EPA Phase 1 Evaluation Report

EXECUTIVE SUMMARY

Overview

In February 2002, EPA issued a Record of Decision (ROD) for the Hudson River PCBs Site, which called for environmental dredging targeting approximately 2.65 million cubic yards (CY) of PCB-contaminated sediment. The ROD stipulated that dredging will be conducted in two phases. Phase 1 was to be implemented initially at less than full-scale, and was to include an extensive monitoring program. Phase 2 is the remainder of the project, which is to be conducted at full-scale. In selecting the remedy, EPA required establishment of performance standards for resuspension, residuals, and productivity, together called "Engineering Performance Standards for Dredging." These performance standards are designed to promote accountability and ensure that the cleanup meets the human health and environmental protection objectives set forth in the ROD. The final peer-reviewed standards were published in April 2004.

The ROD states that dredging equipment and methods of operation were to be selected based on their expected ability to meet the performance standards. The data gathered during Phase 1 were expected to enable EPA to determine if adjustments are needed to operations in Phase 2 or to the performance standards. The ROD also states that EPA will continue to monitor, evaluate performance data and make necessary adjustments during the full-scale remedial dredging in Phase 2. Thus, the purpose of Phase 1 was to begin the project, providing a "shakedown" period during which the various operations are initiated and evaluated. It was not expected that every detail would go according to plan during Phase 1; rather the experiences are the source of learning to refine later efforts. Some problems were identified during the implementation of Phase 1. Most of these problems are not related to the standards themselves, but represent issues with design and implementation. Improvements can be made based on the experiences from Phase 1 that, along with certain changes to the standards, will further the success of the project in Phase 2.

General Electric Company (GE) implemented Phase 1 based on the requirements of the ROD and the 2006 Consent Decree. This report evaluates Phase 1 operations relevant to the issues in the charge to the independent peer review panel that will evaluate this report and the similar report prepared separately by GE. The peer review panel has been given a set of charge questions to address in their review of the documents. In summary, the charge questions address whether the Engineering Performance Standards can be met individually and simultaneously during Phase 2 of the dredging project, with consideration of any proposed modifications to the Standards. Some of the matters and issues discussed in this report and its appendices are beyond the scope of the peer review. EPA has included such material in the report to inform the public and provide background and contextual information for the Peer Review Panel.

A high-profile project: The Hudson River PCBs Superfund site cleanup is among the largest sediment remedies performed to date. This project is the first sediment remediation project where EPA has required and implemented performance standards as a basis to assess the success of the project construction phase (*i.e.*, the dredging). Further, no dredging project that was undertaken before the Hudson River PCB Superfund site cleanup has been so highly monitored or scrutinized. The experience from the implementation of Phase 1 provides many opportunities to learn lessons applicable to Phase 2 and to other sediment remediation projects.

Phase 1 had many successes: Three significant guideposts for success during Phase 1 were achieved. These are:

1. Both the sediment volume and the PCB mass removed in Phase 1 met or exceeded the amounts initially estimated for the Phase 1 portion of this project. Eighteen Certification Units (CUs) were planned to be dredged during Phase 1, but ultimately 10 were actually dredged (48.3 acres out of 88 acres). The dredging of these 10 CUs resulted in the removal of a greater volume of sediment (284,000 CY[1]) than EPA had planned to remove from all 18 Phase 1 CUs (265,000 CY), exceeding the Productivity Standard requirements for the year. The mass of PCBs removed was equivalent to the planned mass of 20,000 kg for all 18 planned Phase 1 CUs, but represented an 80 percent increase over what was expected for the 10 CUs dredged (11,000 kg).

2. There were few shut-downs due to exceedances of the Resuspension Standard, with limited impact on dredging productivity. Fish tissue impacts were limited to within 2 to 3 miles downstream of the Thompson Island Pool, and the data do not indicate any measurable impacts to fish or water quality in the Lower River.

