which may be expressed as TPCB, consistent with the respective “Applicable or Relevant and Appropriate Requirement.”

***Finding Rsp.3-2: There is insufficient information from Phase 1 upon which to base a revised Resuspension EPS.***

Neither the tools nor the data presented to the Panel will support definitive revisions of the Resuspension EPS that will be protective of the near-field and far-field receptors identified in the ROD and the EPS. Additional near-field data are needed to develop tools that can relate the release mechanisms associated with various dredging unit processes to the increased risks of downstream transport. The Panel’s finding that there is insufficient information from Phase 1 upon which to base a revised Resuspension EPS is based on the observation that insufficient data exists to correlate dredge-related operations to PCB resuspension release rates. Also, there is insufficient near-field data to quantify near-field deposition rates and corresponding impacts to human health and wildlife risks.

***Finding Rsp.3-2.1: There is insufficient data to correlate dredge-related operations to PCB resuspension release rates.***

Table 1 shows Phase 1 estimated and actual PCB resuspension release rates. In reviewing the documents leading up to implementation of Phase 1, the estimated transport loads varied with the estimation of the mass to be removed. The loss rate in the ROD was clearly underestimated at 0.13 percent, whereas the 2004 EPS predicted a range of loss rates (0.25 percent to 2 percent) prior to settling on a predicted rate of 1 percent. The estimates changed again during the Phase 1 Design and subsequent Phase 1 Performance Standard Compliance Plan, but all remained optimistic, predicting less than 1 percent release as per the 2004 EPS. Much higher release rates were reported by EPA and GE, based on the Phase 1 results. EPA and GE’s Phase 1 reports differed with respect to the actual total mass removed and total PCBs released past the TIP and Waterford. However, the differences predicted by EPA and GE were largely due to different computational approaches for PCBs removed and for suspended PCB concentrations and resuspension loads. At TIP, EPA estimated a 2.2 percent loss compared to GE’s 3.1 percent; at Waterford, EPA estimated a loss of 0.8 percent compared to GE’s 1.2 percent. Despite the differences in resuspension release rates reported by EPA and GE, the range of losses reported at TIP (i.e., in 2 percent to 3 percent) are consistent with near-field losses reported in the engineering and scientific literature (Steuer 2000, Connolly et al. 2006).

EPA’s Phase 1 Report Figure I-3-18a (Figure 2) presents a compelling representation of PCB mass removed against losses measured at TIP, Lock 5, and Waterford. The Panel confirmed EPA’s mass removal projection with the data in GE’s Appendix Table G-1c (Summary of Daily Bucket Analysis by CU), and the release rates at the TIP with GE’s Figure 5.3-8 (Net Total PCB concentrations at Thompson Island) (Figure 3). While dredge releases are a contributor, there does not appear to be a consistent relationship between mass removed and mass lost solely by the physical act of dredging. Based on EPA’s

analysis, PCB release is not solely controlled by dredging rates or mass removed. GE presented an empirical model that relies on rates of dredged PCB mass removed plus current velocities to predict water column PCB concentrations and resuspension release rates at Waterford. The model reasonably predicts Waterford PCB concentrations, suggesting a strong relationship between PCB mass removed and river flow velocities. This information, combined with EPA's analysis, suggests that river flow was a significant contributor to PCB resuspension and release. What is unclear is the extent to which the various aspects dredging operations contributed to resuspension and release (e.g., open CUs, scow operations, dredge rates, dredge depths, bucket size, bucket overflow, and other dredge-related unit processes, such as single lane advance of dredging downstream).

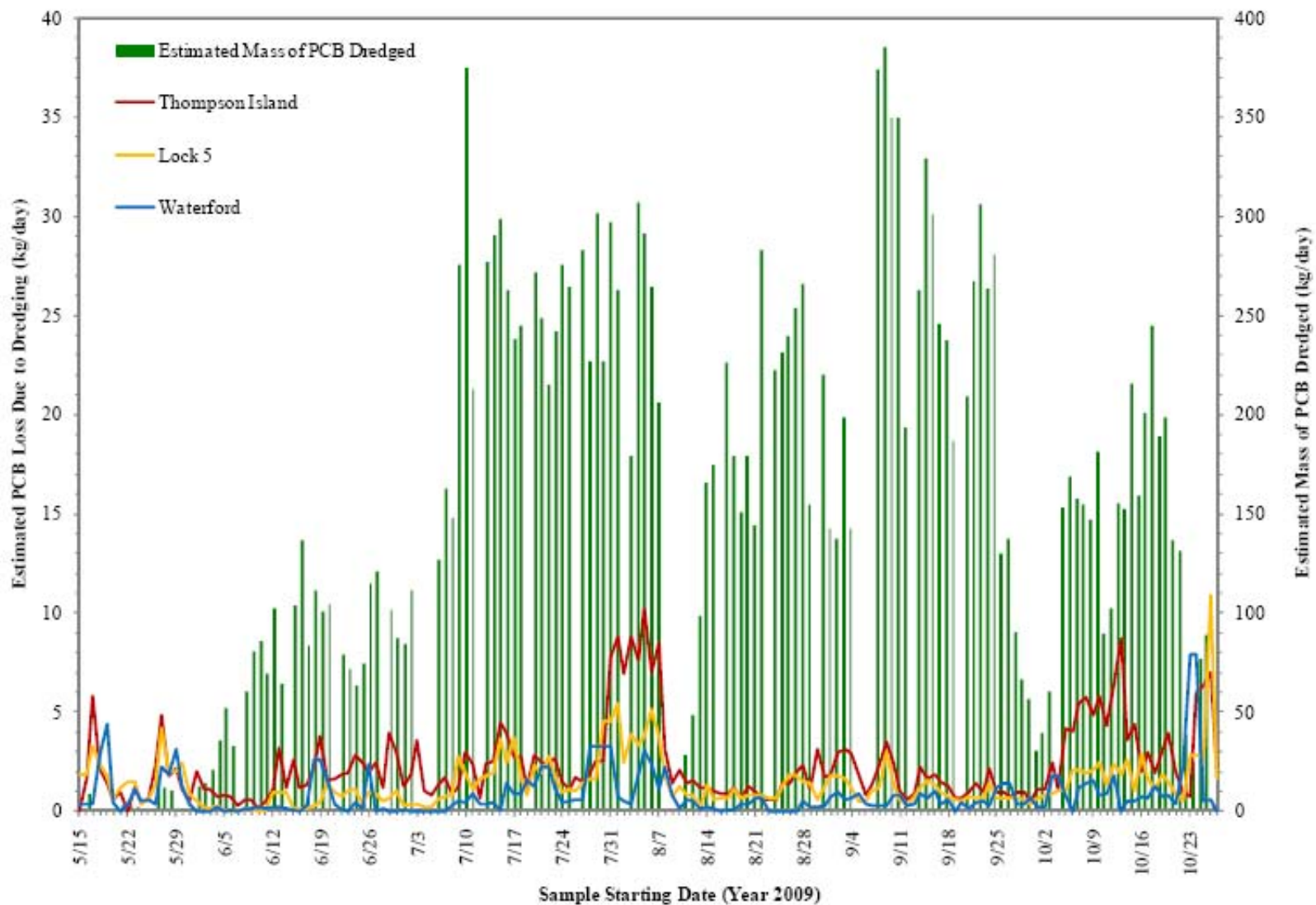


Figure 2: EPA Phase 1 Report March 2010, Figure I-3-18a

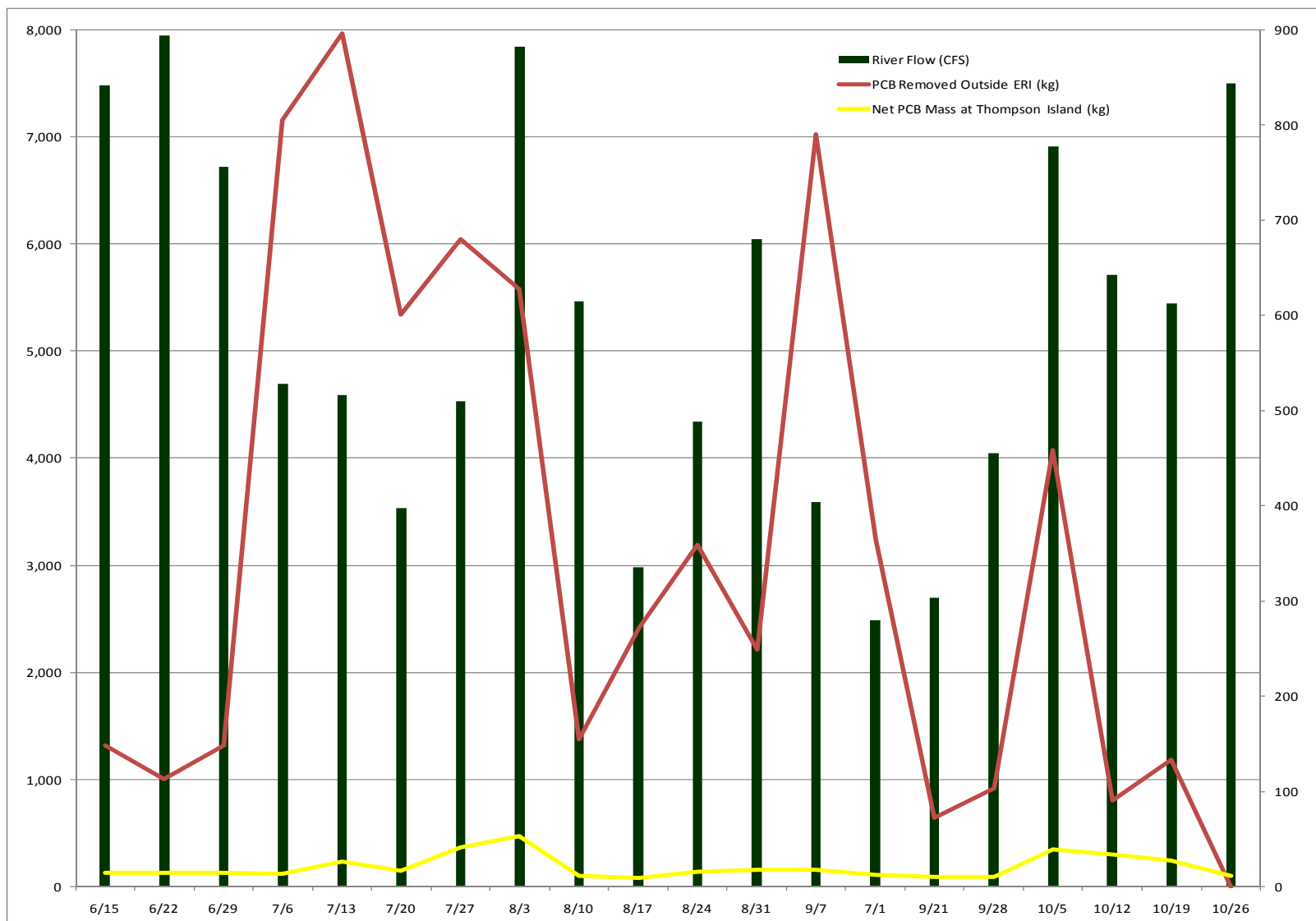


Figure 3: Plot of GE Phase 1 Report Table 5.3-2 Weekly Summary on PCB Removed Outside of East Rogers Island (ERI) and Net PCB Mass at the Thompson Island Station

***Finding Rsp.3-2.2: There is insufficient near-field data to quantify near-field deposition rates and corresponding impacts to human health and wildlife risks.***

A careful evaluation of the remedy release and redeposition processes is needed; these processes have the potential to undermine the benefits of the remedy that EPA set out in its 2002 ROD. The analyses presented by EPA and GE are neither complete nor compelling. EPA's evaluation compares the downstream transport of PCBs to the MNR trajectories for total PCB loads and fish; EPA does not address redeposition. GE's analysis of potential redeposition (presented in a handout at the meeting in Glens Falls, New York on May 5, 2010) contained a number of simplifying assumptions, and was expressed in terms of change to bed mass. The available data indicate that PCB deposition downstream of dredged areas may be significant.

The Panel evaluated PCB deposition in terms of potential changes in net PCB concentrations downstream of dredged areas using, in part, the assumptions provided by GE during the May 4-6, 2010 Public Meeting. While GE's analysis focused on the potential for newly deposited mass of PCBs, the Panel was interested in the deposited concentrations relative to conditions that currently exist. The following assumptions were employed.

- Area of impact between Thompson Island and Waterford: 2,228 acres (GE handout, May 4-6, 2010 Public Meeting)
- Depositional area between Thompson Island and Waterford: 347 acres (GE handout, May 4-6, 2010 Public Meeting)
- Depositional rate: 0.5 cm/yr (GE estimate, May 4-6, 2010 Public Meeting comment)
- Bulk Density: 1 g/cm<sup>3</sup> (based on Panel-experience with dredge residuals at other sites)
- Phase 1 mass unaccounted for: (GE Phase 1 Report estimate)
  - ▶ 506 kg release measured at Thompson Island Dam
  - ▶ 199 kg measured at Waterford
  - ▶ Delta is 306 mg/kg unaccounted for PCB mass during Phase 1

The unaccounted-for mass of 306 mg/kg would have been lost either through volatilization or deposition. The actual amount of PCB transfer to sediment is less than the amount lost from the water column, because some of the PCB will have volatilized to the air. Volatilization will favor the mono-, di-, and tri-chlorinated biphenyls. However, volatilization is not the primary loss mechanism in this reach of the river, based on the changes in PCB homologue composition with progress downstream. For the initial analysis, the Panel applied the simplifying assumption that all of the Phase 1 mass would be redeposited.

The Panel then predicted conditions after completion of the project, using the 5-year 2004 EPS project timeframe, the proposed new total load limits proposed by EPA (2,800 kgs) and GE (1,200 kg), the projected PCB mass estimates for the entire project, and the observed Phase 1 mass balance loss rates between TIP and Waterford (60 percent).

The results of this relatively simple analysis are presented in Table 5. Assuming deposition across all the available acres between the TIP and Waterford, the surface TPCB and Tri+PCB concentrations from Phase 1 redeposition alone would be 6.8 and 2.3 mg/kg, respectively. Assuming all of the material deposited solely within the known depositional acreage identified by GE, the concentrations would be 44 and 14.5 mg/kg. Notably, these PCB concentration estimates are relatively close to the sediment trap measurements reported by GE.

*Table 5. Estimated Phase 1 and Phase 2 near-field PCB depositional potential between TIP and Waterford*

Phase 1 or Phase 2 Condition	Depositional Area	Surface TPCB Concentration	Surface Tri+PCB Concentration
<b>Phase 1</b>	2,228 total acres	6.8 mg/kg	2.3 mg/kg
Upper 0.5 cm following Phase 1	347 depositional acres	44 mg/kg	14.5 mg/kg
<b>EPA Target of 2000 kg</b>			
Upper 2.5 cm following Phase 2	2,228 total acres	7.5 mg/kg	2.5 mg/kg
Assumes 60% of 2000 kg release	347 depositional acres	48 mg/kg	16 mg/kg
<b>GE Target of 1200 kg</b>			
Upper 2.5 cm following Phase 2	2,228 total acres	3.2 mg/kg	1.1 mg/kg
Assumes 60% of 1200 kg release	347 depositional acres	20.5 mg/kg	6.8 mg/kg

The Panel then considered how these projected concentrations would compare to those currently downstream of the TIP. Using a table provided in GE's May 5, 2010, handout (Table 6), the projected concentrations are within the range of the surface-weighted average concentrations reported by Reach for both total and Tri+PCBs. Focusing solely on the depositional areas—with the understanding that most of those would be dredged areas—again, the concentrations ranges projected and observed are similar.

*Table 6. GE handout to Peer Review Panel May 5, 2010  
(Table 3. Average 0 - 2" PCB Concentration in Dredge and Non-Dredge Areas)*

Reach	Tri+PCB(mg/kg)		TotalPCB(mg/kg)	
	Dredge	Non-dredge	Dredge	Non-dredge
8	Phase1: 26.7	3.6	Phase 1: 83.6	7.3
	Phase 2: 22.4		Phase 2: 57.6	
7	24.4	4.1	49.3	7.9
6	21.3	3.9	49.3	7.5
5	5.4	1.7	10.6	2.8
4	12.4	1.8	31.0	3.4
3	6.4	2.2	9.8	3.5
2	8.1	3.2	11.1	4.7
1	2.1	0.5	3.8	0.8



The Panel does not find its own analysis particularly compelling or satisfying. There are too many assumptions, areas over which data were averaged, are too large and too many variables are missing to provide confidence upon which to draw conclusions or to set long-term project resuspension criteria. Within the TIP (Reach 8), some portion of the PCB will have deposited within the Phase 2 dredging footprint and thus will be recaptured. However, some of the PCB will deposit outside the dredging footprint, and the extent of such deposition is unknown. Also, as future dredging progresses downstream, more of the resuspended PCB mass will necessarily deposit outside the dredging footprint. Assuming deposition over a large area ignores what may be very important increases in the near-field PCB concentrations in Phase 2 where the CUs are more spread out. The redeposited material will, at least for a time, remain unconsolidated and available for further migration and may contribute to increased or sustained elevated fish tissues concentrations. The data and evidence needed to credibly and transparently balance the benefits and adverse consequences of different configurations of remedial action and operation simply do not exist. Additional information that would test this condition is discussed in the next finding.

***Finding Rsp.3-3: Collect additional near-field and far-field data in Year 1 of Phase 2 to relate operational activities to sediment resuspension and release.***

The Panel recommends that EPA and GE develop a comprehensive conceptual model that relates operational activities to resuspension of sediments, chemical release of PCBs, and the production of residual contaminated sediment both within and without the dredging prism. This conceptual model should then be used as a basis for developing a quantitative understanding that facilitates credible predictions about the consequences of operational practices over time. Proposed modifications for the EPS or operational practices made by GE and EPA are largely based on speculations regarding key processes contributing to PCB release. The speculative nature of these proposals is due to the incompleteness of Phase 1 monitoring data and the inability to integrate those data using a comprehensive modeling tool that would provide the technical basis for meaningful adaptive management. The following specific tasks are recommended to further refine the Resuspension EPS.

- Establish TIP and Waterford monitoring programs that are adequately designed to monitor load releases during dredging and that correlate releases to near-field dredging activities and near-field data.
- Collect near-field data surrounding the various dredging related activities (e.g., monitoring releases associated with open CUs, scow operations, dredge rate of advance and other dredge-related unit processes).

***Finding Rsp.3-4: Set an interim resuspension standard for Year 1 of Phase 2 that tri+PCB release rates measured at the TIP Dam and Waterford to 2 percent and 1 percent, respectively, of the Tri+PCB mass removed.***

A revised resuspension standard should recognize the potential for increased risks associated with downstream transport (including between TIP and Waterford) and should be modified as necessary to address those risks. Based on the Phase 1 results, 2 percent and 1 percent release rates at TIP and Waterford, respectively, are reasonably aggressive target values for mass released during dredging activities. The Panel does not recommend interrupting dredging activities if the targets are not achieved during Year 1 of Phase 2. The goal of the interim standards is to establish baseline targets during Year 1

of Phase 2 and to allow dredging to recommence in 2011, while near-field and far-field data are collected.

***Finding Rsp.3-5: A sound remediation process includes a rigorous, formalized process for adaptively managing the project over time to address uncertainties affecting remedial objectives, operations, and performance standards. Therefore, EPA and GE should jointly develop a formal adaptive management plan.***

The results of Phase 1 dredging tangibly demonstrate that there are practical limits to our collective ability to predict outcomes for sediment remediation projects. The physical, chemical, and biological processes involved are complex and the uncertainties associated with data and models relevant to those processes are significant. This reality has been amply demonstrated during Phase 1 as well as at contaminated sediment remediation projects across the country.

The pragmatic approach for addressing this reality is to establish an expanded, rigorous, and formalized process for implementing adaptive management. The essential elements for such an adaptive management process are: 1) a comprehensive conceptual model that incorporates remedial activities and regular updating as new information about the system is gained; 2) a formal, mathematical representation of this conceptual model that is used as the basis of remedial design and directing operational practices; 3) operational and performance monitoring that is targeted to address key processes and uncertainties in the conceptual and mathematical models; 4) a commitment to a formal process for capturing information about the remedial system and incorporating that information in the conceptual and mathematical models; and 5) using the integrated understanding provided by the modeling to inform decisions to revise remedial designs and operations as necessary and indicated by the assembled evidence.

