Hudson River PCBs Site

Revised Engineering Performance Standards For Phase 2 Dredging

DRAFT

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1 Introduction

1.1 Overview

In April, 2004, EPA issued performance standards for dredging PCB contaminated sediment from the Hudson River. These standards were published in a document entitled, *Hudson River PCBs Superfund Site, Engineering Performance Standards, Statement of the Engineering Performance Standards for Dredging*. The document was printed in five volumes, as follows:

- *Volume 1 – Statement of the Engineering Performance Standards for Dredging*
- *Volume 2 – Technical Basis and Implementation of the Resuspension Standard*
- *Volume 3 – Technical Basis and Implementation of the Residuals Standard*
- *Volume 4 – Technical Basis and Implementation of the Productivity Standard*
- *Volume 5 – Appendix – Case Studies of Environmental Dredging Projects*

In accordance with the Record of Decision (ROD) the project is being implemented in two phases. Phase 1 dredging, which was completed during 2009, consisted of dredging initially at a reduced production rate to test the effectiveness of the Performance Standards and of the Phase 1 design, implementation of sediment dredging, sediment processing and disposal. Phase 2 is to be completed at full production rates and is expected to begin in the spring of 2011.

Upon completion of Phase 1 dredging in the fall of 2009, an evaluation was made to identify what, if any, changes should be made to the Performance Standards for Phase 2 of the project. Separate Phase 1 Evaluation Reports were prepared by EPA and GE which proposed changes to the Standards, and a peer review panel was convened to assist EPA in deciding which of the proposed changes should be made. The report by the Peer Review Panel was published on September 10, 2010, and contained recommendations for a number of changes to the performance standards for the Phase 2 work. Copies of the Panel's report are available online at EPA's web site for the Hudson River PCBs Site (www.epa.gov/Hudson) or by calling the EPA's Hudson River Field Office at 518-747-4789 or toll free at 866-615-6490.

Following receipt of the Peer Review Panel's report, EPA adopted a number of revisions, as described herein, to the original Engineering Performance Standards published in 2004, which are to be implemented during Phase 2 of the Project.

1.2 Document Organization

This addendum to the Engineering Performance Standards presents the revised standards and gives explanations for changes from the original standards. The structure of this document is similar to that of the original 2004 documents. To assure that the original text can be compared directly with the revised standards, volume, section, and page numbers are provided where references are made back to the 2004 document.

This document is divided into the following sections:

1.0 Introduction

2.0 Statement of the Revised Performance Standards for Phase 2

3.0 Residuals Performance Standard for Phase 2

4.0 Resuspension Performance Standard for Phase 2

5.0 Productivity Performance Standard for Phase 2

6.0 Water Quality Requirements for In-River Releases of Constituents Not Subject to Performance Standards

7.0 Estimation of PCB Mass in Phase 2 Remediation Areas

8.0 References

Appendices

1.3 Summary of Rationale for Changes to the Standards

The first phase of the dredging program was undertaken between May and December 2009. During this time, measurements, analyses, and observations were made and recorded regarding the ability of the dredging program to adhere to the Engineering Performance Standards. Other influences on the program were noted that were not necessarily anticipated during the design of dredging or the development of the standards. This record of lessons learned during Phase 1 helps lay the basis for the changes to the Engineering Performance Standards, following an adaptive management approach for operations to assure that the Engineering Performance Standards are met. The standards have been modified based on the findings of the EPA and GE as reported in their respective Phase 1 evaluation reports, and the recommendations and observations of the Peer Review Panel. Further, the standards have been simplified and streamlined to more directly reflect the conditions that were observed during the day-to-day operations of the dredging project.

As recommended by the Peer Reviewers, an adaptive management approach to operations is being implemented ~~as well~~ to assure that the Engineering Performance Standards ~~have the ability to conform to the conditions being observed in the river~~will be met as the project progresses. As such, additional studies are planned that will continue to inform the adaptive management process. These studies will allow modifications to the ~~standards~~operations from year to year based on the experience of the previous year and knowledge of the upcoming year's geographic scope and production targets. The EPS and the approaches identified herein are predicated on the development of accurate Depth of Contamination (DoC) lines. If the DoC is not accurately identified, the ~~EPS~~approach to achieving DoC may need to be modified as per the Adaptive Management Plan (AMP) to be developed. Adjustments in accordance with a pre-approved list of Best Management Practices (BMPs) may be called for ~~either~~ at the end of a season ~~or within a season, or both~~if the amount of capping for that year exceeds the annual capping limit.

1.3.1 Observations from Phase 1 Dredging

Phase 1 was intended as an initial working period where production goals would be relaxed so that unanticipated conditions could be evaluated and lessons learned, providing guidance to the future and more accelerated dredging during Phase 2. The pause in production between Phase 1 and Phase 2 was planned as a time to adjust the performance standards to be aligned with the lessons learned during the Phase 1 dredging program. The following describe some of EPA's more salient observations from Phase 1 that have direct bearing on the Engineering Performance Standards.

Observations Concerning Residuals Based on Phase 1 Dredging Experience

- Some of the elements of the original Residuals Standard were not used and proved not to be needed.
  - A streamlined process was recommended by the Peer Review Panel that is based on a better characterization of DoC and a single dredging pass.[1] The recommended single-pass dredging process replaces the original complex decision process with a simple metric to determine if backfilling or capping is appropriate after dredging achieves the designed elevation. This process will be ~~tested~~used during Phase 2 ~~to see if it results~~and will be structured to result in the removal of the planned inventory with minimal inventory being capped. ~~If it is successful, then EPA expects this method will continue throughout the duration of Phase 2.~~ The AMP will be structured to allow modification to the ~~standard based on conditions found in the river, the accuracy of the DoC, and the success or failure of the single-pass approach~~dredge prisms and/or the dredging approach as needed to remove the targeted PCB inventory while minimizing removal of "clean" sediments and controlling, to the extent practical, the amount of inventory capped.
- For many post-dredging cores, only the top 6-inch segments were analyzed, consistent with the Phase 1 Residuals Standard, but missing an opportunity to re-characterize the DoC where multiple dredging passes had already indicated that the DoC was not well-known. In cases where post-dredging cores indicate non-compliant levels of PCB contamination with respect to the standard, the use of the data to re-characterize DoC, in addition to characterizing the surface concentration after the dredging pass to meet the design cut line, is essential, as borne out by the Phase 1 experience with incomplete post-dredging cores.
  - For Phase 2, ~~as part of the verification of the single-pass dredging strategy recommended by the Peer Review Panel,~~ post-dredging cores will be collected to represent a minimum 4-foot sediment column (or to the depth of uncontaminated materials defined below, if shallower) and should be analyzed as individual 6-inch segments to verify that detected

[1] For the purposes of this document, all references to a "single pass" mean a dredging pass which achieves the required elevation of contamination (EoC) in at least 95% of a given subunit, and that if this elevation is not achieved, the additional dredging that must be done to bring at least 95% of the area at or below the EoC is still part of the same "pass."

PCBs are associated only with a true residuals layer and not underlying inventory.[2] ~~This assessment will determine if the single-pass dredging strategy is successful in achieving the goals of the ROD. This requirement may be changed in the future in accordance with the AMP.~~

- The majority of the dredging passes after the initial pass conducted during Phase 1 were targeting inventory that was not adequately characterized prior to design, rather than addressing a true, post-dredging layer of residual sediments. The Phase 1 design cut lines were set too shallow in ~~general~~many locations; many times even post-dredging cores did not fully penetrate the depth of the contaminant inventory. The application of the Residuals Standard served to detect inventory rather than to sample and manage comparatively thin layers of dredging residuals. The number of dredging passes ~~could~~may have been reduced had the depth of contamination been robustly re-characterized following the initial dredging pass.
~~The final dredging depth was more than 6 inches beyond the original design surface for nearly 70 percent of the original Sediment Sampling and Analysis Program (SSAP) locations. Of the remaining 30 percent, only 16 percent (about half of the 30 percent) had a final dredging depth within ± 3 inches of the original design cut lines. The final dredging depth was greater than 12 inches beyond the original design cut lines for 55 percent of the SSAP locations.~~
    - The DoC for Phase 2 areas must be better defined and uncertainty in the DoC estimate must be accounted for in setting the Phase 2 design elevations. The Peer Review Panel recommended that locations of incomplete cores and missing cores from the SSAP program be fully characterized and that 20 percent of the complete cores be re-sampled. The new and existing data should be combined to design new dredging prisms based on elevation. EPA and GE are engaged in the effort to better define the DoC as of the time of preparation of this document.
- ~~Too many~~Several passes were required to dredge to the DoC in most CUs and the number of passes ~~could~~may have been reduced had the depth of contamination been robustly re-characterized following the initial dredging pass. ~~Despite the underestimated DoC and inaccurate dredging cut lines, three~~ Three dredging passes ~~were adequate to get~~got most CUs close to compliance.
    - Based on the Peer Review Panel's recommendation, a single-pass approach ~~will be tested in Phase 2 and if successful,~~ will be implemented for the remainder of the project ~~(as subject to the AMP)~~. The success of a single-pass approach relies on accurately defining the DoC ~~with a high degree of confidence~~.
- The inaccurate estimate of the depth of contaminated sediment was due, in part, to the presence of wood debris. Improvement needs to be made in the collection of cores, especially after dredging, including actions to re-confirm the depth of contamination. PCB-contaminated wood debris is

[2] For the purposes of the EPS, residual contamination in a post-dredging core is defined as a measured concentration at or above 1 mg/kg TPCBs in the top 6-inch segment of a confirmatory core, and a concentration less than 1 mg/kg TPCBs in all lower layers. ~~Inventory in a post dredging core refers to a TPCB concentration at or above 1.0 mg/kg in any lower 6-inch segment. Finally, a~~A post-dredging core with an unacceptable residual concentration is a post-dredging core where contamination is limited to the 0-6 inch interval but the Tri+ PCB concentration causes the mean value of all residual-containing cores in the CU or sub-unit to exceed ~~1.49~~3.49 mg/kg Tri+ PCB. ~~Since the goal of the remediation is to achieve a residual concentration of 1 mg/kg Tri+ PCB or less, ideally all residual concentrations should be below this concentration.~~

present throughout the river and was observed in essentially all Phase 1 CUs. CUs at the northern end of the Thompson Island Pool had more debris than those in the southern end of the Pool, but it is anticipated that wood debris will be found throughout the Pool in the Phase 2 areas.

- Deposits of wood debris should be removed entirely, where encountered, as a component of the dredging project management unless data exist to show that some or all of the debris layer does not contain PCBs above 1 ppm. Complete removal of wood debris to depth is necessary because the Phase 1 experience showed that wood debris was contaminated with PCBs to its complete depth and sediment beneath the wood debris was also contaminated.

Observations Concerning Resuspension Based on Phase 1 Dredging Experience

- Based on the Resuspension Standard, monitoring data collected were used to temporarily halt dredging operations when the 500 ng/L water column Total PCB (TPCB) criterion was exceeded on three occasions. When all dredging-related activities ended, water column concentrations returned to baseline levels at all far-field stations. [Note to EPA: The report should acknowledge that water column concentrations remained elevated after dredging related activities ended.]
  - Far-field monitoring will be required throughout the Phase 2 period. A2,000 ng/L TPCB threshold will be used at Thompson Island and Lock 5, and a 750 ng/L TPCB threshold will be used at Waterford to help ensure that the dredging process does not cause excessive resuspension. Exceedances, if any, of the 750 and 2,000 ng/L TPCB level will result in implementation of Best Management Practices that have been agreed upon by GE and EPA.
  - ~~Far-field monitoring will be required throughout the Phase 2 period~~Monitoring at the nearest public water supply withdrawing water from the Hudson River will be required throughout the Phase 2 period and the 500 ng/~~L~~l TPCB threshold will ~~still be used to help ensure that the dredging process does not cause excessive resuspension. Exceedances, if any, of the 500 ng/L TPCB level will not necessarily lead EPA to require a shutdown, however~~be used to ensure protection of the public water supply. EPA will supply the towns of Waterford and Halfmoon with an alternate water source during the dredging period, eliminating direct withdrawals by municipal water systems in the Upper Hudson River for consumption during dredging. GE must inventory the direct use of river water by private and agricultural users from Fort Edward to Waterford and provide alternate water supplies or treated water for their use. ~~As a result, the strict requirement of shutdown at 500 ng/L TPCB has been revised to allow for operational changes or shutdown, at EPA's discretion.~~ Exceedances, if any, of the 500 ng/L TPCB level will result in implementation of Best Management Practices that have been agreed upon by GE and EPA.
- PCBs in the vicinity of the dredge operations were dominated by the dissolved phase, and ~~non-aqueous phase liquids (NAPL)~~ sheens were observed during dredging at many locations. Although PCB daily loads decreased down river significantly, a concurrent decrease was not observed in solids transport. This discrepancy suggests that PCB transport was not controlled by solids transport, especially given the significance of non-particulate PCB in the near-field. Other

mechanisms that were not measured, including volatilization and dilution, likely significantly affect the transport of PCB downriver.

- Special studies will be undertaken to assess the contributions and effects of NAPL and dissolved phase PCBs and to assess the mechanisms controlling PCB transport.

- Turbidity was not a reliable surrogate for suspended solids concentrations observed in daily transect samples and suspended solids concentrations were not a good predictor for TPCB transport downstream of the dredging operations.

  - Turbidity will not be used as a surrogate for suspended solids and will not be a required measurement during Phase 2. Near-field monitoring requirements for suspended solids may also be reduced as Phase 2 progresses if monitoring continues to show that suspended solids do not yield useful information. Suspended solids measurements at a reduced scope can still be used as a guide to potential adverse impacts attributable to dredging but alternative means for determining sampling locations should be evaluated. ~~PCB should be analyzed in all suspended solid samples so that comparability between PCB concentrations and suspended solids concentration may be assessed.~~

- There was no significant increase in the transport of solids during dredging beyond the immediate vicinity of the dredging operation as indicated by suspended solids data, and average suspended solids concentrations in the near field were well below the suspended solids evaluation criteria for Phase 1.

  - The suspended solids criteria should ~~continue to be evaluated during Phase 2 and adjusted in accordance with the AMP.~~ be discontinued following Year 1 of Phase 2.

- At Thompson Island, Lock 5, and Waterford stations, the 7-day running average net loadings for the Resuspension Standard performance targets for cumulative load for both TPCBs and Tri+ PCBs were exceeded. However, EPA's goal of a maximum 1 percent loss rate to the Lower Hudson River was achieved at Waterford. EPA's estimated rate of loss at the TI station was slightly more than 2 percent.

  - As recommended by the Peer Review Panel, the load standards should be 2 percent and 1 percent (as measured at the Thompson Island Dam and Waterford monitoring stations, respectively) of the Tri+ PCB mass removed. As Phase 2 progresses, these load standards will be adjusted, as appropriate, in accordance with ~~the AMP, as informed by data and, if available,~~ an acceptable, peer-reviewed model. Prior EPA modeling analysis as well as initial recent model results submitted by GE suggest these levels will have no long term impacts to the recovery of PCB levels in fish.

  - The total project net cumulative load is the maximum load to the Lower Hudson River allowable without unacceptable impacts on remedy benefits. Based on modeling conducted by GE, EPA has concluded that a net Total PCB load of 3,000 kg is allowed during the project. This load may be revised based on modeling conducted after the model has been refined using the data collected during the first year of Phase 2 dredging. The total project load will be monitored at Waterford and will be allocated to each year of the dredging project based on estimates of the Phase 2 PCB mass to be dredged in each year of the project. This load will be used in conjunction with the percentage-based seasonal loads described above to trigger between dredging years engineering evaluations and operational changes.

- Several processes contributed to the PCB transport to the far-field at Thompson Island including, but not limited to: PCB mass and volume removal, velocity, vessel traffic, and disturbance of exposed contaminated surface sediments.
  - ~~Improvements to various aspects of the dredging operations will be made which EPA expects will reduce the rate of PCB release in Phase 2.~~ [Note to EPA: This statement is speculation on the part of EPA and will only be answered following 2011 dredging.]
- It is not apparent from the available data that the dredging led to significant redistribution of contaminated sediments to non-dredged areas. Baseline water concentrations in the Upper Hudson have returned to normal, 2010 fish tissue data show no appreciable difference from baseline, and samples of sediments collected on the floodplain from 2010 spring floods immediately downstream of the areas dredged during Phase1 were found not to contain PCBs, lending further support to this finding. [Note to EPA: GE disagrees with EPA's view on redeposition. Data collected during the 2011 dredging season will provide the data necessary to answer this question.]
  - The Peer Review Panel recommended that a special study of redeposition be undertaken to assure that PCBs released during dredging are not causing significant increases in the surface sediment concentrations outside of the dredge prisms.
- The monitoring data on PCB concentrations in the river water show no dredging impacts to water quality in the Lower Hudson River.
  - Anticipated dredging impacts to water quality are temporally and spatially limited.
- Fish tissue impact was limited to the vicinity of dredging. Dredging had no significant effect on PCB levels in fish more than 2-3 miles downstream of the Thompson Island Pool. Furthermore, 2010 fish tissue data, collected less than a year after dredging in both the Upper and Lower Hudson, show no appreciable difference from baseline.
  - The overall improvement to the aquatic ecosystem health attainable by the proposed PCB mass removal outweighs temporary increases in fish PCB levels. Any increases appear to be localized and transient.
- The estimate of PCB inventory and the rate of PCB release are both larger than originally estimated in the ROD and EPS calculations, although the increased rate of PCB release showed little downstream impact to fish tissue concentrations.
  - The cumulative PCB load criterion will be eliminated due to insufficient information to estimate the total mass to be removed. The standard will instead be based on daily and annual net loads. Using the 1% and 2% load standards referred to above, the net load criteria (grams/day and Kg/year) for any given year will be established once EPA has an

estimate of the mass of PCBs to be removed in that year. ~~These standards will be evaluated and potentially revised as the project progresses, in accordance with the AMP.~~

Observations Concerning Productivity Based on Phase 1 Dredging Experience

- During Phase 1, approximately 1.8 times more sediment was removed from the CUs dredged than shown on the design drawings. The poor definition of the actual depth of contamination in those CUs calls into question the associated estimate of the total volume of sediment to be dredged during Phase 2 of the project. As a result, in spite of the extensive sampling and analysis program conducted prior to Phase 1, the actual volume of sediment cannot be estimated with any great degree of certainty and it is not currently possible to accurately define the yearly production rate needed to complete the project over any specified time period.
  - The current estimates of the Total volume to be dredged during both phases of the project range from about 2.3 to 3 million CY. The uncertainty in defining DoC precludes making a rigorous engineering estimate of the amount of contamination remaining to be dredged. The Peer Review Panel recommended that the target for each year be about 350,000 CY, based on Panel members' understanding of the process' capacity. EPA agrees that dredging of 350,000 CY/year is achievable, but maintains that this should be the minimum volume ~~expected~~targeted and that changes to the process should result in greater capacity. It is EPA's goal to complete Phase 2 as quickly as is practicable.
- The original Engineering Performance Standards did not establish a hierarchy for compliance with the Resuspension, Residuals, and Productivity Standards, but gave equal weight to each Standard. Thus, the dredging contractor was required to achieve a given rate of productivity while, at the same time, attempting to meet the Residuals Standard and ~~minimize resuspension of PCBs as required by the~~ Resuspension Standard. The operational imbalance ~~resulting primarily from poorly defined DoC~~, coupled with a lack of an institutional adaptive management framework, proved difficult to manage during Phase 1. The application of best management practices aimed at reducing resuspension caused ~~some~~ reduction in productivity, and the difficulties experienced in meeting the Residuals Standard reduced dredging productivity significantly.
  - During Phase 2, the Productivity Standard should be subordinated to the Resuspension and Residuals Standards, as the Peer Review Panel recommended. The annual "required" dredging volumes in the original Productivity Standard should be eliminated and only target volumes should be specified. ~~In addition, an adaptive management approach is needed to address the incomplete understanding of the sediment regime that will exist even when additional cores are collected.~~
- The system intended to unload scows at the dewatering site failed to meet the EPA approved design capacity of approximately ~~5000~~4,300 CY per day. Scow unloading could not keep up with dredge production and significant losses of productivity were experienced due to a lack of empty scows at the dredge platforms. Of a total available Phase 1 dredging time of 18,100 hours, approximately 4,800 hours, or 26 percent, were lost as dredges waited for empty scows to return from the dewatering site.

- Improvements to the sediment unloading system will be required if the unloading facility fails to have sufficient operational ~~redundancy~~capacity and to be operated in a manner that can process a minimum of ~~330,000~~350,000 cy/year and ship out a minimum of ~~380,000~~350,000 cy/year of sediment.

- The failure to accurately predict DoC resulted in more dredge passes than anticipated and combined with delays in decision making resulted in significant delays ~~in dredging~~ while additional rounds of residuals sampling were conducted, additional bathymetric maps were prepared, and new dredge cut lines were developed.
  - Dredging productivity will increase if DoC is better defined and the Residuals Standard is simplified in Phase 2.

- GE's specifications for the Phase 1 project required the dredging contractor to dredge to the design cut line with a precision tolerance of plus ~~or minus~~ 3 inches, measured as the average cut over a 10 foot by 10 foot square area, and to remove the ~~total~~ volume of sediment called for in the design such that the volume removed below the design cut line was greater than the volume removed above the design cut line as measured over ~~any 1-acre area~~a CU. The subsequent bathymetric survey ~~frequently~~ indicated that some 10-foot by 10-foot squares had not been dredged to a sufficient depth, and the dredging contractor was required to return to those spots and remove additional sediment to meet the 3-inch precision tolerance. ~~Residual~~Initially, residual samples were not collected until it was confirmed that the design cut lines had been met within the 3-inch tolerance only to find from the subsequent sampling that the design cut lines had been drawn above the actual DoC. Shortly after the initiation of dredging, this process was revised to take the residual samples concurrent with the survey.

~~o~~ The Peer Review Panel recommended a shift to a "single-pass" dredging approach which requires the contractor to reach the elevation of contamination (EoC)[3] in 95% of the certification unit (CU) area during the first pass, dropping outliers representing areas of less than 3 square feet before calculating the percent of grade that is compliant, and further recommended that the Residuals Standard should specify setting *"the Design Dredge Elevation initially to 4 inches below the modeled DoC Elevation* [*i.e.*, EoC] *to account for the vertical accuracy of the dredge, referred to as dredge tolerance"*). ~~EPA agrees that with a better understanding of DoC and sufficient allowance for uncertainty, this approach may be effective and will streamline the dredging process. This approach will be assessed during Phase 2 to determine if it can achieve the removal of "all *PCB-contaminated sediment within areas targeted for remediation, with an anticipated residual of approximately 1 mg/kg Tri+ PCBs (prior to backfilling)*" (Record of Decision,~~

[3] For the purposes of Phase 2, the depth of contamination (DoC) is depth within a core corresponding to the ~~bottom~~top of the first segment (typically six inches thick) whose TPCB concentration is less than 1.0 mg/kg. The term DoC is also used in a generic sense to refer to the thickness of contaminated sediment at a given location. The elevation of contamination (EoC) is the absolute elevation corresponding to the ~~bottom~~top of the first segment less than 1 mg/kg TPCB. For an individual core, the EoC is determined by measuring the absolute elevation of the sediment-water interface and then subtracting from it the DoC of the core. The EoC between cores is estimated by interpolating both the DoC and bathymetric survey data to create a continuous estimate of the EoC. The Peer Review Panel [s]*et the Design Dredge Elevation initially to [be] 4 inches below the modeled DoC Elevation* [i.e., the EoC] *to account for the vertical accuracy of the dredge, referred to as dredge tolerance.* (Peer Review Panel Report, 2010, page vii) The design dredge elevation surface will be provided to dredge operator as the target elevation for dredging.