3. Seventy five percent of the adjusted area (which excludes structure and shoreline setbacks) was completed and closed in compliance with the Residuals Standard, although it was necessary to cap portions of several CUs out of compliance with the Residuals Standard due to schedule constraints (approximately 25 percent of the adjusted area). The residuals standard proved to be an effective tool to identify and manage previously uncharacterized inventory.

These successes were achieved despite multiple complications experienced during the Phase 1 effort, including an inaccurate estimate of the depth of contamination (DoC), extensive wood debris, high river flows, shallow navigation channels, and limitations to dredged sediment transport and processing. As lessons learned in Phase 1 are considered in refining the design for Phase 2, significant improvements to operational efficiencies should be expected, thereby enabling the performance standards to be met consistently and simultaneously. A tabulation of

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[1] The number cited here is GE's estimate of the volume. EPA's estimate of the volume is 274,000 CY which represents a minor difference in the way it was estimated.

important findings related to implementation of each of the Performance Standards is presented at the end of this Executive Summary.

Problems with compliance in Phase 1: Due to imprecise estimates of DoC, the first dredging passes collectively succeeded in removing only 49 percent of the total inventory by volume and only 58 percent of total inventory by mass. As a result, dredging of contaminated sediment inventory (as distinguished from residuals) represented about 50 percent of the area dredged during the second and third dredging passes as well. That is not the way the dredging was intended to work. The Residuals Standard assumed that only a small fraction of the area dredged would require inventory dredging after the first dredging pass. Because at least two cuts (or lifts) with the dredging bucket were done at each location for each dredging pass,[2] the inability to capture the full depth of contaminated sediment on the first pass meant that many more dredging cuts were made than necessary, resulting in more resuspension.

The dredging in Phase 1 released about 440 kg of Total PCB as measured at Thompson Island, exceeding the Phase 1 Total PCB mass load criteria of 117 kg. The measured loads at the Schuylerville and Waterford stations were significantly reduced but still exceeded the Phase 1 load criteria. However, the load at Waterford, 151 kg Total PCB, did not exceed 1 percent of the mass removed, which was an important factor underpinning the load criteria.

Despite exceeding the load standard, the PCB concentrations of river water at Thompson Island only exceeded the federal maximum contaminant level (MCL) for drinking water of 500 ng/l on three occasions. Although these exceedances were not confirmed (*i.e.*, not reproduced) by the next day's sampling, EPA chose to halt dredging temporarily to ensure that these concentrations would not arrive at downstream public water intakes.[3] EPA's conservative approach took into account the uncertainties in the highly variable data for the upstream river water time-composite samples. According to GE's estimates, these temporary work stoppages consumed less than 6 percent of the available dredging hours and did not have a major impact on the ability to meet the Productivity Standard.

A one-month maximum production rate of 89,000 CY was planned; however, it was not met. The maximum one-month productivity of about 78,000 CY, based on GE's records, was attained from early July through early August.

Observation of dredging-related impacts: The data do not demonstrate that the dredging led to significant redistribution of contaminated sediments to non-dredged areas. However, limited investigations into such redistribution and settling were not properly executed by GE. While sediment trap data showed elevated PCB concentrations in the vicinity of dredging operations,

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[2] It is important to note that in this project, "dredging pass" refers to dredging to the designed dredge prism limits, and can include multiple dredging cuts at one location.
[3] Note, in any case, that the downstream Upper Hudson public water intakes, located at Waterford and Halfmoon, were not in use at that time, as those communities were obtaining their drinking water from an alternate source.

significant settling of PCB-contaminated sediment was not clearly demonstrated. If redistributed sediments were settling out of the water column, they would do so first in the hole left behind by the dredge. However, empirical evidence from CU closure documentation showed that locations within CUs after dredging had limited residuals in many places once inventory was removed, implying that little sediment had re-deposited.