A central component of this adaptive management plan will include development of a process for adaptively managing all EPS to achieve the expected benefits of the project. With respect to the Resuspension EPS, based on the Phase 2 Year 1 results, EPA should establish appropriate and achievable criteria that balance the benefits of reducing risks through contaminated sediment removal against the detriments of increased downstream transport of PCBs and the risks produced through that redistribution of PCBs within the river.

Further, the Panel recommends that development of a revised Resuspension EPS include the following.

- The revised Resuspension EPS should be consistent with current dredging practices and practicable limits to reducing resuspension during dredging. This must include an improved sediment characterization for all remaining CUs (i.e., establish high confidence for all CUs) and a more streamlined method for closing CUs in a timely fashion. The Panel recognizes that limited approaches exist for reducing resuspension, including improved BMPs with respect to dredge operations, more rapid closure of CUs, and reduced dredging volumes.
- The Panel does not support the use of silt curtains or other physical barriers to control resuspension release rates given the time requirements and logistical complexities associated with their use and their limited effectiveness in constraining transport of sediment and PCB release.
- The Panel recommends that the project continue to make use of an external panel to help in focusing efforts to establish revised performance standards for the remainder of Phase 2. This effort

should not entail the submittal of new reports by EPA and GE. Instead, the Panel recommends coordinating the analysis and interpretation of the Phase 2 Year 1 data while engaging with the external panel in an iterative manner so as to accelerate the development of a revised Resuspension EPS.

***Finding Rsp.3-6: Use the 500 ng/L total PCB threshold at the far-field monitoring stations as a trigger to consider operational changes, not shutdown. Drop the 350 ng/L Control Level.***

The goal of the Far-Field PCB Concentration standard established in 2004 was to prevent water supplies for the towns of Waterford, Halfmoon, and Stillwater from exceeding the PCB MCL. However, Waterford and Halfmoon now have an alternate connection to Troy. Stillwater, which draws its water from an aquifer adjacent to the river, has an adequate treatment system for PCBs. Regardless, the Panel agrees it is important to maintain the MCL criterion as part of any revised standard, consistent with the original intent of the EPS that “no public water supplies will be adversely impacted by the remediation, regardless of a given water treatment plant’s (WTP’s) ability to treat PCB-bearing water.”

The Panel recommends maintaining the 500 ng/L total PCB threshold at the far-field monitoring station as a *trigger* to consider operational changes. This standard recognizes that the 500 ng/L remains an “Applicable or Relevant and Appropriate Requirement” and is based on protection of human health in drinking water. However, because the source of drinking water was relocated from the Hudson River, at least for the duration of the dredging work, the standard can be relaxed so as not to require an operational shutdown in the event of a short-term exceedance, and the 350 ng/L control level is unnecessary and should be eliminated.

***Finding Rsp.3-7: The basis for the TSS criterion must be reevaluated. Continue near-field TSS compliance monitoring and levels at a minimum for completion of the Phase 1 CUs (9 - 16), and then re-evaluate the utility of TSS after Year 1 of Phase 2. Add PCB homolog measures to stations where TSS is being collected.***

The Phase 1 data demonstrate a complete lack of statistical significance between TSS and the transport of PCBs from removal operations during Phase 1. The transport of non-particulate phase PCB clearly indicates that TSS concentration cannot be a reliable indicator of PCB releases as envisioned in the 2004 EPS. Thus, the TSS measurements provided no useful information for managing far-field PCB resuspension and release during dredging operations.

The 2004 EPS numeric TSS standards are adequate for Phase 2, Year 1, and for completing the targeted Phase 1 CUs. The TSS standard should be evaluated in relation to the results of the revised monitoring program, including enhanced near-field monitoring, which the Panel believes will aid in developing a more complete understanding of relevant resuspension processes and what actions should be taken to manage those processes. The reevaluation of the TSS criterion must also consider its relationship to the Residuals EPS and Productivity EPS during the 2011 dredging season.

EPA should discontinue the collection and use of turbidity data.

***Finding Rsp.3-8: Transport loads should be based on empirical data as well as risk reduction targets. Set allowable transport loads for Phase 2 based upon the findings from Year 1 of Phase 2.***

Insufficient information was provided to the Panel to assess the effects of PCB resuspension and transport on fish tissue concentrations; the only tissue data available were taken during Phase 1, relatively soon after cessation of operations in 2009—the spring 2010 data were not available to the

Panel. Available data indicated short-term, transient exposures due to water column PCB concentrations during dredging. The potential for long-term exposures to increased surface sediment PCB concentrations, if significant, is likely to lead to more substantial and long-lasting impacts.

Because PCB concentrations in fish take time to equilibrate, tissue concentrations may continue to increase after dredging, so monitoring of fish should continue, and should include near-field and far-field locations.

Resuspension criteria for near-field and far-field PCB load targets for Phase 2 based on limiting impacts to fish in the Upper Hudson and ensuring that dredging accrues a benefit to both the Upper and Lower Hudson need to be developed. The sediment and fish tissue data collected in 2010, along with near-field and continued far-field PCB measures, will help determine the relationship between PCB releases and downstream effects and update MNR and remedy forecasts, and to develop a PCB load standard that ensures a net environmental benefit from the remedy.

MNR comparisons also should be based on surface sediment recovery rates inside and outside the CUs, and not on a cumulative mass loading to a downstream location alone. Resuspension criteria should be based on the changes occurring in surface sediment concentrations due to remedial action, both in the CUs and in areas external to and downstream of the CUs; this is as opposed to basing resuspension criteria solely on far-field release load calculations. At a minimum, changes to sediment concentrations in all portions of the river must be calculated and measured. The fate, transport, and risk model must enable EPA and GE to understand the implications of operational changes on long-term recovery rates.

An adequate standard is one which achieves the goal articulated in the 2004 EPS, that is, the maximum allowable load must result in a net reduction of transport to surface sediments in the upper and lower Hudson compared to MNR within a timeframe that corresponds with the ROD (i.e., 20-25 years). Development of the standard requires calculating the following,

- Transported load that would cause a perceptible increase in fish tissue concentrations in the lower Hudson (short-term and long-term), and compare those to MNR
- Transported load that would compromise risk reduction in the upper Hudson, due to contamination of non-footprint areas
- Transported load associated with excessive surface water concentrations

CHARGE QUESTION 4. If EPA and/or GE has proposed modifications to the monitoring and sampling program for Phase 2, are the proposed modifications adequate and practicable for determining whether the Phase 2 Engineering Performance Standards will be met?

Both EPA and GE proposed changes to the EPS with concurrent changes to the monitoring and sampling program for Phase 2. However, the Panel finds that it will not be practicable to consistently and simultaneously meet the EPS being proposed by either party and, thus, cannot make a finding regarding the monitoring and sampling programs relative to these proposed standards except for those items that have been specifically addressed under Charge Question 2, above. Rather, the Panel addressed Question 4 relative to the modified EPS and processes recommended by the Panel in response to Charge Question 3.

***Finding Rsp.4-1: Monitor residuals outside the dredge prism.***

Phase 1 inadequately evaluated the generation of residuals outside of the dredge prisms and CUs. Near-field and far-field PCB deposition have the potential to adversely increase ecological and human health risks. EPA and GE should evaluate whether off-CU deposits have the potential to increase risks to levels that are unacceptable when compared to the reduced risks associated with dredging and backfilling.

EPA and GE should establish a residuals monitoring program that evaluates the potential for near-field PCB deposition outside of dredged CUs. The program should test the potential for near-field and far-field off site deposition and generation of dredged residuals in low-, moderate-, and high-flow areas downstream of dredged CUs. Continued monitoring requirements after Year 1 of the Phase 2 dredging program should be determined by EPA and GE, based on the results of Phase 2, Year 1, and subsequent years. Based on the off site/off-prism monitoring results, EPA and GE may adjust BMPs and/or dredge volumes if the risks associated with the generation of residuals outweigh the reduced risks associated with dredging.

The near-field and far-field monitoring results should be integrated into updated site-specific sediment transport and risk exposure models to consider the role of generated residuals outside of the prism on ecological and human health risks. Off-CU residual deposits should not adversely increase baseline surface sediment Tri+PCBs concentrations on off-CU areas, such that post-dredge recovery rates are slower than would be achieved via MNR. This evaluation should not be based on a comparison of cumulative loads, but instead should be based on long-term potential fish exposures associated with surface sediment deposits and surface water PCB resuspension and releases, and should include a combined assessment of dredged and undredged areas over a 25-year period.

***Finding Rsp.4-2: The revised Resuspension EPS must be based on an updated conceptual model of the fate and transport of PCBs during dredging, and the ecological risks associated with releases during remedial operations. Data collection in Phase 1 was inadequate to calibrate and validate such a model. Therefore, develop a project-specific fate, transport, and bioaccumulation model (to be used in common by EPA and GE) to set near-field and far-field resuspension criteria.***

Developing an appropriate and achievable Resuspension EPS requires balancing the benefits of reduced risks within the dredging footprint against the risks associated with increased downstream transport and air releases. Currently, the project lacks a transparent, scientifically sound and state-of-the-art model that adequately addresses dredging-related release mechanisms and contributions to downstream transport from remedial activities, potential for deposition of released PCBs associated with the entire

project area, and impacts to fish tissue during and after completion of the remedy. Resuspension, release, and residual-formation processes must be clearly represented to ensure that operational decisions made over subsequent phases of the project, and the consequences of those decisions, are transparent to the public, stakeholder communities, and EPA and GE. As discussed previously, the HUDTOX FISHRAND models used in the development of the ROD and EPS do not provide a reliable basis for evaluating and setting release loads. The results of the mechanistic modeling presented to the Panel by GE is insufficient to make near-field operational decisions to control resuspension, release, and residuals, and Phase 1 data collection were insufficient to compare MNR and dredge-related impacts on or benefits to the environment.

The Panel found other critical problems with data collection, models, and analysis in Phase 1, such as:

- Insufficient near-field data were collected during Phase 1, making it difficult to understand cause-and-effect relationships between the various dredging-related activities and downstream resuspension and release.
- EPA’s “Multiple Regression Model” that attempts to simultaneously consider “over 28 dredging-related variables...for association with water column concentrations”—while potentially helpful to screen important variables for future monitoring that may influence resuspension (e.g., for further monitoring)—provides insufficient causal evidence for explaining relationships between near-field activities and far-field releases.
- The mechanistic modeling results presented by GE that correlated release with PCB mass removed and flow rates present a reasonable correlation between measured and model-predicted releases, but fail to explain the relationship between the multiple dredging-related processes and release rates. Figure I-3-18a (PCB Mass Dredged and PCB Mass Lost to Water Column at Far-field Stations during Phase 1) of the March 2010 EPA report indicates that the PCB mass removed is not well correlated to PCB release rates at TIP, Lock 5, and Waterford. The GE modeling results suggest that river currents contributed significantly to release rates. This important finding suggests that factors such as unclosed CUs may have contributed substantially to resuspension and release rates.

There is a very real need to set an allowable load limit for the Hudson River dredging project, but neither the data nor tool(s) needed to do so currently exist. To that end, the project must develop a set of models that incorporate hydrodynamics, sediment transport, fate and transport of PCBs, and bioaccumulation of PCBs in the Upper Hudson River (from Fort Edward to Troy Dam).

- Use a single model, developed collectively by EPA and GE; the GE model may be a useful foundation for this model. The model structure and parameterization must be agreed to between EPA and GE. The model must be peer reviewed by an expert panel once EPA and GE complete its development. Similar arrangements have been successful at other Superfund Sites, including the Passaic River, the Lower Duwamish Waterway (WA), and the Lower Willamette River (OR).

The model should meet the following requirements:

- For transparency, all code must be made available to the full development team (GE and EPA) and the Peer Review Panel.

- Establish a steering team made up of technical representatives from GE and EPA in order to ensure the best application of scientific and engineering principles.
- Apply the Panel's changes to the Residuals and Productivity EPS in Year 1 of Phase 2.
- Use data from Phase 1 for initial model calibration, but incorporate data from Year 1 of Phase 2 for final model calibration and validation.
- Complete model efforts and projections in a reasonable timeframe, in order to set criteria for Year 2 and beyond.

The Panel further recommends the following be considered in model development.

- The model should be populated with variables that reasonably predict real-world conditions. In other words, the goal of the model should not be to develop overly conservative estimates to overcome uncertainties, but rather to develop predictions based on reasonable and defensible assumptions and variable parameters so that the model can be useful for adaptive management.
- The model should reflect uncertainties associated with the data and the model's ability to predict future conditions. To this end, the model should predict the range of results associated with MNR predictions and with dredging-related releases. (A single number, whether 1200 kg or 2000 kg, inadequately represents the complexity of the system and uncertainties associated with data collection, chemical analysis, modeling, and interpretation of results.)
- Comparing the effectiveness of dredging with MNR is reasonable; dredging should not make conditions worse than MNR. However, comparisons made to date have been inadequate, particularly the cumulative load comparison between MNR and dredging responses. Therefore, the model should be designed to predict surface sediment concentrations, fish PCB uptake, and long-term recovery for the entire river, and should include near-field and far-field reaches of the river, including those areas that undergo dredging. The goal should be to ensure that the long-term trajectory of PCB-related impacts on the river, during and after dredging, does not exceed the impacts associated with baseline conditions.

Finally, the Panel recommends that an independent review of the projections with results from Year 1 of Phase 2 be conducted, similar to that conducted after Phase 1. This Panel is willing to participate in independent review for the model, project, and EPS for the duration of Phase 2; however, the independent review team also should include a modeling expert.



## 4 RESIDUALS

CHARGE QUESTION 1. Does the experience in Phase 1 show that each of the Phase 1 Engineering Performance Standards can consistently be met individually and simultaneously?

***Finding Rdl.1-1: Phase 1 did not achieve the 2004 Residuals EPS.***

The 2004 Phase 1 Residuals EPS for the Hudson River PCBs Superfund Site were not consistently met. The Residuals EPS assumed the removal of all inventory with a maximum of 2 passes, plus a maximum of 2 dredging passes to address generated residuals (with a potential additional pass to remove inventory). Poorly defined DoC resulted in more inventory than expected, causing disagreement between EPA and GE regarding the effectiveness of inventory removal. Because inventory was not sufficiently characterized before construction commenced, the Panel believes that the Residuals EPS were not truly tested as envisioned.

Residuals management decisions were confounded because the Residuals EPS were not intended to address excess inventory. Even with inventory left behind, CUs were not closed in a timely manner, only about half of the CUs designated for Phase 1 were finished, and PCB concentrations left behind after dredging were higher than allowed in the Residuals EPS. Thus, residuals management during Phase 1 required multiple production passes and the CUs were open longer than had been planned.

EPA suggests that the additional inventory passes were entirely due to poor characterization of the DoC and that the Residuals EPS were achieved once the inventory was removed. The Panel disagrees with this assessment and believes that inventory and generated residuals are linked and should be managed in concert.

***Finding Rdl.1-2: The experience in Phase 1 does not show that the Residuals EPS could be met simultaneously with the Productivity and Resuspension EPS.***

During Phase 1, 18 CUs were targeted for dredging. With a 150-180-day dredging season, 1 CU should have been closed every 8-10 days. In actuality, only 10 CUs were dredged; therefore, 1 CU should have been closed every 15 to 18 days. Further, upstream CUs should have been closed prior to downstream ones to avoid recontamination of closed CUs. With 3 or 4 dredges at work, a single CU should not have been open for more than 35 days. In fact, however, Phase 1 CUs were open for an average of 113 days.

Only 1 CU (CU 17) was closed in adherence with the Residuals EPS (i.e., only CU 17 was backfilled after having achieved residuals less than 1 ppm Tri+PCBs, as defined in the upper 6-inch sediment surface). Seven CUs were closed by capping at least a portion of their respective areas because it was not possible to achieve a residual Tri+PCBs concentration of less than 1 ppm in the upper 6 inches within the maximum allowable number of post-inventory dredge passes. The other 2 CUs were forced to be closed via capping as the end of the season approached. About 25 percent of the total area in these CUs were closed out of compliance with the Residuals EPS and would have required further dredging if there had been enough time. While additional dredging could have reduced Tri+PCBs concentrations in residuals, it is unclear that dredging would have achieved levels required by the Resuspension EPS.



In the attempt to meet the Residuals EPS, a disturbed residuals layer was created on the sediment surface, which was subject to erosion by currents and vessel traffic. Erosion of the residuals layer was likely a significant source of resuspension, possibly accounting for as much as 75 percent of PCB losses according to the data shown in Table 7. The losses from CU 18 were estimated to be at least 75 percent less than the losses from the West Rogers Island CUs; even the East Rogers Islands CUs, which had vessel traffic, were estimated to be at least 60 percent less than the losses from the West Rogers Island CUs.

*Table 7. Summary of PCB losses*

Location*	Conditions	Approximate PCB Loss, %
CU 18	Very restricted flow and traffic by the use of a sheet pile enclosure	0.5 to 1
East Rogers Island CUs	Restricted flow by use of rock dike but unrestricted traffic	1.3 to 1.7
West Rogers Island CUs	Unrestricted flow and traffic Below a weekly average flow at Fort Edward of 5,000 cfs At flows greater than 6,000 cfs	Average: 3.5 to 4.2 Between 0.9 and 4.3, with an average of 2.1 Between 4.6 and 7.4, with an average of 6.1

\* Data sources include: GE May Deliberations presentation, GE Chapter 5 key findings, GE 5.3.2.2 Effect of River Velocity on PCB Release Rate, and GE 5.7.1 Overall Extent of PCB Release.

***Finding Rdl.1-2.1: Inaccurate DoC makes it unlikely that the Residuals EPS can be met.***

Phase 1 demonstrated significant challenges associated with the Residuals EPS:

- Insufficient distinction was made between generated residuals and undisturbed residuals (termed inventory), mainly because the DoC was inadequately delineated in most CUs.
- As applied in the decision flowchart, the Residuals EPS defines residuals as inventory whenever the surface-sediment average concentration measured greater than 6 ppm Tri+PCBs after dredging; however, the reasoning for this distinction was not clearly grounded in science or risk management.
- Coring was conducted using ineffective techniques for the conditions encountered, particularly debris and sediment types.
- Data from cores with poor recoveries (i.e., material recovered was less than the depth that the core was pushed) and incomplete core penetration into soft sediments (i.e., there were soft sediments below the core sampling depth) were fed into the Terrain Model that inaccurately predicted dredge elevations.
- Data input to the Terrain Model were not tied to absolute elevations. Instead, the model output was defined in terms of depth below sediment surface. As a result, the DoC changed with surface-sediment elevation changes, contributing to the inaccuracy of the Terrain Model.

***Finding Rdl.1-2.2: The experience in Phase 1 does not show that the Residuals EPS can be met for Phase 2.***

For Phase 2, there is low confidence in the DoC for approximately 40 percent of the areas to be dredged. Furthermore, the lack of vertical control on DoC elevations—as discussed previously—increases the uncertainty associated with the high-confidence cores, which may be inadequate to accurately establish the DoC elevation using the Terrain Model.

According to EPA, only in CU4 did the average Tri+PCB concentration consistently decline with each dredge pass. This underscores the difficulty associated with achieving target PCB concentrations via repeated dredge passes, and the importance of establishing an accurate DoC based on core results that confidently determine the absolute elevation of the 1 ppm Total PCB depth. In the absence of better data that more accurately establish DoC elevations with certainty, the experience in Phase 1 demonstrates that the Residuals EPS cannot be met during Phase 2.

***Finding Rdl.1-2.3: Excessive complexity makes it unlikely that the Residuals EPS can be met.***

The Residuals EPS is overly complex, as reported by the 2004 EPS Peer Review Panel. The EPS includes 8 different cases for determining how to address residuals; only 4 of the cases were actually employed during Phase 1. Determining which of the 8 cases applies to a particular CU entails analysis of the following metrics for each CU or portion of a CU being evaluated:

- Average Tri+PCBs concentration
- Individual sample concentrations
- Median Tri+PCBs concentration
- Area weighted average Tri+PCBs concentration in a moving 20-acre area consisting of the CU under evaluation and the 3 or 4 previously dredged CUs within 2 river miles of the current river unit (measured along the river centerline)

These metrics were compiled into the following tabulation to determine the next step for the CU being evaluated:

Certification Unit Arithmetic Average (mg/kg Tri+PCBs)	No. of Sample Results >15 mg/kg Tri+PCBs AND < 27 mg/kg Tri+PCBs	No. of Sample Results > 27 mg/kg Tri+PCBs	No. of Redredging Attempts Conducted
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The 20-acre CU averaging was never implemented in part because the unexpected inventory made it difficult or impossible to analyze generated residuals, and in part because the timing of CU closures with neighboring CUs made 20-acre averaging not practicable. Thus, considering upstream CUs became irrelevant to closing individual CUs.