~~2002). Dredging specifications must be revised to provide for confirmation sampling as soon as the dredging contractor reaches the 95% threshold and to eliminate the plus-or-minus 3-inch precision tolerance and incorporate the 4-inch overdredge tolerance. Once the sampling is complete, the CU can be covered with a backfill or sand cover, and subsequently backfilled or capped based on the sampling results.~~ The Dredge Prism shall be determined by applying an adjustment to account for both uncertainty in the DoC and also uncertainty associated with the dredge cut. The adjustment is subtracting either four inches (reflecting the Phase 1 Peer Reviewers' recommendation) or the 60th percentile of the DoC difference distribution of co-located high confidence cores for a given dredge depth, whichever is greater from areas of the Engineered EoC Surface except areas where physical characteristics determine the final elevations (e.g. clay areas, bedrock areas, etc.). This approach results in subtracting six inches in elevation if the DoC (as determined using the 1 mg/kg interpolator see Section 2.5.1) is less than or equal to 18 inches, and subtracting four inches in elevation if the DoC is greater than 18 inches.

Achievement of the required elevations shall be met when the Engineered EoC Surface elevations are met in 95% of each CU subunit after a single dredge pass and when the volume of material removed below the Dredge Prism is greater than or equal to the volume of material remaining above the Dredge Prism in each CU subunit after a single dredge pass.

- Small barges, referred to as "mini-hopper scows," were used when dredging in shallow areas of the ~~river~~west channel of the river due to bedrock and boulder fields. Once filled, the scows were moved to a transfer station where the sediment was unloaded and placed in a large barge for transport to the dewatering site. ~~If~~Although seven (7) mini-scows were ultimately used, if an empty mini-scow was not immediately available, the dredge operator was unable to work until the filled scow was unloaded and returned to the dredge. The mini-hopper scows had 2 foot high walls, but one foot of freeboard was required ~~to prevent water from overflowing the walls~~for stability when the scow was moved. This reduced the capacity of these scows considerably. In an effort to increase the volume of sediment that could be placed in a mini-scow and to ensure the stability of the scows, the dredge operators were allowed to drain free water from a closed or partially closed bucket before emptying it into the scow. Draining the water from the bucket typically took from one to two minutes and increased the bucket cycle time significantly. ~~This practice also increased the amount of PCB lost to the water column and may have been partially responsible for the time lost in dredging due to high PCB resuspension rates.~~
    - During Phase 2, use of 'mini-hopper scows" should be minimized ~~or eliminated. If their use is required in a limited number of instances, GE should evaluate the transfer of excess water from the mini-hopper scows to a large hopper scow or a tanker scow using a pump and floating pipeline to remove excess water~~. Alternate methods and shallow draft scow equipment should be considered to dredge efficiently in shallow areas. ~~GE should present their study of this subject in writing to EPA. Regardless, draining of buckets back into the river is not permissible and, if a solution to this issue is not brought forth by GE, EPA will require that access dredging be conducted so that larger scows and barges can access shallow dredging~~The RAWP will address the equipment and methods to be used in shallow draft areas.

- The performance standards and design specifications for Phase 1 limited inventory dredging to a maximum of two contiguous CUs. During Phase 1 operations, GE requested a revision to this requirement to permit opening a third CU when inventory targeted by the design had been completed in the upstream CU, and only clean-up dredging remained. This request was approved by EPA with the stipulation that closure occur sequentially from upstream to downstream.
  - Permitting dredging in more than two contiguous CUs simultaneously may be necessary during Phase 2 to meet productivity targets. This consideration will be important when all dredging is occurring in the main stem of the River.
  - Dredging in multiple areas will be allowed if the area is at least 1,000 feet downstream of the next nearest certification unit.
- During Phase 1, backfilling and capping operations didn't begin until late in the season~~ as a result of the poor characterization of the DoC and the need to conduct multiple dredge passes before a CU could be closed~~. Backfilling and capping operations produced a visible plume of turbidity as fine-grained soil ~~incorporated~~required in the backfill and capping materials washed downstream during installation.
  - As the Peer Review Panel recommended, a 3-6 inch cover should be immediately placed once the EoC has been achieved in 95% or more of a 1-acre CU sub-unit and residual cores are collected. Backfilling or capping in a CU needs to be accomplished as soon as possible after dredging is completed in that CU to minimize potential contribution to resuspension and so that the CU is closed out quickly. Furthermore, productivity will be increased if backfilling or capping in an upstream CU can occur while dredging continues in the downstream CUs. However, since the turbidity plume created when installing backfill or caps may interfere with monitoring resuspension at the dredging operations, it may be necessary either to change the method of installing the backfill or cap material to reduce the turbidity plume or delay the backfilling and capping until the dredges working in downstream CUs are far enough away so that the turbidity plume does not affect the necessary monitoring. The Remedial Action Work Plan (RAWP) must contain plans or procedures to address this issue. Changes to the operation will follow the AMP.

1.3.2 Critical Questions to be Addressed for Phase 2

Observations made and obstacles encountered during Phase 1 raise some questions that need to be addressed during Phase 2, including the following major concerns:

- The depth of contamination encountered during Phase 1 was underestimated by the pre-dredging investigations and hence the design of the dredging program. This underestimation resulted in several additional dredging passes to remove inventory at many locations dredged. DoC for the Phase 2 area was characterized by the SSAP coring program, which is the same investigation that characterized the DoC for Phase 1. The same coring methods were used for the Phase 2 areas, yielding similarly large areas that are characterized by incomplete cores. Because of this, the uncertainty of the DoC must be addressed in the Phase 2 design so that the Residuals Performance Standard can be achieved in an efficient manner.

- A coring program, as recommended by the Peer Review Panel, began in the fall of 2010 to address the uncertainty in the DoC. This program will re-collect cores at the SSAP locations where incomplete cores were originally collected and at 20 percent of the SSAP locations where complete cores were collected. Additionally, the program will collect cores from sparsely sampled areas to match the sampling density in most areas identified for dredging. The 2010 effort will collect cores from the areas slated for remediation in Year 1 of Phase 2. Similar sampling surveys will be conducted prior to the start of each subsequent year of dredging. Statistical analyses of the DoC found in these cores will be tied to elevation and used to evaluate the inherent uncertainty in measuring and interpolating the elevation of contamination (EoC), which in turn will be used to develop the Phase 2 design dredge elevations coupled with the dredge tolerance.
    - The success of a single-pass dredging approach recommended by the Peer Review Panel ~~is a critical question to be evaluated during Phase 2. Specifically, is a single dredging pass sufficient to attain the cleanup objective of the ROD? ("Removal of all PCB-contaminated sediments within areas targeted for remediation, with an anticipated residual of approximately 1 mg/kg Tri+ PCBs (prior to backfilling)")? If not, then the Phase 2 design prisms must account for more uncertainty or, if the uncertainty is deemed too great, then a second pass will be necessary to satisfactorily remove the contaminated sediment. If ROD cleanup objective is not met with sufficient frequency, adjustments will be necessary. Changes considered through adaptive management may include: use of better coring techniques (*e.g.*, sonic coring); mathematical "stretching" of cores with <100% recovery; closer spacing of cores (*e.g.*, on 40' or 50' centers); application of higher confidence level in DoC algorithm to better address uncertainty; adjusting to a two-pass approach.~~ will be achieved through compliance with the established capping limits. Adaptive management will allow modifications to approaches to achieving DoC or approaches to dredging.

- The water quality threshold of TPCB 500 ng/L was exceeded on three occasions during Phase 1 and estimates of the amount of PCB mass lost during dredging indicate that the original long term load standard could be exceeded during the life of the project. However, there were unanticipated conditions in the river, such as the presence of oil sheens ~~(NAPL)~~, which may affect these estimates. Further, the Peer Review Panel noted, "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." During Phase 2, the critical question in this regard is the estimate of the load above baseline that can be tolerated without causing recovery to be longer than what would occur naturally.
    - GE and EPA have begun working together on development of a model that can be used to inform a response to the concerns raised by question, the Peer Review Panel. The initial results of the model as supplied by GE show that the load standard presented here sets a level that can be tolerated by the system (2 percent at Thompson Island Dam and 1 percent at

Waterford; and the total project maximum net cumulative load of 3,000 kg measured at Waterford) with no long term impacts to recovery.

1.4 Interaction amongst Performance Standards for Phase 2

The Phase 1 Engineering Performance Standards were designed to balance each other, with each standard setting the requirements that potentially impacted those required by the other two standards. However, the difficulties that were encountered showed that it would be necessary to make achievement of the Productivity Standard subordinate to the other two standards, as discussed below.

1. The Residuals Performance Standard – meeting this standard is critical to achieving the long-term remedial goals of the dredging program. ~~The Productivity Performance Standards should not be achieved at the expense of this standard;~~

2. The Resuspension Performance Standard – meeting this standard will prevent short-term releases from affecting the long-term remedial goals of the dredging program. ~~The Productivity Performance Standard should not be achieved at the expense of this standard;~~

3. The Productivity Performance Standard – meeting this standard is desirable to reduce costs and short term impacts to the river and community. ~~However, adherence should not come at the expense of the Residuals or Resuspension Performance Standards~~A shorter project will also result in the project benefits occurring sooner.

2 Statement of the Revised Performance Standards for Phase 2

2.1 Development of the Phase 2 Engineering Performance Standards

The fundamental principles that have guided the development of the Phase 2 EPS are described below. The Phase 2 principles have been developed to create a flexible set of revisions to the existing Phase 1 standards to guide the Phase 2 remediation and to ensure that the cleanup meets the human health and promote the achievement of the goals of the ROD.

The principles include the following:

- The standards have been developed to protect human health and the environment, while offering as much flexibility as practicable in the Phase 2 final design and implementation.
- The standards have been developed to be performance-oriented rather than prescriptive in regard to means and methods.
- The standards have been developed to include goals to be achieved in Phase 2 and incorporate new management practices based on the lessons learned from Phase 1.
- The standards have been designed to work both together and individually to achieve the overall goals of the project.
- The standards have to be feasible and practicable.

Based on the foregoing principles, each standard incorporated the standard-specific guidelines discussed in the following subsections.

2.1.1 Fundamental Principles for Development of the Phase 2 Residuals Standard

Principles for development of the Phase 2 Residuals Standard were developed to reflect the Peer Review Panel's recommendations as well as EPA's responses to the Panel. They are as follows:

- Sediment sampling following dredging, but prior to placement of backfill, is necessary to verify the effectiveness of the remediation. The inclusion of an approximately 1 mg/kg Tri+ PCBs concentration for sediment residuals in the ROD contains an implicit directive to conduct verification sampling.
- The post-dredging sampling should allow investigation of both dredging-related residuals (*e.g.*, sediments that escaped the dredge during removal and resettled or re-deposited) and potential "missed inventory" (i.e., the original "inventory" of contaminated sediment targeted for removal by the ROD).
- Based on the Phase 1 Evaluations conducted by EPA and GE as well as the Peer Review Panel's recommendations, a modified single-pass dredging program will be applied in Phase 2. This program includes a set of procedures that specify backfilling or capping as the completion method based on post-dredging sediment sample analyses. These procedures will facilitate the comparison of residual sediment concentrations to the ROD's objective of approximately 1 mg/kg Tri+ PCBs. ~~After several CUs are completed during~~At the end of the 2011 dredging season, the effectiveness of the modified dredging program and the associated procedures will be evaluated ~~relative to the objectives of the ROD~~as against the established capping limit. As needed, the program and procedures will be subject to modification at that time according to pre-approved BMPs to be implemented at GE's discretion, consistent with the AMP, to better achieve those objectives. In addition, based on data obtained during 2011 (the first year of Phase 2) and after each subsequent dredging season, the modified

dredging program and the procedures should be re-evaluated and adjusted ~~for the remaining dredging seasons as needed, consistent with the AMP~~ as discussed above.

- The primary measure of compliance with the ROD's objective will be the arithmetic mean at 1 mg/kg Tri+ PCB concentration from the top six inches of post-dredging cores in a dredged area within a 1-acre sub-unit or a 5-acre CU with no underlying inventory.
  - It is anticipated that the success of the single-pass approach will ~~be primarily dependent~~depend on whether the design dredge elevation ~~is sufficiently robust to capture~~captures the true EoC. While the ROD selected a remedy focused on removal of PCBs, consistent with provisions in the 2004 EPS, capping of a small fraction of the bottom is expected. For Phase 2, an extent of capping specified as a percentage of the area dredged (described below) will be ~~allowable~~allowed. If these percentages are exceeded during Phase 2, ~~EPA will require~~GE will implement changes to the dredging program. These changes could include changes to the design dredge elevation in remaining CUs or to the approach to dredging. The initial review of the success of the design and single-pass approach will be conducted ~~after several CUs are completed during~~at the end of the 2011 dredging season, and annually thereafter.
  - Depending on the success of the ~~design DoC and the extent of uncertainty that may have to be incorporated in the design to satisfy a single-pass dredging approach, EPA~~ dredging program, GE may ~~ultimately~~ conclude that a two-pass approach is needed to ~~properly capture the DoC as per the ROD and~~ keep capping to below the percentages specified below,
- The portion of each 5-acre CU or 1-acre sub-unit to be capped will be based on the results of the post-dredge sampling nodes. ~~Identification of nodes for capping will consider both the presence of inventory and the occurrence of elevated residual contamination. The initial step will identify the nodes in the unit where sediment concentrations above 1 mg/kg TPCB are present below the top 6-inch segment and remaining inventory is present[4]. TPCB is applied in this instance since TPCB is the original metric used to define the DoC in the individual cores and to estimate the EoC in the remedial design. Thus its use here is consistent with the basis for the development of the original EoC interpolation and represents a direct measure of the accuracy of the EoC surface. These nodes will be designated for capping and withheld from the subsequent evaluation. Although these nodes will be initially withheld from the subsequent calculations, for areas outside the navigation channel, GE may petition EPA to deploy a less rigorous isolation procedure for such nodes under certain circumstances. Specifically, EPA will consider less rigorous isolation procedures (*i.e.*, simpler caps or backfill) if the concentrations at these nodes is less than or equal to the average of the uncapped area of the CU. Remaining nodes (where post-dredging contamination is limited to 6 inches or less in depth)~~Nodes will be ranked by Tri+ PCB concentration. Those nodes that bring the simple average for sediment 0-6 inches above ~~1~~3 mg/kg Tri+ PCB for the unit will be capped ~~also~~. In each sub-unit or CU, backfill will be placed on the remaining uncapped area~~, where the average surface concentration is 1 mg/kg Tri+ PCB or less~~. It is EPA's intention to choose the evaluation basis (1-acre or 5-acre) that minimizes the area required to be capped.

[4] ~~The DoC in an individual core is defined as the bottom of the first segment (typically 6 inches thick) whose TPCB concentration is less than 1 mg/kg. Thus the finding of a TPCB concentration above 1 mg/kg in a post-dredging core at 6 to 12 inches identifies at least 12 inches of contaminated sediment at the location as well as a substantive error in the interpolation of the DoC and EoC at that location.~~

- ~~EPA has chosen to leave the cap or backfill decision threshold at 1 mg/kg Tri+ PCB rather than accepting the Panel's recommendation to raise it to 3 mg/kg Tri+ PCB. This choice is based on the current lack of technical support to confirm that raising the threshold to 3 mg/kg will still achieve the goals of the remedy. As part of the supporting analysis for the ROD, EPA conducted extensive model simulations based on remedies that utilized the 1 mg/kg cap or backfill threshold. Given expectations at the time of the ROD and the preparation of the original peer-reviewed EPS (EPA, 2004), EPA did not conduct any analysis to examine the impacts of capping at a 3 mg/kg Tri+ PCB threshold. In particular, raising the threshold to 3 mg/kg Tri+ PCBs raises the residuals concentration and associated PCB mass essentially three-fold in areas whose cover (*i.e.*, the backfill) is considered sacrificial and will not be maintained through time. Thus, these areas have the potential to release about 3 times as much Tri+ PCB when the sacrificial layer is lost, relative to what was originally simulated in the modeling analysis. Without further modeling analysis, the importance of this change in conditions is not known. The Panel's assertion is correct that much of the surrounding areas are more contaminated than 3 mg/kg (*e.g.*, up to 10 mg/kg Tri+ PCBs in River Section 1 and up to 30 mg/kg in River Sections 2 and 3). However, this perspective may not have evaluated the importance of having large areas of low concentration to effectively "dilute" the impact of the unremediated areas. This is of greatest importance in River Section 1, where more than 60 percent of the river bottom is to be remediated. It is EPA's intention to reexamine the possibility of raising the cap or backfill threshold through the use of the model currently being developed by GE and EPA once it has been is validated and peer-reviewed.~~ [Note to EPA: This text was deleted because the ROD modeling examined post-backfilling Tri+ PCB concentrations of 0.25 ppm and 0.5 ppm, which represent reductions of 83% to 92% from a residual Tri+ PCB concentration of 3 ppm. This range of reductions is consistent with field experience at other sites.]

- The lateral extent of residuals or inventory capping will be defined by the edge of the CU and by half the ~~perimeter of~~distance to acceptable (*i.e.*, compliant) nodes adjacent to the area required to be capped. ~~The boundaries of 1-acre sub-units will not be used to limit the extent of capping unless they coincide with the CU boundary.~~
- The Peer Review Panel's recommendations support the approach of a single dredging pass to a previously determined design dredge elevation ~~provided that the elevation captures the true DoC (*i.e.*, is below the EoC).~~ .

  The exceptions to this approach involve the navigation channel and shoreline areas, where other considerations may require a second dredging pass.
  - Special considerations apply to dredging conducted in the navigation channel. A single dredging pass will be sufficient in a given area of the navigation channel if, after the first dredging pass, the residual Tri+ PCB concentration is less than or equal to ~~1~~3 mg/kg at every node and there is no PCB inventory or if the first dredging pass is deep enough that after placement of a cap, there will be at least ~~14~~12 ft of draft above the cap at mean low water. Additional post dredging samples may be required in the channel if the prescribed residual sampling grid does not provide sufficient coverage to completely delineate post-dredging contamination. Locations in the channel where the depth after the first dredging pass is less than ~~15~~13 feet and Tri+ PCB concentrations are above ~~1~~3 mg/kg must be dredged in a second

pass to a depth that will allow the placement of a cap, or to the re-defined EoC, whichever is greater. Specifically, if the EoC is not achieved after a single pass within the channel, the subsequent pass will require the removal of all sediment to the re-defined EoC, or to sufficient depth for placement of a cap such that there will be at least ~~14~~12 feet of draft above the cap at mean low water. In this manner, the channel areas will meet the ROD requirements for PCB mass removal and the navigational requirements of the NYS Canal Corporation (NYSCC) in two passes or less~~. Due to the routine maintenance of the channel by NYS prior to the Fort Edward Dam removal in 1974, all material above the elevation equivalent of 14 feet of draft at mean low water is expected to be contaminated with PCBs. This was borne out in Phase 1 as the depth to which contamination was found in the Navigation Channel was greater than 14 feet at most locations. Thus this requirement does not entail the removal of extensive amounts of clean sediment, if any. All caps in the navigation channel must be appropriately designed high velocity caps. Because the channel will continue to undergo routine maintenance by the NYSCC after completion of the remedy, it is important that all remedially applied layers (*i.e.*, backfill or cap material) be placed below the canal maintenance level of 14 ft below mean low water, as noted by the Peer Review Panel. Thus, no backfill will be placed in the navigation channel unless there is 15 ft of draft available prior to placement~~.

  - For shoreline areas where the DoC is greater than the depth allowed by the stable side slope considerations (defined as 3 horizontal to 1 vertical or existing side slope if steeper), if TPCB concentrations in sediments below the design dredge elevation (defined as 4-inches below the EoC) are equal to or greater than 50 mg/kg, these sediments must be removed. If TPCB concentrations in sediments below the design dredge elevation are less than 50 mg/kg, additional dredging can be performed or a cap can be placed based on the capping criteria defined below in Section 2.2.1 and the Phase 2 Final Design. Shoreline nodes will not be included in the calculation of 1-acre sub-unit and 5-acre CU averages. ~~In the event that shoreline cores are not available prior to dredging in a shoreline area, the initial removal at the shoreline shall be 2 feet, following the stable slope requirements out to the area bounded by dredging design cores (existing SSAP and newly collected cores).~~

- The success of the design of the Phase 2 elevations and the single-pass dredging approach will be ~~evaluated based on a number of criteria, including the extent of capping relative to backfilled areas~~areas achieved through compliance with capping limits. To evaluate the capping component, it will be necessary to track the extent of capping as well as the basis for cap selection. The basis for cap selection and extent will be classified into the following categories:
  - Structural Offsets and Cultural Resources
  - Presence of Bedrock
  - Presence of glacial Lake Albany clay (GLAC)
  - Shoreline stability areas
  - Low Residual Concentrations (~~less than 15 mg/kg~~concentrations causing the CU average Tri+ PCB concentration to be between 3 and 6 ppm)
  - High Residual Concentrations (concentrations causing the CU average Tri+ PCB concentration to greater than ~~or equal to 15 mg/kg Tri+ PCB)~~
  - ~~Inventory (TPCBs greater than 1 mg/kg in sediments below 6 inches~~6 ppm)

Of these, the capping required for Structural Offsets and Cultural Resources will not count in the total area basis nor in the area capped total. Similarly, the presence of bedrock and GLAC and shoreline stability limitations on dredging are considered conditions beyond GE's control, and therefore capping in these areas will not count in the percentage area capped when evaluating the success of the design and single pass approach. ~~For the remaining three categories, up to XXX, YYY and ZZZ percentage~~Finally, the low residual concentration category, which has little potential impact on remedy benefits, will not count toward the capping limit. For the high residual concentration category, up to 10 percent of the area dredged will be allowable~~, respectively. These percentages reflect~~. This percentage reflects the preference of the ROD for a dredging remedy, keeping capping to a minimum. This is further discussed in Section 3. ~~As noted previously, if these percentages are exceeded during Phase 2, EPA will require changes to the design dredge elevation in remaining CUs. The initial review of the success of the design and single-pass approach will be conducted after several CUs are completed during the 2011 dredging season~~

Any adjustments to the approach between seasons should also account for year-to-year variability. Therefore, changes will not occur unless a certain percent threshold above the capping percent limit is exceeded. This will allow for year to year variability that may occur and still keep the project on track to meet the definition of success from a capping limit – 10% or less of the Phase 2 footprint for the high residual concentration caps. In a five year program, the first two years has to be within 120% of the capping limit (i.e., 12% of the total remediated Phase 2 area); the third year, 115%; the fourth, 110%; and the final year, at the capping limit of 10% of the total remediated Phase 2 area.

- The standard reflects the ROD's preference for dredging over capping. The ROD requires that backfill be applied where appropriate. Backfill may not be appropriate for use in the navigation channel when the residual surface concentrations is equal to or less than the residual requirement of ~~1~~3 mg/kg Tri+ PCBs but the draft below mean low water is less than the navigational requirements (It was noted in the Responsiveness Summary to the ROD that backfill may not be required in the navigation channel). Additionally there may be certain areas where habitat requirements restrict the placement of backfill. The backfill design, the cap design and the development of design criteria for backfill and cap selection have been intentionally left to the final Phase 2 design of the project.