Some increases in fish tissue PCB levels were seen in 2009 when compared to baseline data in the Thompson Island Pool, with limited evidence of responses downstream. There were no increases in fish tissue PCBs below river mile 180 near Schuylerville. EPA expected short-term increases in fish tissue PCBs during the project. EPA also expects that the levels of PCBs in fish will return to baseline conditions relatively quickly following the cessation of dredging, as was observed after the Allen Mill event (a release of PCB-bearing oil originating at Hudson Falls in 1991), and will continue to decline further toward the ultimate remedial goal for fish tissue (0.05 mg/kg wet weight).

Water column concentrations in the Lower Hudson River did not increase in response to loads from the Upper Hudson. In particular, there were no discernable increases in Total PCB or Tri+ PCB[4] at the Lower Hudson monitoring locations near Poughkeepsie, Port Ewen or Rhinebeck. Tri+ PCB concentrations were also unchanged at the Albany monitoring station, roughly 15 miles downstream of Waterford. Further, there were no statistically significant increases in fish tissue PCBs at the Albany/Troy monitoring station below the Federal Dam at Troy, the first station in the lower river.

Since the end of all Phase 1 dredging activities, river water concentrations have returned to pre-dredging levels as demonstrated by monitoring results at all far-field stations from Mid-December through February.

Underlying Issues that Need to be Addressed in Phase 2

Depth of Contamination (DoC) was Significantly Underestimated

DoC underestimates resulted in dredging nearly twice the volume planned for the CUs dredged: Additional dredging in the Phase 1 CUs was necessary because the design cut lines underestimated the true DoC. Overall, if design volumes are adjusted for the physical offsets adjacent to structures that were necessary to manage sediments at the shoreline, the amount dredged in the 10 CUs was nearly double the originally planned volume. The primary consequence of the underestimation of the DoC, *i.e.,* additional unplanned dredging, profoundly affected Phase 1 with respect to compliance with all three performance standards. The relevance and consequences of uncertainty in the DoC measurements was a point of disagreement between EPA and GE over the course of the remedial design. In the comments and associated responses that were exchanged between EPA and GE regarding the Intermediate Design Report (IDR) in

[4] Tri+ PCB refers to the sum of the concentrations of homologues with three or more chlorine atoms.

December of 2005, EPA warned GE that the uncertainty at individual core locations, which EPA estimated to be about 1 foot, would outweigh GE's estimate that DoC measured in the cores would be conservative; EPA went on to warn that "underestimating DoC may lead to additional re-dredging to remove inventory."

In light of GE's concerns about cost-effectiveness, EPA took a performance-based approach in approving the Phase 1 design and allowed GE flexibility to manage the uncertainty in DoC through other means as they implemented the project. Phase I results support EPA's warnings regarding DoC, as the average thickness of additional dredging required was greater than 1 foot and was up to 13 feet. This exchange is documented in more detail in EPA's Phase 1 Observations Report provided in Appendix I-H. Underestimation of the DoC resulted in significant re-dredging to remove inventory and not residuals. This also resulted in multiple re-dredging passes which adversely impacted resuspension. Since it is clear that GE considered its design sufficiently robust to deal with DoC uncertainty during implementation, it is not appropriate to consider the consequences of this design flaw as an unexpected impediment to productivity, nor to attribute the need to re-dredge on the Residuals Standard.

Cores were not vertically referenced at collection: The lack of a vertical reference for the sediment cores collected under the Sediment Sampling and Analysis Plan (SSAP) is a limitation that propagated through the rest of the design. The river system is dynamic as demonstrated by a comparison of bathymetric surveys *(i.e.,* river bottom maps) conducted in 2001, 2005 and 2009 which showed surface elevation changes of 2 ft or more in places. This likely exacerbated the impact of underestimated DoC.

Incomplete SSAP cores confounded DoC interpolation: One significant factor in underestimating DoC was the occurrence of incomplete cores used to design the dredging. About 35 percent of the SSAP cores used in the design of Phase 1 did not fully penetrate the PCB-contaminated sediment (*i.e.,* they were 'incomplete'). At these locations, the DoC was estimated through an extrapolation method. The greater uncertainty in these locations was reflected in the greater additional dredging depth at these locations. More than three quarters of the incomplete core locations required more than 12 inches of additional removal. Many of these SSAP cores were incomplete due to refusal during collection. The refusal was likely due to pieces of wood debris in the sediment, masking an extensive inventory of contaminated sediment beneath..