Depending on confirmation sample results, the Residuals EPS requires redredging all or part of a CU, backfilling, or capping. EPA asserts that 2 dredge passes is sufficient to remove inventory and GE agrees that most of the inventory was removed in 2 dredge passes. Based on EPA and GE’s observations, better coring results will provide more confidence in the DoC output of the Terrain Model, and thus will contribute to improved residuals management by reducing the number of passes required.

***Finding Rdl.1-2.4: Reliance on individual sample results makes it unlikely that the EPS can be met.***

The current Residuals EPS relies on the results of individual samples, in addition to CU averages, to determine the need for redredging, backfilling, or capping. Redredging or capping is required if individual sample Tri+PCB concentrations are greater than 15 ppm or 27 ppm.

**Table 8. Residual PCB (Tri+ppm) sampling results for 6-inch confirmation sampling after dredging**

CU	Number of Sampling Nodes	Number of Residual Samples with High PCB Concentrations after Dredging Passes*					
		Tri+PCBs Concentration of 15-27 ppm			Tri+PCBs Concentration >27 ppm		
		After 1 <sup>st</sup> Pass	After 2 <sup>nd</sup> Pass	After 3 <sup>rd</sup> Pass	After 1 <sup>st</sup> Pass	After 2 <sup>nd</sup> Pass	After 3 <sup>rd</sup> Pass
1	43	0	-	4	0	-	1
2	40	7	6	5	12	11	9
3	47	3	2	0	10	5	0
4	42	2	5	3	17	7	1
5	28	5	3	3	2	0	0
6	40	3	1	0	1	2	2
7	41	3	4	1	15	8	2
8	52	4	3	3	6	3	5
17	40	3	0	0	8	1	0
18	47	5	0	0	8	1	0
Total	420	35	24	19	79	38	20

\* Compiled from EPA's Phase 1 Evaluation Report (March 2010) figures in Appendix IIB Post Dredging Core Maps from Different Dredging Passes.

After 3 dredging passes, 6 out of the 10 CUs contained at least 1 node above 27 ppm Tri+PCBs, and 5 out of the 10 CUs contained more than 1 node between 15 and 27 ppm Tri+PCBs, precluding backfilling or capping. Redredging provided limited and apparently diminishing returns. In 3 of 10 CUs, more than 40 percent of the area contained Tri+PCBs concentrations above 15 ppm after the first pass (based on an average 33 core samples); in 3 of the 10, more than a quarter of the area contained Tri+PCBs concentrations above 15 ppm after the second dredging pass. About 10 percent of the dredged areas contained Tri+PCBs concentrations above 15 ppm after the third dredging pass.

From these data the Panel concluded that:

1. The poorly delimited DoC contributed significantly to the increased number of dredging passes required and the length of time CUs were left open.
2. The increased number of dredging passes and erosion for exposed contaminated sediments significantly contributed to the downstream PCB loads (i.e., exceedances of the Resuspension EPS).
3. An accurate DoC based on better coring would lead to quicker and more efficient removal of PCB inventory.
4. Backfilling or capping the relatively minor residual mass left in place was the norm for Phase 1, and this norm should be carried forward into Phase 2.

CHARGE QUESTION 2. If not, and if EPA and/or GE has proposed modified Engineering Performance Standards, does the experience in Phase 1 and any other evidence before the panel show that it will be practicable to consistently and simultaneously meet the Engineering Performance Standards that are being proposed for Phase 2?

***Finding Rdl.2: The experience in Phase 1 and other evidence before the Panel does not show that it will be practicable to consistently and simultaneously meet the Residuals EPS proposed for Phase 2 by EPA and GE.***

Both EPA and GE provided tables of their respective proposed changes for Phase 2 to the Residuals EPS at the May 2010 Peer Review meeting in Glens Falls, New York. While some of these changes have merit, as a group they do not result in a consistently achievable EPS that meets the requirements of the ROD in concert with the Resuspension EPS and Productivity EPS. Specifically, the Panel did not find the proposed changes addressed the critical needs for a well-defined DoC with appropriate elevation controls, and a means to decrease the number of dredging passes and quickly close the CUs (Table 9 and Table 10).

The Panel noted that EPA's proposed changes do consider the need to reduce dredging passes to both shorten the time that CUs are open and subject to erosional forces, and also to increase productivity (Table 3). However, the proposed changes seem designed to formalize modifications implemented as part of Phase 1, and practicably do little to change the cycle of dredge-test-dredge-test. For example, EPA's proposal to reduce the number of response categories from 8 to 4 in effect carries over the Phase 1 decision process to Phase 2. This will result in a continuation of the dredge-test cycle, and continue to leave CUs open for many months. To meet the Productivity EPS, the duration that the CUs are open needs to be reduced by at least 70 percent (from 113 days to 35 days as presented in Finding Rdl. 1-2); EPA's proposed changes are likely to reduce the duration by the time for the last redredging pass. Typically, sampling, analysis and dredging of the last redredging pass took about 3 weeks, yielding a reduction in the duration of about 20 percent (21 days out of 113 days). To meet the Resuspension EPS as well as the Productivity EPS, dredging would need to be reduced to 1 or 2 passes; however, EPA's proposed changes would reduce removal to a minimum of 2 passes and a maximum of 4 passes, with 3 to 4 passes most likely.

Navigation channels present a special case for consideration in Phase 2, and the Panel agrees with EPA's proposed change that would avoid capping in navigation channels to the degree practicable. If/where capping occurs within the navigational channel, a minimum of 14 feet of draft must be maintained. The Panel recommends that EPA and GE work with the New York State Canal Corporation to establish an operational elevation that would consistently maintain 14 feet of vessel draft.

The Panel found that GE made some practical recommendations to the Residuals EPS, including cessation of dredging upon contact with either hard (rock) substrate or GLAC, and requiring capping only when the residual surface sediment Tri+PCB concentration is greater than 3 mg/kg. The Panel also supports resampling within low-confidence areas, but finds that GE's proposal does not go far enough to solve the overall problem of identifying the DoC. As discussed in response to Charge Question 3, 100 percent resampling in low-confidence areas is required, and confirmation sampling is needed even in high-confidence areas.

Table 9. Summary of EPA's proposed modifications to the Residuals EPS

EPA-Proposed Change to Residuals EPS			Panel Finding	
Proposed Change to EPS	Proposed Numerical Criteria	Rationale	Accept Proposed Change?	Rationale
Reduce the number of cases from 8 to 4 primary response categories.	The 4 maintained cases are: 1. The standard is met or almost met 2. Residuals are present 3. Inventory is present 4. Recalcitrant residuals or inventory is present	The intention is to simplify and streamline the standard based on Phase 1 results. Four of the cases included in the Residuals Standard were not encountered during Phase 1 and are not likely to be encountered during Phase 2.	No	While the reduction in cases simplifies the decision flow chart, it does not improve productivity or resuspension. The proposed criteria would still result in multiple dredging and resampling cycles instead of closing CUs quickly.
Remove the 20-acre averaging option and backfill testing requirement.	N/A	The conditions where the 20-acre averaging could be applied did not occur during Phase 1 and are unlikely to occur in Phase 2.	Yes	Panel agrees that this was not applied in Phase 1, and would not be applicable to Phase 2.
Eliminate use of the 99% UCL (6 mg/kg criterion) as a basis to decide CU sampling requirements.	N/A	Rather than use 6 mg/kg criterion to trigger sampling at depth, full penetration and analysis of all 6" core segments in a minimum 24" core (unless bedrock or dense clay is encountered) will be required for all post-dredging cores due to Phase 1 experiences with missed inventory and underestimated DoC.	No	The proposed change as worded by EPA implies that the cycle of dredging followed by testing and then more dredging would continue. This pattern negatively impacted the Resuspension EPS and Productivity EPS, and must be changed. The Panel agrees that additional sampling must occur, but it must occur prior to any additional dredging in Phase 2.
Permit capping without formal petition to EPA only after completion of the first pass and at least 1 additional dredging pass targeting only the top 6" of material. In other words, in order for capping to be permitted, the inventory must have been removed as confirmed by post-	No numerical criteria are changed for this revision. This applies only to Case 4 – Recalcitrant residuals or inventory present.	The Residuals EPS contemplated limited capping as a contingency to address residuals in the presence of difficult bottom conditions. The option for capping is not meant to compensate for any deficiency in dredging design. However, during Phase 1, capping was sometimes employed primarily to isolate inventory and this should be avoided in Phase 2.	No	Productivity could be improved by eliminating the second dredging pass and streamlining the decision process. However, without accurate DoC data prior to dredging, the benefits would be minimal as multiple inventory passes might still be required.

#### 4. Residuals

EPA-Proposed Change to Residuals EPS			Panel Finding	
Proposed Change to EPS	Proposed Numerical Criteria	Rationale	Accept Proposed Change?	Rationale
dredging coring and an additional pass targeting just 6" (residuals) must have been performed.				
Confirm DoC in post-dredging cores.	Two contiguous segments less than 1.0 mg/kg Total PCBs are required to confirm that DoC is known.	During Phase 1, there were situations where sediment cores were observed to reach a value of less than 1.0 mg/kg in a single 0 - 6" segment only to see concentrations rise again deeper in the profile.	No	The proposed change does not provide for reduction of dredging passes or quick closure of CUs, both of which directly affect productivity and resuspension. Unless DoC is determined prior to dredging, the dredging plan will remain suboptimal, entailing extra dredge cuts, passes, surveys, sampling, and testing. In addition, depth of coring must be limited when bedrock or GLAC is encountered.
Simplify identification of noncompliant nodes for reviewing dredging pass results.	Target average value of 1.0 mg/kg Tri+PCB, using only the ranked, measured nodal values in a simple accumulating average.	As implemented in Phase 1, locations that appeared to be compliant with the standard on 1 pass caused the mean to exceed the Residuals EPS threshold after later passes, requiring redredging (or capping) in the previously compliant location. This problem is eliminated by this simplified process.	No	This change, which specifically calls for a second—laterally more extensive—dredging pass to increase captured inventory, addresses a symptom (in Phase 1, locations that appeared to be compliant with the EPS on 1 pass caused the mean to exceed the EPS after later passes, which resulted in redredging or capping), but fails to account for the mechanisms that render formerly compliant nodes noncompliant. Unnecessary dredging is likely to result, reducing productivity and increasing resuspension.
Simplify identification of redredging or capping boundaries.	The area associated with noncompliant nodes extends to the periphery of compliant nodes or to the edge of the CU. Where a compliant node is surrounded by noncompliant nodes, the area associated with the compliant node is dredged to the average depth of the surrounding noncompliant nodes. Generally, 3 compliant nodes are required to define an area that does not require redredging.	In Phase 1, a sophisticated algorithm was a source of much discussion and often resulted in unusual dredging geometries. A more conservative approach is needed in light of poor spatial correlation and DoC uncertainty.	No	The proposed simplified geometry would reduce the potential for compliant nodes to become noncompliant by using a common-sense approach that recognizes the lack of precision in dredging and DoC. However, without a broader framework, built on averaging rather than a patchwork approach, benefits would be minimal.

#### 4. Residuals

EPA-Proposed Change to Residuals EPS			Panel Finding	
Proposed Change to EPS	Proposed Numerical Criteria	Rationale	Accept Proposed Change?	Rationale
Identify nodes with high probability of exceeding the Residuals EPS threshold early in the CU dredging process to mitigate uncertainty in DoC estimation.	Target concentration of 1.0 mg/kg Tri+PCB, permitting only a mean of 1.49 after the last pass.	As implemented in Phase 1, locations that appeared to be compliant with the Residuals EPS on 1 pass later caused the mean to exceed the EPS threshold after later passes, requiring dredging (or capping) in the previously compliant location. Areas identified in this manner will meet the true threshold of 1 mg/kg, regardless of the outcome of subsequent dredging attempts at the noncompliant locations.	No	This approach would set a target concentration of 1.0 mg/kg Tri+PCB, permitting only a mean of 1.49 after the last pass. The goal is to reduce conversions from compliance to noncompliance after subsequent passes. This approach shows some of the flexibility required for variability in site conditions and dredging performance, but the specified concentration is impractically low for the PCB concentrations observed in the sediment profile and realistically achievable dredging residuals.
Avoid capping in the navigation channel whenever possible. If it is necessary, however, design and implement such that the top of cap allows for a minimum of 14 feet of draft to allow for future maintenance dredging by the NYS Canal Corporation.	Caps must allow 14 feet of draft in navigation channels.	Capping was not expected in the navigation channel. However, during Phase 1 the installation of a subaqueous cap was required in and around Rogers Island. The caps in the navigation channel were placed such that the navigation depth of 12 feet was met. The 12-foot depth, however, does not account for the need to conduct maintenance dredging of sediments that become naturally deposited on top of the cap. The tops of any caps placed in the navigation channel in Phase 2 must be at least 14 feet deep in order for NYSCC to maintain adequate channel depths.	Yes	This proposed change will reduce potential adverse impacts of prop wash on cap stability while accommodating maintenance dredging.
Eliminate the concepts of 'inventory pass' and 'residuals pass' from the Residuals Standard. Consider all passes simply as dredging passes.	N/A	Rarely in Phase 1 was subsequent dredging after the first pass exclusively done to remove inventory or residuals. The categorization of particular dredging passes, which has no impact on implementation of the Residuals EPS, became a distraction during project discussions.	Yes	This change may reduce confusion and streamline decision making. However, the categorization of individual dredging passes is not expected to have any impact on productivity or resuspension.

Table 10. Summary of GE's proposed modifications to the Residuals EPS

GE-Proposed Change to Residuals EPS		Panel Finding	
Proposed Change to EPS	Rationale	Accept Proposed Change?	Rationale
In high-confidence areas, dredge to the design prism and sample to determine the appropriate cap or backfill.	In Phase 1, the design dredge prisms in high-confidence areas removed close to 90% of the inventory in these areas. Each subsequent pass removed only a few percent of the mass, but impacted productivity and prevented CU closure.	No	The Panel agrees in principle with the proposed change, but finds that without accurate DoC—including elevation controls—prior to dredging, the approach is inadequate to meet the Productivity EPS and Resuspension EPS. Thus, this approach must be accompanied by more accurate DoC delineation. In Phase 1, design dredge prisms (i.e., first dredge pass) in high-confidence areas removed 80 to 85% of inventory. According to GE, subsequent passes removed only a few percent of PCB mass while reducing productivity and preventing CU closure. Based on the overall PCB removal reported, subsequent dredging passes appear to have removed possibly 20% or more of the PCB mass originally in some high-confidence areas being redredged. This large additional removal in some high-confidence areas results from inadequate elevation controls (the DoC appeared to be off by about 4" in high-confidence areas) in the original sediment coring to determine the DoC and from the 3" tolerance allowed above the dredge prism that was set roughly at the DoC.
Collect data in low-confidence areas—redefine DoC to convert to high-confidence areas. Then, dredge to the design prism and sample to determine the appropriate cap or backfill.	See Above	Yes	Additional core data should be collected in all low-confidence areas, but also in high-confidence areas. Inadequate penetration of the cores and lack of elevation controls for all cores was directly responsible for improper DoC characterization.
When hard bottom is encountered above a dredge prism elevation, do not dredge further in that location, but install the appropriate cap or backfill.	Dredging on bedrock is illogical and difficult to implement.	Yes	Dredging on bedrock is impracticable. No dredging of bedrock or rock outcroppings should be attempted.



#### 4. Residuals

GE-Proposed Change to Residuals EPS		Panel Finding	
Proposed Change to EPS	Rationale	Accept Proposed Change?	Rationale
When glacial clay is encountered above a dredge prism elevation, do not dredge further in that location, but install the appropriate cap or backfill.	Dredging GLAC is illogical because it is not contaminated with PCBs and slows productivity by impacting the processing facility.	Yes	GLAC is not contaminated with PCBs and dredging this clay slows productivity. No dredging of GLAC should be attempted.
Modify the existing dredge removal tolerances to allow a certain percentage of the 10 x 10 ft. compliance grid cells to be above the existing tolerance on an acre basis following the dredge pass to minimize the amount of unproductive time spent removing small quantities of sediment above the dredge cutline tolerance limit.	Achieving the Phase 1 removal tolerance on a 10 x 10 ft. grid was very time-consuming, and ultimately residual PCB concentrations determined the next step in any event.	No	This proposal is not compatible with GE's first 2 proposed changes, above. If the Phase 2 Residuals EPS retains multiple dredge passes, then this change would improve productivity somewhat.
Capping should not be required unless the residual surface sediment Tri+PCB concentration is greater than 3 mg/kg.	This would allow the simple application of backfill to residual concentrations that pose no significant threat to the recovery of the river. The existing Residuals EPS allows backfilling in areas containing up to 3 mg/kg in certain circumstances. Experience in the Grasse River indicates that 1 foot of backfill achieves about 95% reduction in surface sediment PCB concentrations (Connolly et al. 2007). This reduction would achieve a Tri+PCB concentration of 0.15 mg/kg when applied to 3 mg/kg sediments. The proposed criterion for capping is similar to the criterion adopted for the Fox River (EPA 2007), which allows a 6" sand cover over Total PCB concentrations as high as 10 mg/kg.	Yes	Surrounding areas not designated for dredging have surficial Tri+PCB concentrations greater than 1 mg/kg (typically 3 to 6 mg/kg). The change would improve productivity and avoid resuspension, achieving significant risk reduction via isolation.
The dredging completion form (Form 1) and the backfill and capping form (Form 2) should be combined into a single review and approval step.	EPA would oversee verification of dredged elevations, determination of residual core sampling locations, residual core sample collection and analysis, redelineation of any dredge surfaces, development of backfill or cap surfaces, and verification of placed backfill or cap surface elevations; no formal approval would be required before proceeding to the next step in the process.	Yes	This would speed the re-dredging and CU-closure process, increasing the area that can be remediated in a season. A single review and approval step is particularly appropriate if the proposed single dredge pass changes are adopted; dredge surfaces will not be required in that case.

**CHARGE QUESTION 3.** If the experience in Phase 1 and other evidence before the panel does not show that it will be practicable to consistently and simultaneously meet the Engineering Performance Standards that are being proposed for Phase 2, can the Phase 1 Engineering Performance Standards be modified so that they could consistently be met in Phase 2, and, if so, how?

Phase 1 demonstrated that the Residuals EPS had a substantial impact on project success and on the interaction with the Resuspension EPS and the Productivity EPS. Incomplete DoC characterization combined with adherence to the 2004 EPS residual target levels directly affected both the Resuspension and Productivity EPS. Repeated dredge passes and prolonged exposure of sediments in the CUs resulted in increased PCB resuspension and release. The unexpected increase in inventory due to incomplete DoC characterization had the greatest effect on the Productivity EPS in terms of numbers of CUs remediated. The Panel proposes revising the Residuals EPS to accelerate CU closure by establishing an elevation-focused dredge design paradigm, thereby reducing resuspension, effectively managing residuals, and accelerating productivity without sacrificing goals of the ROD with respect to overall recovery of the river.

Attempts to meet the Residuals EPS led to the need for repeated dredging and cleanup passes, surveys, sampling, and chemical analyses that delayed closure and reduced overall productivity by as much as 30 percent. Table 11 shows that 50 percent of the dredge time was spent redredging, sometimes in response to individual sample values. Despite repeated dredging and cleanup passes to achieve a residuals concentration of less than 1 mg/kg Tri+PCBs, it was achieved throughout the entire area in only 1 of the ten CUs dredged in Phase 1.

**Table 11. Days spent dredging per CU (composed from March 2010 GE Table 6.4-1)**

CU	1st Pass (d)	2nd Pass (d)	3rd Pass (d)	4th Pass (d)	5th Pass (d)
1	37	19	28	16	9
2	38	17	9	4	-
3	28	20	12	-	-
4	30	14	2	-	-
5	31	17	8	-	-
6	31	19	6	-	-
7	26	16	16	2	-
8	27	10	22	5	-
17	22	14	5	-	-
18	38	16	1	-	-
Total	308	162	109	27	9

Risk management should be strongly factored into determining how much redredging to undertake. When dredged areas are covered with backfill or an engineered cap (standard practice for this project), residuals become isolated, making them unavailable to biota. Excessive redredging reduces productivity, increases project costs and time, and poses increased environmental risks by increasing the time that contaminated sediment surfaces are exposed to the environment and by increasing resuspension potential during periods of exposure. The Productivity EPS measured project progress on a cubic-yard-dredged basis, whereas progress is more accurately reflected by the size of the area remediated and contained. Thus, focus on achieving target Tri+PCBs concentrations in accordance with the Residuals EPS hindered productivity on an areal basis. This is especially true under conditions where a) risk reduction is affected primarily by the area remediated, as opposed to the volume or mass remediated, and b) the total volume targeted for removal in each area is uncertain—both conditions are true of this project.