2.1.2 Fundamental Principles for Development of the Phase 2 Resuspension Standard

Principles for development of the Phase 2 Resuspension Standard are as follows:

- Concentration criteria are needed to maintain water column PCB levels that do not exceed the MCL at Lower Hudson public water supplies ~~and private users in the Upper Hudson~~ under the requirements of the Safe Drinking Water Act. Private users in the Upper Hudson will addressed on a case-by-case basis by providing alternate water supplies or treatment.
- Operations should be conducted to minimize long-term downstream transport and redistribution of PCBs.
- Short-term impacts to the water column resulting from the remediation are acceptable provided that the goals of the remediation defined in the ROD are met.

- Along with the lessons learned during Phase 1, EPA is currently working with GE to develop a model for the Upper Hudson River that will aid, in conjunction with actual data (including fish tissue and sediments) in assessing any potential impacts of dredging-related PCB releases.
- Water column monitoring is needed outside the immediate vicinity of the dredging operations, to establish upstream baseline values, to address potential impacts of the full range of remedial operations, and to document water quality in the Lower River throughout the remediation.
- Water column monitoring is needed in the near-field at least in the first year of Phase 2 to assess the impacts of various dredging-related operations as well as to understand the nature of PCB release and subsequent fate.
- The primary means of contaminant release (PCBs) is believed to be in dissolved ~~or NAPL~~ form, based on the limited number of near-field measurements that show high "dissolved" ~~or "aqueous"~~ phase concentrations of PCBs and low suspended solids concentrations. As such, the Phase 2 standard cannot rely on measurements of suspended solids concentrations or a real-time surrogate as an early indication of TPCB release.

2.1.3 Fundamental Principles for Development of the Phase 2 Productivity Standard

Principles for the development of the Phase 2 Productivity Standard are as follows:

- The Productivity Standard targets 350,000 CY per year, inferring but not requiring a seven to nine year time frame for the completion of dredging. Allowing this flexibility to the Productivity Standard is recommended by the Peer Review Panel, based on a variable estimate of the volume necessary to be removed. The volume and spatial extent of Phase 2 are sufficient to allow compliance with the other two standards as well as the Productivity Standard itself.
- In addition, as the Peer Review Panel recommended, an area-based element to the Productivity Standard will be useful in assessing the progress of the operation, since reduction of surface concentration is one of the ROD goals.
- Faster dredging does not necessarily equate to a higher resuspension rate. Based on experience gained during Phase 1 and from other environmental dredging projects, dredging slower, as well as faster than an optimal operating range, may increase resuspension.
- ~~While it is desirable to meet the Productivity Standard, satisfaction of this standard must not come at the expense of the long term goals of the project~~Phase 2 should be completed as quickly as practicable to realize the intended benefits of the remedy at the earliest time.

2.2 The Phase 2 Standards

This section provides a brief statement of the criteria for each of the standards. Additional details on the implementation and supporting discussion for each of the standards can be found in Sections 3 through 5.

2.2.1 Residuals Standard

The *Performance Standard for Dredging Residuals for Phase 2* (referred to as the Phase 2 Residuals Standard) is designed to detect and manage contaminated sediments that may remain after initial dredging in the Upper Hudson River. It is also designed to confirm that the EoC has been accurately identified and interpolated. The residual sediments may consist of:

- Contaminated sediments that were disturbed but escaped capture by the dredge.

- Resuspended sediments that were redeposited (settled).
- Contaminated sediments remaining below the design dredging cut elevations (e.g., due to uncertainties associated with interpolations between pre-design sampling nodes or insufficient core recovery).

The EPA's 2002 ROD states that the selected remedy includes the "removal of all PCB-contaminated sediments within areas targeted for remediation, with an anticipated residual of approximately 1 mg/kg Tri+ PCBs (prior to backfilling)." The primary objectives of the revised Residuals Standard for Phase 2 dredging are:

- Achieving, with a single dredging pass, the design DoC elevation (also known as the EoC) ~~in 95% of the dredge areas~~.
- Achieving, with a single dredging pass, a residual concentration of ~~no more than~~ 1 mg/kg Tri+ PCBs, with subsequent backfilling, while minimizing the need for capping;
- Identifying areas where capping is needed because the residual sediment arithmetic average Tri+ PCBs concentration is greater than ~~1~~3 mg/ kg Tri+ PCBs in the top six inches;
- Identifying areas where capping is needed because PCB contamination remains at depth after dredging is complete;
- Discerning and mapping the extent to which EoC has been accurately identified and interpolated as a basis to revise the Residuals Performance Standard criteria and the Phase 2 design in the event that the extent of capping for either residuals or inventory exceeds the limits on capping that are set forth in Section 2.1.1 above.

The requirements of the Phase 2 Residuals Standard are listed below which outlines how the Residuals Standard will be used to accomplish these objectives. As indicated in the table, a single-pass approach to dredging requires an accurately defined EoC that ~~also incorporates~~takes account of the uncertainty of the DoC measurement and the EoC interpolation process. ~~Without that, the ROD's objective of "removal of all PCB-contaminated sediments within areas targeted for remediation, with an anticipated residual of approximately 1 mg/kg Tri+ PCBs (prior to backfilling)" will not be met.~~

Statement of the Residuals Performance Standard

1. Upon completion of a single dredging pass to a previously determined Design Dredge Elevation ~~(*i.e.*, the elevation of contamination less the 4 inches to account for dredge tolerance) and achievement of the EoC in 95 percent or more of the dredged area within an 1-acre sub-unit~~, post-dredging cores will be collected 80-ft on center offset 46 feet (at the midpoint between nodes) from the original sampling grid (SSAP grid) for a minimum of 40 core sites per CU (8 core sites per 1-acre sub-unit). Post-dredging cores will be collected to 4 feet or bedrock, whichever is encountered first. Cores will be analyzed for PCBs (both TPCB and Tri+ PCB) down the entire length of the core, or to the occurrence of glacial Lake Albany clay. Post-dredging cores will also be collected in shoreline areas to sample the wedge left behind due to engineering constraints; sampling density of these cores will be the same as in Phase 1 (100 feet on-center). Additional post-dredging cores may also be required in the navigation channel to define the capping or additional dredging required there. The collection of data on the EoC in the CU after dredging will allow the evaluation of the success of the EoC

interpolation and the subsequent Phase 2 dredging prism design. These analyses are necessary to calculate the inventory volume remaining and to assess the design's success in capturing the EoC.

2. A 3 to 6-inch layer of cover material (*e.g.*, Type 2 backfill) will be placed over the dredged CU (or sub-unit) immediately after post-dredging sampling, with the exception of areas in the navigation channel. EPA anticipates that the initial cover will be amended with organic carbon but the final selection of material for the initial cover will be completed as part of the Phase 2 Final Design.
3. Post dredging cores will be segmented into 6-inch intervals. Each 6-inch interval of the post-dredging cores will be analyzed for TPCBs and Tri+ PCBs~~ until 2 consecutive 6-inch intervals have TPCB concentrations below 1 mg/kg. If two consecutive segments~~. If one segment that ~~have~~has TPCB concentrations below 1 mg/kg ~~are~~is not found, a second 8-foot core will be collected and the bottom 4.feet will be segmented into 6-inch intervals and analyzed. This process will continue until ~~two consecutive~~one 6-inch ~~segments~~segment with TPCB concentrations below 1 mg/kg ~~are~~is identified or glacial Lake Albany clay or bedrock is encountered.

~~4. After the single dredging pass, the post-dredge sampling results will be documented and used to characterize the nodes of the CU (or sub-unit) into one of four categories:~~

   ~~a. Inventory is present in some or all areas (*i.e.*, sediment below 6 inches contain TPCB concentrations greater than 1 mg/kg).~~

   ~~b. High residual concentrations are present (the average surface concentration of all nodes exclusive of those with inventory is greater than 1 mg/kg Tri+ PCB wherein the residual values causing the higher mean are greater than or equal to 15 mg/kg Tri+ PCB.~~

   ~~c. Low residual concentrations are present (the average surface concentration of all nodes exclusive of those with inventory is greater than 1 mg/kg Tri+ PCB wherein the residual values causing the higher mean are less than 15 mg/kg Tri+ PCB.~~

   ~~d. The standard is met or almost met (the average concentration of all nodes exclusive of those with inventory or unacceptable residual is 1 mg/kg Tri+ PCB or less).~~

4. ~~5.~~ The decision to backfill or cap the CU (or sub-unit) will depend on whether the mathematically averaged surface Tri+ PCB concentration in the a sub-unit or CU are equal to or less than ~~1 mg/kg, exclusive of those nodes where inventory has been identified. All inventory nodes will be capped, unless EPA permits otherwise~~3 mg/kg. If the average surface concentration in the sub-unit or CU (excluding the inventory nodes) exceeds ~~1~~3 mg/kg Tri+ PCBs, ~~non-inventory~~ nodes will be capped such that the average of the remaining area is less than ~~1~~3 mg/kg Tri+ PCB. Detailed instructions for backfilling or capping the sub-unit are provided in a flow diagram (presented as a figure in Section 3). Caps must extend half the distance to the ~~perimeter of~~nearest compliant nodes or the edge of the CU. ~~There must be at least 2 and more typically 3 adjacent nodes at or below the 1 mg/kg Tri+ PCB level to define a backfill area.~~
5. ~~6.~~ If the depth after the first pass in an area of the navigation channel is less than ~~15~~13 feet below mean low water and individual Tri+ PCB concentrations exceed ~~1~~3 mg/kg, a second dredging pass to a depth that will allow the placement of a high velocity cap will be required. In addition, no backfill will be placed in the navigation channel unless there is ~~15~~13 ft of draft available at mean low water prior to placement. If capping is necessary in the navigation channel, its design and implementation must be such that the top of the cap allows for a minimum of ~~14~~12 feet of draft at mean low water to allow for future maintenance dredging by the NYS Canal Corporation (NYSCC).
6. ~~7.~~ For shoreline areas where the EoC surface is steeper than the stable side slope (defined as 3 horizontal to 1 vertical or existing side slope if steeper), if TPCB concentrations in sediments below the design dredge elevation (typically equivalent to an initial 2-ft removal) are equal to or greater than 50 mg/kg, these sediments must be removed. If TPCB concentrations in sediments below the design dredge elevation are less than 50 mg/kg, additional dredging can be performed or a cap can be placed based on the capping criteria. The shoreline area will be evaluated as part of the CU and not as a separate area for capping purposes.

~~8. In the event that shoreline cores are not available prior to dredging in a shoreline area, the initial removal at the shoreline shall be 2 feet, following the stable slope requirements out to the area bounded by dredging design cores (existing SSAP and newly collected cores).~~
~~9. For nodes identified for capping, GE may petition EPA for relief from the capping requirements if the concentrations in the surface and subsurface sediments are less than or equal to the average of the uncapped area of the CU.~~

7. ~~10. After several CUs are completed~~At the end of each dredging season, the results of the single-pass dredging approach will be evaluated ~~to determine whether dredging is achieving the true EoC and the ROD's cleanup objective is being met~~against the capping limits. The design EoC and the Design Dredge Elevation ~~will~~or the approach to dredging may be adjusted in accordance with the AMP ~~within seasons and~~ between seasons, as needed to ensure that the percentage of capping does not exceed the ~~percentages~~percentage specified above.

In addition to the discussion of the Phase 2 Residuals Standard in this subsection, Section 3, *Technical Basis and Implementation of the Residuals Standard*, provides the technical background and approach, supporting analyses, rationale for the development of the standard, and a full version of the Phase 2 Residuals Standard. The following subsections briefly describe the action levels, sampling requirements, and decision points included in the Phase 2 Residuals Standard.

2.2.1.1 Application of the Residuals Standard Criteria

The Phase 2 Residuals Standard refers to each dredged area to be evaluated as a 1-acre sub-unit within a 5-acre CU, and uses a group of action levels to evaluate the sediment quality in each sub-unit as well as the entire CU after dredging. Certification units are defined as 5-acres in size, based on the average size of existing targeted areas. Once it has been confirmed that the dredging has reached the ~~EoC at 95 percent or more of the area within a particular 1-acre sub-unit~~required elevations, 8 sediment cores are to be collected. Each core should be advanced to obtain four feet of sediment or until refusal. Each core is then segmented in 6 inch intervals beginning at the sediment surface, with each core segment analyzed for its Tri+ PCB and TPCB concentrations. Segments comprised entirely of glacial Lake Albany clay do not require analysis. The results for the individual cores are compared on both a sub-unit and a CU basis to the action levels for the Phase 2 Residuals Standard, which are associated with the required actions summarized below.

Core segments for 0 to 6 inches are used to characterize surface contamination. Core segments from deeper intervals are used to identify the presence of inventory. Specifically, deeper core segments will be collected and analyzed until a compliant horizon is encountered (see below). This is necessary to ensure that the vertical extent of contaminated residual sediment is adequately characterized prior to implementing the required actions of the Phase 2 Residuals Standard (*e.g.*, backfilling or capping).

As part of the simplification of the standard, the Phase 2 Residuals Standard now includes review of the following:

- Tri+ PCB concentrations in all individual sediment samples;
- Mean (*i.e.*, arithmetic average) Tri+ PCB concentration in the top six inches of post dredging cores collected from the sub-unit or CU exclusive of sites with contamination at depth (inventory) which are automatically selected for capping.

~~The standard will be revised by EPA as necessary during and at the end of each Phase 2 dredging season for application to the remainder of each season as well as future seasons, in accordance with the AMP, based upon cumulative site-specific knowledge gained from each successive dredging season of the remediation.~~

2.2.2 The Resuspension Standard

The *Performance Standard for Dredging Resuspension during Phase 2*, hereafter referred to as the Phase Resuspension Standard, is designed to limit the export of PCBs from sediment during remedial dredging and to protect downstream water quality. The Phase 2 Resuspension Standard addresses both long-term and short-term impacts in terms of long-term and short-term criteria. In general, short term criteria are intended to aid in setting operational controls for resuspension so that long term impacts can be minimized. Long-term criteria are intended to help secure the long-term recovery of the river and its biota. The Phase 2 Resuspension Standard for water quality is the control level concentration of ~~500 ng/L TPCB~~750 ng/L TPCB at the Waterford far field monitoring station and 2,000 ng/L at Thompson Island and Lock 5 far field monitoring stations. The summary of the framework for this standard is listed in the box below.

Statement of the Resuspension Performance Standard

1. Far-field sampling at Thompson Island, Schuylerville, and Waterford will comprise the main monitoring stations for determining compliance with the Resuspension Performance Standard. These stations will be sampled daily by collecting 24-hour composite samples. ~~Stillwater will be sampled weekly until dredging begins in River Section 3 at which time it will be sampled daily akin to the other stations.~~
2. Water column TPCBs concentrations will be compared to the control level of ~~500 ng/l~~750 or 2,000 ng/lL depending on the far field station. Exceedances of this threshold may require operational changes, monitoring contingencies, engineering evaluations and engineering solutions, at EPA's discretion.
3. ~~The Water Column TPCBs concentration of 350 ng/L will be retained by EPA as an Advisory Level. At its discretion, EPA may use this Advisory Level as a basis to recommend engineering evaluations and solutions.~~
3. ~~4.~~ The Thompson Island (TI) and Waterford stations are designated as the compliance monitoring stations for PCB load due to dredging-related activities, provided that the dredging operations are greater than ~~1-mile~~2-miles upstream from these stations. These loads are assessed as the increase over baseline loads (i.e., they are net loads). Estimation of baseline and net PCB loads is described in Section 4.4. The cumulative net Tri+ PCB load criteria (dredging release rate) as measured at TI and Waterford will be 2 percent and 1 percent, respectively, of the Tri+ PCB mass dredged during the dredging season (starting with Year 1 of Phase 2). The methodology for calculating the Tri+ PCB mass to be dredged is provided in Section 7. These thresholds will be evaluated and potentially refined for each dredging season based on the mass of PCB that is anticipated to be dredged.
4. ~~5.~~ During Year 1 of Phase 2, the far-field cumulative net Tri+ PCB load criteria are xxx kg and zzz kg as measured at the TI and Waterford stations, respectively, which corresponds to 2 percent and 1 percent, respectively, of the Tri+ PCB mass to be dredged during the season. This is equivalent to a

daily net Tri+ PCB load at the TI and Waterford stations of aaaa g/day and bbb g/day, respectively, based on a 7-day running average. (*These numbers will be supplied after the estimated inventory to be removed during the dredging season has been revised to reflect the results from the additional coring and associated statistical interpolation analyses before the dredging season begins.)*

$$\text{Net Daily Load}\left(\frac{g}{d}\right) = \frac{(\text{Tri} + \text{PCB Mass targeted for dredging in season} \times \%\ \text{allowable release})\ [\text{kg}]}{\text{number of dredging days in season}} \times \frac{1000\text{g}}{1\text{kg}}$$

Where

% allowable release = 2 percent at Thompson Island
= 1 percent at Waterford

5. The total project net cumulative load is the maximum load to the Lower Hudson River allowable without unacceptable impacts on remedy benefits. Based on modeling conducted by GE, EPA has concluded that a net Total PCB load of 3,000 kg is allowed during the project. This load may be revised based on modeling conducted after the model has been refined using the data collected during the first year of Phase 2 dredging. The total project load will be monitored at Waterford and will be allocated to each year of the dredging project based on estimates of the Phase 2 PCB mass to be dredged in each year of the project. This load will be used in conjunction with the percentage-based seasonal loads described above to trigger between dredging years engineering evaluations and operational changes.
6. The permissible net TSS increase in the near-field is 100 mg/L above ambient (upstream) conditions at ~~a location 300 m~~the first near field monitoring transect downstream of the dredging operation~~ or 150 m downstream from any suspended solids control measure, based on a six-hour average concentration. Also, sustained TSS concentration should not exceed 100 mg/L above ambient (upstream) conditions at near-field stations located to the side of dredging operations or 100 m downstream of dredging operations. In addition to TSS, PCB homolog measurements will also be required at each near-field monitoring station.~~.
7. If and when exceedances of the load standards occur, ~~EPA, at its discretion, may require~~ operational changes ~~(not necessarily including shutdown)~~as set forth in the pre-approved list of BMPs, monitoring contingencies, engineering evaluations and engineering solutions may be required. ~~However, EPA reserves its right to require a shutdown, if at any time conditions are deemed unsafe or unacceptable with respect to the goals of the remedy.~~

Detailed definitions of near-field and far-field are presented in Section 4. Additional monitoring requirements for the Lower Hudson are described in Section 4 as well.

This standard, as described in this document, is to be applied during the Phase 2 remediation. ~~The standard will be revised as necessary at the end of each Phase 2 dredging season for application to the remainder of Phase 2, based upon cumulative site-specific knowledge gained from each successive dredging season of the remediation, including monitoring of surface sediments and fish tissue.~~ PCB export as it applies to this Phase 2 standard is defined as the downstream transport of PCB contamination directly resulting from activities associated with the removal of PCB-contaminated sediments from the river bottom.

This definition includes PCBs released by:

- The dredge itself.
- Tender and tugboat movements.
- Barge transport.
- Debris removal.
- Materials handling.
- Other remedial activities.

Like the Phase 1 Standard, the Phase 2 Resuspension Standard does not regulate resuspension within control barriers, except where such resuspension results in unacceptable downstream PCB transport beyond the barriers.

2.2.2.1 Application of the Resuspension Standard

The Phase 2 Resuspension Standard specifies criteria for both formulations of PCBs used throughout the Reassessment RI/FS: TPCBs and Tri+ PCBs. TPCBs refers to the sum of all measurable PCB congeners in a sample, whereas Tri+ PCBs refers to the sum of PCB congeners containing three or more chlorine atoms. To date, this has been defined by GE's modified Green Bay Method (mGBM). ~~However, to further the understanding, a subset of the samples will be analyzed by Method 1668b to more fully and accurately quantify the PCB concentrations and loads on a congener basis. EPA's review of the results of mGBM for 2009 has raised a concern with quantitation for some of co-eluting peaks representing substantive fraction of the mass. As a result the correction factor used to modify the peak 5 mass for BZ4 plus BZ10 is being eliminated from the mGBM (please see October 2010 letter to GE).~~ The water quality requirements for non-PCB parameters such as metals, dissolved oxygen (DO), and pH are addressed in the 401 Water Quality Certification that was developed by the NYSDEC and as will be outlined in the Remedial Action Monitoring Quality Assurance Project Plan to be developed for Phase 2.

Monitoring requirements and the procedure for notifying downstream public water supplies and other private users in the event that PCB concentrations are elevated ~~(*i.e.*, approach or exceeded drinking water criteria)~~ will be provided in a Community Health and Safety Plan developed for Phase 2. The ROD requires development of a Community Health and Safety Plan to protect the community, including persons in residences and businesses, from potential exposures as a direct result of remedial work activities. The Community Health and Safety Plan will provide for community notification of ongoing health and safety issues, monitoring of contaminants and protection of the community from physical and other hazards.

2.2.3 Productivity Standard

Phase 1 consisted of initial dredging during 2009 at a reduced scale with extensive monitoring to evaluate compliance with the 2004 performance standards. The *Performance Standard for Dredging Productivity for Phase 2* includes a target of dredging at 350,000 cubic yards per year, as recommended by the Peer Review Panel. EPA is hopeful that this level of production can be exceeded each year. The Panel also recommended the following:

> "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." (Peer Review Report, page iv)

While the Panel did not recommend a completion date for the project, it is currently estimated that the dredging operation will require 7 to 9 years to remove the remainder of the contaminated sediments that are targeted for removal. As more information is gathered regarding the volume of contaminated sediments to be removed and the annual rate of productivity achieved, EPA will be able to refine its prediction of the total duration of Phase 2.

2.2.3.1 Productivity Standard Criteria

The Phase 2 Productivity Standard establishes a target sediment dredging volume of 350,000 CY for each year of an assumed, seven to nine season dredging schedule to complete the work. This rate results in approximately 70 acres of remediation (14 CUs) per year for the first 4 years of Phase 2, followed by a rate of about 40 acres per year (8 CUs) for the remainder of the project. This change in area per year reflects the deeper deposits of RS-2 and 3 relative to RS-1. Habitat replacement and reconstruction work for areas dredged during the final season will be done in the spring of the following year.

The target dredging volumes have been developed on the basis of the experience gained during Phase 1 and the Peer Review Panel's recommendations, as described in Section 5.2.2, and the EPA assumption that the Total volume of contaminated sediments remaining to be dredged is approximately 2.3 to 3 million CY. The target volumes and areas are to be used for planning and design purposes, and a serious attempt should be made to achieve them. However, they are not firm requirements which must be met in any given year. It is expected that the Phase 2 design will establish a separate target volume and area for each year based on the location of the sediment to be dredged and the difficulty of dredging. It is also likely that adjustments will be required as the project progresses and more data become available to firm up the estimate of the Total volume remaining to be dredged.

The term "Dredging," as used in this Phase 2 Productivity Standard, includes removal of the contaminated sediment, dewatering and disposing of the dredged sediments, backfilling dredged areas with one foot of clean fill as appropriate, and stabilizing shoreline areas disturbed by the work. The volume of dredged sediment to be credited toward meeting each years' target dredging volume includes all inventory, residual and access dredging required to complete the work including side slopes and any overcut.