Incomplete post-dredging cores were common: The issue of core completion was not limited to the SSAP program. GE continued to obtain incomplete cores in many CUs during Phase 1. The inability to obtain complete post-dredging cores also made subsequent DoC estimates inadequate for design of the next dredge pass. This occurred because adjustments were not made to the core collection process to reflect field conditions in Phase 1.

Scow Unavailability

Scow capacity was underutilized due to shallow access draft: Large hopper scows (or barges) used for Phase 1 were designed to operate at drafts (*i.e.*, depth of the boat's bottom in the water) of up to about 11 feet. However, the dredging contractor limited the maximum draft to about 8 feet due to concerns about their stability when carrying large volumes of free water removed from the river with the sediment or added to reduce air emissions during loading and transport. Under average loads the draft was around 5 feet. Had all large hopper scows been loaded to a draft of 8 feet before transporting them to the unloading wharf, the number of scows to be unloaded would have been reduced by over one third, and the amount of time lost at the wharf in maneuvering scows could have been similarly reduced.

The water depths in many of the areas dredged during Phase 1 also restricted the draft available to the large hopper scows, particularly in CUs along the east and west side of Rogers Island. Deepening the channel (*i.e.*, access dredging) near CU-1 would have allowed hopper barges to be loaded to a deeper draft, however loaded barges could not exit the channel until after dredging had been substantially completed in CU-2 and CU-3 due to shallow drafts in those CUs. If DoC had been correctly characterized at CU-1 during design, rather than discovered incrementally during dredging operations, the need for access dredging there would have been obvious.

Scow unloading was inefficient because scows were only partially filled: The efficiency of the unloading excavator dropped significantly when the depth of sediment in the barge fell below that required to completely fill its 5 CY bucket. Had all large hopper scows been loaded to a draft of 8 feet, the unloading rate achieved by the excavator would have been substantially higher and the time lost at the dredges awaiting empty scows would have been reduced substantially.

Limited capacity to unload scows and process sediment: The inability of the scow unloading operation to keep pace with dredging was also affected by problems with the equipment used to separate coarser from finer sediment to be dewatered using filter presses. Specifically, the trommel screen (*i.e.,* size separator) could not handle a full, 5-CY bucket of sediment from the unloading excavator. Other operational problems with the trommel screen occurred nearly every week and several problems occurred with the shaker screens. Once dredging began, it was very difficult to make major improvements to the scow unloading system without stopping the operation altogether. However, a number of improvements were made to the unloading and coarse materials separation systems during the project, such as adding a second pump system to remove free water from the scows and adjusting the amount of recycle water supplied to the trommel screen, among others.

Large quantities of clay in some scows also caused difficulties with the operation of sediment separation equipment. This was particularly evident during the last few weeks of dredging as attempts were made to remove a thin layer of contaminated sediment immediately above an uneven clay surface. Although attempts were made to minimize the amount of clay removed, many dredge buckets contained mostly clay. Ultimately, a decision was made to handle the clay separately from other dredged sediment.

Presence of PCB-bearing Oils in the Sediments

PCB-bearing oils were released from the sediments during dredging in several areas. These oils were observed as sheens on the water during oversight and were also sampled and analyzed during Phase 1. However, the oils were not isolated for analysis such that a specific congener pattern could be identified. The presence of free product oil also likely hampered the collection of precise field replicates at the far-field stations during Phase 1. It is believed that the presence of oil was partially responsible for the high degree of variability observed in sample replicates when concentrations of PCBs in river water approached the 500 ng/L threshold. There was little evidence of the presence of such oils prior to the start of dredging during Phase 1; hence the near-field monitoring requirements for the Resuspension Standard focused on the mobilization of suspended solids. In practice, suspended solids did not approach thresholds set in the Resuspension Standard and were well controlled.