***Finding Rdl.3: The Phase 1 Residuals EPS can be modified to be consistently met in Phase 2; however, additional steps are necessary to simultaneously meet the Productivity EPS and Resuspension EPS, achieve risk reduction goals, and accomplish the requirements of the ROD.***

The Productivity EPS and Resuspension EPS must be integrated with the Residuals EPS so that all 3 standards are achievable. This approach requires an understanding of the limitations of dredging productivity, residuals management, and resuspension/release potential. Using improved DoC elevations, EPA and GE should establish fixed dredge elevations and revise the predicted Phase 2 dredge volume accordingly. This information should be used to establish a realistic productivity goal and dredging timeline, relying on predetermined dredge elevations, rapid CU closure, and more liberal use of backfilling or capping, as appropriate. This approach must also rely on an expanded and formalized adaptive management process to facilitate routine operational modifications based on experience.

***Finding Rdl.3-1: The project should focus on single-pass sediment removal (i.e., efficient dredging of DoC output with an acceptable confidence), quickly dealing with residuals through backfilling or capping.***

The value of redredging beyond the DoC is questionable, since all dredged areas will ultimately be backfilled or capped. This is especially true for multiple redredging passes. According to GE, greater than 90 percent of the PCB inventory was removed in the first 2 dredge passes, and only approximately 7 percent more inventory was removed via subsequent dredge passes (in general, during dredging of what would be deemed residuals instead of inventory).

According to EPA, except for CU1, 98 percent of the Phase 1 inventory was removed from completed CUs. However, extreme measures were taken to achieve this level of inventory removal; the time and effort dedicated to dredging residuals would have been spent more effectively on activities that would have improved overall productivity, accelerated CU closure, and reduced resuspension and dredge-generated residuals to a considerably greater extent.

Significant changes in approach will be required to attain the desired rate of closure (1 CU per 8-10 day period). For example, compositing confirmation samples would manage the occurrence of outliers that pose limited risk to biota. Compositing also obviates the need for trigger concentrations of 15 and 27 ppm Tri+PCBs, further simplifying the CU closure process.

It should be noted that the ROD, which calls for removal of all inventory in the defined footprint (based on mass-per-unit-area analysis) operationally defined as above 1 ppm Total PCBs, was written prior to

issuance of specific technical guidance by EPA that clearly acknowledges the viability of capping for managing risks (*Contaminant Sediment Remediation Guidance for Hazardous Waste Sites* (EPA 540-R-05-012)). Further, it is common knowledge among dredging practitioners and environmental scientists and engineers that dredging activity always leaves behind some residual material. Though the Phase 1 Residuals EPS allow for capping, the decision process to use capping requires extensive and repeated dredging to demonstrate that dredging alone cannot achieve target residuals levels, violating the spirit of the dredged residuals standard which attempted to limit the number of dredging passes. More efficient and extensive use of capping would improve productivity and reduce resuspension while achieving risk reduction goals. Furthermore, the fact that EPA and GE employed caps fairly extensively during Phase 1, including for areas where PCB concentrations above the Residuals EPS were left in place for near shore areas with steep slopes, establishes precedence and indicates acceptance for the use of capping to manage areas with elevated PCB levels.

***Finding Rdl.3-2: Perform investigations to define DoC, confirm DoC, and drive dredging plans and residuals management.***

The project's failure to meet the Residuals EPS in Phase 1 can be directly attributed to poor DoC modeling, which was itself due to poor cores. Only about 40 percent of Phase 1 cores characterized DoC with high confidence. In Phase 2 only about 60 percent of cores characterize the DoC with high confidence. In addition, the DoC determined from the coring lacks adequate vertical positioning controls to tie the DoC to a datum for accuracy, even when a reasonable level of precision was achieved.

DoC must be accurately and precisely defined prior to designing dredge cuts to avoid repeated dredging passes and inventory recharacterization, which can adversely impact the river's long-term recovery and impose unacceptable environmental and human health risks. Accurate DoC provides confidence that residual PCB concentrations are generally derived from generated residuals and are much lower than those in the volume targeted to be dredged.

The following steps should be taken to establish an accurate and useful DoC that can drive dredging plans and residuals management.

- **Coring Program.** Perform recoring of all low-confidence samples. Samples now designated as high-confidence should be verified as high-confidence. All sampling must be performed to attain at least 80 percent recoveries of soft sediments and must be cored either to bedrock or GLAC. Sediment layers must be reported as elevations rather than as depth below mudline, using state-of-the-art positioning for horizontal and vertical control. All cores should be analyzed until 2 6-inch layers have Total PCBs below 1 ppm.
- **DoC Elevation.** Remodel the DoC using all high-confidence cores to establish the topography (terrain model) of the DoC throughout each CU, referred to as the DoC Elevation. Consideration should be given in the modeling to precision/uncertainty of the DoC measurements in order to ensure that the inventory is captured in the dredge prism. The uncertainty of the DoC is a matter of concern when single pass dredging is being considered, especially in light of reported paired cores having an averaged difference in DoC 11.2 inches in 67 paired high-confidence cores and a median differences of 9 to 12 inches (EPA March 2010, Chapter II, Section 2.5).
- **Design Dredge Elevation.** Set the Design Dredge Elevation initially to 4 inches below the modeled DoC to account for the vertical accuracy and precision of the dredge, referred to as dredge

tolerance. The goal for dredging is to achieve the DoC elevation in 95 percent or more of the dredged area after a single dredge pass (i.e., at least 95 percent of the area dredged in the 1-acre subunit should be at or below the modeled DoC elevation). Incorporating a factor for dredge tolerance ensures that the dredger attains the modeled DoC Elevations as quickly as practicable (i.e., in a single pass).

- **Post-Dredge Elevation.** Confirm that the DoC Elevations have been met after dredging, allowing closure of the CU, or subunit. Adaptive management should be used to update the dredge tolerance. If the dredger demonstrates that the DoC is consistently achieved with a single pass (i.e., at least 95 percent of the dredged area at or below the DoC Elevation), then the magnitude of the dredge tolerance included in the Design Dredge Elevation can be reduced for subsequent areas. If the dredger has trouble consistently capturing the DoC in 95 percent or more of the dredged area after a single pass, then the magnitude of the dredge tolerance in the Design Dredge Elevation should be increased for subsequent areas.
- **Confirmation Sampling.** Collect and composite 6-inch residuals samples as soon as possible after EPA confirms dredging is complete in a CU, or subunit, based solely on the elevation measurements. Recommendations for this sampling are given in Table 12.
- **Sand Cover.** Place a 3-to-6-inch sand cover over the CU subunit as soon as possible after residuals samples are collected (PCB analytical results are not required for this step). No verification of placement thickness is required at this time.
- **Backfill or Cap.** Use PCB analytical results for the residuals composite sample to determine whether an area should be backfilled or capped. Then install appropriate final layers on top of the sand cover for closing the subunit after dredging of the CU and all upstream CUs are completed. Perform appropriate confirmation monitoring to verify backfill or cap placement in accordance with design specifications. Do not redredge to capture residuals.

***Finding Rdl.3-3: Prior to dredging a CU, update the Design Dredge Elevations and remove inventory with a single dredging pass.***

The Phase 1 dredging program required multiple unplanned redredge efforts to remove unanticipated inventory. This resulted in the CUs being opened for extended periods. In open CUs, PCB-contaminated sediment was exposed to ongoing disturbance from river flow and vessel traffic, which continued to erode and transport contaminated sediment down river. CUs should be closed more quickly during Phase 2 to reduce the magnitude of PCB release prior to closure and to simultaneously meet all the engineering performance standards. The only way to reduce the number of passes while satisfying the goals of the Residuals EPS is to more precisely establish Design Dredge Elevations prior to dredging. The dredge prism should be updated as follows.

- Establish DoC using high-confidence cores throughout each CU, and generate an updated high-confidence DoC Terrain Model to establish the topography of the DoC throughout the CU (DoC Elevation) such that the DoC topography contains all of the inventory with acceptable certainty, considering the variability of the DoC in paired high-confidence cores.
- The Design Dredge Elevation should be established based on the updated DoC Terrain Model, limitations of the dredge to cut a slope, river hydrodynamic conditions, and a realistic estimate of

residuals generation and management that are based on an understanding of exposure risks associated with surface sediment PCB deposits.

- The Design Dredge Elevation should initially be set at 4 inches below the DoC Elevation to compensate for tolerances in vertical positioning of the dredge bucket.
- Use an adaptive management approach to adjust the Design Dredge Elevation according to actual dredge performance, integrating knowledge of dredge productivity, CU closures, and resuspension.
- Set the Contractor's Dredge Prism to capture the full extent of the Design Dredge Elevation.

***Finding Rdl.3-4: Use an adaptive management approach to adopt dredging BMPs to manage residuals.***

Dredging activity disturbs sediment and increases short-term environmental exposures to buried contaminants, resulting in the resuspension of PCBs in the water column and the formation of loose, PCB-containing residuals on the bed surface, both within and outside of dredged areas. Changing the manner in which the dredge removes the material from the river can reduce the amount of resuspension and residuals that are generated. An adaptive management approach should be used to incrementally implement the following dredging BMPs, monitor benefits, and adopt, modify, or eliminate BMPs and performance standards based on monitoring results.

### **Single-Pass Dredging Program**

Preparing the Contractor Dredge Prism based on an updated high-confidence DoC Terrain Model and a Design Dredge Elevation will allow for single-pass dredging (including an allowance to compensate for the vertical tolerance in dredge bucket positioning) with a high degree of confidence that inventory is being removed effectively. With a well-defined dredge prism, dredging can be completed in a single event, accelerating CU closure and minimizing exposed PCBs. Monitoring the post-dredging bed elevation with high-precision bathymetric surveys provides an adequate basis to confirm that the targeted material is removed, and provides feedback to adjust (i.e., to adaptively manage) the Contractor Dredge Prism (i.e., to adjust vertical dredge tolerance requirements) to assure removal in a single pass.

Incorporation of a vertical dredge tolerance in the Design Dredge Elevation is prescribed to assure that the DoC Elevation is achieved in a single pass. The dredge tolerance factor is intended to balance the goals of attaining required elevations in a single pass and limiting the dredging of non-target material.

Each certification subunit should be dredged until completion, and dredging should proceed from upstream to downstream to the extent practicable. As soon as practicable and following completion of each subunit, a bathymetric survey should be conducted to confirm that the sediments were removed in accordance with the criteria established in the revised Residuals EPS (e.g., the elevation of 95 percent or more of the dredged area should be at or below the established DoC Elevation).

### **Stop Dredging at Rock and Clay**

The contractor should stop dredging whenever till is encountered, whether GLAC, bedrock, or other hard bottom/rock. Continuing to dredge into till material provides no environmental benefit, while increasing the downstream release of PCBs by keeping the CU open, and unnecessarily expending energy and time.

### **Stair Step Cuts**

The Phase 1 dredge plan allowed for a vertical cut face for the full depth of the dredge prism. Vertical cuts can result in bank sloughing, which can release contaminants to the water column (resuspension) and increase dredge-generated residuals.

Stair-stepping the cut involves offsetting the bucket placement through the depth of the cut to produce a more stable, sloping cut face that is less likely to slough or fail. This approach will reduce bank failure and associated residuals and resuspension release.

### **Sequence Dredging Bank to Bank and from Upstream to Downstream**

The Phase 1 report shows cases where a single dredge lane was advanced downstream as far as 600 to 800 feet in the direction of flow. This longitudinal approach creates a thalweg effect that can increase local river flow velocities, and can contribute to resuspension and release by eroding the cut's side slopes and bed. Vessels passing through such a cut also have the potential to accelerate resuspension via slipstream and prop wash velocities. Erosion and sloughing in the cut area increase resuspension of PCBs into the water column and downriver. This condition is exacerbated during higher river flow conditions. Modifying the dredging sequence and monitoring the effects will optimize productivity while reducing generated residuals and resuspension by erosion of residuals within the cut area, and encouraging deposition within the CU instead of downstream of the CU.

Instead of dredging long downstream longitudinal lanes, dredging should be short cross-stream lanes dredged from bank-to-bank, then upstream to downstream. Dredging should target 1-acre CU subunits (or another appropriately sized subunit) that are designed to limit creation of a thalweg-like channel. The subunit should be dredged from bank to bank or in predefined areas not necessarily aligned with the direction of water flow. To accelerate closure, and to the extent reasonably practicable, each dredged subunit should be surveyed, sampled, and covered while dredging on adjacent or downstream subunits proceeds.

Final backfilling or capping should occur strictly from upstream to downstream.

The Panel recognizes that dredging will have to occur simultaneously at multiple locations along the river, making strict adherence to an upstream to downstream requirement impossible. For this reason, the BMP may involve dredging in multiple CUs located upstream and downstream of each other, as long as the final backfilling or capping is completed sequentially from upstream to downstream. Because Phase 1 indicates that residuals likely contribute to resuspension and release from upstream to downstream, the immediate placement of a 3-6-inch coarse sand layer will control near-term releases, buying time within a single dredge season to complete the final backfill and capping from upstream to downstream. All backfilling and capping must be completed before dredging terminates at the end of each year.

### **Initial Sand Cover Immediately After Dredging**

Dredging generates a layer of residual sediment with a higher water content and lower shear strength than the native deposit, commonly referred to as dredge-generated residuals. This residual layer is more easily eroded than the native, undisturbed sediment bed, and consequently results in more erosion and resuspension of PCBs than the predredge condition. Leaving the disturbed residual sediment exposed in the river for long periods increases resuspension to the water column.

An Initial Sand Cover consisting of a thin layer (3 to 6 inches) of coarse sand should be placed as soon as possible after dredging of a CU subunit is complete, and following EPA verification of the dredged elevation. The Initial Sand Cover will provide a relatively clean, less erodible surface within the footprint of the dredge cut, limiting the resuspension and release of contaminated residuals and limiting short-term surface sediment exposures during construction. The Initial Sand Cover will also act as the first lift of a sand backfill or cap layer. The thickness of this cover does not require confirmation after placement, beyond the verification that an appropriate volume of sand was placed to achieve the target fill amount; in other words, placement can be controlled by the volume or weight of cover materials delivered to each defined area combined with global positioning system (GPS) information provided by the placement contractor. This cover is critical to controlling resuspension and is applied most effectively as soon as possible to contain the residuals. The cover can be placed before the data from confirmation sampling are collected.

The entire CU can be closed after dredging of all of CU subunits is completed and all upstream dredging is complete. The method of closure, backfilling or capping, is based on analytical results of composite 6-inch residuals cores as described in Table 12.



**Table 12. Summary of recommended changes to the Residuals EPS**

CHANGE TO RESIDUALS EPS	NUMERICAL CRITERIA	RATIONALE	IMPACT ON OTHER EPS
<p><b>1. DEPTH OF CONTAMINATION (DoC)</b></p> <p>a. Collect additional cores in high- and low-confidence areas, as well as areas of missing data, to more accurately define the elevation of the DoC for all Phase 2 CUs with a high degree of confidence.</p> <p>b. Use coring methods and equipment capable of penetrating debris and reaching the rock or clay substrate with good to excellent core recovery (i.e., &gt;80%). The equipment used in the SSAP does not meet this criterion.</p> <p>c. Collect, log, and process intact cores.</p> <p>d. Generate a high-confidence DoC Terrain Model for each CU based on the new coring data.</p>	<p>Cores will be characterized in 6” intervals for TPCB and Tri+PCB concentrations.</p> <p>The DoC Terrain Model will establish a DoC at the level where Total PCBs are &lt; 1 ppm. The data also will be used to establish surface sediment and till elevations at the time of collection.</p> <p>The project also will benefit by the collection of some high-confidence cores to validate the current understanding of DoC elevations in high-confidence areas. At a minimum, collect:</p> <ul style="list-style-type: none"> <li>◆ Low Confidence Cores: Repeat 100% of these cores</li> <li>◆ Missing Data: 100% collection in areas lacking data</li> <li>◆ High Confidence Cores (recommended): Repeat 20% of high confidence cores to validate elevation DoC elevations. If new cores do not adequately validate the DoC, resample high confidence cores as necessary to establish high-confidence DoCs for input into the Terrain Model.</li> <li>◆ Vertical Positioning Controls. When coring, measure surface sediment and till elevation to 0.1 ft; include real time water</li> </ul>	<p>The Phase 1 closure process for Residuals negatively impacted both the Resuspension and Productivity EPS. Leaving CUs open to scour while going through the validation and redredging process was very likely a significant source of PCBs resuspension and downstream release. Two factors contributed to prolonged open CUs: incomplete DoC determination during the design phase, and preoccupation with sediment volume and PCB mass removals as the primary metrics of success in lieu of a risk-based goal that focuses on remediated areas and CU closure. These two factors contributed to resuspension and release and reduced productivity rates. The focus should be on effective single-pass dredging, rapid CU remediation and closure, improved productivity, and reduced resuspension and release. The intent for resampling is to improve confidence in the DoC and the 1 ppm Tri+PCBs neat line, obviating the need for multiple</p>	<p>Confident characterization of sediments and the DoC in remaining CUs along with single-pass dredging have the greatest potential of any modification to the dredging program to reduce PCB resuspension and release and to increase overall project productivity.</p>

CHANGE TO RESIDUALS EPS	NUMERICAL CRITERIA	RATIONALE	IMPACT ON OTHER EPS
	<p>elevations measurements.</p> <p>Horizontal Positioning Controls. Established x-y coordinates using GPS system capable of sub-foot accuracies.</p>	<p>redredging passes and providing confidence in removing the target inventory.</p> <p>The recoring program is a monumental task and may not be accomplished in a single construction season. The revised and improved DoC delineation should be staged to meet the needs of each subsequent dredging season (i.e., next year's CUs).</p>	
<p><b>2. DESIGN DREDGE ELEVATION</b></p> <p>a. Prior to dredging a CU, update the Design Dredge Elevation using high-confidence cores and the updated DoC Terrain Model, combined with an understanding of hydrodynamic conditions and risk reduction goals.</p> <p>b. The Design Dredge Elevation should initially be set to below the level where Total PCBs are &lt; 1 ppm to accommodate the vertical dredge positioning tolerance.</p> <p>c. Adjustments to the Design Dredge Elevation at CUs or subunits could be considered if the following can be demonstrated: a) adequate inventory removal, b) the ability to design and construct a cap that will meet predefined</p>	<p>The Design Dredge Elevation should initially be set to 4" below the DoC Terrain Model to compensate for tolerances in vertical positioning of the dredge bucket.</p> <p>If more than 95% of the dredged area is consistently below the DoC Terrain Model Elevations in the bathymetric survey after the design dredging pass, the 4" vertical dredge tolerance may be relaxed through adaptive management. Likewise, if 95% of the area is not consistently at or below the DoC Terrain Model Elevations in the bathymetric survey after the design dredging pass, the vertical dredge tolerance adjustment to the dredge prism should be maintained or increased through adaptive management.</p>	<p>The updated DoC Terrain Model, using reliable DoCs from the new core sampling, will provide the degree of certainty necessary to allow for single-pass dredging (including an allowance to compensate for the vertical tolerance in dredge bucket positioning) with a sufficient degree of confidence that inventory will be removed effectively and efficiently. Multiple passes to remove generated residuals are inefficient, have limited success in achieving the 1 mg/kg Tri+PCB goal, and leave CUs open unnecessarily.</p>	<p>Efficient and effective removal of inventory will speed up closure of CUs, which in turn will reduce resuspension and release and increase productivity.</p>