Stabilization of shorelines and backfilling or capping, where appropriate, of areas dredged during Phase 2 must be completed by the end of the work season (*i.e.* typically late November or early December).

All dredged material should be processed and shipped off-site for disposal by the ~~end of each calendar year~~beginning of the next dredging season. Processed sediment shall not be stockpiled for disposal during the following dredging season.

Planting of riverine fringing wetlands and subaqueous vegetation shall be done in the spring following each year's dredging work unless otherwise agreed to by EPA.

Monthly and annual productivity progress reports shall be submitted to the EPA ~~according to a schedule to be defined by the agency,~~ for use in determining compliance with the Productivity Standard~~. Monthly productivity progress reports will include daily reports of operations that will address the same information required by a USACE Daily Report of Operations for the appropriate dredge type~~. Monthly progress reports will be compared to the production schedule submitted by the Construction manager and will be the primary tool for demonstrating whether the project is meeting the target dredging schedule and for keeping an account of any differences in the volumes of contaminated sediment dredged versus those shown in the design drawings.

At the close of each dredging season, but no later than two weeks after the end of dredging (backfilling and capping may still be in progress), an annual summary report on the total volume and area dredged during the year, with a comparison of that volume and area to the volume and area anticipated in the design, shall be submitted to EPA. Any material that was targeted but not dredged in a given year will be targeted in the next year.

By February 1 of each year of dredging, the construction manager shall provide EPA with a production schedule showing anticipated monthly sediment production for the upcoming dredging season. The schedule should meet or exceed the target dredging volumes defined in the final design unless they have been revised by agreement of EPA and GE (or, if EPA and GE cannot agree, then as determined by EPA).

2.3 Data Quality for the Performance Standards Monitoring Programs

Data Quality Objectives for the Residuals and Resuspension Standards are provided in Sections 3 and 4. Laboratory analytical requirements for monitoring programs required by the Phase 2 EPS will be similar ~~or more stringent than~~ to those in Phase 1 due to the analytical issues observed, particularly in the water column and these are described in the RAM QAPP. On-site laboratory audits and performance evaluation sample analysis programs will be required to evaluate laboratory data quality and facilitate field decisions in advance of full data validation.

2.4 Summary of Special Studies during Phase 2 Dredging

The special studies that will be conducted during Phase 2 are summarized in Table 2.4-1 and described in greater detail in Sections 3, 4 and 5. The following is a summary of the special studies, more details on special studies are provided in the Chapters 3, 4, and 5:

- Diagnostics and pre-dredging sampling of the water column and sediment;
- Near-field array-based monitoring~~ (including vertical integration for TSS and PCBs)~~;
- Water column sampling with vertical integration techniques in the vicinity of dams between far-field stations;
- ~~PCB measurements above and below the confluences with tributaries;~~
- ~~Establish the nature of PCB transport due to boat prop wash and assess how the various factors determined to affect releases from dredging by statistical analysis will be investigated further and used to implement operational controls;~~
- A sediment redistribution study; and
- ~~Evaluation of missed inventory and effectiveness of the EoC/DoC interpolation process in the estimation of uncertainity in the DoC;~~
- ~~Comparison between composite samples and individual post-dredging nodes in a 1-acre sub-unit; and,~~
- Evaluation of PCB contamination outside the dredge prisms resulting from the redistribution of PCBs via dredging-related activities.

2.5 Ongoing Evaluation of Dredging and Possible Refinements during Phase 2

In order to ensure the protection of human health and the environment to the maximum practicable extent, EPA believes, as the Peer Review Panel recommended, that the ongoing Phase 2 remediation efforts in the Upper Hudson River must follow an adaptive management approach that continually relies on the site-specific observations and data from Phase 1and from the first and each succeeding year of Phase 2, as well as a validated, peer-reviewed model. This approach will then seek to improve as appropriate the ~~Phase 2 performance standards and~~ operational practices in the subsequent years of the Phase 2 remediation program. Following such an approach will enable the attainment of the benefits of the remedy in the shortest practicable time and help avoid or minimize any adverse short-term and long-term impacts of implementing the dredging and related efforts.

Therefore, as the Peer Review Panel recommended, the ~~performance standards and the~~ operational practices for the remaining dredging seasons should be regularly re-evaluated for application through the end of the remediation~~. The Phase 2 performance standards will be revised as necessary at the end of each Phase 2 dredging season for application to the remainder of Phase 2, based upon cumulative site-specific knowledge gained from each successive dredging season of the remediation. Adjustments to one or more of these standards may also be made during each Phase 2 dredging season, if sufficient information is obtained during a particular Phase 2 dredging season to identify these changes~~.

Information collected during the Phase 1 experience and Phase 2 design will be used to improve the monitoring and engineering design for Phase 2. Sediment core collection will be completed to refine the depth of contamination estimates in Phase 2 areas as well as the volumes to be removed. GE will not be required to collect all additional data for Phase 2 in one event. Rather, GE may obtain the cores necessary on an annual basis sufficient to refine the following year's dredging design.

Prior to commencement of the 2011 Phase 2 dredging, the offseason monitoring program water column sampling will be conducted and the initial portion of the Phase 2 remedial design sediment sampling will be completed. The additional data from these efforts, collected in parallel to the issuance of these revisions to the EPS, will improve the ability to estimate cumulative PCB loads due to dredging, but ~~are~~will not ~~expected to~~ change the ~~main~~ criteria of the Resuspension Standard. The acceptable rate of PCB loss and the acceptable water column concentrations ~~are~~will not ~~expected to~~ change unless and until ~~Phase 2 provides additional data to form a basis to revise the criteria. These criteria will also be informed by~~ a validated, peer reviewed model ~~when it becomes available~~indicates that such changes are required to meet the identified benefits of the remedy.

Diagnostic studies of the far-field automated sampling stations (to be conducted in 2010 and 2011) are expected to enhance and improve the ongoing water column monitoring program and provide critical information for the ongoing model development.

As a part of the Phase 2 final design, GE is collecting sediment samples throughout the Upper River to more precisely define the vertical extent of contamination, as per the Panel's recommendations. Given the scale of this effort, the sampling will continue for several seasons, while ensuring that all new data required for each upcoming dredge season are available in time to prepare the final design dredge elevations. These data will also be used to revise the estimate of mass to be removed during the remediation.

~~Load~~The annual load load-based criteria in the Phase 2 Resuspension Standard will be adjusted to reflect the revised mass of PCBs to be removed each year based on the results from the Phase 2 remedial design sediment sampling. Adjustments to the daily and annual load criteria may also be made if the length of the dredging season differs greatly from what is anticipated. While these adjustments represent changes to the absolute values for loads, it is anticipated that the percentage criteria of 1 and 2 percent of the mass removed will remain ~~roughly~~ the same throughout the remediation. Thus the anticipated changes referenced here are merely to prorate these percentage criteria to reflect the actual mass and rate of removal. The formulas to incorporate these data and revise the criteria are given in Section 4, the Resuspension Standard. The following sections discuss potential changes to each standard prior to the start of Phase 2.

2.5.1 Possible Refinements for the Residuals Standard

The Residuals Standard shall be reviewed as data on residual contamination and CU closure are obtained during Phase 2, beginning after the completion of the first ~~several CUs. The standard~~year of dredging. The approach to setting DoC and potentially dredging processes will be revised at GE's discretion as necessary during and at the end of each Phase 2 dredging season for application to the remainder of each season as well as the remainder of Phase 2 following the adaptive management processes described in the AMP, based upon cumulative site-specific knowledge gained from each successive dredging season of the remediation. Adjustments ~~to this standard~~at GE's discretion may also be made during each Phase 2 dredging season, including Year 1 of Phase 2, if sufficient information is obtained during a Phase 2 dredging season to identify these changes. Adjustments may include the re-evaluation of the one pass approach as well as adjustments in the incorporation of uncertainty in the DoC/elevation of contamination determination process.

2.5.2 Possible Refinements for the Resuspension Standard

The Peer Review Panel-recommended recharacterization of the sediment to be removed began in the Fall of 2010, and is currently underway. Because this recharacterization is not complete, the mass of PCB to be removed in each year of Phase 2 has not been finalized. Prior to the start of Year 1 of Phase 2, the water column concentrations corresponding to the daily and annual PCB load criteria will be adjusted according to the final production schedule and estimated mass of PCBs to be removed in 2011 (see the calculation in the text box in Section 4 to see how the length of dredging and estimated mass are related to determine ~~daily and~~ annual loads). The allowable ~~daily and~~ annual loads and the associated allowable concentrations will be presented with the dredging design for each year of Phase 2.

In addition to the estimates of mass removal and associated loads due to dredging, there is also a list of tasks to be performed prior to Phase 2 to determine best estimates of the new updated baseline water column levels and the dredging-related load criteria, provided below:

1. Review the 2004 through 2008 Baseline Monitoring Program data and offseason monitoring data through 2010.
2. Calculate the mean concentration and upper 95th percentile confidence limit (UCL) of the mean for all far-field stations to establish baseline concentrations by month, corrected for flow variation as appropriate.
3. Revise the PCB ~~daily and~~ annual load criteria to reflect 1 and 2 percent of the revised inventory estimates, incorporating the additional sampling completed in response to the Panel's recommendations, beginning with the 2010 program. This information should be available in the Phase 2 final design reports.
4. Revise the PCB load limits to adjust for differences in the length of the dredging season and incorporate the information from the Baseline Monitoring Program data, the Phase 1 monitoring data, and offseason monitoring data through 2010.

2.5.3 Possible Refinements for the Productivity Standard

As discussed previously, the results of the Phase 2 final design sediment sampling program currently underway will be used to finalize the delineation of Phase 2 target dredging areas for the first year of Phase 2. This program will be continued annually in subsequent years ~~to satisfy the Panel's recommendation, with~~, sampling areas during the year prior to the planned year of dredging for that area. This subsequent sampling will be used to finalize the volume and mass estimates for later years of Phase 2. These results will also be used with existing data to facilitate adjusting the ~~calculation~~forecast of an overall project dredging estimate in terms of cubic yards of contaminated sediment to be removed. ~~If at the end of Phase 2 final design sediment sampling program, the total estimated removal volume for the Phase 2 final design differs by more than 10% from the current estimated project volume~~As additional refinements to the forecast of overall cubic yards of sediment to be dredged are made, the Phase 2 schedule forecast will also be ~~amended~~updated to allow for the additional volume by extending the schedule ~~unless~~ , and adjusting for efficiencies ~~developed~~achieved during in Phase ~~2 can make up the additional volume by dredging greater volumes annually.~~2. The revised forecast of Phase 2 volumes shall be prepared as part of the design addendum to be submitted prior to each dredging season. That is, a revised estimate of the Total mass and volume of sediment and PCBs (both Total and Tri+ PCBs) to be removed will be prepared with each design addendum, reflecting the data available at the time of the addendum.

3 Residuals Performance Standard

3.1 Overview of Phase 2 Residuals Standard

The United States Environmental Protection Agency's (EPA) 2002 Record of Decision (ROD) states that the selected remedy includes the "removal of all PCB-contaminated sediments within areas targeted for remediation, with an anticipated residual of approximately 1 mg/kg Tri+ PCBs (prior to backfilling)." Based on the experience gained in Phase 1, the Peer Review Panel recommended that the dredging be completed in a single pass and that the CU proceed directly to closure. This approach will be implemented for Phase ~~2, subject to possible changes through adaptive management.~~2. As the Peer Review Panel stated, an accurate definition of the EoC, which accounts for uncertainty, is the foundation of a successful single-pass dredging program. The primary objectives of the revised Residuals Standard for Phase 2 dredging are:

- Achieving, with a single dredging pass, the design DoC elevation (also known as the EoC) ~~in 95% of the dredge areas~~.
- Achieving, with a single dredging pass, a residual concentration of ~~no more than~~ 1 mg/kg Tri+ PCBs, with subsequent backfilling, while minimizing the need for capping;
- Identifying areas where capping is needed because the residual sediment arithmetic average Tri+ PCBs concentration is greater than ~~1~~3 mg/ kg in the top six inches;
- ~~Identifying areas where capping is needed because PCB contamination remains at depth after dredging is complete;~~
- Discerning and mapping the extent to which EoC has been accurately identified and interpolated as a basis to revise the Residuals Performance Standard criteria and the Phase 2 design in the event that the extent of capping for either residuals or inventory exceeds the limits on capping that are set forth in section 2.1.1 above.

The ~~performance~~success of the single dredging pass approach will be ~~evaluated in accordance with the AMP and modified as necessary for subsequent Phase 2 dredging (including in-season, if necessary)~~achieved through established capping limits and implementation, if necessary, of pre-approved BMPs. The issue of contaminant redistribution to areas outside the CU boundaries is not strictly part of this standard but is examined as part of a special study described in Section 3.5.

3.2 Phase 1 Observations and Additional Data Needs in Support of the Residuals Standard for Phase 2

The Phase 1 effort had many successes; however, the information gathered during Phase 1 also provides a basis to improve and streamline the performance standards specific to Hudson River conditions. As described in the Engineering Performance Standards document (EPA, 2004), it was anticipated that changes to each of the performance standards would be facilitated and guided by the observations, successes and problems that arose in Phase 1.

The Phase 1 Residuals Performance Standard was developed with the expectation that the DoC would be accurately defined by the remedial design sampling program (*i.e.*, the SSAP cores) and that the designed dredging cut lines would be sufficient to target existing PCB inventory for removal. Additionally, there was provision in the Phase 1 Residuals Standard for multiple dredging passes to address unacceptable residual concentrations or the presence of unanticipated inventory below the estimated DoC used in design. The dredge design elevations were also expected to address uncertainty and thus minimize 'missed' inventory (and the number of dredging passes); however, this was not implemented in the final Phase 1 design.

During Phase 1, the majority of the re-dredging passes conducted in the CUs removed inventory that was not adequately characterized prior to design. The Phase 1 design dredge elevations were set too shallow in ~~general~~many locations; many times even post-dredging cores did not fully penetrate the depth of the contaminated sediments. It is concluded from the Phase 1 data that the Residuals Standard can be appropriately implemented and readily achieved during Phase 2 if the DoC is better characterized and appropriate measures to address uncertainty are incorporated in the design DoC elevations (*i.e.*, EoC).

To reflect the lessons learned during Phase 1, and in keeping with the recommendations of the Peer Review Panel, the Residuals Standard has been simplified for Phase 2 to accelerate CU closure by establishing a single-pass dredging design followed by rapid isolation of remaining sediments and quickly dealing with residuals through backfill or capping.

To support this approach, the data on which the Phase 2 design is developed must be improved, including the following (this work has begun as of the date of this document):

1. Resample all the incomplete design cores to more accurately define the DoC and EoC for all the CUs in Phase 2 with an acceptable statistical uncertainty.
2. Resample 20 percent of the Level 1A (complete) cores to assess uncertainty in the DoC estimates derived from these cores.
3. Augment the existing design core data set to achieve a sampling density in all areas to be dredged of 80 feet on center by collection of additional cores.
4. ~~Achieve a minimum of 80 percent recovery in all new cores collected and adjust the sampled interval depths and associated DoC estimates for existing SSAP core data to compensate for core recoveries.~~
4. ~~5.~~ Use the results from the uncertainty analysis to adjust the design DoC elevations (EoC).

3.3 Implementation of the Residuals Standard

The Residuals Standard covers the collection and analysis of sediment samples representing dredging residuals in all Phase 2 target areas and describes the procedures by which the sediment sampling data will be used to characterize residuals, evaluate the effectiveness of the dredging remedy, and plan post-dredging construction actions.

The Residuals Standard is comprised of the following tasks (refer to Figure 3.2-1a through f for the flow diagram):

- Verification that the design (modeled) DoC elevation (EoC) has been achieved~~in 95 percent of the 1-acre sub-unit of the CU~~.
- Sample Collection and Analysis
- Initial Cover Placement
- Evaluation of Sample Data

- Required Actions

Each of these tasks is addressed below.

3.3.1 Verification of Design Dredge Elevations

The Phase 2 dredge elevation design will incorporate the new data collected in 2010 and include a revised DoC, an associated elevation of contamination that also includes engineering considerations (Engineered EoC Surface), and a design dredge elevation comprised of the ~~elevation of contamination plus a 4-inch dredge tolerance, as recommended by the Peer Review Panel. Per the Peer Review Panel's recommendation, "[a] *dredging pass will be deemed to be successfully completed in a given sub-unit once 95% or more of the subunit is at or below the DoC elevation*," (pp 59, Peer Review of Phase 1 Dredging, Final Report, 2010). Also per the Panel, "*individual small contiguous areas of less than 3 sq ft each that protrude above the DoC Elevation* [will not be included] *in the calculation of achieving 95% of the post-dredge surface below the DoC Elevation*". In order to perform the verification with the recommended exclusion, comparisons will be performed as measured on a 1x1-ft grid. Figure 3.2-1a presents the flow logic diagram for the verification of the design dredging elevation and placement of the initial cover layer.~~Engineered EoC Surface and an overcut to set the dredge prism elevations equating to the 60th percentile estimate of a revised DoC or the 50th percentile estimate of a revised DoC plus 4 inches, whichever is greater (Dredge Prism). The dredging contractor will be required to meet the following two criteria: a revised DoC or the 50th percentile estimate of a revised DoC plus 4 inches, whichever is greater. The dredging contractor will be required to meet the following two criteria:

- No more than 5 percent of the final elevations are above the engineered EoC Surface; and
- The volume dredged below the Dredge Prism is equal to or greater than the volume that remains above the Dredge Prism

As part of the completion of this task for each CU, post-dredging bathymetry maps and grid electronic files must be provided to EPA for verification purposes as soon as they are completed, and they should consist of the following:

- Maps and grid files of target and post-dredging elevation. The maps should be submitted in 1x1 foot grid spacing, but the grid files should be submitted in 1x1 and 10x10-foot grid spacing as well as the original compiled raw data.
- ~~Maps and grid files of the dredging removal thickness. The maps and the grid files should be submitted in both 1x1 and 10x10-foot grid spacing.~~

3.3.2 Sample Collection and Analysis

~~During the Phase 1 dredging effort, for many post-dredging cores, only the top 6-inch segments were analyzed, consistent with the Phase 1 Residuals Standard, but missing an opportunity to re-characterize the DoC. In the revised Residuals Standard, the~~The post dredging cores will be analyzed on 6 inch intervals to a depth of 4 feet, bedrock or glacial Lake Albany clay, whichever occurs first. The results of the entire core will be used to determine the response action. The results of the segments below 6 inches will be used to quantify the amount of PCB mass (if any) left behind. ~~In all cases, the DoC must be well-defined by a minimum of two contiguous 6-inch core segments at 1.0 mg/kg TPCB or less. If two~~If one clean (*i.e.*, 1 mg/kg TPCB or less) 6-inch ~~segments are~~segment is not found within 4 feet, an additional 8 foot core will be collected at that node location, and the bottom eight 6-inch segments analyzed, providing at least 1 foot of overlap between the original and subsequent cores based on absolute elevation. This process will be repeated by collection of still deeper cores until ~~two~~one consecutive "clean" (*i.e.*, 1.0 mg/kg TPCB or less) ~~segments are~~segment is found.

~~Also, the experiences gained from Phase 1 and the previous design sampling investigations show that Vibracore collection is not a consistently reliable method to obtain cores for DoC determination due to frequent poor recoveries (more than 25 percent of Phase 1 area Level 1A cores had recoveries less than 70 percent) as well as refusal caused by the presence of woody debris in the subsurface.~~ If post-dredging sampling by Vibracore does not~~: a)~~ reach a sufficient depth to produce ~~two consecutive~~a core ~~segments~~segment with less than 1 mg/kg TPCB, needed to confirm DoC~~, and b) yield core recoveries greater than or equal to 80 percent,~~ then an alternative sampling method that will produce sufficient core length ~~must~~may be employed. This alternative method may include test pitting using a dredge; collecting cores using other drilling methods, such as geoprobe, roto-sonic, or rotary drilling rigs; conventional split spoon sampling; or other method approved by EPA. The 2010 sample program being conducted by GE is testing the use of sonic coring methods.

3.3.2.1 Sample Collection

Post-dredging sediment sample collection will take place promptly once the design DoC elevation (EoC) has been achieved in 95 percent or more of a 1-acre sub-unit but prior to the placement of any cover layer, consistent with Figure 3.2-1a.

Post-Dredging Sampling Grid

The post-dredging sampling grid will follow the same design as used in Phase 1. Sampling at 80-foot centers, as required for Phase 1, represents the absolute minimum acceptable sampling density; a wider spacing of core samples would not be acceptable. The basic assumptions underlying the framework of the Residuals Standard have been largely borne out by the observations of Phase 1. Specifically, residuals have poor spatial correlation and form a skewed distribution, which can be approximated as log-normal.

The cores of the residual sediment will be collected at 40 locations in each 5-acre CU. The cores will be collected on a regular triangular grid developed to maximize the spatial distribution of samples within each dredged area. ~~This grid should be offset from the design support sampling grid so that the average distance between the design grid nodes and the residuals grid nodes is roughly 46 feet. Essentially, each post-dredging sampling location is placed in the center of the triangle formed by three pre-dredging sampling locations.~~ In the event an obstruction is encountered (*e.g.*, a grid node "falls" on exposed bedrock), the sample is to be relocated within a 20-ft radius of the original location.

The following guidelines remain unchanged from Phase 1 and will be used for implementation of a sampling grid on certification units other than 5-acres in size:

- Isolated dredging areas smaller than 5-acres in size are to be designated single certification units and 40 residual sediment cores must be collected on a triangular grid with a proportionate spacing.
- Noncontiguous dredging areas smaller than 5 acres in size and within 0.5 miles of one another can be "corralled" into a single certification unit; the sum of the grouped dredging areas must be less than 7.5 acres. If the sum of the grouped areas is still less than 5 acres, the sampling grid is to be proportionally sized so that a minimum of 40 cores is collected from within the dredging areas.

Otherwise, within areas grouped into a single certification unit with a total dredged area of 7.5 acres, up to 60 cores are to be collected by applying the 80-ft grid spacing.

- If a number of noncontiguous dredging areas smaller than 5 acres in size are contained within a common resuspension containment barrier during dredging, the construction manager must submit a proposal to EPA that explains how the dredging project will be managed to minimize the spread of significant contamination to the interstitial, non-targeted areas, or propose additional sampling to investigate those areas during the residuals sampling in the CU (see Special Studies Section 3.5).
- Dredging areas up to 7.5 acres in size can be considered a single certification unit and the sampling grid can be extended at an 80-ft spacing to allow collection of up to 60 core samples.
- For dredging areas between 7.5 and 10 acres in size, the dredging area is to be divided into two CUs with approximately equivalent areas and 40 samples collected from each using proportionally sized grids.
- Dredging areas larger than 10 acres in size are to be divided equally into approximately 5-acre certification units and a triangular grid with 80-ft spacing established in each certification unit. (For example, a 32-acre dredging area would be divided into six certification units, each 5.33 acres in size.)