Extensive Wood Debris in all CUs

Wood debris, consisting primarily of slab wood from saw mills, was encountered in portions of most CUs dredged during Phase 1 of the project. This material had accumulated over decades behind the former dam at Ft Edward and was released and washed downstream after the dam was removed in the 1970s. The extent of material was so great that it blocked the channel at Ft. Edward and the mouth of the Champlain Canal, necessitating an emergency removal project at that time so that commerce on the canal could continue. It is expected that slab wood debris will continue to be encountered during Phase 2 dredging in the Thompson Island Pool. Wood debris is also known to exist in River Section 2 near the entrance to Lock 6. Whether this debris is also present in any significant amount in River Section 3 is currently unknown.

The presence of wood in the sediment prevented the dredge buckets from closing fully, and time was lost as the dredge operator attempted to close the bucket before lifting it from the river bottom. In many instances where slab wood was encountered, complete closure of the bucket could not be achieved and sediment and water drained from the bucket as it was lifted above the water surface. This led to increased PCB resuspension rates and a reduction in the amount of sediment placed in the scow during each bucket cycle.

Presence of Bedrock at or above Dredge Cut Lines

In CUs 2, 5 and 6, shallow bedrock at or above the design surface resulted in bucket refusal. The bedrock surface was uneven, so the full design cut lines could not be reached in some areas. Due to the extent of underlying bedrock, EPA and GE had to work out a separate process for dredging in these areas. After this was resolved, dredging over bedrock areas proceeded expeditiously and the PCB-contaminated sediments were removed in compliance with the Residuals Standard. For example, more than 50 percent of the sediment volume ultimately removed from CU-6 was dredged after the bedrock management scheme was put in place.

Cause and Effect

- The underestimated SSAP DoC resulted in:
  - Multiple bucket cuts and dredge passes, resulting in more resuspension losses (more bucket impacts on river bottom, fewer efficient bucket bites);
  - Multiple dredging passes that were ineffective at removing inventory reduced productivity and consumed an inordinate portion of the dredging season;
  - CUs that were left open for long periods and consequently subject to resuspension; and
  - Multiple cuts (or lifts) per dredging pass in anticipation of reaching an incorrectly estimated DoC.
- Multiple dredging passes to remove inventory meant GE's required tolerance of only 3 inches above or below the estimated DoC led to extensive and unnecessary fine grading by the dredging contractor.
  - Such a tolerance implies a level of precision in the knowledge of the DoC that does not exist, and, given the conditions, may not be possible. Hence multiple dredging passes and frequent need for redefinition of the DoC resulted in multiple events of fine grading at surfaces that were not ready to be closed. This unnecessarily increased resuspension;
  - GE imposed this requirement as a cost-saving measure, to minimize the amount of clean material being dredged. However, on the first dredging pass, only 1 location out of 443 of post-dredging coring locations was non-detect for PCBs and only 50 locations out of 443 (*i.e.*, 11 percent) achieved a concentration less than 1 mg/kg Total PCB. This means that the amount of clean material removed if an overcut had been applied would have been minimal; and
  - GE ultimately achieved its cost-saving goal of minimizing removal of clean material but at the expense of all three standards.
- Scow unavailability limited productivity.
- Presence of PCB-bearing oil in the sediments
  - Resulted in extensive PCB losses not tied to solids releases; and
  - Contributed to water quality issues and load exceedances.

- Extensive wood debris in all CUs prevented bucket closure, resulting in resuspension losses
- Unexpected presence of bedrock and variability of bedrock surfaces
  - Decreased bucket productivity; and
  - Had to be field mapped for accurate identification of overlying inventory.
- Incomplete post-dredging cores
  - Prevented accurate DoC re-characterization; and
  - Led to multiple dredging passes.