CHANGE TO RESIDUALS EPS	NUMERICAL CRITERIA	RATIONALE	IMPACT ON OTHER EPS
<p>performance goals regarding chemical exposure and hydrodynamic conditions, and c) advantages in terms of reduced risks, e.g., where removal of deep sediment deposits may incur greater environmental harm via resuspension and release than benefits gained by additional inventory removal.</p>			
<p><b>3. DREDGE METHODS AND SEQUENCE</b></p> <ul style="list-style-type: none"> <li>a. Eliminate the concepts of ‘inventory pass’ and ‘residuals pass’ from the Residuals EPS. Consider all passes simply as dredging passes.</li> <li>b. Dredge to the Design Dredge Elevation within a subunit in a single pass. Once the DoC Elevation is achieved, there normally will be no further dredging; rather, dredging will be followed by expeditious confirmation monitoring and placement of an Initial Sand Cover.</li> <li>c. Within a CU, and to the degree reasonably possible, dredge from upstream to downstream, sequentially completing each subunit (typically on the order of an acre each) before moving to the next downstream subunit.</li> <li>d. Within a dredging season, allow</li> </ul>	<p>No numerical criteria.</p>	<p>Modifications to the dredge methods and sequencing are intended to reduce the amount of time that each CU remains open and to reduce the loss of PCBs downstream through resuspension. With an accurately defined DoC, the dredging can be completed in a single pass, and the CU can proceed directly to closure.</p> <p>Expeditious placement of an Initial Sand Cover following dredging provides immediate reduction of resuspension losses and improves long-term effectiveness.</p> <p>Dredging CU subunits from upstream to downstream will eliminate the dredging of a narrow channel running the full length of a CU area, which concentrates river flow and likely increases PCB losses</p>	<p>Efficient and effective removal of inventory will speed up closure of CUs, which in turn will reduce resuspension and release and increase productivity.</p>

CHANGE TO RESIDUALS EPS	NUMERICAL CRITERIA	RATIONALE	IMPACT ON OTHER EPS
<p>for dredging of multiple CUs that are located downstream of one another, provided that the final cap or backfill placement proceeds from upstream to downstream, within a single year's dredging, to complete all annual dredging, backfilling, and capping before the year's end.</p> <p>e. Stop dredging wherever GLAC is encountered in the dredge prism.</p> <p>f. Stop dredging wherever rock or hard bottom conditions are encountered in the dredge prism.</p> <p>g. Complete dredge cuts with stair-stepped side walls, rather than vertical side walls, to reduce bank sloughing and associated generation of residuals and resuspension.</p> <p>h. Avoid longitudinal dredging that creates thalweg-like conditions in the presence of exposed PCBs.</p>		<p>downstream caused by scour of disturbed PCB-containing residuals in the dredge face.</p> <p>Allowing dredging of CUs downstream of other active CUs is based on the understanding that limited upstream to downstream recontamination will occur as soon as upstream areas are covered with an initial backfill layer, provided that the final backfilling and capping is completed from upstream to downstream within a single season.</p> <p>Stopping dredging wherever either GLAC or hard bottom/rock is encountered is based on the understanding that no benefit is achieved by attempting to remove such material, while at the same time increasing the downstream release of PCBs by the ongoing dredging.</p> <p>Completing dredging with stair-stepped side walls, rather than dredging multiple bucket depths at the same location, will reduce bank sloughing. Bank sloughing can be a significant source of generated residuals and resuspension/release.</p>	

CHANGE TO RESIDUALS EPS	NUMERICAL CRITERIA	RATIONALE	IMPACT ON OTHER EPS
<p><b>4. CONFIRMATION MONITORING – DREDGE PRISM</b></p> <p>a. Once dredging is complete to the Design Dredge Elevation, use bathymetric surveys to confirm elevations.</p> <p>b. Set CU subunits (roughly 1-acre each) as the performance area for completing dredge design prisms.</p> <p>c. Redredging within a CU subunit is only required when less than 95% of its area is at or below the DoC Elevation, and only to the degree necessary to bring at least 95% of the area at or below the DoC Elevation.</p> <p>d. Remove the existing dredge removal tolerances on percentage of the 10 x 10 ft compliance grid cells.</p>	<p>Dredging should be conducted such that at least 95% of the post dredge surface within each CU subunit (approximately 1 acre) is at or below the DoC Elevation. See Item 2, Design Dredge Elevation, for adjustments to the vertical dredge tolerance associated with meeting this criterion.</p> <p>Do not include individual small contiguous areas of less than 3 sq ft each that protrude above the DoC Elevation in the calculation of achieving 95% of the post-dredge surface below the DoC Elevation.</p>	<p>Achieving the Phase 1 removal tolerance on a 10 x 10 ft grid was time consuming, and ultimately residual PCB concentrations determined the next step in any event.</p> <p>Small protrusions above the dredge surface, such as logs and rocks and even small ridges between bucket placements, will be detected by surveying techniques. However, the small isolated areas do not represent significant undredged material, and attempts to capture them with a redredge pass will further increase resuspension releases and delay the timely closure of CU areas.</p>	<p>Timely closing of CUs will reduce resuspension and increase productivity.</p>
<p><b>5. CONFIRMATION MONITORING – PCBs</b></p> <p>a. Sample the surface sediment (top 6”) immediately after reaching the Design Dredge Prism.</p> <p>b. Use post-dredge surface sediment chemistry results to determine whether a backfill or a cap is appropriate to complete the remedial action at the CU subunit.</p> <p>c. Use a composite sampling</p>	<p>The Panel recommends an 8-point composite sample of the post-dredge surface sediment (top 6”) for each CU subunit (approximately 1 acre). Submit the composite sample for PCB analyses. (Do not archive original samples for future analyses.)</p> <p>The PCB Confirmation Monitoring analyses can occur after placement of the Initial Sand Cover, provided the PCB monitoring program</p>	<p>Completing 40 discrete cores with multiple vertical subsections for confirmation monitoring within a CU was time-consuming and caused a backlog in the PCB analyses, which contributed to the extended length of time required to close a CU, without sufficient benefit of reduced residuals, reduced exposures, or reduced ecological risks. With</p>	<p>Timely closing CUs will reduce resuspension and increase productivity.</p>

CHANGE TO RESIDUALS EPS	NUMERICAL CRITERIA	RATIONALE	IMPACT ON OTHER EPS
<p>approach for CU subunits.</p> <p>d. Set CU subunits as the performance area for PCB confirmation monitoring to be used to select backfill or capping.</p>	<p>penetrates through the sand layer into 6” of the post-dredging surface sediment. In that case 1 ft cores should be collected and the sand discarded prior to sub-sampling the top 6” of sediment to create the composite.</p> <p>PCB concentrations measured from the 8-point surface sediment composite within a subunit will establish whether backfilling or capping is required as the final action in a subunit as follows:</p> <ul style="list-style-type: none"> <li>• Backfill if less than or equal to 3 mg/kg Tri+PCBs.</li> <li>• Cap if greater than 3 mg/kg Tri+PCBs.</li> </ul>	<p>improved delineation of the DoC, the extensive coring program is no longer necessary.</p> <p>A composite sample provides an average PCB concentration that is more representative of the risk presented by the CU subunit after dredging.</p> <p>A 3 mg/kg Tri+PCBs criterion for capping is more achievable, practicable and representative of surrounding surficial sediments that are not being actively remediated. 3 mg/kg Tri+PCBs would not retard natural recovery of surrounding areas if the backfill were to erode.</p>	
<p><b>6. BACKFILL AND CAPPING</b></p> <p>a. As soon as practical after removing the sediments in the Design Dredge Prism, place an Initial Sand Cover to a depth of 3-6” over the surface of the dredged area.</p> <p>b. Select either backfilling or capping for the CU subunit based on the post-dredging PCB concentration in surface sediment.</p> <p>c. Complete backfilling and capping in a dredging season, working from upstream locations to downstream locations.</p>	<p>The Initial Sand Cover will be placed on a volume-per-area basis and not require sampling to verify the thickness of sand placed throughout the CU subunit.</p>	<p>The near-immediate placement of an Initial Sand Cover will reduce resuspension and redeposition outside the dredge prism and will provide risk reduction until a decision is made to cap or add more sand to complete backfilling after dredging of the CU and other upstream CUs is completed.</p>	<p>Timely closing of CUs will reduce resuspension and increase productivity. The Initial Sand Cover will reduce resuspension.</p>

CHANGE TO RESIDUALS EPS	NUMERICAL CRITERIA	RATIONALE	IMPACT ON OTHER EPS
<p><b>7. MONITOR RESIDUALS OUTSIDE OF THE DREDGE PRISM</b></p> <p>a. EPA and GE should establish a residuals monitoring program that evaluates the potential for near-field PCB deposition outside of dredged CUs.</p> <p>b. The program should test the potential for near-field and far-field off site deposition and generation of dredged residuals in low-, moderate-, and high-flow areas downstream of dredged CUs.</p> <p>c. Continued monitoring requirements after Year 1 of the Phase 2 dredging program should be determined by EPA and GE, based on the Year 1 results.</p> <p>d. Adjustments to BMPs or dredge volumes should be considered if the risks associated with the generation of residuals compromise the benefits to be achieved in terms of reduced risks resulting from dredging.</p>	<p>The numerical criteria for off-CU residual deposits should be based on the following: The generation of off site (i.e., off-CU) residuals should not adversely increase baseline surface sediment Tri+PCB concentrations on off-CU areas, such that post-dredge recovery rates are slower than would be achieved via MNR. This evaluation should NOT be based on a comparison of cumulative loads, but instead should be based on long-term fish exposures associated with surface sediment deposits, and should include a combined assessment of dredged and undredged areas.</p>	<p>Phase 1 inadequately evaluated the generation of residuals outside of the dredge prisms and CUs. Near-field and far-field PCB deposition has the potential to adversely increase ecological and human health risks. EPA and GE should evaluate whether off-CU deposits have the potential to increase risks to levels that are unacceptable when compared to the reduced risks associated with dredging and backfilling. The sediment surface (e.g., top 0 - 2") should be characterized and the data used to determine if upstream releases are redepositing in depositional areas, and to determine whether redeposition results in unacceptable changes to the surface sediment in off-CU / off site areas.</p>	<p>No impact on the other EPS is anticipated unless the results indicate a need to change dredging plans, BMPs, and operations, which might decrease productivity and resuspension.</p>

CHARGE QUESTION 4. If EPA and/or GE has proposed modifications to the monitoring and sampling program for Phase 2, are the proposed modifications adequate and practicable for determining whether the Phase 2 Engineering Performance Standards will be met?

Both EPA and GE proposed changes to the EPS with concurrent changes to the monitoring and sampling program for Phase 2. However, the Panel finds that it will not be practicable to consistently and simultaneously meet the EPS being proposed by either party and, thus, cannot make a finding regarding the monitoring and sampling programs relative to these proposed standards except for those items that have been specifically addressed under Charge Question 2, above. Rather, the Panel has addressed Question 4 relative to the modified EPS and processes recommended by the Panel in response to Charge Question 3.

***Finding Rdl.4: The experience in Phase 1 shows that the monitoring and sampling program for residuals in Phase 2 will need more rapid characterization of surficial samples to determine whether dredging residuals—based on a proactive determination of the DoC—can be backfilled or should be capped.***

Since risk is driven by average surficial contaminant concentrations, confirmation sampling of residuals for verifying attainment of the Residuals EPS should be based on surficial samples that are composited to represent an average surface. With a well-characterized DoC, dredging will remove the vast majority of the inventory, ideally leaving only generated residuals without any undredged inventory; therefore, there is little reason to monitor for contamination at depths below the top 6 inches of dredged sediment surface. Because risk reduction will be provided by the isolation created by the backfill or the cap covering all dredged areas, little benefit is gained from attempting to remove the small contaminant mass present in generated residuals. The average Tri+PCBs concentration in the composite of surficial residuals samples is compared with the residuals criteria to determine if the area can be backfilled or should be capped as described in Table 12. The Residuals EPS monitoring for removal of inventory should focus on determining whether a dredged area has removed the sediment down to the Design Dredge Elevation in 95 percent or more of the dredged area. PCB mass removal should be based on the DoC coring program results.

After the bathymetric survey results of the dredged subunit are verified, the 1-acre subunit should be sampled as soon as practicable to determine whether the residuals need to be backfilled or capped. Eight 6-inch-deep samples (1-foot samples followed by removal of the sand layer if collected after sand cover is placed) should be collected, composited into a single sample, and analyzed for Tri+PCBs concentration. If the 1-acre composite concentration is less than 3 ppm Tri+PCBs, then the subunit should be backfilled to close the area; otherwise, the subunit should be capped. 3 ppm Tri+PCBs is selected as the decision criterion because it is representative of the concentration achieved in Phase 1 at the end of the cleanup passes. It is also representative of the surficial concentration outside the dredge areas in TIP and, as such, is comparable to the concentration that would result from recontamination by surrounding undredged sediments.

In Phase 1, about 25 percent of the high-confidence areas had Tri+PCB concentrations greater than 3 mg/kg and the apparent DoC was off on average about 6 inches (GE Table 6.1-3). With improved DoC delineation and an allowance for vertical dredge tolerance in setting the Design Dredge Elevation, the Panel expects the inventory to be routinely removed.



However, based on the failure to correctly establish the DoC during Phase 1, and thus the lack of performance data to gauge the adequacy of the Panel's recommended DoC delineation approach, a limited confirmation monitoring program is recommended to verify the effectiveness of the updated DoC delineation approach. For example, following GE's development of the updated DoC for the first year of Phase 2, a limited number of cores may be collected to confirm that the DoC was adequately characterized, by analyzing the cores in 6-inch sections for Tri+PCB. The results of the confirmation samples may be used to adjust the coring density in subsequent years during Phase 2, particularly if the additional cores do not adequately validate the updated DoC for the first year of Phase 2.

The additional cores could be completed either before or after the dredging for the first year of Phase 2. If done after dredging, the Panel does not recommend redredging of any missed inventory, as doing so would adversely impact resuspension and productivity. As appropriate and as necessary for the design process, geotechnical testing (i.e., water content, organic matter, etc.) should also be performed on these core sections to permit better interpretation of the findings for the adaptive management process.

## 5 PRODUCTIVITY

CHARGE QUESTION 1. Does the experience in Phase 1 show that each of the Phase 1 Engineering Performance Standards can consistently be met individually and simultaneously?

The 2004 Phase 1 Productivity EPS for the Hudson River PCBs Superfund Site defines “productivity” as the volume of sediment in cubic yards (cy) that is removed from the waterway, processed, and shipped off site to an approved landfill for permanent disposal, per unit of time.

Specifically, the Productivity EPS states:

*The minimum volume of sediment to be removed, processed, and shipped off site during Phase 1 shall be 200,000 cubic yards.*

The removal component in this report includes the dredging and haul barge transport to the processing site. Project productivity criteria are expressed as cy/day, cy/mo, and cy/yr.

Contrary to this definition, the GE and EPA Phase 1 Evaluation Reports both used *productivity* to refer to the output of a single operational component (i.e., removal). Thus, both reports incorrectly evaluated project performance by comparing dredging output to the Productivity EPS, which explicitly includes all 3 outputs (i.e., “The minimum volume of sediment to be removed, processed, and shipped off site...”).

*The maximum monthly dredging production rate achieved during Phase 1 was approximately 78,000 cy, only 12 percent less than the Phase 1 requirement of 89,000 cy. (EPA’s Phase 1 Evaluation Report, Hudson River PCBs Site, pg. ES-20).*

*The best 1-month production that was accomplished in Phase 1 was 77,300 cy. More typically, the weekly productivity rate during Phase 1 resulted in a monthly production of 64,000 to 77,000 cy. This rate is 15% to 30% lower than the production rate necessary to achieve the 89,000 cy per month target rate. (GE’s Phase 1 Evaluation Report, Hudson River PCBs Superfund Site, pp. ES-23 & -24).*

In both cases, the “production rate” or “productivity rate” refers only to the achieved removal output, and did not account for processing or shipping outputs. Output is distinct from productivity as it relates to 3 individual components of the sediment remediation project; productivity represents the total volume of material that is handled by all 3 components over a specified time.

The project’s Phase 2 annual productivity goal was set at 490,000 cy/yr. EPA’s criteria for monthly productivity changed between the time EPA issued the 2004 EPS for Dredging and the start of Phase 1 dredging in 2009. EPA originally based its monthly productivity standard on a 7-month dredging season, which yielded a 70,000 cy/mo standard (490,000 cy divided by 7 months = 70,000 cy/mo). During remedial design, the planned dredging period was changed from 7 months to 5 ½ months. As a result, EPA revised its monthly productivity standard to 89,000 cy/mo (490,000 c y divided by 5.5 months = 89,090 cy/mo).

***Finding P.1: Phase 1 did not achieve the 2004 Productivity EPS and the experience in Phase 1 does not show that the Productivity EPS can be met for Phase 2.***

The Panel evaluated Phase 1 outputs reported in Appendix D<sup>1</sup> and Appendix E<sup>2</sup> of GE's *Phase 1 Evaluation Report, Hudson River PCBs Superfund Site* (March 2010) against EPA's 4 numerical productivity criteria. As shown in Table 13, Phase 1 did not meet any of the productivity criteria set forth in the 2004 EPS. Phase 1 also failed to demonstrate that the existing Productivity EPS could be met in Phase 2.

**Table 13. Phase 1 productivity results vs. 2004 EPS for Dredging**

Productivity Standard 2004 EPS for Dredging	Numerical EPS	Achieve EPS?	Actual Phase 1 Productivity	Discussion
1.a. Minimum Phase 1 volume to be removed, processed, and shipped off site during Phase 1.	200,000 cy	No	100,000 cy 50% of EPS	The total material removed and processed was 371,229 tons. Of that, 128,550 tons were shipped off site (35% of total). 35% of the total reported volume removed (286,354 cy) is 100,000 cy. 100,000 cy/yr is 50% of the 200,000 cy/yr EPS.
1.b Targeted Phase 1 volume to be removed, processed, and shipped off site during Phase 1.	265,000 cy	No	100,000 cy 38% of EPS	Only 100,000 cy was removed, processed and shipped off site during Phase 1. See discussion 1.a. 100,000 cy/yr is 38% of the 265,000 cy/yr EPS.
2. Minimum 1-month production rate, for removal, processing, and shipping off site.	89,000 cy/mo	No	42,400 cy/mo 48% of EPS	The peak 1-month productivity for Phase 1 removal, processing, and shipping off site was 42,400 cy/mo, achieved during the period ending October 17, 2009. It was controlled by the shipping output (42,400 cy/mo) which was less than the processing output (62,800 cy/mo) and less than the removal output (63,300 cy/mo) during that period. See Table 14. 42,400cy/mo is 48% of the 89,000 cy/mo EPS
3. All material removed and processed shall be shipped off site to final disposal by end of calendar year.	100% shipped off site	No	35% shipped 35% of EPS	See discussion 1.a above.

***Finding P.1-1: Phase 1 achieved 50 percent (100,000 cy / 200,000 cy = 0.5) of the minimum volume specified in the Productivity EPS.***

The minimum volume of 200,000 cy/yr applies to the volume of design inventory sediment that was removed, processed, and shipped off site during 2009 (see footnote 3 to EPA's Table 2-6 of the 2004 EPS). During Phase 1, transportation issues and delays constrained productivity to the extent that only 35 percent of the material that was removed and processed was actually shipped off site by the end of

<sup>1</sup> Appendix D is titled *Detailed Discussion of Productivity During Phase 1 Dredging*, and is referred to as "GE's Appendix D."

<sup>2</sup> Appendix E is titled *Detailed Discussion of Processing and Disposal During Phase 1 Dredging* and is referred to as "GE's Appendix E."

the calendar year. Specifically, of the total volume removed during 2009 (286,354 cy), only about 100,000 cy was shipped off site.<sup>3</sup>

GE reported delays in off site transport in July and August, relating to the cleaning and marking of empty rail cars, as well as later delays due to materials management problems at the disposal cell.

Consequently only 2 unit trains<sup>4</sup> were shipped during June, July, and August of 2009 (1 unit train is approximately 8,350 tons, or about 6,400 cy of dredged material). Eleven unit trains were shipped off site from mid-September through the end of October (see GE's Table E-5), averaging just under 1.5 unit trains per week. During the following 6 weeks, there was no off site transportation. The year ended with 2 unit trains plus a partial train (2,900 tons) shipped off site during the last 2 weeks of December.

***Finding P.1-2: Phase 1 achieved 38 percent (100,000 cy / 265,000 cy = 0.38) of the target volume specified in the Productivity EPS.***

The Phase 1 Target Volume EPS of 265,000 cy/yr also applies to the volume of design inventory sediment that was removed processed, and shipped off site during 2009 (see footnote 3 to EPA's Table 2-6 of the 2004 EPS). Again, by the end of Phase 1 the transportation component constrained the total volume of material that was actually removed and processed and shipped off site, with approximately 100,000 cy shipped off site by the end of the calendar year.