Sample Collection Method

The sediment samples will be collected via coring, using Vibracoring or other methods approved by EPA. Core samples will be retrieved in clear Lexan® (or other appropriate) sleeves or liners. Where Vibracoring techniques are used, the Vibracoring rig will be activated at the sediment water interface and used throughout the depth of the core. Where difficult conditions preclude collection of core samples, for example shallow bedrock, sediment samples will be collected using small grab samplers (*e.g.,* ponar dredge). The core sampling locations are to be located using GPS and referenced to an appropriate horizontal coordinate system and vertical datum at the time of collection. The core sampling location data is to be recorded with the other information collected in the field. Core collection will target a recovery of 80 percent or higher. ~~Cores may require an adjustment to the measured contamination depths to account for the recovery.~~

Prior to core collection, sediment probing will be conducted in an area adjacent to the target location (so as not to disturb the sediments in the target area) to identify the approximate depth and the texture of the sediments. The information will be used to guide core collection and whether a grab sampler should be deployed after the initial coring attempts. If sediment probing indicates a sediment depth of less than 6 in over bedrock, at least one attempt will be made to collect a core. If a sediment sample cannot be retrieved via coring, a Ponar grab sample will be collected. For all locations where a thin layer of sediment is suspected to overly shallow bedrock, sampling is to continue, either by coring, a grab sampler, unless exposed bedrock can be demonstrated within the entire 20-foot radius circle around the sampling node. A minimum of 3 attempts must be made in these instances. If the sample is not collected in three attempts, EPA approval is needed before abandoning the location. In each location within the target circle, a core must be attempted prior to deployment of a grab sampler. If a Ponar grab sampler is deployed, it must be of sufficient size to penetrate at least 6 inches or the thickness of sediment believed present on the river bottom, whichever is less.

Core recovery in clear Lexan® (or other appropriate) tubes will be measured directly though visual inspection of the sample. The actual sample recovery will be calculated by dividing the length of the sediment recovered by the Total penetration depth of the core. The sampler will then document the sediment recovery and visually classify the sediment sample, including the thickness of the residual veneer.

3.3.2.2 Sample Analyses

Each sample will be extracted and analyzed for PCB via an analytical method approved by EPA and that provides at least equivalent sensitivity and accuracy to the analytical method used during the design support sediment sampling. Grain size, moisture content and bulk density analyses will also be required for selected core sample analyses. A performance evaluation sample analysis program will be required as part of the residual sediment sample analytical program.

3.3.3 Initial Cover Placement

As per the Peer Review Panel recommendations, an initial 3-6 inch layer of sand or backfill cover will promptly be placed over a 1-acre CU sub-unit after the design (modeled) DoC elevation (EoC) has been achieved in 95 percent or more of the dredging sub-unit and post-dredging samples have been collected. Thus each CU will be initially treated as up to five sub-units, assuming dredging operations and CU geometry permit. Since the purpose of this initial cover is to prevent resuspension of the dredging residuals, verification of the placement thickness of this initial cover layer is not required. This placement is represented as the last step in the process outlined in Figure 3.2-1a. Specifications for the initial cover layer will be CU-specific and possibly sub-unit-specific, and will be developed as part of the Phase 2 design.

3.3.4 Evaluation of Sample Data

As in the original Performance Standard, the results of the sediment sample analyses will be used to evaluate the CU by converting the validated results to Tri+ PCB equivalents~~, identifying locations with remaining PCB inventory~~ and comparing the arithmetic average Tri+ PCB concentration in the surface (6 inches) sediment to the action levels in the standard. The ~~procedures to identify inventory and~~procedure to calculate the arithmetic average of the Tri+ PCB concentration in each sub-unit or CU ~~are~~is as follows:

- ~~Identify those nodes where PCB contamination is present at depth (*i.e.*, PCB inventory). The logic for this process is described in Figure 3.2-1b and on Table 3.2-1. Exclude these from subsequent calculations of the mean for the CU or sub-unit since they will be capped as inventory areas unless other treatment is approved by EPA. For these locations perform the following tasks (these should be completed after the initial cover layer has been placed):~~
    - ~~Analyze the 6" segments of the 4-foot post dredging cores to find the DoC as defined by the occurrence of two contiguous segments below 1 mg/kg TPCB. The results of the overlying six inch samples will be used to quantify the amount of inventory left behind.~~
    - ~~If two contiguous clean (*i.e.*, with 1 mg/kg TPCB or less) 6" segments are not found within 4 feet of the surface, an additional 8 foot core is collected at the node location and~~

~~the bottom eight 6" segments are analyzed. This process is repeated until two consecutive clean segments are found.~~

- ~~While these locations have been initially identified for capping by the presence of contaminated sediment at depth, GE may petition EPA to allow a less rigorous isolation treatment in the event that both the surface concentration and the concentrations at depth at the location are at or below the average of the non-capped areas of the CU.~~

- ~~For each CU, evaluate both the 1-acre sub-units and the entire 5-acre CU according to the logic described in Figure 3.2-1c and on Table 3.2-1.~~
- For ~~the remainder of~~ the CU or sub-unit, target an average value of ~~1~~3 mg/kg Tri+ PCB or less[~~5~~4] in the top 6" segments, using only the ranked, measured nodal values in a simple accumulating average. The logic for this process is outlined in Figure 3.2-1c and on Table 3.2-1. Note that the use of composite samples recommended by the Peer Review Panel to evaluate the 1-acre sub-units is not part of this process ~~but will be examined as a special study, described in Section 3.5.~~.
- Non-detect sample results are to be included in the calculation of the mean at a value of one-half the detection limit.
- If no sample is available from a grid node due to field difficulties that cannot be resolved, the mean should be calculated based on the reduced total of data points (*e.g.*, 39 data points instead of 40, or 7 instead of 8 cores for a sub-unit). The missing node should be considered as no information and excluded from the process to delineate areas for capping and backfilling. Essentially the surrounding nodes determine the treatment at the missing location.
- If in a 1-acre sub-unit, more than 2 locations are not available due to field difficulties, the arithmetic average should be calculated jointly with the adjacent 1-acre sub-unit.
- Identify the post-dredging sampling locations whose concentrations cause the average for the CU or sub-unit to exceed ~~1~~3 mg/kg Tri+ PCB. These locations will be capped ~~as having unacceptable residual concentrations~~. Identify these non-compliant nodes as ~~being less-than or greater-than-or-equal-to 15 mg/kg Tri+ PCB. The concentration of 15 mg/kg Tri+ PCB is based on the original EPS analysis which identified this value as the 97.5 percentile for individual residual contamination levels in post-dredging sediments. It is used here to separate the residual categories for compliance with the current standard~~contributing to a PCB Tri+ average of 3 to 6 ppm or greater than 6 ppm.
- Evaluate the amount of area identified for capping based on the integration of the five 1-acre sub-units and the 5-acre CU. Subject to EPA approval, select the result that yields the least amount of capped area.

3.3.5 Required Response Actions

The following actions are required by the revised Residuals Standard, based on the sediment sample analytical results obtained (refer to Figure 3.2-1c for the flow diagram and to Table 3.2-1).

Response 1: Apply backfill within the sub-unit or the CU

[~~5~~4] In the original EPS, the average residual was evaluated on a whole number basis, and this approach will be continued for Phase 2. Thus, an average of up to ~~1.49~~3.49 mg/kg Tri+ PCB, which rounds to ~~1,~~3, will be acceptable to meet this criterion.

- ~~Exclusive of the areas identified with inventory, assess the average of the top 6" segments of the post-dredging cores in the 1-acre sub-units and the 5-acre CU. If inventory considerations yield fewer than 5 post-dredging cores in a 1-acre sub-unit, combine with the adjacent sub-unit and calculate the arithmetic average.~~
- To warrant this response, the arithmetic average of the top 6" segments of the 1-acre sub-units or the 5-acre CU must be less than or equal to ~~1~~3 mg/kg Tri+ PCB.
- There must be~~ at least 3 adjacent locations at or below the 1 mg/kg Tri+ PCB level to define a backfill area and~~ at least 5 nodes in all in the 1-acre sub-unit to support evaluation of the sub-unit as a single entity. Otherwise it must be combined with an adjacent sub-unit.
- The ideal outcome for dredging falls under this category, wherein the average for the whole CU is less than or equal to ~~1~~3 mg/kg Tri+ PCB, in which case the whole CU is be backfilled.

Response 2: Cap the node(s) that cause the arithmetic average of the sub-unit to be greater than ~~1~~3 mg/kg Tri+ PCB

- To warrant this response ~~after exclusion of the nodes with identified inventory, ~~the arithmetic average of the top 6" segments of the 1-acre sub-unit (or the joint sub-units) is greater than ~~1~~3 mg/kg Tri+ PCB.
- Identify those nodes whose values cause the average to exceed ~~1~~3 mg/kg Tri+ PCB, as described in Section 3.3.4. Separate the nodes into the high and low residual categories, since these will likely warrant different capping treatments and are evaluated differently for the purposes of compliance with the Residuals Performance Standard.
- Design the area to be capped, bounded by the edges of the CU or a perimeter line ~~connecting~~half the distance to the compliant node locations. A compliant node is simply defined as a location whose sample concentration does not cause the average of the remaining nodes to exceed ~~1~~3 mg/kg Tri+ PCB (see Section 3.3.5.1).
- If different caps are required for adjacent high and low residual nodes, the cap design for the high residual nodes shall extend to the perimeter defined by the low residual nodes.
- Construct subaqueous cap at the nodes causing the arithmetic average to be greater than ~~1~~3 mg/kg Tri+ PCB, leaving the remaining area with an average concentration equal to or less than ~~1~~13 mg/kg Tri+ PCB. The type of cap will be based on the location in the river (high velocity/ low velocity area), the resulting average concentration, and the individual node concentrations.
- A typical scenario under this response involves the case where the average for the whole CU is greater than ~~1~~3 mg/kg Tri+ PCB but there are multiple 1-acre sub-units or adjacent post-dredging sampling nodes within the CU that have an average of ~~1~~3 mg/kg Tri+ PCB or less, in which case those particular areas should be backfilled.

Response 3~~: Capping nodes where inventory was found after dredging~~

- ~~This response addresses those locations shown to have PCB contamination below 6 inches in depth (*i.e.*, the TPCB concentration in samples below 6 inches is greater than 1 mg/kg).~~
- ~~Design the area to be capped, bounded by the edges of the CU or a perimeter line connecting the surrounding compliant node locations. A compliant node is simply defined as a location whose residual sample concentration (*i.e.*, in the top 6-inch segment) does not cause the average of the remaining nodes to exceed 1 mg/kg Tri+ PCB (see Section 3.3.5.1).~~

- ~~If the area to be capped for inventory is adjacent to areas to be capped due to non-compliant residual contamination (*i.e.*, in the top 6 inches), the more rigorous cap design, whether for residuals or inventory, shall extend to the perimeter defined by the nodes requiring the less rigorous cap.~~
- ~~Construct subaqueous cap at the nodes containing inventory, leaving the remaining area with an average concentration less than or equal to 1 mg/kg Tri+ PCB or to be capped as part of Response 2. The types of caps will be based on the location in the river (high velocity/ low velocity area) and peak concentrations at depth.~~
- ~~The anticipated case under this response is likely to be completed at the CU level, wherein inventory, residual and compliant nodes are all found within the CU, resulting in varying levels of capping requirements as well as backfill in completing the CU closure. Response 4~~: Debris layer, bedrock and glacial Lake Albany clay encountered
- If a debris layer is encountered and has not been found through sampling to contain PCBs at less than 1 ppm, continue dredging to 6 inches below the bottom of the debris layer. Then test the underlying sediments for PCB contamination following the prescribed approach given in Section 3.3.
- If bedrock or a rocky area is encountered, the area needs to be capped or backfilled to prevent contamination release through small pockets/crevices of soft sediments in the rocky areas. The choice of cap or backfill will be based on the concentrations found in the bedrock area, or as directed by EPA if samples cannot be obtained.
- If a native (glacial Lake Albany) clay layer is encountered at or above the target dredging depth, notify EPA and collect core samples to define its extent and its surface elevation. Prior to beginning Phase 2 dredging, a plan for dredging over an uneven clay surface shall be prepared and submitted to EPA for approval. The choice of cap or backfill will be based on the concentrations found in the clay area, or as directed by EPA if samples cannot be obtained.

As part of the evaluation of the CU, and sub-units, GE shall track the amount of area and the number of nodes subject to the various treatments, grouped into the ~~four~~three categories below:

~~A. Inventory is present (*i.e.*, sediment below 6 inches contain TPCB concentrations greater than 1 mg/kg).~~

A. ~~B.~~ High residual concentrations are present (the average surface concentration of all nodes ~~exclusive of those with inventory~~ is greater than 1 mg/kg Tri+ PCB ~~wherein the residual values causing the higher mean are~~and includes nodes that cause the average concentration to be greater than ~~or equal to 15~~6 mg/kg Tri+ PCB.

B. ~~C.~~ Low residual concentrations are present (the average surface concentration of all nodes ~~exclusive of those with inventory~~ is greater than 1 mg/kg Tri+ PCB ~~wherein the residual values causing the higher mean are less than 15~~and includes nodes that cause the average concentration to be between 3 and 6 mg/kg Tri+ PCB.

C. ~~D.~~ The node is compliant (inclusion of the node in the average calculation for the CU or sub-unit exclusive of those with inventory or unacceptable residual yields a value of ~~1~~3 mg/kg Tri+ PCB or less).

~~This information~~The high residual concentration nodes shall be evaluated against the ~~percentages of~~10 percent allowable capping ~~for each category as ZZZ, YYY and XXX percent for inventory, high residual and low residual areas, respectively~~criterion. The areas limited by shoreline stability, bedrock or GLAC will also be categorized as above but tracked separately since they are not subject to the percentage allowances.

Any adjustments to the approach between seasons should also account for year-to-year variability. Therefore, changes will not occur unless a certain percent threshold above the capping percent limit is exceeded. This will allow for year to year variability that may occur and still keep the project on track to meet the definition of success from a capping limit – 10% or less of the Phase 2 footprint for the high residual concentration caps. In a five year program, the first two years have to be within 120% of the capping limit (i.e., 12% of the total remediated Phase 2 area); the third year, 115%; the fourth, 110%; and the final year, at the capping limit of 10% of the total remediated Phase 2 area.

These responses describe the anticipated conditions to be found across most CUs. Side slope areas located laterally outside the areas identified to be dredged are to be backfilled. The handling of shoreline areas and the navigation channel warrants additional consideration and is described in Section 3.3.5.2. ~~Note that the results of these response actions will be evaluated after several CUs are completed, to determine whether the design dredging elevation achieves the true EoC in one pass or whether PCB inventory is being capped. Adjustments to the design dredge surface or the one-pass approach may be made based on these findings.~~

3.3.5.1 Extent of Area to be Capped

~~Locations to be capped will be identified as described above, based on the presence of PCB inventory or a high concentration in the 0-6 inch sample. Both types of locations are considered non-compliant.~~ The area associated with non-compliant nodes should extend half the distance to the ~~periphery of~~ surrounding compliant nodes or to the edge of the CU. ~~The handling of adjacent residual and inventory non-compliant nodes is described above.~~ Where a compliant node is surrounded by non-compliant nodes, the area associated with the compliant node should be capped as well. Generally, ~~three~~two compliant nodes ~~arranged in a triangle~~ are required to define an area that does not require capping. ~~Two adjacent compliant nodes can also define an area not needing capping if they are both adjacent to the CU boundary.~~

~~For locations where a single non-compliant node is surrounded by compliant nodes, the non-compliant node should be capped to a perimeter line formed by connecting the surrounding compliant nodes. See Figure 3.3-1 for examples of these capping and backfill configurations. These steps will eliminate the more complex algorithm developed for Phase 1 that was a source of much discussion and often resulted in intricate geometries for response actions.~~

Any capped areas in the navigation channel must have a minimum of ~~14~~12 feet of draft above the cap based on mean low water elevation in the pool and all caps in the channel shall be high velocity caps. Backfill will not be allowed in the navigation channel unless the dredged surface is ~~15~~13 feet below the mean low water prior to any backfill placement. See further discussion in Section 3.3.5.2

The type of cap selection depends on the Tri+ PCB concentration of the non-compliant nodes, the velocity of the river, and other considerations. The cap specification will be developed during Phase 2 design period.

3.3.5.2 Shoreline Areas and the Navigation Channel

The shoreline areas and navigation channel require special treatment after the primary dredging pass is completed. In both areas, it is possible that a second dredging pass will be required. Specifically, for shoreline areas, bank stability concerns may preempt contaminated sediment removal below 2 ft. In these cases, capping is often required, but in cases where the remaining contamination levels exceed 50 mg/kg TPCB, additional dredging to remove these sediments will be required. In the case of the navigation channel, cap or backfill placement cannot take place if the placement will interfere with navigational use. Thus, if contaminated sediment is found after the first pass above an elevation equivalent to ~~14~~12 ft of water depth based on mean low water, the sediments will need to be removed via a second dredging pass, and need to be deep enough to accommodate a cap, with~~14~~ 12 ft of water depth based on mean low water above the cap. Decisions to conduct a second dredging pass, cap, or backfill in shoreline areas and the navigation channel must consider:

- For both the shoreline areas and navigation channel, additional post dredging samples must be collected in these areas to assure that they are adequately characterized regardless of the geometry of the post sampling grid. For shoreline areas, the sampling ~~frequency~~density will be the same as during Phase 1, with 1 sample per 100 feet of shoreline, collected 20 feet off shore. For the navigation channel, there should be 1 sample for every 1/8 acre of channel area with a minimum of 2 samples in the navigation channel at every CU that includes the navigation channel. The information from adjacent CUs that contain contiguous navigation channel areas must be considered when assessing the need for additional dredging, capping, or backfilling.
- If the water depth (based on mean low water) after initial dredging in an area of the navigation channel is less than ~~15~~13 feet (the originally defined DoC was found to be less than ~~15~~13 feet below mean low water) and Tri+ PCB concentrations still exceed 1 mg/kg at any depth in the channel, a second dredging pass will be required. The dredging in the second pass must be to a depth that will allow the placement of a high velocity cap with ~~14~~12 feet of draft at mean low water, or to the actual EoC, whichever is deeper. Additional post dredging sampling will then be necessary to characterize the remaining sediment. In addition, no backfill will be placed on the dredged surface in the navigation channel unless there is ~~15~~13 ft of draft available, based on mean low water. Capping in the navigation channel should be avoided whenever possible. If capping is necessary, its design and implementation must be such that the top of the cap allows for a minimum of ~~14~~12 feet of draft to allow for future maintenance dredging by the NYS Canal Corporation (NYSCC). This is consistent with the recommendation of the Peer Review Panel and the advance maintenance requirements of the canal.
- For shoreline areas where the DoC is greater than the stable side slope (defined as 3 horizontal to 1 vertical, or existing side slope if steeper), if TPCB concentrations in sediments below the design dredge elevation are equal to or greater than 50 mg/kg, these sediments must be removed. If TPCB concentrations in sediments below the design dredge elevation are less than 50 mg/kg, at GE's discretion additional dredging can be performed or a cap can be placed based on the capping criteria. Nodes used for shoreline areas will ~~also~~not be considered as part of the 1-acre subunit and 5-acre CU averaging. This approach for the shoreline area is the similar to what was required in Phase 1, except that there are no individual criteria other than the 50 mg/kg threshold. Shoreline nodes will be treated

for backfill or capping in the same fashion as regular post-dredging nodes. ~~In the event that shoreline cores are not available prior to dredging in a shoreline area, the initial removal at the shoreline shall be 2 feet, following the stable slope requirements out to the area bounded by dredging design cores (existing SSAP and newly collected cores).~~

3.4 Reporting and Notifications

EPA and GE will work together to simplify data management and transfer. A streamlined data exchange process, such as internet data sharing, should provide additional time for EPA review while actually shortening the calendar time in the review process. ~~It is imperative that~~ EPA will receive ~~both draft and final versions of~~ the data as it is delivered to GE by the analytical laboratories, but following verification.

3.4.1 Routine Reporting

Data sets such as post dredging elevations, sample analysis results, non-compliant boundaries etc. should be provided to EPA digitally ~~at least 4 hours~~as soon as practicable before the daily meetings with GE. A consistent distribution list should be maintained. Bathymetric surveys should be provided upon completion of the surveys in electronic ~~form, and at least 1 day~~formas soon as practicable prior to any presentation to EPA at the daily meetings.

3.4.2 Contingency Reporting

Weekly progress reports will be prepared by the construction manager and submitted to the EPA site manager~~, according to a schedule to be defined by EPA,~~ for EPA's use in evaluating compliance with the Residuals Standard. The reports will need to summarize, at a minimum, the results of residual sediment sampling, exceedances of the Residuals Standard criteria by CU, the courses of action taken or proposed to be taken, and rationale. Laboratory data must be made available to EPA immediately upon receipt from the laboratory, but following verification, and in a useable database format to be agreed to by EPA.

Following the completion of remedial activities in each CU, the construction manager will prepare individual CU reports and submit them to the EPA Hudson River Field Office director, according to a schedule to be defined by the EPA, for the EPA's use in evaluating compliance with the Residuals Standard. Each CU report must include, at a minimum, the following information:

- CU identification
- Description of type(s) of dredging equipment used
- Description of sediment type(s) encountered
- Residual sediment sampling results
- Sediment imaging results (if available)
- An attestation that the sampling data was validated, including a discussion of any data qualifiers applied
- Discussion of any contingency actions taken

3.5 Special ~~Studies~~Study

There will be ~~three~~a special ~~studies~~ study for the Residuals Performance Standard to :

~~1. Comparison between composite samples and individual post-dredging nodes in a 1-acre sub-unit.~~

~~2. Evaluation of missed inventory and effectiveness of the EoC/DoC interpolation process in the estimation of uncertainity in the DoC.~~

~~3.~~ ~~Evaluation~~ evaluate of PCB contamination outside the dredge prisms resulting from the redistribution of PCBs via dredging-related activities.

~~The Peer Review Panel recommended the collection of composite samples (8 locations within 1-acre sub-units) to streamline evaluation of the success or failure of inventory removal in a CU and speed closure. A special study to evaluate whether a composite residuals sample created for a 1-acre sub-unit is representative of the arithmetic average of the individual sample locations within that sub-unit will be conducted during Year 1 of Phase 2. This evaluation will determine if that method is comparable to the use of single nodes to dictate CU closure. This special study will be used to assess the decision that would have resulted from the use of the composite sample relative to the individual nodes, including but not limited to the decision to cap or backfill, the amount of area capped and the type of cap applied.~~

~~The second special study will be conducted to evaluate the amount of missed inventory remaining after the first dredging pass, and how addressing measurement/estimation of uncertainty in determining dredging cut line elevations may reduce the amount. This special study will serve to assess the potential effectiveness of both the single-pass dredging approach recommended by the Peer Review Panel, and the application of uncertainty estimates in describing the thickness and elevation of sediment removal. The process of estimating the mass remaining after dredging is described in Section 7 of this Revised EPS document.~~

~~Lastly, a~~This special study will be conducted to examine the impact of PCB release due to dredging-related activities on areas that will not be subject to dredging. This study will entail the collection of surface sediments ~~throughout the Upper Hudson. EPA is currently conducting a study which will serve to describe the baseline conditions for Phase 2, by obtaining samples from over 300 locations in the Upper Hudson. These locations will be revisited in the spring prior to the onset of dredging for at least the first three years of dredging (*i.e.*, prior to Year 1, Year 2 and Year 3 of Phase 2, at a minimum). The results of these annual spring sampling events will be compared with the baseline data obtained in 2010 to examine the change in surface concentrations with time during dredging.~~in the area of dredging.