GE reported a Phase 1 total dredging output of 286,354 cy, of which 144,438 cy was designated as design inventory, 119,964 cy as extra inventory, and 21,952 cy as residual dredging (GE's Table D-4). In accordance with the 2004 EPS for Dredging, only design inventory counts toward meeting the Production EPS (see footnote 3 to EPA's Table 2-6 of the 2004 EPS). During Phase 1, GE requested and EPA agreed to include the extra inventory (119,964 cy, GE's Table D-4) that was removed towards the productivity target. The actual Phase 1 removal output (design inventory plus extra inventory) is 264,402 cy/yr, which happens to approximate the productivity target volume of 265,000 cy. However, as discussed previously, removal output is not the same as volume removed, processed, and shipped off site, and thus does not represent achievement of the Phase 1 Productivity EPS.

***Finding P.1.3: Phase 1 achieved 48 percent of the minimum monthly productivity (42,400/89,000 = 0.48) specified in the 2004 EPS for Dredging.***

The Phase 1 Minimum 1-Month Productivity of 89,000 cy/mo applies to the volume of design inventory sediment that was removed, processed, and shipped off site for a continuous 1-month period during 2009 to "verify the capabilities of the dredging operations, including the equipment and the sediment processing and transportation systems" (pg. 66, 2004 EPS for Dredging).

Evaluation of the peak monthly production rate requires a tabulation of monthly removal output, monthly processing output, and monthly transportation output, to identify the peak monthly volume that was removed and processed and shipped off site (productivity). GE's Table D-5 presents a 30.66-day running total of monthly removal output by 3 categories: design inventory, residual and extra

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<sup>3</sup> 128,550 tons was shipped during Phase 1 and 243,000 tons remained on site, which calculates as 35 percent of the material that was removed and processed (371,229 tons). The total volume reported as dredged (removed) by GE was 286,354 cy (Table D-4). 35 percent of 286,354 cy is approximately 100,000 cy removed, processed, and shipped off site.

<sup>4</sup> Unit train: 81 cars each carrying approximately 103 tons, or about 8,350 tons per unit train.

inventory, and total volume. Comparable cumulative 30.66-day running output tabulations were not found for sediment processing and sediment transportation off site.

GE's Table E-5 provides a weekly total output in tons/wk for sediment processing and shipping. The Panel estimated monthly outputs in cubic yards based on these data, as shown in Table 14.

- The running total of tonnage processed or shipped over the 4 weeks leading up to the noted week-ending dates on Table 14 were calculated and posted in the "4-week" column.
- The tonnage processed or shipped over a month (30.66 days) was approximated by multiplying the tonnage processed over 4 weeks by a time-based scaling factor ( $30.66 \text{ days} / 28 \text{ days} = 1.095$ ) and posted in the "Month" column.
- The monthly tonnage estimates were converted to cubic yard outputs (rounded to 100 cy) by dividing the tonnage production by 1.3 tons / cy.

The 1.3 tons/cy factor is based on the reported 371,229 tons processed during Phase 1 divided by the reported 286,354 cy removed during Phase 1 ( $371,229 / 286,354 = 1.3$ ).

The calculated outputs, in cubic yards per month, are presented on Table 14 under the header "Process/Ship Output (cy/mo)" for both processing and off site shipping. The last 2 columns of Table 14 present the monthly removal output from GE's Table D-5 for the week-ending dates listed. Note that GE's Table D-5 and Table 14 provide a different tonnage summary. Table D-5 provides a monthly cumulative removal output for every day of dredging from June 4, 2009 through October 31, 2009, while Table 14 only presents a monthly cumulative output calculation once per week.

Table 14. Phase 1 monthly output summary

Week	Ending	Tonnage Processed			Tonnage Shipped			Process/Ship Output (cy/mo)		Removal Output (cy/mo)	
		GE Table E-5			GE Table E-5			at 1.3 tons/cy		GE Table D-5	
		Week	4-week	Month	Week	4-week	Month	Processed	Ship	Design Inv	Total
1	5/9/2009	0			0						
2	5/16/2009	1330			0						
3	5/23/2009	1200			0						
4	5/30/2009	1300	3,830	4,195	0	0	0	3,200	0		
5	6/6/2009	4656	8,486	9,295	0	0	0	7,200	0	8,171	8,171
6	6/13/2009	8502	15,658	17,151	0	0	0	13,200	0	14,554	14,554
7	6/20/2009	13318	27,776	30,425	0	0	0	23,400	0	22,556	22,556
8	6/27/2009	12,231	38,707	42,398	8,447	8,447	9,252	32,600	7,100	31,172	31,172
9	7/4/2009	10,013	44,064	48,266	8,366	16,813	18,416	37,100	14,200	35,295	35,295
10	7/11/2009	13,480	49,042	53,719	0	16,813	18,416	41,300	14,200	40,105	40,105
11	7/18/2009	18,160	53,884	59,022	0	16,813	18,416	45,400	14,200	50,133	50,133
12	7/25/2009	22,432	64,085	70,196	0	8,366	9,164	54,000	7,000	58,052	58,533
13	8/1/2009	24,525	78,597	86,092	0	0	0	66,200	0	66,987	68,045
14	8/8/2009	22,321	87,438	95,776	0	0	0	73,700	0	<b>71,423</b>	<b>75,566</b>
15	8/15/2009	16,054	85,332	93,469	0	0	0	71,900	0	53,966	66,254
16	8/22/2009	24,543	87,443	95,781	0	0	0	<b>73,700</b>	0	39,856	65,326
17	8/29/2009	19,896	82,814	90,711	0	0	0	69,800	0	24,530	63,200
18	9/5/2009	18,746	79,239	86,795	0	0	0	66,800	0	11,940	59,199
19	9/12/2009	16,432	79,617	87,209	16,652	16,652	18,240	67,100	14,000	15,220	70,632
20	9/19/2009	18,171	73,245	80,229	0	16,652	18,240	61,700	14,000	16,592	72,897
21	9/26/2009	19,290	72,639	79,566	16,784	33,436	36,624	61,200	28,200	20,909	69,577
22	10/3/2009	18,861	72,754	79,692	8,430	41,866	45,858	61,300	35,300	17,826	67,926
23	10/10/2009	17,384	73,706	80,734	16,709	41,923	45,921	62,100	35,300	12,790	71,403
24	10/17/2009	18,989	74,524	81,630	8,382	50,305	55,102	62,800	<b>42,400</b>	8,198	63,267
25	10/24/2009	18,253	73,487	80,495	16,765	50,286	55,081	61,900	42,400	2,985	62,881
26	10/31/2009	11,367	65,993	72,286	8,392	50,248	55,040	55,600	42,300	0	51,897
27	11/7/2009	0	48,609	53,244	0	33,539	36,737	41,000	28,300	0	N/A

Table 14 presents an estimated monthly cumulative output (cy/mo) for removal, processing, and shipping as of the last day of each week of the project. The tabulation only goes through week 27 (11/7/2009), following the last week of Phase 1 dredging and processing.

The peak cumulative monthly output for each component (removal, processing, and shipping) is bolded and boxed on Table 14. The maximum cumulative removal output for both design inventory (71,423 cy/mo) and total volume (75,566 cy/mo) occurs during the month ending August 8, 2009.<sup>5</sup> During that same time period, the processing output is 73,700 cy/mo, the same as the maximum processing output for the period ending 8/22/2009. However, no shipping occurred in August. Consequently, the peak removal output reported in August cannot satisfy the Productivity EPS.

The maximum cumulative monthly productivity for removal, processing, and off site transportation is 42,400 cy/mo, recorded during the period ending October 17, 2009. During this period, the removal output was 63,267 cy/mo,<sup>6</sup> the processing output was 62,800 cy/mo, and the transportation output was 42,400 cy/mo.

Table 15 presents the peak individual monthly outputs achieved during Phase 1 for removal, processing, and shipping, based on the calculations presented in Table 14. Both removal and processing achieved a peak monthly output on the order of 70,000 to 75,000 cy/mo, while shipping off site peaked at 42,400 cy/mo. EPA's Phase 2 targeted monthly production rate of 89,000 cy/mo was not achieved by any of the 3 individual components (removal, processing, or shipping) during Phase 1.

**Table 15. Peak Phase 1 monthly output rates**

Production Component	Peak Output cy/mo	Period Ending
Removal		
Design Inventory	71,423	8/8/2009
Total Volume	75,566	8/8/2009
Processing	73,700	8/22/2009
Shipped off Site	42,400	10/17/2009

***Finding P.1-4: Phase 1 achieved 35 percent of the off site shipping standard specified in the Productivity EPS.***

The Productivity EPS requires that all material removed be processed and shipped off site for disposal by the end of the calendar year. Only 35 percent of the material removed and processed was actually shipped off site by the end of the calendar year.

<sup>5</sup>Note that GE's Table D-5 reports the maximum design inventory removal of 73,377 cy/mo and maximum total volume removed of 77,284 cy/mo on the period ending August 7, 2009. The discrepancy between Table 14. Phase 1 monthly output summary and GE's Table D-5 is due to GE's daily calculation of running totals; Table 14. Phase 1 monthly output summary shows the results of weekly calculations.

<sup>6</sup>63,267 cy assumes that dredging production can include both design inventory and extra inventory volume to meet the standard. However, if meeting the standard can only be based on design inventory removal, as stated in the 2004 Productivity EPS, then the peak monthly production rate would be 20,909 cy/mo as achieved during the period ending 9/26/2009, when the processing rate was 61,200 cy/mo, the shipping rate was 28,200 cy/mo, and the design inventory removal rate was 20,909 cy/mo.

CHARGE QUESTION 2. If not, and if EPA and/or GE has proposed modified Engineering Performance Standards, does the experience in Phase 1 and any other evidence before the panel show that it will be practicable to consistently and simultaneously meet the Engineering Performance Standards that are being proposed for Phase 2?

***Finding P.2: The experience in Phase 1 and other evidence before the Panel does not show that it will be practicable to consistently meet the Productivity EPS proposed for Phase 2 by EPA and GE.***

Both EPA and GE have proposed changes to the Productivity EPS for Phase 2. Some of these changes have merit, as discussed below. However, collectively, the changes do not result in a consistently achievable EPS that meets the requirements of the ROD and facilitates simultaneous achievement of the Resuspension EPS and Residuals EPS. For example, EPA’s proposed annual required and targeted productivity criteria are not practicable for Phase 2. The total volume to be removed, processed, and shipped is likely underestimated by EPA and consequently the annual and monthly productivity rates to complete the program in 5 years is likely underestimated. The annual and monthly productivity rates that are actually achievable are well below EPA’s recommended required productivity rates. On the other hand, GE is essentially recommending that productivity be eliminated from the Phase 2 EPS, reflecting the Panel’s concerns expressed during the public Peer Review meetings. This is certainly practicable, but may not be in keeping with the ROD.

**Table 16. Summary of EPA's proposed modifications to the Productivity EPS**

EPA’s Proposed Change to Productivity EPS	EPA’s Proposed Numerical Criteria									
1. Add a provision to extend the timeframe for Phase 2 at the discretion of EPA.	Every reasonable effort will be made to maintain the 5-year duration of Phase 2. EPA may allow 1 or 2 additional years if conditions require.									
2. Recalculate the annual required and target productivity volumes to reflect the revised Phase 2 removal volume.	<table border="1"> <thead> <tr> <th data-bbox="841 1201 906 1230">Year</th> <th data-bbox="909 1201 1026 1230">Required Vol., CY</th> <th data-bbox="1029 1201 1247 1230">Target Vol., CY</th> </tr> </thead> <tbody> <tr> <td data-bbox="841 1255 863 1285">2</td> <td data-bbox="909 1255 1026 1285">475,300</td> <td data-bbox="1029 1255 1146 1285">528,100</td> </tr> </tbody> </table>	Year	Required Vol., CY	Target Vol., CY	2	475,300	528,100			
Year	Required Vol., CY	Target Vol., CY								
2	475,300	528,100								
3. Count sediment volumes removed during residuals dredging and when dredging missed inventory toward meeting required and target volumes listed in the Productivity EPS.	<table border="1"> <tbody> <tr> <td data-bbox="841 1310 863 1339">3</td> <td data-bbox="909 1310 1026 1339">475,300</td> <td data-bbox="1029 1310 1146 1339">528,100</td> </tr> <tr> <td data-bbox="841 1344 863 1373">4</td> <td data-bbox="909 1344 1026 1373">475,300</td> <td data-bbox="1029 1344 1146 1373">528,100</td> </tr> <tr> <td data-bbox="841 1377 863 1407">5</td> <td data-bbox="909 1377 1026 1407">475,300</td> <td data-bbox="1029 1377 1146 1407">528,100</td> </tr> </tbody> </table>	3	475,300	528,100	4	475,300	528,100	5	475,300	528,100
3	475,300	528,100								
4	475,300	528,100								
5	475,300	528,100								



**Table 17. Summary of GE's proposed modifications to the Productivity EPS**

GE's Proposed Change to Productivity EPS	GE's Proposed Numerical Criteria
1. No firm Productivity EPS. Allocate the PCB load (revised Resuspension EPS) among CU areas, specifically targeting the CU areas where PCBs are, or may become, bioavailable.	Eliminate numerical criteria for target and required volumes. Productivity to be governed by the Resuspension and Residuals EPS criteria.
2. Implement Phase 2 such that the goal is to complete the removal within 5 years.	No numerical criteria. Project incorporating GE's approach can likely be completed within 5 years.
3. Change the metric for tracking productivity from sediment volume removed to area remediated	None presented. Area remediated is a measure of benefits achieved and an appropriate means to track production.

***Finding P.2-1: There should be flexibility in the Phase 2 timeframe to accommodate anticipated and unanticipated conditions that will be encountered during the work.***

EPA has proposed extending the timeframe for Phase 2 to adjust the project schedule if necessary to accommodate conditions beyond the control of EPA and GE, such as extreme flows, force majeure, or the discovery of significant additional inventory to be removed, as well as possible resuspension impacts. This proposal is consistent with the Phase 1 experience, which demonstrated that many factors were not understood or anticipated when Phase 1 dredging was initiated. Examples include:

- Phase 1 removed 83 percent more contaminated sediment than was anticipated by the design. According to GE's Table D-4, Phase 1 removed 144,438 cy of design inventory, and another 119,964 cy of extra inventory ( $119,964 \text{ cy} / 144,438 \text{ cy} = 0.83$ ).
- Transportation and placement of processed material into a Texas landfill encountered significant complications and delays, with only 35 percent of the removed and processed material moved off site during 2009 ( $100,000 \text{ cy} / 286,354 \text{ cy} = 0.35$ ).
- Dredges spent 24 percent of the available dredging time waiting for barges (GE's Figure D-15) due to numerous issues associated with the complexity of the project. The issues included shallow draft in some CUs, higher than normal river discharge, transfer time from mini hopper barges to deeper-draft hopper barges, controlling PCB volatilization, offloading, and processing variable material types from sand to silt to stiff clay.

Experience during Phase 1, as well as experience of the Panel members at other large complex sediment remediation projects, demonstrates the need for schedule flexibility to deal with the complexities and complications that arise during the remedial action.

***Finding P.2-2: Extra inventory and residual dredging should be included as part of tracking productivity.***

The 2004 EPS for Dredging explicitly states that only material included in the dredge prism of the final design (design inventory) will count toward meeting the Productivity EPS (see footnote 3 to Table 2-6 of the 2004 EPA for Dredging). EPA's revised Productivity EPS proposes to count all sediment volumes removed, including missed inventory, toward meeting required and target volume criteria. GE requested—and EPA approved—a change for Phase 1 to count extra inventory towards meeting the Productivity EPS. EPA has proposed that since there is some uncertainty in the remaining inventory to be removed for Phase 2, and since all dredging contributes to resuspension losses, the extra inventory

and residual dredging should count toward the Phase 2 Productivity EPS. The Panel concurs with this proposal.

***Finding P.2-3: Depth of contamination (DoC) is not well-defined, leading to likely underestimates of total and annual required and target volumes.***

Setting annual and project target volumes requires knowledge of the amount of material yet to be removed. EPA found that there are insufficient data available at present to complete a rigorous analysis to determine the remaining volume of material to be removed. Instead, EPA started with the original design estimate of volume to be removed in the remaining CUs (1,664,500<sup>7</sup> cy) and multiplied it by various scaling factors to update the estimate of volume to be removed during Phase 2.

EPA employed 3 methods to estimate the remaining volume. First, EPA multiplied the original design estimate of volume remaining by a factor of 1.6, which is the ratio of actual Phase 1 dredging (design plus extra inventory) divided by the design volume, with CU-1 excluded from the calculation.<sup>8</sup> This resulted in an estimate of remaining material to be removed of 2,663,000 cy.<sup>9</sup> Second, EPA applied a Phase 1 experience factor<sup>10</sup> to increase the assumed DoC by 1.13 feet beyond GE's design estimates, and applied it to the 442 acres yet to be dredged for an added increment of 805,800<sup>11</sup> cy and a total estimate of remaining material to be removed of 2,470,000 cy, which equates to a scaling factor of 1.5 times the original design volume.<sup>12</sup> Third, EPA started with the original ROD estimate of 2,650,000 cy total volume, subtracted their estimate of the Phase 1 dredging (273,600 cy) to come to an estimate of 2,376,500<sup>13</sup> cubic yards yet to be removed. This equates to a scaling factor of 1.43 times the original design volume, and EPA's current estimate of Phase 2 annual productivity of 475,300 cy/yr.

EPA used the 2,376,500 cy estimate of total volume yet to be removed to derive recommended changes to the annual production rate criteria: 475,300 cy/yr and a monthly average of 86,420 cy/mo.

The Panel finds significant shortcomings with these estimates, which do not account for changes in lithology between Phase 1 and Phase 2 areas, anticipated TIP deposits, and uncertainty associated with current DoC estimates. EPA's proposed Phase 2 annual productivity criterion is based on the low end of the estimated range of possible dredging volume remaining. However, if CU-1 is not excluded from the experience during Phase 1, then Phase 1 removed a volume equal to 1.83 times the design

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<sup>7</sup> Following the May 2010 deliberation meeting, GE provided a table of the design volume for each of the remaining COs, totaling 1,664,500 cy.

<sup>8</sup> GE's Table D-4 identifies Phase 1 dredging as 144,438 cy of design inventory and 119,964 cy of extra inventory for a total "design plus extra inventory" volume of 264,402 cy. GE's Table D-10 identifies 34,363 cy of extra inventory dredging for CU-1 (sum of 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> redredge passes). Subtracting the CU-1 extra inventory from the overall summation results in an estimate of total "design plus extra inventory" of 230,039 cy. EPA's scaling factor of 1.6 is calculated as  $230,039/144,438 = 1.6$ .

<sup>9</sup> Multiplying 1,664,500 cy by 1.6 yields an estimate of 2,663,000 cy remaining to be dredged.

<sup>10</sup> Excluding CU-1 from the calculation, EPA reported that the net increase in volume dredged during Phase 1 was 82,100 cy over an area of 44.86 acres, or an average of 1.13 feet of increased dredging depth.

<sup>11</sup> See Section 3.3, pg III-25, of EPA's Phase 1 Evaluation Report, March 2010.

<sup>12</sup> Adding in 805,800 to the original design volume of 1,664,500 cy brings the estimate of volume remaining to 2,470,300 cy. The scaling factor is calculated as  $2,470,300/1,664,500 = 1.5$ .

<sup>13</sup> See Section 3.3, pg iii-26, of EPA's Phase 1 Evaluation Report, March 2010.

volume (264,402 cy / 144,438 cy = 1.83). Applying a scaling factor of 1.83 to the design volume (1,664,500 cy) yields an estimate of 3,050,000 cy yet to be removed.

Until the DoC is better defined, EPA should recognize the potential that the estimate of material remaining to be removed could be significantly greater than anticipated. Based on the upper end of the range of values presented (i.e., 2,376,500 to 3,050,000 cy), the monthly productivity requirement is 86,400 to 111,000 cy/mo, based on a 5-year project with a 5.5 month dredging season.

Based on the results of Phase 1 and the Panel's productivity calculations (refer to the discussion under Charge Question 3, following), it is not expected that these rates can be practicably and consistently met during Phase 2.

***Finding P.2-4: The Productivity EPS should not be eliminated.***

GE's proposed the elimination of the Productivity EPS while applying a revised Resuspension EPS and Residuals EPS to constrain the volume of sediment to be removed during Phase 2. GE's proposal would likely require a ROD amendment as it deviates from a fundamental ROD requirement. This represents a significant shift in the remedial action objectives, and additional studies and evaluations would be required before such an approach could be approved. The Panel was not presented with sufficient evidence to support the need for eliminating productivity considerations entirely and strictly limiting the volume of sediment to be dredged, nor did the Panel's charge include an evaluation of the requirements of the ROD.

For the revised EPS, the Panel recommends that EPA and GE explicitly acknowledge that there are tangible and substantial trade-offs between dredging production rates and the potential for resuspension and residual generation. Thus, the Panel supports the use of productivity targets rather than standards, as strictly defined. In this sense, the productivity target would be informed by a more complete understanding of how operational activities contribute to sediment resuspension and residuals formation and what the short- and long-term environmental implications of resuspension and residuals are for achieving remedial objectives pertaining to both the upper and lower river.

The Panel understands that both GE and EPA are working to incorporate Phase 1 data into models that are expected to provide insight regarding the relationship between dredge productivity and resuspension/residuals. Iterative use of such modeling should be used in conjunction with onsite adaptive management to calibrate productivity, both within and between operational seasons, in a manner that preserves the integrity of the project's risk reduction objectives over the long term. This approach must recognize uncertainties associated with future operations, including conditions that cannot be predicted today and unanticipated operational adjustments that will be needed to accommodate those conditions.

In addition, the Panel recommends that the project team develop productivity targets for closing CUs in an efficient and rapid manner, as this particular aspect of the operation is most closely related to achieving remedial objectives for the upper river.

CHARGE QUESTION 3. If the experience in Phase 1 and other evidence before the Panel does not show that it will be practicable to consistently and simultaneously meet the Engineering Performance Standards that are being proposed for Phase 2, can the Phase 1 Engineering Performance Standards be modified so that they could consistently be met in Phase 2, and, if so, how?

***Finding P.3: The Phase 1 Productivity EPS can be modified to be consistently met in Phase 2.***

In order to evaluate the practicability of the existing and proposed Productivity EPS, and to develop practicable modifications, the Panel assessed likely annual productivity that could be achieved on the Upper Hudson. This involved estimating the possible annual output of dredging, processing, and transport from several perspectives, including:

- Peak monthly output achieved during Phase 1 for each component of the remedial action (i.e., dredging, processing, and transportation)
- Added dredging output that would have been achieved during Phase 1 if the dredges had all started at the beginning of the season and if the impacts from CU-1 were removed
- Removal output, assuming barge arrival and waiting times were improved
- Shipping output, assuming rail and landfill issues are resolved and no longer a significant productivity limitation

Through review of Phase 1 operations, the Panel did not discover any single factor that could be adjusted to significantly increase overall productivity. For example, neither increasing the number of barges in service nor increasing the offload rate at the processing facility provided a dramatic increase in productivity. Rather the Panel found multiple lines of evidence that indicated 350,000 cy/yr as a reasonable annual productivity estimate for the start of Phase 2.

The Panel's recommendations for modifying the Productivity EPS are summarized in Table 18, and discussed further below.

Table 18. Summary of recommended changes to the Productivity EPS

CHANGE TO PRODUCTIVITY EPS	NUMERICAL CRITERIA	RATIONALE	IMPACT ON OTHER STANDARDS
<p><b>1. TOTAL VOLUME</b> Eliminate total volume from the Productivity EPS.</p>	None	<p>EPA found that there are insufficient data available at present to determine the volume remaining to be removed in the remaining CUs. The Panel agrees, primarily because of incomplete DoC characterization. Estimates of material remaining range from about 2.3 million to 3.0 million cubic yards.</p> <p>Consequently, due to the real uncertainty about material remaining to be removed, the Total Volume should be eliminated as a productivity criterion. It does not make good sense to use an uncertain quantity to set a certain standard.</p> <p>Until DoC is better defined, the Panel recommends that EPA use at least 2,700,000 cy as planning-level estimate of material remaining to be removed.</p>	Shift focus away from annual productivity to managing residuals and resuspension.
<p><b>2. ANNUAL VOLUME</b> Change annual volume to reflect Phase 1 experience, and adjust the volume annually, based on experience and appropriate adaptive management.</p>	350,000 cy/yr base value, adjusted for site conditions and to meet the Resuspension EPS and Residuals EPS.	<p>Since the total volume to be removed is not known, it is not reasonable to project what the annual production would be based on a 5-year schedule for Phase 2.</p> <p>The Panel's evaluations indicate that 350,000 cy/yr is a reasonable initial planning level production rate for the project, subject to modification due to changing site conditions during Phase 2, (such as different material types, longer barge-transport and lockage requirements, and annual variations in weather and river flow), and productivity modifications necessary to maintain the Resuspension EPS and Residuals EPS.</p>	Shift focus away from annual productivity to managing residuals and resuspension.
<p><b>3. PHASE 2 DURATION</b> Shift focus away from the Phase 2 duration from the Productivity EPS while still taking into consideration the consequences of prolonged construction activities on the river.</p>	None	<p>Experience during Phase 1, as well as the experience of Panel members at other large complex sediment remediation projects, demonstrates the need for schedule flexibility to deal with the complications that arise during the remedial action. In addition, the productivity schedule should be subordinated to the Resuspension EPS and Residuals EPS.</p> <p>For planning purposes, the duration of Phase 2 can be roughly estimated by dividing the crude estimate of total volume remaining (2.3 to 3.0 million cy) by a planning level estimate of annual productivity (350,000 cy/yr). The resulting planning-level estimate of the duration of Phase 2 is 7 to 9 years.</p>	Shift focus away from annual productivity to managing residuals and resuspension.

***Finding P.3-1: Drop the Total Volume Productivity EPS criterion.***

There are insufficient data available to determine the volume remaining to be removed in the remaining CUs, primarily because of incomplete DoC characterization. Existing estimates (with limited confidence) of material remaining range from about 2.3 million to 3.0 million cubic yards. Because it does not make sense to use an uncertain quantity to set a certain standard, the Panel recommends dropping the Productivity EPS criterion for Total Volume.

The Panel recommends establishing monthly and annual volume “targets,” combined with established total and annual areas to be remediated. Area remediated reflects a substantial measure of environmental benefit and could be expressed as a specified number of CUs to close each year.

Tracking of total volume and mass of PCBs removed should continue, but the environmental benefit accrued should be based primarily on area remediated.

***Finding P.3-2: Initially set the Annual Volume Productivity EPS criterion at 350,000 cy/yr.***

Since the total volume to be removed is not known, it is not reasonable to project what the annual production would be based on a 5-year schedule for Phase 2. The Panel’s evaluations, described below, indicate that 350,000 cy/yr is a reasonable initial planning level production rate for the project to be applied for the next dredging season. This rate is near to the peak monthly dredging or processing output achieved during Phase 1, and assumes there will be some net output improvement over Phase 1. Maintaining 350,000 cy of annual productivity will likely require that the removal and processing outputs be decoupled from the shipping output. The annual rate is also subject to modification due to changing site conditions during Phase 2, (such as different material types, longer barge-transport and lockage requirements, and annual variations in weather and river flow), and productivity modifications necessary to meet the Resuspension EPS and Residuals EPS.

***Finding P.3-2.1: A reasonable target for Phase 2 removal output is 350,000 cy/yr.***

Removal rates were evaluated from several perspectives to identify a practicable annual output estimate of 350,000 cy/yr for Phase 2. Considering the multiple factors of uncertainty at the site, the Panel considers 350,000 cy/yr to be a reasonable Phase 2 removal output target, until project experience during Phase 2 demonstrates otherwise. The annual productivity must be managed adaptively, from year to year, and should consider such factors as the revised approach to managing residuals (i.e., the elevation-based design paradigm), changes in barge travel distances and lock throughput requirements from year to year, changes to the sediment bed lithology as dredging progresses downstream, and increased experience and management of BMPs.

## **Phase 1 Peak Monthly Output**

As presented in Table 14, the peak monthly removal output, calculated once per week, was 75,566 cy/mo, for the period ending 8/8/2009. The peak monthly removal output, calculated daily by GE, was 77,284 cy/mo for the period ending 8/7/2009. If these peak outputs are applied to a 5-month dredging season<sup>14</sup>, the removal output would be in the range of 375,000 cy/yr to 385,000 cy/yr. It is not reasonable to consider achieving the peak monthly Phase 1 removal output during every month of

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<sup>14</sup> Five months is considered a reasonable timeframe for calculating annual dredging output, considering the annual variability in weather and river flows.

Phase 2. A more reasonable estimate for Phase 2 removal would be based on 90 percent of the monthly peak rate, or on the order of 350,000 cy/yr.

### Adjusted Phase 1 Total Output

The actual Phase 1 total removal output of 286,354 cy was adjusted upward by estimating the additional output that would have been achieved if all of the dredges started working in mid May (added 67,000 cy) and by factoring out the impacts of significant excess dredging at OU-1 (added another 17,000 cy), for a total adjusted removal output in Phase 1 of 370,000 cy/yr (286,000 cy + 67,000 cy + 17,000 cy).

### Dredge Output Calculations

The Phase 1 dredging fleet was used as a basis for estimating dredging output during Phase 2. Considering the relatively small channel dimensions of the river, and the limited draft conditions in the river, it is not evident at this time that adding more dredges to the project will provide a proportional increase in overall dredge output. The peak output of the existing dredging fleet was estimated<sup>15</sup> to be in the range of 375,000 cy/yr to 400,000 cy/yr, assuming that the barge wait times experienced during Phase 1 were reduced considerably during Phase 2. The calculations were based on a dredge effective working time percentage in the range of 50-55 percent, which is reasonable for new-work projects in constricted work areas with multiple potential output constraints. In addition, considering that Phase 2 will have longer barge transport distances, with multiple locks to pass through, a reasonable output estimate would be on the order of 375,000 cy/yr for Phase 2 with the existing dredge fleet. Nonetheless, the Panel maintains that a target removal rate of 350,000 cy/yr is a reasonable estimate to commence Phase 2.

#### ***Finding P.3-2.2: A reasonable target for Phase 2 processing output is 330,000 cy/yr.***

As presented in Table 15, the peak monthly processing output, calculated once per week, was 73,700 cy/mo, for the period ending 8/22/2009. If applied to a 5-month dredging season, the implied processing output would be 368,000 cy/yr if the peak output during Phase 1 was achieved every month during Phase 2. A more reasonable estimate for Phase 2 processing output would be based on 90 percent of the monthly peak rate, or on the order of 330,000 cy/yr for a 5-month season. The annual processing could be increased if some stockpiling was available to allow processing to occur for a period of time after dredging was completed.

#### ***Finding P.3-2.3: A reasonable target for Phase 2 shipping output is 380,000 cy/yr.***

As presented in Table 15, the peak monthly shipping output, calculated once per week, was 42,400 cy/mo, for the period ending 10/17/2009. It was achieved by averaging 1.5 unit trains per week.

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<sup>15</sup> Dredge output calculations for existing fleet: Dredge D385 (4 in fleet): 5 cy bucket, dredge 45cy/effective hr., cap 149 sy/effective hr.; Dredge D345 (1 in fleet): 2 cy bucket, dredge 24.4 cy/effective hr., cap 135 sy/effective hr.; Dredge D320 (7 in fleet): 1 cy bucket, dredge 16.1 cy/effective hr., cap 85 sy/effective hr.; 120 work days: 154 calendar days May 15 to October 15, 22 maintenance days (Sundays), 4 vacation days, 8 non-working days (high flows, resuspension, contingency). Assume 1 sy capping for every cy dredged based on Phase 1. Annual dredge output is approximately 345,000 cy/yr at 45 percent effective working time (EWT), 375,000 cy/yr at 50 percent EWT, and 400,000 cy/yr at 55 percent EWT. Effective working times higher than 55 percent are not considered appropriate for planning a new-work sediment remediation project with multiple and complex operational constraints, including but not limited to the presence of significant debris / rock substrate / clay substrate, shallow draft, small navigation channel, river locks, potential high river flows, and output constraints related to resuspension and air quality.



If applied to a 5-month season, 1.5 unit trains output per week would be about 210,000 cy/yr.<sup>16</sup> Recognizing that shipping can continue longer each year because it is not constrained by the river conditions, a 7-month shipping season would be about 295,000 cy/yr, and a 9-month shipping season would be about 380,000 cy/yr.

Phase 1 established that 2 unit trains could be loaded and shipped in a week's time. Two unit trains were shipped every other week from the week ending 9/12/2009 through the week ending 10/24/2009. GE's Appendix E indicated that a unit train could be loaded every 2 days. Provided that other site factors would not limit the ability to ship 2 unit trains per week, the monthly shipping output at 2 trains per week would be approximately 55,000 cy/mo. This would equate to 275,000 cy/yr for a 5-month season, 385,000 cy/yr for a 7-month season, and 495,000 cy/mo for a 9-month season. If the duration of shipping is decoupled from the dredging season, which would be reasonable to do, then the annual shipping output can match the estimated annual dredging and production outputs.

***Finding P.3-3: The project, as designed, cannot be completed in 5 years.***

For initial Phase 2 planning purposes, the duration of Phase 2 can be roughly estimated by dividing the current estimate of total volume remaining (2.3 to 3.0 million cy) to be removed by a planning level estimate of annual productivity (350,000 cy/yr). The resulting planning-level estimate of the duration of Phase 2 is 7 to 9 years. As the DoC is refined with improved coring results, and as annual productivity is demonstrated, the total volume estimate and duration of Phase 2 can be refined accordingly.

Experience during Phase 1, as well as the experience of Panel members at other large sediment remediation projects, demonstrates the need for schedule flexibility to deal with the complications that arise during the remedial action, as discussed above. In addition, the productivity schedule should be subordinated to the Resuspension EPS and Residuals EPS. Consequently the 5-year productivity criterion should be dropped in favor of providing more flexibility to complete the work in a manner that protects the integrity of the project and its risk reduction objectives.

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<sup>16</sup> 1.5 unit trains per week, at 8,350 tons per unit train, is 12,500 tons/week, or 54,750 tons / mo, which is roughly 42,000 cy/ mo (assuming 1.3 tons/cy), or 210,000 cy over 5 months.



CHARGE QUESTION 4. If EPA and/or GE has proposed modifications to the monitoring and sampling program for Phase 2, are the proposed modifications adequate and practicable for determining whether the Phase 2 Engineering Performance Standards will be met?

Both EPA and GE proposed changes to the EPS with concurrent changes to the monitoring and sampling program for Phase 2. However, the Panel finds that it will not be practicable to consistently and simultaneously meet the EPS being proposed by either party and, thus, cannot make a finding regarding the monitoring and sampling programs relative to these proposed standards except for those items that have been specifically addressed under Charge Question 2, above. Rather, the Panel has addressed Question 4 relative to the modified EPS and processes recommended by the Panel in response to Charge Question 3.

Improving the efficiency and timeliness of closing CUs will require a significant improvement in the accurate definition of DoC before dredging is initiated. It will also require the implementation of an ongoing adaptive management program where various “best management practices” for removal are evaluated with regard to productivity, resuspension, and residuals generation, and then either accepted, modified, or rejected. The Panel’s response to Charge Question 3 for Residuals provides additional discussion of the need for improved DoC characterization, as well as a discussion of monitoring programs to support adaptive management of the removal activity to reduce resuspension and generation of residuals.

## 6 SUMMARY BY CHARGE QUESTION

The preceding sections present the Panel's detailed review of the charge questions, with each section devoted to a different EPS. This section reorganizes the information presented in the preceding sections and addresses the charge questions in order. This section is intended to provide a synopsis, and the summary information presented herein should not be used as a substitute for the detailed findings and recommendations presented in Sections 3 through 5.

### 6.1 Summary of Response to Charge Question 1

**CHARGE QUESTION 1.** Does the experience in Phase 1 show that each of the Phase 1 Engineering Performance Standards can consistently be met individually and simultaneously?

The experience in Phase 1 does not show that each of the Phase 1 EPS can be met consistently, individually, and simultaneously. None of the Phase 1 EPS were met consistently during Phase 1. The EPA and GE evaluations of the Phase 1 experience do not provide evidence that the EPS could be met consistently and simultaneously if applied without modification during Phase 2.

The Resuspension EPS were not achieved in Phase 1. Total PCB concentrations and total and Tri+PCB loads were not met consistently. Suspended solids concentration requirements were met; however, the Panel does not consider this parameter relevant to understanding PCB resuspension and release. Resuspension was likely due to a combination of factors including dredge operations and the management of the CUs. Evidence from Phase 1 does not suggest that this standard could be met without modification during Phase 2.

The Residuals EPS were not achieved in Phase 1. The Residuals EPS were developed based on the assumption that all inventory would be removed with a maximum of 2 passes, followed by additional passes to remove dredge-generated residuals. However, the EPS did not work as envisioned in Phase 1, mainly because inventory was improperly characterized, requiring multiple production passes and leaving CUs open longer than intended. Similar issues would be expected if the Residuals EPS were to be applied without modification during Phase 2.

The Productivity EPS were not achieved in Phase 1. None of the 4 numerical productivity criteria (i.e., minimum removal, target removal, maximum monthly rate, and transportation of all material off site by the end of the year) was achieved. The goal of transportation and disposal of all Phase 1 dewatered sediment by the end of 2009 was not accomplished. While ramping up of individual unit processes is possible, the project cannot be scaled up to meet the anticipated inventory using the current design data.

Phase 1 demonstrated that the 3 EPS were not and cannot consistently be met simultaneously. In the attempt to meet the Residuals EPS under the conditions of inadequately characterized DoC, CUs were left open longer than intended. As a result, disturbed residuals layers were left exposed and subject to erosion by currents and vessel traffic. Erosion of the residuals layer was likely a significant source of resuspension. The 3 EPS cannot be consistently met simultaneously without significant modifications that take into account the complex interactions among operational factors and release mechanisms.

## 6.2 Summary of Response to Charge Question 2

CHARGE QUESTION 2. If not, and if EPA and/or Settling Defendant has proposed modified Engineering Performance Standards, does the experience in Phase 1 and any other evidence before the panel show that it will be practicable to consistently and simultaneously meet the Engineering Performance Standards that are being proposed for Phase 2?

Both EPA and GE proposed changes to the EPS. Based on the Panel's review of EPA and GE's evaluations of Phase 1 and experience with environmental dredging, the Panel finds that it will not be practicable to consistently and simultaneously meet the EPS being proposed by either party for Phase 2. Phase 1 demonstrated that the 3 EPS interact in complex ways and that in order for the EPS to work individually and simultaneously, these interactions need to be better understood and addressed. Neither proposal provides a framework to generate the information needed to better understand these interactions and adapt the implementation of EPS so they can be met individually and simultaneously.

The first step toward achieving an integrated set of EPS would be to revise the Residuals EPS and Productivity EPS by better characterizing the DoC and creating an elevation-based design that would allow for a simplified decision process, less dredging, and the timely closure of CUs. EPA's proposal attempts to simplify the process but still relies too heavily on dredging and a complex decision process for closing CUs. In addition, EPA's proposed modifications would not provide the information needed to better understand PCB release mechanisms and the implications of productivity and residuals decisions on resuspension and implications for downstream risk to fish.

GE's proposed modifications to the EPS are based on an assertion that downstream loading is tied directly to dredging. Based on this, GE strongly recommends closing CUs with single-pass dredging in high-confidence areas, 2-pass dredging in low-confidence areas, and limiting the mass of PCBs dredged. The Panel finds that delayed closure of CUs was likely a major contributor to downstream loading and, thus, supports an approach that minimizes dredge passes and provides for quick CU closure. However, such an approach would need to be predicated on better characterization of the DoC and use of a target dredge elevation that takes into account the vertical accuracy of the dredge.

The Panel does not support placing an absolute limit on the mass of PCBs to be dredged, as proposed by GE, because the mass of PCBs to be removed is unknown and constraining the remedy to such a limit appears to be contrary to the ROD.

## 6.3 Summary of Response to Charge Question 3

CHARGE QUESTION 3. If the experience in Phase 1 and other evidence before the panel does not show that it will be practicable to consistently and simultaneously meet the Engineering Performance Standards that are being proposed for Phase 2, can the Phase 1 Engineering Performance Standards be modified so that they could consistently be met in Phase 2, and, if so, how?

Based on the Panel's review of Phase 1 evaluations and the Panel members' collective experience, the Panel finds that the Phase 1 EPS can be modified so that they could be consistently be met in Phase 2.

However, modifications to the EPS would not be enough to successfully complete the project; changes to the overall management of the project and its objectives would also be necessary.

In terms of objectives, the Panel recommends the following: focus must be placed on achieving rapid CU closure to minimize resuspension and release; productivity should be measured with regard to the remediated footprint (i.e., equal focus on the area remediated as well as inventory removed); and the decision to backfill or cap must be made and implemented more immediately based on the residual concentration of PCBs. These combined objectives could be achieved by: improved characterization of the DoC; using this information to establish Design Dredge Elevations that more accurately capture the target inventory; dredging the inventory based on updated Design Dredge Elevations, not residuals chemistry; and closing the CUs as quickly as possible.