4 Overview of Resuspension Standard for Phase 2

EPA's 2002 ROD requires the development of a Resuspension Standard but does not set forth any framework or numerical value for such a standard. The Resuspension Standard provides that framework and is designed to limit the concentration of PCBs in river water, such that downstream transport of PCB-contaminated dredged material is appropriately constrained and potential users of Hudson River water are protected.

The Resuspension Standard consists of a control level TPCB concentration in the water column of 500 nanograms per liter (ng/L) (*i.e.*, 500 parts per trillion) ~~and~~ at the first downstream public water supply location and 2,000 ng/L at Thompson Island and Lock 5 far field monitoring locations, and 750 ng/L at Waterford. The Resuspension Standard also includes a numerical Tri+ PCB net load criteria developed based on observations during Phase 1, sampling data and analyses obtained since completion of Phase 1, updated modeling results, and the recommendations of the Peer Review Panel. Specifically, the numerical net load criteria will be equal to specified percentages of the Tri+ PCB mass to be dredged during the season. For Phase 2 dredging operations, the numerical net load criteria at the Thompson Island and Waterford monitoring stations are 2 percent and 1 percent of the targeted Tri+ PCB mass to be dredged during the season, respectively, as recommended by the Peer Review Panel. ~~These numerical net load criteria will be adjusted as needed in accordance with the AMP, again following the recommendations of the panel. Among the factors to be considered by EPA in the adaptive management of PCB loads are the estimates of the mass of PCB remaining for removal, the rates of PCB mass loss observed, the observations of PCB impacts to fish and downstream sediments, and the projected impacts (if any) of the PCB resuspension and redeposition on the long-term rates of recovery, based on evaluation of data trends and simulation by an acceptable, peer-reviewed model.~~ [Note to EPA: The AMP should not be used to modify the performance standards.]

For each dredging season, the specified numerical net load criteria will consist of ~~the following: 1)~~ seasonal net loads, which are equivalent to 1 percent and 2 percent (as measured at Waterford and Thompson Island, respectively) of the estimate of the targeted Tri+ PCB mass to be dredged that season~~, and 2) the daily net loads, which represent proration of the cumulative net loads for the season, based on the anticipated number of dredging days in the season.~~. [Note to EPA: GE believes that the daily net load criterial should not be utilized due to the large day-to-day variations in PCB mass removed and river flow.]

Further details on the calculation of the resuspension numerical seasonal net load~~, and the daily average net load criteria~~ are provided in Section 4.2 and the Resuspension Standard criteria are summarized in Table 4.1-1. In addition, the methodology for calculating the Tri+ PCB mass to be dredged is described in Section 7. It should be noted that the numerical seasonal net load criteria described herein will be evaluated during Phase 2 based on the estimate of PCB mass to be removed in that season and the 2 percent and 1 percent release rates referred to above. .

The ~~net load criteria, including the 2 percent and 1 percent levels, are also subject to adjustment based on additional information, in accordance with the AMP.~~ total project net cumulative load is the maximum load to the Lower Hudson River allowable without unacceptable impacts on remedy benefits. Based on modeling conducted by GE, EPA has concluded that a net Total PCB load of 3,000 kg is allowed during the project. This load may be revised based on modeling conducted after the model has been refined using the data collected during the first year of Phase 2 dredging. The total project load will be monitored at Waterford and will be allocated to each year of the dredging project based on estimates of the Phase 2 PCB mass to be dredged in each year of the project. This load will be used in conjunction with the percentage-based seasonal loads described above to trigger between dredging years engineering evaluations and operational changes.

The Resuspension Standard calls for the implementation of a routine water quality monitoring program at ~~both near and~~the far-field stations to evaluate compliance with the standard and specifies that engineering evaluations and corrective actions may be required if the criteria are exceeded. ~~The standard further requires~~ [Note to EPA: GE does not believe that monitoring contingencies ~~when the control level TPCB concentration is exceeded, consisting of increased sampling frequency and more rapid laboratory turn-around of analytical data from sampling stations, to better characterize developing changes and trends in water quality.~~ are required should the control level be exceeded because the Upper River public water supplies will be on alternate non-Hudson water during Phase 2.]

4.1 Phase 1 Observations and Additional Data Needs in Support of the Resuspension Standard for Phase 2

The original Resuspension Standard anticipated refinements to the load-based criteria (EPA, 2004; Vol.1, Section 4.0). Specifically, the criteria in the Resuspension Standard were to be reviewed and refined if the estimate of PCB mass to be removed is significantly different from previous estimates. It has been clearly documented based on Phase 1 that the mass to be removed is indeed significantly higher than anticipated at the time the standard was originally developed. ~~Besides increased PCB mass, other experiences/lessons learned from Phase 1 underscore the need for additional changes to the Resuspension Standard. The information will continue to be collected and evaluated.~~

The revised release estimates must account for updated baseline load estimates and the new, significantly larger estimates of the amount of PCB mass to be removed.

The ROD originally estimated the PCB mass to be removed as approximately 70,000 kg, and the total project cumulative load standard was set at just below 1 percent of this total, or 650 kg. Based on the Phase 1 experience and additional sampling results, the estimated PCB mass for the entire project has been revised to the range 140,000 to 200,000 kg. The Peer Review Panel recommended that on an interim basis the numerical net load criteria be set at 2 percent and 1 percent (as measured at the Thompson Island Dam and Waterford monitoring stations, respectively) of the projected annual Tri+ PCB mass removal. They concluded final standards could not be set until further data was collected in 2011 and a PCB fate model completed. The projected mass to be removed in Year 1 of Phase 2 is currently unknown (investigations are currently underway and will inform the estimates of mass for 2011 and should be provided in the Phase 2, Year 1 RAWP). When that information becomes available, the load calculation formula provided in Section 4.3.1 below will be used to determine the daily numerical net load criteria for Thomson Island Pool and Waterford monitoring stations for Phase 2, Year 1. The daily net load criteria will be updated each year for the coming season's dredging, based on the estimate of PCB mass to be removed in that season and the 2 percent and 1 percent release rates referred to above.

~~The net load criteria, including the 2 percent and 1 percent levels, are also subject to adjustment based on additional information, in accordance with the AMP.~~

~~It should be noted that the observed baseline loads to the Lower Hudson prior to the Phase 1 dredging were substantially greater than the previous model forecast under Monitored Natural Attenuation (MNA) and show very little decline (from 2004 to 2008). Hence, the anticipated loads to the Lower Hudson River under baseline conditions will be significantly greater than those forecast by the HUDTOX model. Also the surface sediment concentrations in the Upper Hudson River remain elevated despite the passage of time and continue to provide a greater reservoir of contaminated sediments for transport to the Lower Hudson than was envisioned when the remedy was selected. These observations provide further impetus for the remedy and highlight the need for revising the PCB net load criteria to account for the greater PCB mass and higher baseline loads.~~

[Note to EPA: The statements in this paragraph have been removed as they are not observations from Phase 1. Further, EPA statements on surface sediment concentrations remaining elevated are not supported by the data.]

4.1.1 Technical Background and Approach

The Hudson River ROD requires Engineering Performance Standards ~~that address~~to ensure that the expected ROD benefits are protected by addressing specified dredge-related issues, including resuspension rates during dredging. It was recognized in the ROD that there is a likelihood of localized temporary increases in water column and potentially fish tissue PCB concentrations as a result of dredging activities. In compliance with the requirements of the ROD, EPA developed the Resuspension Standard, which includes several Action Levels for suspended solids, TPCB and Tri+ PCB that were established for near-field and far-field locations to ensure that dredging-related problems can be quickly identified and corrected before criteria are exceeded that might require temporarily halting the dredging operations. The ROD further anticipated the need for refinement and revisions of the Performance Standards to reflect lessons learned during Phase 1 dredging. The ROD also contemplated that final standards would be set for Phase 2 and did not envision further changes after Phase 2 began.

The Phase 2 Resuspension Standard incorporates some of the recommendations of the Peer Review Panel, experiences gained from Phase 1 in terms of actual PCB mass to be removed, projected PCB loss rates during dredging, and dredge-related release and transport of suspended solids, among others. The Phase 2 Resuspension Standard criteria are summarized in Table 4.1-1. Compliance with the criteria will be tested through monitoring, which comprises routine monitoring when the dredging operations are in compliance and contingency monitoring when either the ~~500~~750 or 2,000 ng/L control level TPCB ~~concentration is~~concentrations are exceeded. As specified in Table 4.1-1, exceedance of the criteria may require engineering evaluations and review of the dredging operations to identify potential causes and implement corrective measures as necessary. In addition to compliance monitoring, there are sampling requirements in the form of special studies to gather information that can be used to further refine ~~elements of the standard~~operations.

4.2 Implementation of the Phase 2 Resuspension Standard

This section describes the Resuspension Standard criteria in terms of TPCB concentrations and Tri+ PCB numerical net loads, as applicable at near-field and far-field locations. These criteria are summarized in Table 4.1-1.

4.2.1 Far-Field TPCB Concentration Action Levels

Control Level Total PCB Concentration

The ~~500~~2,000 ng/L control level TPCB concentration as measured at Thompson Island station (this compliance station will move downstream ~~as~~to Lock 5once the dredging moves ~~closer~~ to within 2 miles of Thompson Island Dam and ~~into River Sections 2 and 3~~to Waterford once dredging moves to within 2 miles of Lock 5) is to be used as a trigger to require operational changes~~, but not necessarily an operational shutdown, at EPA's discretion~~ as detailed in the pre-approved Best Management Practices. Should continued operational changes not reduce water concentrations below the ~~500~~750 or 2,000 ng/L control ~~level~~levels, particularly if elevated concentrations are occurring at multiple far-field stations simultaneously, EPA may require ~~temporary shutdown.~~ ~~**Advisory Level Total PCB Concentration**~~operational slowdown. A second control level of 500 ng/L TPCB measured at first downstream public water supplier withdrawing water from the Hudson River will trigger similar operational changes as described above.

~~A water column TPCB concentration of 350 ng/l serves as an Advisory Level for discretionary use by EPA to recommend appropriate operational changes.~~

4.2.2 Far-Field Tri+ PCB Numerical Load Criteria

The far-field numerical net load ~~criteria consist of both~~is a seasonal~~ or cumulative net load and a daily~~ net load. As recommended by the Peer Review Panel and described below, the cumulative net load criteria for each dredging season~~ and associated daily numerical load criteria~~ are based on 2 percent (as monitored at Thompson Island station) and 1 percent (as monitored at Waterford station) of the Tri + PCB mass to be removed during the dredging season~~The following equation may be used for the daily numerical net load criteria calculations:~~

~~Where~~
~~% allowable release = 2% at Thompson Island~~
~~= 1% at Waterford~~~~As an example application of the above equation, assume that 11,000 kg Tri+ PCB will be removed in Year 1. The cumulative net load criterion for Year 1 at Thompson Island monitoring station is calculated as 220 kg Tri+ PCB (*i.e.*, 2% of 11,000 kg), while the cumulative net load criterion at Waterford monitoring station is 110 kg (*i.e.*, 1% of 11,000 kg). Applying the above equation and assuming 150 dredging days in the season yields allowable daily numerical net load criteria of 1,500 g/day Tri+ PCB and 750 g/day Tri+ PCB for~~

~~Year 1 at Thompson Island monitoring station and Waterford monitoring station, respectively.~~ .

$$\text{Net Daily Load}\left(\frac{g}{d}\right) = \frac{(\text{Tri + PCB Mass targeted for dredging in season} \times \%\ \text{allowable release})\ [\text{kg}]}{\text{number of dredging days in season}} \times \frac{1000\text{g}}{1\text{kg}}$$

Numerical Net Load Criteria (i.e., Control Level Loads) for the Far-Field

- A net increase in Tri+ PCB load of xxx g/day at Thompson Island and yyy g/day at Waterford based on a 7-day running average and assuming ~~150~~120 dredging days in the year. The cumulative net Tri+ PCB load criteria for the dredging season are vvv kg at Thompson Island and uuu kg at Waterford. For Year 1, the actual cumulative net load and associated daily net load criteria will be calculated when the target Tri+ PCB mass to be removed during the dredging season becomes available. The EPA derived methodology for calculating the Tri+ PCB mass to be removed is described in Section 7. For comparison with the cumulative and daily net load criteria, the net resuspension loads caused by dredging and other in-river activities will be calculated as described in Section 4.4. ~~For subsequent years of Phase 2, the far- field numerical net load criteria will be adjusted after each year of Phase 2 in accordance with the process described in the AMP, evaluation of a peer reviewed updated fate and transport model and the sampling data collected.~~ The numeric daily net load criteria for the remaining years of Phase 2 will be calculated as outlined above, using data gathered during the previous year and an estimate of Tri+ PCB mass to be removed the following year, a specified percentage of that mass, and number of dredging days in the season.

4.2.3 Near-Field TSS Concentration Action Levels

The criteria for the two action levels (Evaluation Level and Control Level) from Phase 1 have been combined into a single Advisory Level for TSS concentration. Real-time turbidity monitoring, however, will no longer be required. The TSS Advisory Level for the near-field is as follows:

Advisory Level for the Near-Field

The Near-Field Advisory Level is a net increase in TSS concentration of 100 mg/L above ambient (upstream) conditions at ~~a location 300 m~~the first near-field monitoring transect downstream of the dredging operation ~~or 150 m downstream from any suspended solids control measure and any side channel locations~~(0.25 to 0.5 miles).

4.2.4 Monitoring Plan

The Phase 2 dredging water column monitoring program will be performed to assess achievement of the Resuspension Standard criteria presented in Section 4.3. The monitoring will be performed during dredging and associated operations that can potentially result in resuspension of significant amounts of sediment. These include, but are not necessarily limited to:

- Dredging
- Debris removal

- Resuspension control equipment removal
- Cap placement
- Backfill placement
- Installation of containment devices other than silt curtains, such as sheet piling and other structural devices requiring heavy equipment operation and disturbance of the river bottom
- Boat traffic

The monitoring program consists of routine monitoring conducted to evaluate compliance with the Resuspension Standard~~, and contingency monitoring that will be performed in the event that exceedances of the control level TPCB concentration are observed~~. Details of the planned routine~~ and contingency~~ monitoring programs are presented in the RAM Scope:

- Near-field sampling
- Far-field sampling
- Off-season water column monitoring performed to provide a continuation of baseline data

A summary of the near-field, far-field and off season monitoring programs to be performed for Phase 2 is described below.

4.2.4.1 Routine Monitoring

Near-Field Water Column Monitoring - General

The Resuspension Standard defines the near-field monitoring area as the immediate vicinity of remedial operations, typically extending from 100 feet upstream to one mile downstream. The objective of the near-field monitoring is to evaluate whether dredging activities are causing near-field elevated releases of dissolved and particulate PCBs, as well as TSS, and to relate the fate and transport of these near-field releases to observations in the far-field. During Phase 1, high TSS concentrations were not observed, and TSS levels did not correspond to PCB levels as expected. It was originally anticipated that a relationship between TSS and turbidity could be established, and that turbidity could be used as a surrogate for PCBs. This relationship was not borne out by the Phase 1 results, thus making turbidity a less-important field parameter. The near-field monitoring program needs to be reconfigured to better study the expected relationships among PCB, TSS and turbidity discerned in Phase 1. During Year 1 of Phase 2, it is important to identify appropriate near-field water column sampling locations upstream and downstream of areas targeted for dredging (*e.g.*, a near-field array-based monitoring) as part of the special studies. The ~~TSS monitoring will be performed by a vertically integrated sampler. In addition, analysis of split-phase PCB homologs (dissolved, NAPL and suspended matter) to quantify releases to the water column during dredging will be added. Also, LISST samplers must be deployed at all near-~~near field ~~stations to capture grain size data and describe the different grain size distributions for natural and dredging-related resuspension.~~data is not relevant for compliance with the standards but rather is part of the 2011 Special Study. [Note to EPA: As explained during the meeting of 11/15 this work is unnecessary.] Based on the Phase 1 experience, the collection of turbidity data could be reduced or eliminated.

Additionally, continuous reading water quality meters will be used to collect DO, pH, temperature, and conductivity data on a continuous basis.

The RAM Scope details the planned sampling methodology, collection frequencies, analytical methods and monitoring contingencies.

Because the concentrations of metals were substantially lower than the water quality standards during Phase 1, sampling for metals during Phase 2 will be ~~done at reduced scope compared to Phase 1.~~limited to weekly sampling for Cd and Pb at the first far-field station downstream of dredging.. Further details on near-field monitoring will be refined, as necessary. Additionally, a mid-field array-based monitoring program will be included approximately ~~half~~three quarters of a mile downstream of dredging activities.

Far-Field Water Column Monitoring - General

The Resuspension Standard defined the far-field monitoring area as that portion of the Hudson River that is greater than one mile downstream from an active dredging operation. The purpose of far-field monitoring is to obtain the information needed to verify that PCBs exported to the Hudson River downstream of Waterford are minimized and that water column PCB concentrations do not exceed the levels specified in Section 4.3. Far-field monitoring will start two weeks before Phase 2 dredging operations are initiated in order to provide a baseline for evaluating subsequent PCB transport and water quality conditions, and continue after all dredging and associated remedial operations have terminated for the season or until water quality returns to average baseline conditions, but no later than two weeks after all dredging and associated remedial operations have ceased. Baseline PCB concentrations and loading from upstream of dredging operations will be assessed at upstream stations. Far-field monitoring stations located at Thompson Island, Schuylerville (at Lock 5)~~, Stillwater,~~ and Waterford will be used to monitor the water quality impact of the dredging activities (the possibility of monitoring at other locations is to be discussed). In addition, the far-field monitoring station at Waterford will be used to measure loading to the Lower Hudson River. A summary of the planned far-field sample collection requirements is presented in Table 4.3-1. Figure 4.3-1 shows the planned far-field monitoring locations. The RAM Scope details the planned sampling methodology, collection frequencies, analytical methods and monitoring contingencies. Further details on far-field monitoring will be refined, as necessary.

Off-Season Water Column Monitoring

As specified in the Resuspension Standard, after all dredging and associated remedial operations have terminated for the season, the far-field monitoring program is to continue until water quality returns to average baseline conditions, but no later than two weeks after all dredging and associated remedial operations have ceased. At that time, the off-season monitoring program will be initiated. As summarized in Table 4.3-2, the off-season water column sampling will be performed weekly at Rogers Island, Thompson Island, Schuylerville and Waterford (to the extent that weather and river conditions allow), monthly at Bakers Falls and at the Lower Hudson River stations at Albany and Poughkeepsie~~, and once every other month at the Mohawk River~~. If PCB loading at Thompson Island is significantly above baseline levels, weekly sampling will be added at Schuylerville.

~~4.2.4.2 Contingency Monitoring~~

~~The Resuspension Standard provides monitoring and engineering contingencies in the event that the control level TPCB concentration is exceeded. The RAM Scope details the planned sampling methodology, collection frequencies, analytical methods and monitoring contingencies.~~

~~***Reverting to Lower Monitoring Levels***~~

~~Any reduction in contingency monitoring requires approval from EPA before the changes are made. EPA may approve a reduction in the level of monitoring when the following occurs for TPCB criteria:~~

- ~~For the exceedance of the 500 ng/L control level TPCB concentration at the far-field stations, 2 days of values below 500 ng/L TPCB at all stations are required before returning to routine monitoring.~~
- ~~Routine monitoring will resume in the Lower Hudson after non-routine monitoring has confirmed that the concentrations in the Lower Hudson are below 500 ng/L TPCBs and the estimated concentration at Waterford and Troy have fallen below 500 ng/L TPCBs for at least two days.~~

~~During any temporary halting of in-river remedial operations, routine monitoring of the Upper River far-field stations will continue. If the operations are temporarily halted, monitoring in the Lower Hudson will continue at non-routine frequency until the requirements listed above are met.~~

4.2.5 [Note to EPA: GE does not believe that contingency monitoring should be implemented if Upper Hudson River public water supplies are on alternate water.]Engineering Contingencies and Response Actions

Engineering contingencies may be required by~~ EPA, at its discretion, (or initiated by GE, in consultation with EPA)~~ to reduce the levels of contaminant export in the event that the resuspension criteria are exceeded.

For Phase 2, engineering contingencies shall be considered for the dredging operation if the action levels are exceeded as follows:

- Engineering contingencies~~ will be recommended for consideration when the Advisory Level for TSS in the near-field or the Advisory level for TPCB in the far-field is exceeded by any measure.~~
- ~~Engineering contingencies~~ may be required ~~at EPA's discretion~~from the pre-approved BMPs and implemented if the TPCB concentrations exceed the control level TPCB concentration (~~500~~750 or 2,000 ng/L TPCBs), based on monitoring results at the far-field stations. Additionally, ~~at EPA's discretion,~~ engineering contingencies may be required if the ~~numerical daily net load criteria for Tri+ PCB is exceeded based on a seven-day running average concentration~~TPCB concentrations exceed the control level TPC concentration (500 ng/L TPCBs) at the nearest public water supply withdrawing water from the Hudson River.

~~Engineering evaluations of the source of the exceedance may also be required when the control level TPCB concentration or numerical daily net load criteria are exceeded.~~ Recommended and required engineering contingencies are listed below.

~~4.2.5.1 **Advisory Level for TSS and Advisory Level for Total PCB**~~

~~For exceedances of the Advisory Level for TSS or TPCB concentrations, discussions will be held with EPA field staff to determine if operational changes or other response actions as may be necessary, are warranted.~~

~~4.2.5.2 **Daily Numerical Net Load Criteria for Tri+ PCB**~~

~~If/when the daily numerical net load criteria for Tri+ PCB are exceeded, engineering evaluations and implementation of engineering solutions may both be required, at EPA's discretion, as outlined below:~~

- ~~If directed by EPA, initiate engineering evaluation and continual adjustments to dredging operations until the daily net load is reduced below the Control Level. The engineering evaluation includes the study of all dredge-related operations and supporting components, including review of the dredging operation, barrier installation, and sediment transportation system~~
- ~~Evaluate and identify any problems.~~
- ~~Consider change in resuspension controls or additional resuspension controls, dredge operation, or dredge type.~~
- ~~Consider changing location and rescheduling more highly contaminated areas for later in the year (applies to May and June only), if all other options are not effective.~~
- ~~Consider not dredging highly contaminated areas at the same time.~~
- ~~Temporarily cease operations if required by EPA.~~

4.2.5.1 ~~4.2.5.3~~ Control Level Total PCB Concentration

The following steps may be required, at EPA's discretion, if the control level TPCB concentration is exceeded:

- Initiate engineering evaluation and review of the dredging operation to determine potential causes of the exceedance.
- Implement operational changes as necessary ~~including slowing or cessation of operations if directed by EPA~~from the pre-approved list of BMPs.

4.2.5.2 ~~4.2.5.4~~ Potential Engineering Solutions

Time Frame for Implementing Engineering Evaluations and Engineering Solutions

The time frame for the initiation and completion of engineering evaluations and implementation of the engineering solutions will normally be specified as part of the remedial design, but the actual implementation schedule in the field is subject to EPA review and oversight. ~~As directed by EPA, engineering~~Engineering evaluations will begin upon receipt of data indicating the exceedance of a criterion. Engineering contingency actions from the pre-approved list of BMPs will begin ~~within a week of a directive by EPA, at a minimum~~as soon as is practicable, assuming conditions remain in exceedance. In the case of a temporary halt of the operations, an evaluation should be completed within five days, and every effort should be made to correct the problem and minimize the length of time of the stoppage.