Specifically, the Panel recommends the following framework for dredging and residuals management (see Section 4 for more detailed recommendations):

- Perform recoring of all low-confidence samples and recommends confirmation of 20 percent of high-confidence samples.
- Remodel the DoC using all high-confidence cores to establish the topography of the DoC (the “DoC Elevation”) throughout each CU.
- Update the design with a Design Dredge Elevation based on the remodeled DoC Elevation.
- Set the Design Dredge Elevation initially to 4 inches below the modeled DoC Elevation to account for the vertical accuracy of the dredge.
- Establish BMPs to limit sediment resuspension and release.
- Perform confirmation sampling in each 1-acre sub-CU as soon as possible after attainment of the DoC Elevation in 95 percent or more of the area is confirmed by EPA.
- Place a 3-6 inch sand cover over sub-CU as soon as possible after confirmation samples are collected (before PCB analytical results are obtained).
- Use PCB analytical results of composited surface samples to determine whether an area will be backfilled or capped and install final layers accordingly.

### 6.4 Summary of Response to Charge Question 4

CHARGE QUESTION 4. If EPA and/or Settling Defendant has proposed modifications to the monitoring and sampling program for Phase 2, are the proposed modifications adequate and practicable for determining whether the Phase 2 Engineering Performance Standards will be met?

Both EPA and GE proposed changes to the EPS with concurrent changes to the monitoring and sampling program for Phase 2. However, the Panel finds that it will not be practicable to consistently and simultaneously meet the EPS being proposed by either party and, thus, cannot make a finding regarding the monitoring and sampling programs relative to these proposed standards except for those items that have been specifically addressed under Charge Question 2, above. Rather, the Panel has addressed Question 4 relative to the modified EPS and processes recommended by the Panel in response to Charge Question 3.

Achieving all 3 proposed EPS in Phase 2 consistently and simultaneously according to the proposed approach outlined herein will require a sampling and monitoring program that will provide accurate determination of the DoC for all CUs and post-removal composite sampling to determine whether the CU requires backfilling or a cap.

Further, the interaction of the dredge operations and release mechanisms is not well understood, and this issue is not sufficiently addressed in the current monitoring program. While to date there is insufficient information to demonstrate that transported PCB load outside the currently planned CUs in the Upper and Lower Hudson is causing increased PCB concentrations in bedded-sediment concentrations, the Panel believes that expected benefits of the removal action must be demonstrated in the off site areas. If significant increases are occurring that compromise the expected risk reductions, further changes to the removal program would need to occur. Sufficient monitoring must be conducted to assess whether such increases are occurring and provide the information necessary to effectively modify the removal program.

## 7 CONCLUDING REMARKS

Phase 1 showed that the 2004 EPS for Resuspension, Residuals, and Productivity were not met individually or simultaneously during Phase 1 and cannot be met under Phase 2 without substantive changes. EPA and GE proposed changes to the EPS but the Panel finds that the new proposed standards from either party would not contribute to the successful execution of Phase 2. However, Phase 2 can remove the bulk of the PCB inventory if coring data and the resulting DoC model results are improved and focus is placed on quick closure of CUs. The Panel developed an approach along with modified EPS to maximize removal of PCB inventory in a careful balance with resuspension and residuals goals, while achieving an acceptable level of productivity.

The Panel also recommends building upon the adaptive practices and approaches that have been employed to date by developing a more comprehensive and formalized adaptive management approach to all EPS that includes the annual reassessment of the EPS based on each prior year's data. The challenges encountered during Phase 1, and the adaptations employed by EPA and GE to address those challenges, demonstrate the need for flexibility during Phase 2. This was evidenced in the records of the management meetings to achieve CU closure during Phase 1, and especially by the commitment to this Peer Review process, seeking to refine and improve the EPS and in-field practices. During Year 1 of Phase 2, the Panel recommends collecting additional data to support the further refinement of relevant performance standards to be applied for the remainder of the project's duration. Additional review between Years 1 and 2 of Phase 2, and each subsequent year of the project, should allow for ongoing modification of the EPS to optimize remedial operations, while limiting unintended consequences and adverse environmental impacts from these operations.

Phase 1 demonstrated that the Residuals EPS had a substantial impact on the operational success of the project as well as a tangible interaction with productivity and resuspension processes and their respective EPS. A key obstacle to simultaneously achieving the performance standards involved incomplete, inaccurate, and imprecise DoC characterization combined with disagreement on how to interpret and attain target levels. This directly affected both the Resuspension EPS and Productivity EPS. The repeated dredge passes and prolonged exposure of sediments in the CUs resulted in increased PCB resuspension and release. The unexpected increase in inventory due to incomplete DoC characterization had the greatest effect on the Productivity EPS in terms of numbers of CUs remediated. The Panel presents revised EPS that accelerate CU closure by establishing an elevation-focused dredge design paradigm, thereby reducing resuspension, effectively managing residuals, and accelerating productivity without compromising the goals of the ROD with respect to overall recovery of the river.

The Panel proposes an elevation-focused design of the dredge prism design that builds on accurate, high-precision characterization of the DoC elevation, a 4-inch overdredge based on vertical tolerance of the dredge and precision of the DoC that ensures rapid achievement of the target elevation (the elevation of the DoC not including the overdredge) across at least 95 percent of the CU area or subunit area, verification of the target elevation based on high-precision bathymetry, and rapid closure of CU or subunit areas following EPA validation of confirmed elevations

This approach does not involve redredging to remove dredge-generated residuals or address redefined inventory based on post-dredge confirmation sampling. The CU would be closed based on the results of the residuals sampling results. The CU (or sub-CU) should be backfilled if the average residuals

concentration is less than or equal to 3 mg/kg Tri+PCBs and capped if the average residuals concentration is greater than 3 mg/kg Tri+PCBs. The backfill or cap eliminates the risk from any residual PCBs in the sediments.

This revised removal and closure approach is the first step toward integrating the Residuals, Resuspension, and Productivity EPS. Through better characterization of the DoC and establishing an elevation-based dredging prism design, Resuspension and Productivity EPS also can be revised to be consistent with the updated dredge depths and volumes. For Year 1 of Phase 2, the Panel proposes Resuspension EPS and Productivity EPS based on metrics consistent with Phase 1: for resuspension, target levels are 2 percent and 1 percent of the dredged PCB mass, measured at TIP and Waterford, respectively; for productivity, target volumes are 350,000 CY per year. Both of these targets (i.e., for resuspension and productivity) should help guide BMPs, but should not lead to shutting down operations. In other words, the Panel does not recommend interrupting dredging activities if the targets are not achieved during Year 1 of Phase 2; the goal of the interim standards is to establish baseline targets during Year 1 of Phase 2 and to allow dredging to recommence in 2011, while near-field and far-field data are collected.

Based on the results of Year 1 of Phase 2, combined with the Phase 1 results, EPA and GE should refine the performance criteria to establish practicable targets that can be achieved for all 3 EPS. In addition to evaluating the performance of the modified Residuals EPS, the focus between Years 1 and 2 of Phase 2 should be the Resuspension EPS to manage near-field and far-field resuspension, release, and deposition processes, based on an understanding of whether there are increased risks associated with surface sediment deposits containing PCBs released during dredging. The Productivity EPS should also be updated based on a revised volume estimate derived from the elevation-based dredging paradigm. In addition to an annual volume productivity standard, the Panel advances an additional EPS metric; annual areas to be remediated. Area remediated reflects a substantial measure of environmental benefit and could be expressed as a specified number of CUs to close each year. Tracking of total volume and mass of PCBs removed should continue, but the environmental benefit accrued should be based both on mass removal and on area remediated. Eventually, an area-based standard could supplant the volume-based productivity standard, if appropriately tied to the elevation-based design.

The Panel found that the models used to develop the 2004 Resuspension EPS cannot be used to adapt revised standards for moving forward. The Panel believes that to do so requires a new model that must be developed collectively by EPA and GE. The GE model may be a useful foundation for this model, and both model structure and parameters must be agreed upon by both EPA and GE. The model must be peer reviewed by an expert panel once EPA and GE complete its development. Similar arrangements have been established at other Superfund Sites, including the Passaic River, the Lower Duwamish Waterway (WA), and the Lower Willamette River (OR). The fate, transport, and risk model must enable EPA and GE to understand the implications of operational changes on long-term recovery rates to support EPA and GE in making to appropriate and meaningful risk management decisions about dredging productivity, BMPs, and the long-term fate and transport of PCB residuals and resuspension/release.

The Panel evaluated the results from Phase 1 in order to assess a practicable annual production rate. The evaluation included a detailed review of peak monthly output for each component of the remedial

action (i.e., dredging, processing, transportation), dredging and removal output (i.e., numbers and cycle times for dredges and barges), and shipping output to the landfill. The Panel did not discover any single factor that could be adjusted to significantly increase overall productivity. For example, neither increasing the number of barges in service nor increasing the offload rate at the processing facility provided a substantive increase in productivity. Rather, the Panel found multiple lines of evidence supporting 350,000 cy/yr as a reasonable annual productivity estimate for the start of Phase 2. The Panel also found that the productivity schedule should be subordinated to the Resuspension EPS and Residuals EPS. Consequently the 5-year productivity criterion should be dropped to provide more flexibility to complete the work in a manner that protects the integrity of the project and its risk reduction objectives.



## 8 REFERENCES

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- Pennekamp, J. G. S., R. J. C. Eskamp, W. F. Rosenbrand, A. Mullie, G. L. Wessel, T. Arts, and I. K. Decibel. 1996. Turbidity caused by dredging; viewed in perspective. *Terra et Aqua*, 64:10-17.
- Steuer, J. J. 2000. A mass-balance approach for assessing PCB movement during remediation of a PCB-contaminated deposit on the Fox River, Wisconsin. U.S. Geological Survey Water-Resources Investigations Report 00-4245. December 2000.

## APPENDIX A: DOCUMENTS PROVIDED TO THE PEER REVIEW PANEL

### Background Documents Provided January 2010

#### From EPA

- *Transmittal of Phase 2 Dredge Area Delineation Report*, December 17, 2007, from John Haggard, General Electric to Doug Garbarini, EPA Region 2
- Hudson River PCBs Site Phase 2 Dredge Area Delineation Report, Figures, and Appendices, December 17, 2007
- Report on the Peer Review of the U.S. Environmental Protection Agency's "Draft Engineering Performance Standards—Peer Review Copy" for the Hudson River PCBs Superfund Site, March 4, 2004.
- Appendices: Report on the Peer Review of the U.S. Environmental Protection Agency's "Draft Engineering Performance Standards—Peer Review Copy" for the Hudson River PCBs Superfund Site. March 4, 2004.
- Volume 1. Statement of the Engineering Performance Standards for Dredging, April 2004.

#### From General Electric

- Archeological Reports
  - ▶ NYSDEC boat ramp (area L) testing report
  - ▶ Phase 1 ARA report
  - ▶ Terrestrial survey report
  - ▶ Terrestrial testing report
  - ▶ Underwater resource testing report
  - ▶ Underwater survey report appendices
  - ▶ Underwater survey report
  - ▶ Work support marina survey report
  - ▶ Work support marina testing report
  - ▶ WSM data recovery report
- Consent Decree
  - ▶ Appendices B-D
  - ▶ Modification transmittal letter, Attachment A, and Consent Decree Mod
- Performance Standard Documents
  - ▶ Hudson River Quality of Life Performance Standards (full report). May 2004
  - ▶ Engineering Performance Standards: Volumes 1-5
- Phase 1 Design (this folder contains multiple files related to design and construction specifications)

- ▶ Phase 1 Contract Documents
  - 1 Contract 1: Facility site work construction
  - 2 Contract 2: Rail Yard Construction
  - 3 Contract 3A: Processing facility construction
  - 4 Contract 3B: Processing facility operations
  - 5 Contract 4: Dredging Operations
  - 6 Contract 5: Habitat Construction
  - 7 Contract 6: Rail Yard Operations
- ▶ Phase 1 Dredge Area Delineation Report. Prepared for GE by Anchor QEA. February 28, 2005. (Includes tables, figures and appendices)
- ▶ Phase 1 Final Design Report. March 21, 2006 (includes attachments A-K, figures and tables).
- Phase 2 Intermediate Design Report
  - ▶ Text of Phase 2 Intermediate Design Report
  - ▶ Logistics model output data
  - ▶ Phase 2 shoreline photos
  - ▶ Phase 2 IDR approval and response to comments
  - ▶ Appendix 1 drawings
  - ▶ Appendix 2 specifications
  - ▶ Attachments A-M
  - ▶ Tables and Figures
- Quality Assurance Project Plans
  - ▶ 5/28/2005 BMP QAPP text
  - ▶ 5/28/2005 BMP QAPP appendices
  - ▶ 5/28/2005 BMP QAPP figures
  - ▶ 5/28/2005 BMP QAPP tables
  - ▶ RAM QAPP appendices
  - ▶ RAM QAPP final 5/12/2009 tables and figures
  - ▶ RAM QAPP final 5/12/2009 text only document
- Remedial Action Work Plans
- 2002 ROD and responsiveness summary
- Phase 1 Data Compilation Hudson River PCBs Superfund Site. Prepared for GE by Anchor QEA. November 2009
- Appendices to Phase 1 Data Compilation Report.
- Supplement to Phase 1 Data Compilation Hudson River PCBs Superfund Site. Prepared for GE by Anchor QEA. January 2010.
- Appendices to Supplement to Phase 1 Data Compilation Hudson River PCBs Superfund Site.

### **Items Provided Independent of Panel Requests following February 17 – 18 Introductory Session**

- Hard copy of GE Phase 1 Evaluation Report, Tables, and Figures and CD of Appendices (provided March 10, 2010)
- Hard copy of EPA Phase 1 Evaluation Report, Tables, Figures, and Appendices and CD of same (March 16, 2010)
- EPA Oversight Team Phase 1 Observations Report (sent via email March 24, 2010)
- Addendum to EPA Phase 1 Evaluation Report (sent via email to the Panel May 2, 2010, and provided in hard copy at Peer Review Panel Meeting, May 4, 2010)

### **Items Provided in Response to Panel Supplemental Information Requests following February 17 – 18 Introductory Session**

(submitted to EPA March 2, 2010 and forwarded by EPA to GE March 10, 2010)

- March 26, 2010 GE Initial Response to Panel Supplemental Information Requests from Introductory Session (provided to the Panel March 30), including:
  - ▶ CD with maps showing bucket prints from each pass
  - ▶ Table showing number of closed buckets per pass, per CU
  - ▶ Directions on finding simple CU coring maps within GE Data Compilation Report and GE Final Phase 1 Evaluation Report
  - ▶ Directions to locating productivity dredge data in Appendix D of GE's Final Phase 1 Evaluation Report
  - ▶ Directions to finding pre-RA cores and grabs collected during the design phase in Appendix R of GE's Final Phase 1 Evaluation Report
  - ▶ A CD file for Residual data, including sample descriptions for each residual sample that was analyzed for PCBs
  - ▶ 4 DVDs with electronic dredge pack data, including the software drivers needed to view the data
- March 29, 2010 EPA Response letter to Panel Information Requests following Introductory Session
- April 8, 2010 GE Additional Response to Panel Supplemental Information Requests and Questions Received after the Introductory Session. This response included the following additional items
  - ▶ Hudson River Dredging Project Phase 1 Summer 2009 (DVD)
  - ▶ Operation, Maintenance, and Monitoring Plan for Phase 1 Caps and Habitat Replacement/Reconstruction, March 4, 2010 (CD)
- April 21, 2010 GE Response to Supplemental Panel requests (submitted to EPA April 14, 2010 and forwarded by EPA to GE April 19, 2010). Includes:
  - ▶ Response to request for raw field logs (directions provided to located information in SSAP database in Appendix R of GE Phase 1 Evaluation Report)

- ▶ Dredging elutriate test (DRET) data (directions and link provided Treatability Studies Report which was one of separately bound appendices of the Phase 1 Intermediate Design Report submitted to EPA August 22, 2005)
- ▶ Phase 1 Dredging daily summaries (instruction to locating information in November 2009 GE Data Compilation Report and January 2010 Supplement)
- ▶ Dredging contractor's daily reports and weekly reports (summarized in Appendices A and DC of January 2010 Supplement)
- ▶ CD of GE's Weekly Productivity Summary Reports
- ▶ Construction management contractor's barge reports (Appendix P of Data Compilation Report and Appendix P and January 2010 Supplement contain PDFs of scanned barge reports)
- ▶ Additional GE Monthly RA Reports/Monthly Progress Reports (Appendix F of Data Compilation Report contains monthly RA reports for May – September 2009)
- Public comments on EPA and GE Phase 1 Evaluation Reports (CDs received from EPA April 28 and provided to the Panel on April 29)
- April 29, 2010 GE Response to Supplemental Panel requests (remaining request from March 2 and additional requests from April 23), including:
  - ▶ summary of GE's proposed changes to Engineering Performance Standards
  - ▶ GE cost data for Phase 1
  - ▶ GIS shapefiles of the study area
  - ▶ Attachment A – Technical Memorandum Allowable Load Calculations for Hudson River Dredging Project
  - ▶ Attachment B – Report on PCB Expenditures 1990 – 2009
  - ▶ Attachment C – An Overview of the Upper Hudson River PCB Modeling System
  - ▶ Attachment D – Relevance of EPA's Contaminated Sediment Remediation Guidance to the Engineering Performance Standards
  - ▶ Attachment E – 2010 High Flow Event Technical Memorandum

### **Information Provide to the Panel in Response to Information Requests following the May 4-6 Peer Review Panel Meeting**

- Written public comments submitted at May 4-6 Peer Review Panel meeting (sent via email 5/11/)
- EPA response to 5/11 Panel request for updated table of proposed modifications to the resuspension standard (received from EPA 5/18 and provided to the Panel 5/18)
- CD with public comments on EPA Report Addendum and materials presented at May 4-6 Peer Review Panel meeting, including GE's comments on same (provided to the Panel 5/19)
- GE response to 5/12 Panel request for table of estimated Tri+PCB mass for all Phase 2 CUs (received from GE 5/19 and provided to the Panel 5/19)

- GE response to 5/25 Panel request for modified table of estimated Tri+PCB mass for all Phase 2 CUs to include average existing surface sediment PCB concentrations per CU and design inventory volume per CU (received from GE 5/26 and provided to Panel 5/26)
- EPA response to 5/18 Panel request for clarification on “new model analysis” and “a model simulation of the Upper Hudson” referred to in EPA’s proposed modifications to the resuspension standard table provided on 5/18 (received from EPA 6/2 and provided to the Panel 6/2)
- GE response to 6/1 Panel request for maps and excel spreadsheet that identify surface sediment PCB concentrations in areas not targeted for dredging, upstream of Waterford and figures for Section 5 of Phase 2 DAD (GE replied with letter and accompanying CD dated 6/2 and provided to the Panel 6/3)
- GE response to 6/2 Panel request for clarification of estimate of the total PCBs to be removed for the duration of the project (received from GE 6/3 and provided to the Panel 6/3)
- EPA response to 6/3 Panel request for:
  - ▶ Pre-Phase 1 Surface Weighted Average Concentration by CU, and then for the entire Thompson Island Pool
  - ▶ Post-Phase 1 Surface Weighted Average Concentration by CU, and then for the entire Thompson Island Pool
  - ▶ Post-completion of all the CUs in the TIP (a) estimate of the SWAC by CUs, and for the entire TIP
  - ▶ Pre-Phase 2 SWAC for the Rest of River by CU and then by Segment
  - ▶ Post Phase 2 SWAC for the Rest of River by CU and then by Segment
  - ▶ Estimate of the Phase 1 SWAC after completion of each individual pass  
(received from EPA 6/9 and provided to the Panel 6/10)
- EPA response to 6/2 Panel request for clarification showing how EPA derived the PCB mass to be removed for the remainder of the project, and how EPA derived the Control Level of Tri+PCB of 670 kg (received from EPA 6/11 and provided to the Panel 6/11)
- GE Response to 6/3 Panel request to provide the GIS layers associated with Figures 6-2a-s and 6-3a-s from the April 29, 2010 Upper Hudson Model Technical Memorandum (received letter and CD containing GIS surface PCB concentration figures and Phase 2 Dredge Area Delineation Chapter 5 figures from GE 6/7 and provided to the Panel 6/7)
- GE Response to 6/23 Panel request to provide information on how much material has been sent to the landfill and whether the landfill problems have been resolved (received response from GE 6/25 and provided to the Panel 6/15)