4.3 Estimating Baseline Loads and Loads due to Dredging

[Note to EPA: Due to the limitations of time given by EPA for GE to review and comment on this document, we have not had an opportunity to review and comment specifically on this section. However, please note that GE's approach to estimating baseline loads and loads due to dredging is set forth in GE's Phase 1 Evaluation Report. That document is hereby incorporated by reference.] To estimate the net loads due to dredging, the gross measurements of load must subtract the baseline to determine impacts of dredging. Baseline concentrations and baseline load should be based on the 2004-2008 BMP data. Statistical analysis conducted as part of EPA's Phase 1 evaluation indicates that both parameters used to calculate load, *i.e.*, concentration and flows, vary on a monthly basis. In the case of flows, annual differences are also significant.

Since flows are measured continuously and are available real-time from the USGS during remediation, the question then becomes one of establishing the appropriate baseline concentration of TPCB and Tri+ PCB to be used for load calculation. Because the regression relationships obtained using both flows and months are significant but weak, the following method which takes both the monthly variability and the weak correlation with flow into consideration shall be used to determine baseline mean and UCL concentrations for evaluating dredging impact during Phase 2:

- The TPCB and Tri+ PCB the BMP period from 2004 to 2008 (only May to November considered each year) should be divided into months.
- To account for the possible weak but statistically significant correlation between PCB concentrations and flow, the data should be stratified into three flow categories: These flow categories include: flows less than 5000 cubic feet per second (cfs) at Fort Edward, flows between 5,000 cfs and 10,000 cfs at Fort Edward, and flows > 10,000 cfs at Ft Edward. The 5,000 cfs and 10,000 cfs boundaries are logical break points suggested by the data.
- The baseline mean and UCL concentrations should be calculated for each month and flow bin and directly applied on a daily basis during dredging.
- The formula to calculate load due to dredging is then:

7-day Average Net Load of Tri+ PCBs at the Far-field Station

$$F_7 = \left(\overline{C_{ffs}} - \overline{C_{bl}}\right) \times Q_7 \times T_{d7} \times \frac{0.02832\,m^3}{ft^3} \times \frac{3600s}{hr} \times \frac{1g}{10^9\,ng} \times \frac{1000L}{m^3}$$

F7 = Seven-day average load of Tri+ PCBs at the far-field station due to dredging –related activities in g/day

$\overline{C_{ffs}}$ = Flow-weighted average concentration of Tri+ PCBs at the far-field station as measured during the prior seven-day routine discrete sampling in ng/L.

This is given as:

$$\overline{C_{ffs}} = \frac{\sum_{j=1}^{7} C_{ffs_j} \times Q_j}{\sum_{j=1}^{7} Q_j}$$

Where:

C_{ffs} = The Tri+ PCB concentration at the far-field station for day j. if more than one sample is collected in a day due to exceedance of the near-field or far-field criteria, the arithmetic average of all the measurements will be used.

Q_j = The daily average flow at the far-field station for day j.

$\overline{C_{bl}}$ = Estimated 95% upper confidence limit (UCL) of the arithmetic mean baseline concentration of Tri+ PCBs at the far-field station for the month in which the sample was collected, in ng/L.

Q_7 = Seven-day average flow at the far-field station, determined either by direct measurement or estimated from USGS gauging stations, in cfs.

T_{d7} = Average period of dredging operations per day for the seven-day period, in hours/day, as follows:

$$T_{d7} = \frac{\sum_{j=1}^{7} T_{d_j}}{7}$$

Where: T_{dj} = the period of dredging operations for day j in hours.

<u>Far-field Net Tri+ PCB Seasonal (Cumulative) Load</u>

One of the far-field standards is the Seasonal (cumulative) net Tri+ PCB load. This load will be calculated on a daily basis. The formula to calculate the net Tri+ PCB load at any time during the season is:

$$F_{todate} = \left(\overline{C_{ffst}} - \overline{C_{blt}}\right) \times Q_{todate} \times T_{todate} \times \frac{0.02832\,m^3}{ft^3} \times \frac{3600\,s}{hr} \times \frac{1g}{10^9\,ng} \times \frac{1000\,L}{m^3}$$

Where:

F_{todate} = load loss of Tri+ PCBs at the far-field station for the dredging period to date due to dredging-related activities in g/day.

$\overline{C_{ffst}}$ = flow-weighted average concentration of Tri+ PCBs at the far-field station as measured from the start of the dredging period to date in ng/L. For once per day sampling, this is given as:

$$\overline{C_{ffst}} = \frac{\sum_{j=1}^{n} C_{ffst_j} \times Q_j}{\sum_{j=1}^{n} Q_j}$$

Where:

C_{ffstj} = Tri+ PCB concentration at the far-field station for day j. if more than one sample is collected in a day, the arithmetic average of all the measurements will be used.

Q_j = daily average flow at the far-field station for day j.

n = number of days from the start of dredging period

$\overline{C_{blt}}$ = Estimated arithmetic mean baseline concentration of Tri+ PCBs at the far-field station for the period in which the sample was collected, in ng/L. This value is determined from baseline monitoring data. Time-weighted averages are calculated as the sum of the arithmetic average of each day dividing by the number of days

Q_{todate} = average flow at the far-field station, determined either by direct measurement or estimated from USGS gauging station, in cfs.

T_{todate} = average period of dredging operations per day for the time period, in hours/day, as follows:

$$T_{todate} = \frac{\sum_{j=1}^{n} T_{d_j}}{n}$$

Where: T_{dj} = the period of dredging operations for day j in hours.

4.4 Reporting and Notifications

Weekly progress reports shall be submitted to EPA~~, according to a schedule to be defined by the Agency,~~ as described in the Phase 2 Performance Standards Compliance Plan to be prepared by GE, for the Agency's use in determining compliance with the Resuspension Standard. The reports must summarize the results of far-field and near-field monitoring, exceedances of the Resuspension Standard criteria, and any corrective actions implemented. The description and results of engineering studies shall be provided to EPA separately within a week of completion. Laboratory data shall be made available to EPA upon receipt from the laboratory~~. Data from continuous reading instruments must be made available to an EPA field representative immediately and submitted to EPA within 12 hours of collection. Data logging requirements for both near-field and far-field suspended solids must be sufficient so as to begin increased PCB sampling within six hours of the actual exceedance, as required by the action level exceeded.~~ and verification.

4.5 Special Studies

In addition to sampling that will be performed to assess compliance with the Resuspension Standard, other sampling will be needed to refine implementation of the standard, as necessary. This second category of sampling efforts is designated as "Special Studies" and is intended to be conducted for limited time periods to gather information for addressing specific conditions or issues that may be encountered during dredging. The Special Studies for Phase 2 are summarized in Table 2.4-1, and for Resuspension, include the following:

- ~~Establish the PCB levels and properties of the NAPL phase and determine whether the observed oil sheens indicate that PCB NAPLs are a significant contributor to the river PCB~~

~~contamination.~~[Note to EPA: This is unnecessary and was not endorsed by the peer review panel.]

- Estimate PCB losses from water column at Thompson Island and Schuylerville dam locations and determine if volatilization of PCBs or NAPLs, especially at dam locations, potentially explain observed PCB losses in the downstream direction that exceed losses which might be attributed to conventional gas exchange.
- Estimate PCB losses from water column over flat water and determine dissolved and suspended matter PCB fractions to assess the fractions losing mass. Evaluate whether settling of particulates is primarily responsible for observed decreases in PCBs downstream of Thompson Island, or if particle-associated PCBs are relatively insignificant compared to volatilization.
- ~~Determine PCB concentrations on suspended matter and dissolved phase concentrations above and below reaches where tributaries enter the river, and hence establish whether resuspension and additional solids input from tributaries downstream of the dredging scavenge dissolved PCBs and settle to the sediment bed.~~
- ~~Establish the nature of PCB transport due to boat prop wash and assess how the various factors determined to affect releases from dredging by statistical analysis will be investigated further and used to implement operational controls.~~
- Identify DQOs to examine the regression variables and evaluate the processes or mechanisms that control the kinetics of PCB release to the dissolved phase~~, and quantify PCB flux due to oil sheen for Near-field and Far-field locations~~.

Evaluate operational controls during Phase 2 dredging to determine effectiveness for reducing PCB releases during dredging.

5 Productivity Performance Standard

5.1 Overview of Phase 2 Productivity Standard

The Productivity Standard establishes a ~~schedule~~seasonal production rate for the dredging project and provides guidelines for monitoring its progress to ensure that it is completed in a timely fashion. Maintaining an appropriate dredging production rate is one of many factors that will limit the duration of construction-related impacts.

The original Productivity Standard, published by the EPA in April, 2004, established a schedule six years in duration in accordance with the ROD. The initial year of this schedule, designated Phase 1, consisted of dredging initially at a reduced scale with extensive monitoring to evaluate compliance with the Engineering Performance Standards. Phase 1 dredging was completed in 2009. The remaining dredging seasons of the project, designated as Phase 2, to be defined based on Phase 1 and performed against a fixed set of standards, are characterized by dredging at full production to remove the remainder of the contaminated sediments targeted for removal.

The original Engineering Performance Standards did not establish a hierarchy for compliance with of the Resuspension, Residuals, and Productivity Standards, but gave equal weight to each Standard. The Productivity Standard defined the volume of contaminated sediment required to be dredged each season and a slightly higher "target" volume established to promote completion of dredging in a shorter timeframe. Thus, under the original Productivity Standard, the dredging contractor was required to achieve a high rate of productivity while, at the same time, ~~attempting~~required to meet the Residuals Standard and minimize resuspension of PCBs as required by the Resuspension Standard. The resulting tension between the three Standards proved ~~difficult to manage~~that it was impossible to meet all three standards simultaneously during Phase 1. The application of best management practices aimed at reducing resuspension invariably caused ~~some~~ reduction in productivity, and the difficulties experienced in meeting the Residuals Standard reduced dredging productivity significantly.

During Phase 2, and as recommended by the Peer Review Panel, the Productivity Standard is subordinate to the Resuspension and Residuals Standards. However, completing the project as quickly as reasonable is still a priority and will result in realizing the project benefits at the earliest time practicable. Therefore, except in unusual circumstances, responses to Resuspension and Residual Standards will not include slow down or shutdown of dredging, but will be based on a pre-defined set of Best Management Practices to be implemented. In addition, because the full amount of material to be removed is ~~currently unknown~~uncertain, the annual "required" dredging volumes have been eliminated and only target volumes are specified. The Peer Review Panel also recommended development of an annual metric for completion of an area of the project, which could be expressed as a number of CUs or number of acres to close each year.

The Phase 2 Productivity Standard ~~also de-emphasizes the six-year schedule, establishing a planning-level estimate of Phase 2 duration that balances~~now emphasizes the project goal is to complete the dredging as quickly as reasonable, with a goal of completing the project in six or fewer years, but with a recognition that it needs to balance the total removal volume with consequences of prolonged construction activities on the river rather than a rigid timeframe for completion. ~~Furthermore, the revised standard establishes separate metrics~~[Note to EPA: This change needs to be made throughout this document.] The Peer Review Panel identified separate productivity targets for the evaluation of removal, processing, and shipment offsite, all three of which were evaluated based on the removal volume defined in the Phase 1 Standard. Finally, the corrective actions required in the event that the contractor fails to dredge the required sediment volume in any given year, specified in the original Productivity Standard, have been eliminated under the expectation that all parties have an interest in completing the project as expeditiously as possible. ~~However, failure to meet the targets will set into motion a review of the dredging and materials conveyance and handling processes to assess where revision can be made to increase productivity. EPA will require that such changes are made if necessary.~~Given that all parties have an interest in completion of the project as expeditiously as possible a review of productivity will be conducted at the completion of each season. This review will be conducted jointly by EPA field office staff, the GE project team and the contractors before the end of the calendar year, to identify potential revisions to both the processing facility operations and river operations that will increase overall efficiency and productivity and ultimately reduce the overall project duration. Events and direction given that impacted productivity will be evaluated and alternative methods for dealing with these events will be investigated.

The term "dredging," as used in the Productivity Standard, includes removal of the contaminated sediment, dewatering and disposing of the dredged sediments, backfilling or capping dredged areas as appropriate, and stabilization of shoreline areas disturbed by the work. The volume of dredged sediment to be credited toward meeting each year's target dredging volume is equal to the in-place volume removed as confirmed by bathymetric surveys, and includes all remedial and access dredging required to complete the work, including side slopes. This is a change from the original Productivity Standard, which divided remedial dredging into two categories: inventory and residual, and did not include sediment volumes removed during residuals dredging or those removed below the design cut line, referred to as missed inventory, in the volume counted toward meeting each year's required production.

During design of Phase 1, it was noted that planting of submerged aquatic vegetation should be done in the spring season rather than in the fall. Accordingly, EPA and GE agreed that this work would be done in the spring following each year's dredging work. This change is carried through to the Phase 2 Productivity Standard. Therefore, the planting of submerged aquatic vegetation will take place in the spring following the ~~last~~ year of dredging of any given area.

5.2 Basis for Changes to the Productivity Standard

5.2.1 Technical Background and Approach

The Phase 1 dredging work demonstrated a number of limitations of dredging, including that the depth of contamination ~~has not been well-defined by the sampling performed to date~~was uncertain and, as a result, ~~no reliable engineering estimate of the volume of contaminated~~the final project sediment ~~remaining to be dredged is available~~volume is also uncertain. Current EPA estimates of the remaining volume to be dredged range from about 2.3 to 3.0 million CY, but are not considered sufficiently reliable to establish an estimate for the length of Phase 2. Additional sediment sampling will be needed to improve the present estimate, particularly in areas where the currently available core sample results are not considered reliable~~, and it~~. Since additional sediment sampling will only proceed for a given area during the year prior to dredging is likely that the overall project estimate will change on a yearly basis as the work progresses.

In addition to a lack of a firm, engineering estimate of the volume of sediment to be dredged during Phase 2, the ~~dredging contractor for~~ Phase 1 project did not ~~meet~~achieve a minimum sustained production rate high enough to demonstrate that an estimated total volume of approximately ~~2.3 to 3.0~~2.6 million CY of sediment [Note to EPA: Phase 1 was not based on a range of quantities.] could be dredged in the five years as anticipated for Phase 2 when the original Productivity Standard was developed~~. During the peer review process, EPA provided analyses indicating that with improved scow availability during Phase 2, the annual productivity could meet the original productivity target of 96,000 CY per month (528,100 CY/year)~~. The Peer Review Panel, however, stated that a more realistic annual target is 350,000 cubic yards. EPA accepts the Panel's recommendation and is adopting 350,000 CY/year as a target, but the Agency remains cautiously optimistic that during Phase 2, it will be possible to dredge a larger amount of cubic yards each year. Finally, as noted above, the requirement to meet Resuspension, Residuals, and Productivity Standards simultaneously proved~~ very difficult~~ to ~~manage~~be impossible during Phase 1. The Peer Review Panel summarized their recommendation regarding this issue on page *v* of the executive summary and again on page 78 of Hudson River PCBs Site Peer Review of Phase 1Dredging Final Report (2010): "*… 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*." As a result, EPA has decided that as the Peer Review Panel has said, it is more important to the success of the project that the Resuspension and Residuals Standards are met than that the work be completed on a fixed schedule. ~~Accordingly, and in~~In accordance with recommendations made by the Peer Review Panel, changes have been made to the Productivity Standard for Phase 2. As recommended by the Peer Review Panel, an area metric that can be used to assess productivity will also be evaluated as Phase 2 goes forward.

5.2.2 Supporting Analysis

During Phase 1, approximately 273,600 CY of sediment was dredged. The base target dredging volume for the first year of Phase 2 has been set at 350,000 CY. This value is based on the recommendation of the ~~peer review panel~~Peer Review Panel and reflects the Phase 1 experience. The following considerations also influenced determination of the baseline target volume:

- Dredging ~~will begin by~~should be planned for approximately 120 dredging days. Dredging may begin on or about May 15 each year and continue for approximately 5 months until approximately October 1, ~~followed by~~depending on conditions, allowing 30 days to complete backfilling and capping, ~~and~~followed by 15 days to demobilize heavy equipment before the canal closes on or about November 15.

- As discussed in Chapters 2 and 3 above, dredging during Phase 2 will generally be conducted following the "single-pass" approach. Improved estimates of the depth of contamination and the resulting implementation of the single pass approach will eliminate excessive time spent chasing missed inventory and residual material.

- The scow unloading operation should be improved to keep up with dredge production~~; scows should be managed to minimize dredging delays due to a lack of an empty scow~~.

As indicated above, the Peer Review Panel findings were used to establish a target dredging volume of 350,000 CY per year for Phase 2. To arrive at this number, the Peer Review Panel applied the peak monthly outputs observed during Phase 1, 75,566 and 77,284 CY to the 5-month season and calculated an annual output range of 370,000 to 385,000 CY. The Panel stated that achieving Phase 1 peak removal output during every month of Phase 2 was not necessarily reasonable, and therefore recommended an annual target of 350,000 CY, a value corresponding to 90% of the monthly peak rate. This removal volume is a baseline target. Best management practices will be applied throughout the life of the project to improve this productivity rate. EPA is cautiously optimistic that the annual productivity could meet the original productivity target for of 96,000 CY per month (528,100 CY/year).

In addition to refining the annual target volume, the Panel also recommended reasonable targets for Phase 2 annual processing and shipping volumes based on the currently existing facilities. EPA notes the Peer Review Panel's assessment. The Panel applied the peak monthly processing output observed during Phase 1, 73,700 CY, to the 5-month season and calculated an annual peak processing output of 368,000 CY. The Panel stated that achieving peak removal output during every month of Phase 2 is not necessarily reasonable, and therefore recommended an annual target of 330,000 CY, a value corresponding to 90% of the monthly peak rate. EPA notes the Peer Review Panel's assessment, but again, is cautiously optimistic that the amount processed could meet the original productivity target for of 96,000 CY per month (528,100 CY/year) with appropriate adjustments to the processing system. ~~This will be addressed in accordance with the AMP.~~

The determination of the annual target for shipment off-site performed by the Peer Reviewers took into account two separate Phase 1 factors: the peak monthly shipping output of 42,200 CY observed during Phase 1, and the determination that 1.5 to 2 unit trains could be loaded and shipped in a week's time. A third consideration influencing this criterion was associated with the timeframe. The other two volume metrics (dredging and processing volumes) developed for this Phase 2 Productivity Standard are both dependent on river conditions and must be completed during the timeframe while the Champlain Canal Lock System is operational. Since the transport of material off-site is not tied to conditions on the river, and the current processing facility does allow for the stockpiling of processed sediments, the shipment of material can be decoupled from the dredging season. The ~~Panel applied this peak monthly rate to a 9-month shipping season, and assuming that 1.5 unit trains were shipped per week, calculated that a total of 380,000 CY of material could be shipped off-site each~~shipping season starts approximately 4-6 weeks after the start of dredging, once a surge pile has been built to load railcars from. The shipping season is approximately 5 months long until weather (freezing temperatures and snow) has a real potential to interfere with railcar loading operations and train movements across the country. For that reason unit trains are expected to be loaded at a rate of 2.0 to 2.5 unit trains per week for up to 5 months, or up to 380,000 tons. Any amount of material remaining on the site when weather impacts the loading and shipping operations would then be covered for the winter. Loading operations would resume in the spring of the following year. For each season, all material dredged in one year will be ~~required to be~~ shipped off site by the ~~end of the year~~start of the next season's dredging operations.

Although the Peer Review Panel recommended three different targets for productivity (dredging, processing, and shipping), because each operation is related these must be reconciled into a single seasonal target. The target for Phase 2 productivity is therefore set at 350,000 CY.

In addition to these major considerations, an additional factor should be incorporated in the implementation of the Productivity Standard. During Phase 1, in an effort to increase the volume of sediment placed in a mini-scow before it was emptied, the dredge operators were allowed to drain free water from buckets before emptying it into ~~the~~ a mini-scow. Draining the water from the bucket typically took from one to two minutes and increased the bucket cycle time significantly. ~~This practice also increased the amount of PCB lost to the water column. Draining free water from a bucket before emptying it into the scow is not considered a BMP and will be prohibited during Phase 2. Consideration should be given to transferring excess water from the mini-hopper scows to a large hopper scow or a tanker scow using a pump and floating pipeline or eliminating the use of mini-hoppers~~Acknowledging that the mini-scows were an adaptive management approach implemented from the resources on hand during Phase 1 to deal with the shallow bedrock areas, the Phase 2 contractor(s) will be required to propose shallow draft barges. This is expected to minimize the stability concerns associated with water in the small scows and increase the size of loads handled in shallow areas.

Improving the scow unloading operation to keep up with dredge production, changing the sequence of steps needed to achieve closure of a CU ~~and transferring water from~~, minimizing transload operations and identifying alternatives to the improvised mini-scows ~~by pipeline~~ should provide a comfortable margin of safety in meeting the target dredge volumes established for Phase 2.

Dredging of inventory will be permitted in up to three (3) contiguous CUs as approved in Phase 1. Initial backfill will be placed in an upstream to downstream manner as grade is met. To minimize the potential resuspension from "open" dredged areas, coring through the initial backfill will be permitted.

To increase productivity, dredging may be performed simultaneously in multiple areas of the river. These areas will be separated to minimize the potential for redeposition as upstream areas are completed above areas already dredged. This separation will be based on the ability to isolate work areas such as the landlocked area, West Griffin Island area, areas that are separated by a dam, and areas that are separated by more than 1,000 feet.

In addition, it is recognized that mid-season changes to the various dredging and process facility operations and resources may impact productivity. Decisions to alter operations during the season will be avoided. Shutdowns and slowdowns of the work in response to concerns related to Engineering Performances Standards and Quality of Life Performance Standards will also be avoided. Instead pre-defined Best Management Practices will be implemented in response to concerns regarding elevated metrics.

5.3 Implementation of the Phase 2 Productivity Standard

While additional sampling of Phase 2 areas will be performed to better define the depth of contamination, implementation of the Phase 2 Productivity Standard should require monitoring of dredge production with particular emphasis on identifying and recording any significant amounts of additional contaminated sediment found as each CU is dredged and closed. The experience gained during Phase 1, where approximately 1.8 times more contaminated sediment was found and dredged than shown on the design drawings, indicates that estimates of the depth of contamination were poor. The current estimate of the quantities to be dredged in Phase 2 is ~~not considered a rigorous engineering estimate~~uncertain and changes in the estimated volume can be expected.

In order to maintain a running record of the amount of sediment dredged, including sediment excavated for access purposes, the Phase 2 Productivity Standard calls for monthly and annual productivity progress reports to be submitted to the EPA. These reports shall document progress in meeting the target dredging areas and volumes listed in the Productivity Standard. Monthly productivity progress reports shall ~~include~~be based on daily reports of operations that will address the same information required by a USACE Daily Report of Operations for the appropriate dredge type. The actual daily reports will be maintained by GE and will be available for EPA review at the project field offices. Monthly progress reports will be the primary means of keeping track of the volume of contaminated sediment dredged from each CU and will be used to compare the actual volume of sediment removed to the volume shown in the design. The estimate of the volume of contaminated sediment remaining to be dredged during the year may be adjusted, based on this comparison, and may increase or decrease as indicated by the data.

The Phase 2 Productivity Standard also requires that an annual summary report on the total volume dredged during the year, with a comparison of that volume to the volume anticipated in the design, be submitted to EPA at the end of each dredging season. This report must be submitted no later than ~~two weeks~~thirty days after the end of dredging (backfilling and capping may still be in process) and will help inform ~~EPA's decision making about~~the joint review of productivity by the EPA, GE and the contractor, informing decisions to make any changes to the target dredging volumes for subsequent years.

By February ~~1~~15th of each year ~~following the first year~~ of Phase 2 dredging, ~~the construction manager~~as part of the RAWP submittal, GE shall provide EPA with a production schedule showing anticipated monthly sediment production for the upcoming dredging season.

5.4 Reporting and Notification

Reporting and notification requirements for the Phase 2 Productivity Standard ~~are listed in Section 2.1.3 and~~[reference appears wrong] consist, primarily, of ~~daily~~weekly and monthly productivity progress reports and an annual report showing the total volume dredged during the year with a comparison to the design volume for those CUs dredged~~. These reports are needed to keep track of the volume of sediment dredged and to identify any changes in the volumes removed from each CU as needed to adjust the estimate of the total volume to be dredged during Phase 2 and the target dredging volume for the following seasons~~. Corrective action reports and specific actions to be taken, required under the original Productivity Standard if the contractor failed to dredge the required sediment volume in any given year, have been eliminated from the Phase 2 Productivity Standard under the expectation that all parties have an interest in completing the project as expeditiously as possible.

~~5.5 Special Studies~~

~~Although no special studies are proposed relative to productivity at this time, the EPA is requiring that daily scow tracking be implemented and reported to the EPA so that the impacts of scow unavailability can be evaluated and corrected if necessary. To achieve this, the status of each scow must be reported on a daily basis including at a minimum: at CU being loaded, in transit to unloading, at mooring awaiting space at the unloading dock, at the unloading dock awaiting unloading, being unloaded, at mooring awaiting transit to loading, in transit to loading.~~

6 Water Quality Requirements for In-River Releases of Constituents Not Subject to Performance Standards

All requirements presented in this section are identical to those applied during Phase 1, unless otherwise noted. [Note to ~~**GE:** The contents of this section have not yet been discussed with the New York State Department of Environmental Conservation (NYSDEC) or the New York State Department of Health (NYSDOH), and may be subject to revsions following consultation with the State.]~~EPA: Based on Phase 1, we presented EPA with a proposal for reduced metals monitoring requirements for Phase 2. This proposal will detailed in GE's comments on the RAMP Scope. We need to discuss this proposal further so that appropriate revisions to this section may be made.]

6.1 Substantive Water Quality Requirements

The EPA, in conjunction with the NYSDEC and the NYSDOH, has defined water quality standards in the near- and far-fields for a number of constituents, for example metals, that are not governed by the EPS and will be monitored for compliance during Phase 2. The objectives of these water quality requirements are:

- Protection of aquatic species via Aquatic Acute Standards
- Protection of drinking water supplies via health (water source) standards.
- Protection of drinking water supplies via NYSDOH standards and an action level.

These water quality requirements are known as the Substantive Water Quality Requirements (Substantive WQ Requirements), and consist of the following:

1) Requirements relating to in-river releases of constituents not subject to EPS, as set forth in Substantive Requirements Applicable to Releases of Constituents not Subject to Performance Standards;
2) The substantive requirements for discharges to the Hudson River and Champlain Canal, as set forth in Substantive Requirements of State Pollutant Discharge Elimination System Permit for Potential Discharges to Champlain Canal (land cut above Lock 7);
3) Substantive Requirements of State Pollutant Discharge Elimination System Permit for Potential Discharges to the Hudson River.

These three sets of requirements are contained in a letter document issued by the EPA in January 2005, with slight modifications documented in Attachment A to CD Modification No. 1. Monitoring requirements will be outlined in the Phase 2 RAM Scope.

6.1.1 Aquatic Acute Water Quality and Health (Water Source) Standards

6.1.1.1 Aquatic Acute Water Quality Standards at Near-Field Stations

Aquatic acute standards will be used to evaluate samples collected in the near-field, and to the dissolved phase of the contaminant. Some constituents of the aquatic acute standards are hardness-dependent; as hardness varies along the length of the project area, a range of standards will be calculated for those constituents. For example: based on the limited available data, average hardness values from Corinth and Waterford range from 18 to 55 ppm, respectively.

The ranges of water quality standards are as follows (where applicable, the formulas for calculating the standards are in brackets):

- Cadmium: Aquatic Acute A(A): 0.6 µg/L to 2.0 µg/L [(0.85) exp(1.128 [ln (ppm hardness)] – 3.6867)]
- Lead: Aquatic Acute A(A): 14.4 µg/L to 50.4 µg/L [{1.46203 – [ln (hardness) (0.145712)]} exp (1.273 [ln (hardness)] – 1.052)]
- Chromium: Aquatic Acute A(A): 140 µg/L to 349 µg/L [(0.316) exp (0.819 ln (ppm hardness)) +3.7256)]
- Chromium (hexavalent): Aquatic Acute A(A): 16 µg/L
- Mercury: Aquatic Acute A(A): 1.4 µg/L.
- Water quality standards for pH and DO are specified in NYCRR Title 6, Chapter X, Part 703.3
  - pH will not be less than 6.5 nor more than 8.5
  - DO for non-trout waters:
    - The minimum daily average will not be less than 5.0 mg/L
    - At no time shall the DO concentration be less than 4.0 mg/L.

6.1.1.2 Health (Water Source) Standards at Far-Field Stations

Health (water source) standards will be used to evaluate samples collected in the far-field. These standards are not hardness-dependent, and are applicable to the total phase of each constituent. The following standards should not be exceeded at the Thompson Island, Schuylerville, or Waterford far-field stations:

- Cadmium (Total): 5.0 µg/L
- Chromium (Total): 50 µg/L
- Mercury (Total): 0.7 µg/L
- Lead (Total): 15.0 µg/L (NYSDOH action level)

A confirmed occurrence of a constituent above the standards and NYSDOH action level is required to determine an exceedence of the criteria. A confirmed occurrence is defined as a single, 24-hour composite sample collected in triplicate on the subsequent day exceeding the standard/action level. This represents a revision to the original Attachment A to CD Modification No. 1, and is subject to revisions after consultation with the State.

6.1.1.3 Implementation of the Substantive WQ Requirements, Near- and Far-Field

Routine monitoring for compliance with both the aquatic acute standards and the health (water source) standards will be limited to analyses for dissolved and total cadmium and lead. Evaluation of the metals data from the BMP and Treatability Studies programs by GE indicate that the lead and cadmium standards would be exceeded before the mercury and chromium. Additional data will be collected and reviewed during Phase 2 to further confirm this relationship. If monitoring indicates that cadmium and/or lead concentrations exceed the above standards, near-field total and dissolved and far-field total samples for the entire suite of metals subject to the Aquatic Acute Standards will be collected and analyzed. These analyses will include:

- All Target Analyte List (TAL) metals provided by EPA Method 200.8;
- Mercury by EPA Method 1631; and
- Hexavalent chromium by SW-846 Method 7196A.

The additional analyses will continue in the near-field until compliance with the aquatic acute standards is achieved. In the far-field, additional analyses will continue until compliance with the health (water source) standards is achieved and EPA has authorized a return to routine monitoring. If the metals monitoring results obtained in the near-field indicate that dredging is having a minimal effect on metals concentrations in the river, the scope of the metals monitoring program in that area will be modified.

6.1.1.4 Additional Monitoring Based on Fish Observations

If distressed or dying fish are observed during in-water activities, EPA and NYSDEC shall be notified immediately. If the cause of the effects on fish is determined to be project-related, increased monitoring for metals and additional water quality parameters will be conducted. Details of this increased monitoring are provided in the Substantive WQ Requirements document issued by the EPA in January 2005, with slight modifications documented in Attachment A to CD Modification No. 1.

6.1.2 Discharges to Surface Water

The Substantive WQ requirements also define criteria for treated water discharged to the Champlain Canal Land Cut above Lock 7 via Outfall 001, and a letter issued by EPA to GE on September 14, 2006 presents requirements for non-contact (Type II) stormwater discharges to Bond Creek through Outfalls 002 and 003.

6.1.2.1 Treated Discharges to Champlain Canal

The water treatment system constructed for the RA will treat water originating from the sediment dewatering operations as well as Type I stormwater. Water from these sources will be discharged into the Champlain Canal through Outfall 001. The criteria for these are defined in the Substantive WQ Requirements are as follows:

- Measure discharge flow continuously with a flow meter.

- Monitor pH in the discharge on a monthly basis via grab sampling.
- Analyze the following parameters via weekly grab samples:
    - TSS (Standard Method 2540D)
    - TOC (Standard Method 5310B)
    - Total Cadmium (EPA Method 200.8)
    - Total Chromium (EPA Method 200.8)
    - Total Copper (EPA Method 200.8)
    - Total Lead (EPA Method 200.8)
    - Total Mercury (EPA Method 1631)
    - DO (probe)
- Analyze PCBs as a 24-hour runtime composite sample (EPA Method 60; all reasonable attempts should be made to achieve a Minimum Detection Level of 0.065 µg/L for each Aroclor.

6.1.2.2 Non-Contact Stormwater (Type II) Discharges to Bond Creek

Type II discharges are defined as non-contact stormwater not directly in contact with PCB-related processes resulting from the overflow of the two sedimentation basins at the sediment processing facility. When these basins overflow, they discharge from Outfalls 002 and 003 into Bond Creek. Based on the letter issued by EPA on September 14, 2006, the following monitoring is required under basin overflow conditions:

- Estimate discharge flow daily
- Measure total settleable solids daily via Method 2540F in the Standard Methods for the Examination of Water and Wastewater
- Monitor pH monthly in a grab sample
- Monthly monitoring of:
    - pH (probe)
    - Oil and Grease (EPA Method 1664)
    - PCB Aroclors (EPA Method 608); all reasonable attempts should be made to achieve a Minimum Detection Level of 0.065 µg/L for each Aroclor.
- Monitoring once every two months of:
    - Total Cadmium (EPA Method 200.8)
    - Total Chromium (EPA Method 200.8)
    - Total Copper (EPA Method 200.8)

7 Estimation of PCB Mass in Phase 2 Remediation Areas

[Note to EPA: Due to the limitations of time given by EPA for GE to review and comment on this document, we have not had an opportunity to review and comment specifically on this section. However, please note that this document mischaracterizes GE's approach to estimating PCB mass. GE's approach is set forth in GE's Phase 1 Evaluation Report. That document is hereby incorporated by reference.] The objective of this section is to describe a procedure to estimate the mass of PCB in contaminated sediment (*i.e.,* the PCB inventory of the sediment). This section includes methods for quantifying the mass of PCB inventory removed by dredging and for quantifying unexpected inventory left behind after dredging. These methods include procedures for both estimation of the inventory itself (point estimate) as well as for quantifying the uncertainty in the estimate (confidence limits). The calculation of mass estimates of PCBs in sediments for use in the EPS shall follow the statistically-based procedures given below. These procedures provide unbiased estimators of the inventory given the nature and spatial distribution of the sampling program. These procedures also provide rigorous estimates of the uncertainty in these estimates for consideration in the various calculations required by the EPS.

The methods presented here are tailored specifically to the nature of data available and the sampling design used to select sample locations. The proposed procedures derive their validity from the sample selection methods providing a basis for what is termed design-based estimation (Cochran 1977).

The population parameter of interest is PCB mass defined by

$$Mass = Concentration \times Volume \times Dry\ Bulk\ Density,$$

where terms in the equation must be estimated using sample data because they are incompletely known. The estimation procedure may vary depending on the information supporting each term and at what level the variables are measured, such as at the core-section, core, or full CU basis. For example, at the Hudson River, PCB concentration is known at each core section, but bulk density was only measured on a per-core basis. Methods also vary depending on the level of certainty with which the volume of sediment removed is known. Analysis methods, particularly for quantification of uncertainty, must carefully incorporate the sampling design and randomization procedures used to select locations and subsamples.

7.1 Guiding Principles

1) Procedures described below will provide estimates of the total mass of PCB inventory removed and remaining after dredging on a per CU basis.
2) Procedures described below will include statistical uncertainty bounds (*i.e.* confidence limits) for estimated mass per each CU for inventory removed as well as inventory remaining after dredging.
3) Estimation methods will be unbiased and based on statistical procedures from the published literature, providing comparable estimates of inventory removed and left behind for each CU.
4) Methods for estimation of uncertainty will treat each core location as the primary experimental unit, and each core section will be treated as a subsample within the primary unit.
    a. The number of degrees of freedom for variance estimation is determined by the number of core locations, not subsamples (i.e. individual core sections);
    b. Subsamples do not contribute to the degrees of freedom for variance estimation.

5) Methods requiring use of imputed PCB concentrations or bulk densities are discouraged because:
    a. Such methods are not expected to improve accuracy or precision of estimation;
    b. Incorporation of imputed values would require much more sophisticated geostatistical procedures and models to properly quantify uncertainty.

7.2 Discussion of Methods

In Phase 1 dredging, the GE estimate of the PCB mass removal was obtained using a mechanistic approach in which PCB mass was approximated within each dredge bucket bite and then summed across all bucket bites to arrive at estimates of volume and mass of PCBs removed during dredging. Because the volume, concentration and bulk density of sediments removed by each bucket bite is unknown, this approach required a series of approximations in order to arrive at the fundamental measurement forming the basis of subsequent calculations. The approximations necessary to impute missing data required to populate estimation equations were generally derived through weighted averages of nearby SSAP core data, PCB concentration and fraction of solids. These weighted averages were linear in the original SSAP data and estimating equations were also linear in the imputed values. Therefore the estimation procedure developed by GE is ultimately a linear function of the original SSAP data (i.e. because linear functions of linear functions are linear). Because core locations are sparsely located relative to the size of individual bucket bites, the uncertainties introduced by imputation of these values in the Phase 1 procedure outweigh the perceived benefits of an apparently more careful analysis of said imputed values.

The method used by GE suffers two primary drawbacks; 1) increased uncertainty introduced by imputation of missing data, and 2) failure to provide methods to estimate confidence intervals. The methods provided in this chapter are derived directly from measured data without the need to impute missing values for intermediate steps and also include rigorous estimates of uncertainty. The methods are equally applicable to dredged as well as undredged PCB inventory with some small modifications to account for the unknown volume of undredged inventory. This will facilitate development of comparable estimates of dredged and undredged inventory and estimation of the proportion of total mass removed by dredging.

7.3 Method for Dredged Inventory

The overall strategy is to estimate mass of dry PCBs per unit volume of wet-sediment for each CU and multiply by volume of wet-sediment to obtain an estimate of total mass of PCBs removed. The order of operations for these calculations is important in order that appropriate estimates of uncertainty can be obtained. Because the depth of cut varies spatially, calculations are depth-weighted to insure that thick and thin areas of the removal are represented proportionally. Area weighting is not used in the calculation, because the samples are at the nodes of a regularly spaced grid and are therefore of equal information content. In situations where some cores are not on the regular sampling grid, but not tightly clustered with other cores, they are also treated as equally representative. When core locations are revisited on multiple occasions and complete cores were obtained on each occasion, concentration, bulk density and core length are to be averaged to obtain a single value representative of the centroid of the revisited locations. These locations will contribute one degree of freedom to the estimation procedure.

7.3.1 Mathematical Description

Define i=1,2,3…n to be an index of the core locations within each CU, and let j=1,2,…n_i index the core sections within the i^{th} location. Then L_{ij}, C_{ij} and F_{ij} represent the recovery-corrected length, TPCB (or Tri+ PCB) concentration, and fraction-of-solids measurements for the ij^{th} core section respectively. Each core section is corrected for lack of 100% core recovery by dividing the measured length by the fraction of sediment recovered. The core correction is necessary because loss of recovery is due to undersampling of some sediment strata during the core collection process. In addition to these measurements available for each core section, the wet mass and volume of sediment for the entire core are obtained by weighing the sediment and water filled core, and by subtracting the mass of the core tube and water overlying the sediment. Combined with the fraction solids measurements, the dry bulk density B_i is calculated per each core location. Table 7.3-1 and Figure 7.3-1 define other variables and terminology used in the equations below. Table 7.3-2 illustrates the data handling steps described here in steps 1 through 3 for the data associated with the core shown in Figure 7.3-1.

Step 1. Calculate length-weighted fraction solids per core location:

$$F_i = \frac{\sum_{j=1}^{n_i} L_{ij} F_{ij}}{\sum_{j=1}^{n_i} L_{ij}}$$

Step 2. Convert wet bulk density $(\delta_i)(\delta_i)$ to dry bulk density per location:

$$B_i = F_i \times \delta_i$$

Step 3. Calculate length-weighted mass per unit volume per core location:

$$m_i = \frac{B_i \sum_{j=1}^{n_i} L_{ij} C_{ij}}{\sum_{j=1}^{n_i} L_{ij}},$$

where n_i represents the number of core sections above the identified corrected depth of contamination at location i.

Step 4. Calculate the length-weighted average mass per unit volume

$$Mass\ Per\ Unit\ Volume = \frac{\sum_{i=1}^{n} L_i m_i}{\sum_{i=1}^{n} L_i} = \frac{\sum_{i=1}^{n} L_i m_i / n}{\sum_{i=1}^{n} L_i / n},$$

Step 5. Calculate total mass:

$$M = k \times V \times \left(\frac{\sum_{i=1}^{n} L_i m_i}{\sum_{i=1}^{n} L_i} \right),$$

where k=7.6456e-7 is a units conversion factor and *V* is the total wet-volume of sediment removed from the CU based on subtraction of bathymetric surveys.

7.3.2 Variance Estimation and Confidence Intervals (Known Volume Removed)

Because the numerator and denominator in the mass estimate are both functions of measurements that cannot be known prior to collection of the cores, both the numerator and denominator are random variables and therefore, the variance of the mass estimate Var(M) must be estimated using formulas for the variance of a ratio of random variables.

Defining the intermediate variable $u_i = L_i m_i u_i = L_i m_i$ with $\bar{u} = \frac{1}{\text{n}}\sum_{i=1}^{n} u_i, \bar{u} = \frac{1}{\text{n}}\sum_{i=1}^{n} u_i,$ $\bar{L} = \frac{1}{\text{n}}\sum_{i=1}^{n} L_i, \bar{L} = \frac{1}{\text{n}}\sum_{i=1}^{n} L_i,$ and $R = \frac{\bar{u}}{\bar{L}} R = \frac{\bar{u}}{\bar{L}}$, the mass estimate can be written as

$$M = k \times V \times R.$$

Assuming that uncertainty in the volume of sediment removed is much smaller than that associated with the concentration estimates, the variance Var(M) is given by:

$$Var(M) = k^2 \times V^2 \times Var(R).$$

where $Var(R) Var(R)$ is estimated from un-weighted sample mean, variance and covariance of the intermediate variables $u_i \; and \; L_i u_i \; and \; L_i$ defined above (Casella and Berger 1990):

$$Var(R) = R^2 \left(\frac{var(\bar{u})}{\bar{u}^2} + \frac{var(\bar{L})}{\bar{L}^2} - 2 \times \frac{cov(\bar{u}, \bar{L})}{\bar{u} \times \bar{L}} \right),$$

where,

$$Var(\bar{u}) = \frac{1}{n} \sum_{i=1}^{n} \frac{(u_i - \bar{u})^2}{n-1}, \; Var(\bar{L}) = \frac{1}{n} \sum_{i=1}^{n} \frac{(L_i - \bar{L})^2}{n-1} \;\; ,$$

and $cov(\bar{u}, \bar{L}) cov(\bar{u}, \bar{L})$ is the sample covariance of the means which is equal to the sample covariance of *u* and *L*

$$Cov(\bar{u}, \bar{L}) = \frac{1}{n-1} \sum_{i=1}^{n} (u_i - \bar{u})(L_i - \bar{L}).$$

Sample variance formulas are based on the assumption that core locations are statistically independent whereas it is understood that variables measured at adjacent locations may be positively correlated. Due to this tendency toward spatial correlation, these formulas could be improved by use of equations developed specifically for systematic sampling from populations that are positively spatially correlated. Wolter (1984) provides alternative formulas that could be considered for incorporation into this estimation procedure. In general, the standard variance formulas tend to overstate the true population variance when applied to positively correlated processes. Resulting confidence intervals would tend to be wider than necessary to produce the stated nominal 100(1-α)% level of confidence. Generally speaking unless populations are strongly spatially correlated, the inflation of the confidence interval width is usually minimal.

7.3.3 Variance When Volume is Uncertain but Measured by Bathymetry

If uncertainty in the volume is known to be substantive relative to the mass per unit volume, the variance of the estimated mass is given by:

$$Var(M) = k^2 \times Var(V \times R) = R^2 \times Var(V) + Var(R) \times Var(V),$$

where the mass per unit volume (R) and the total volume (V) for the CU are assumed to be uncorrelated (Goodman 1960).

7.4 Application to Undredged Inventory (Mass and Volume Both Estimated From Core Samples)

Formulas provided above need only slight modification for estimating PCB mass in undredged inventory. The primary differences are that 1) the volume of undredged inventory must be estimated from core data, and 2) only residual cores are applicable because SSAP cores understate PCB concentration in unexpected inventory below the dredge cut elevation. Because confirmation sample locations are to be taken at the nodes of a regular grid, the data are, once again, treated as equally informative in the spatial dimension. This eliminates the need for spatial weighting. Returning to the basic estimating equation

$$M = k \times V \times R,$$

the only change is that the volume term must be estimated from data $\hat{V} = A \times \bar{L}, \hat{V} = A \times \bar{L},$ rather than from bathymetric surveys, where now $L_i L_i$ represents the depth of contamination at the i[th] confirmation sampling core and *A* is the area of the CU. Substituting the volume estimate ($\hat{V}\hat{V}$) for V in the estimating equation and noting that $R = \frac{\bar{u}}{\bar{L}} R = \frac{\bar{u}}{\bar{L}}$ it can be seen that the mass estimate simplifies to

$$M = k \times A \times \bar{u},$$

which is simply the CU-area times the un-weighted average mass of PCB per unit area (MPA). Finally the variance of the mass estimate is also greatly simplified

$$Var(M) = k^2 \times A^2 \times Var(\bar{u}),$$

where again $Var(\bar{u}) Var(\bar{u})$ is simply the sample variance of the mean MPA and is estimated using the equation provided above.

7.5 Confidence Limits for the Mass of PCB

Given the estimated mass and its variance in each of the three situations described above, an approximate 100(1-α)% confidence interval is given by

$$M \pm z_{1-\alpha/2} \times SE(M), where\ \ SE(M) = \sqrt{Var(M)}.$$

These confidence limits provide statistical bounds on the true mass removed and mass remaining. Because they are based on internally consistent data and statistical methods, the estimates are directly comparable and also can be used to bound the mass of PCBs from which resuspension losses occur. Additionally, if variance estimates are developed for the mass of PCBs released during dredging, the fraction released is also a ratio of random variables whose confidence limits can be estimated using the same formulas developed here for ratios. Understanding the magnitude of statistical uncertainty in these estimates will help avoid disagreement over what are often statistically insignificant differences between alternative estimates of resuspension levels.

8 References

(EPA documents that are being prepared now will be referenced as appropriate once completed)

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