Recommendations for Phase 2

<u>Proposed Design and Operational Changes</u>

- The uncertainty in DoC should be addressed by the addition of an overcut of 9 inches to the first dredging pass in each CU as well as any subsequent passes targeting 12 inches or more. This overcut represents setting the dredging cut line to the bottom of the first six-inch core segment (rather than the top) with a Total PCB concentration less than or equal to 1 mg/kg and adding 3 inches for uncertainty in dredging precision. An overcut of 3 inches should be added to subsequent passes targeting 6 inches.
- 3-inch tolerances should only be applied when post-dredging sampling has confirmed that the dredging pass to be undertaken is targeting 6 inches or less (residuals).
- The lack of adequate vertical referencing of sample depths for cores taken during the SSAP is a critical uncertainty that needs to be addressed in the Phase 2 design.
- Scow unavailability needs to be eliminated, possibly by conducting access dredging where necessary, filling scows to the maximum acceptable draft, and enhancing the unloading system (for example, by adding a second unloading station).
- PCB-bearing oil releases should be anticipated and characterized during Phase 2 dredging, and additional measures should be taken to minimize their downstream transport.
- Dredging buckets should be sized and deployed for efficient, controlled cuts on a reduced number of dredging passes. As design refinement addresses the uncertainty in the DoC, the number of dredging passes required to capture inventory should decrease. These factors will allow capturing inventory more efficiently to optimize productivity while minimizing resuspension.

- When wood debris is encountered, dredging should continue until the underlying sediment is uncovered and the area is free of debris.
- There should be better mapping of suspected bedrock areas through probing prior to dredging to supplement SSAP information, and design cut lines should be adjusted as necessary.
- Fully penetrating post-dredging cores should be collected and two segments with Total PCB concentrations less than or equal 1 mg/kg should be used to confirm DoC.

Proposed Changes to the Performance Standards

Table ES-1 presents a summary of the major proposed changes for Phase 2 for each of the three standards, associated numerical criteria, the rationale behind the changes, and expected interactions with the other standards.

Table ES-1. Proposed Changes to the Performance Standards

Proposed Change to Standard	Proposed Numerical Criteria	Rationale	Impact on Other Standards
Resuspension			
Adjust the far-field net PCB load standard; adjust the seasonal load and corresponding daily evaluation and control level loads upwards. [EPA will propose specific control and evaluation levels for net load after completing ongoing analyses.]	Total load due to the project: 2000 kg Total PCBs	Based on preliminary findings, a total project net PCB load of 2000 kg Total PCBs +/- 25% is not expected to significantly impact the Lower Hudson. The best-estimate break-even point with MNA occurs within 25 years. Additional evaluation is underway. The daily load criteria will be set in consideration of the proposed flexibility in the Productivity Standard's schedule and the constraints of the Resuspension Standard's water quality criteria.	Maintain productivity while protecting the Lower Hudson River.
Revise the station of compliance for load to be Waterford, exclusively.	N/A	Waterborne PCB concentrations decrease with distance from dredging. The focus of the analysis of load in the 2004 Resuspension Standard documents was loads that would be released to the Lower Hudson; such loads are best measured at Waterford. Thus, this change is consistent with the intent of the performance standard.	No impacts are expected.
Reduce the near- field net suspended solids (TSS) levels for Phase 2.	Net increase of 50 mg/L TSS above ambient (upstream) conditions at a location: • 300 m downstream of the dredging operation, or	Conditions during Phase 1 showed that current suspended solids criteria are too high to be useful and lower criteria are achievable and needed to monitor solids transport and releases. Proposed levels are consistent with observations of suspended solids	No impacts are expected.

Table ES-1. Proposed Changes to the Performance Standards (cont'd)

Proposed Change to Standard	Proposed Numerical Criteria	Rationale	Impact on Other Standards
	• 150 m downstream from any TSS control measure. Sustained TSS of 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.	during Phase 1 and should not result in the need for more stringent practices than applied in Phase 1 with respect to suspended solids control.	
Use the 500 ng/L threshold at Thompson Island as a trigger to require operational changes, but not necessarily an operational shutdown, at EPA's discretion.	N/A	Phase 1 showed more than a factor of 2 reduction in water column concentrations from Thompson Island Dam to Waterford. Operational changes should be made, as needed, in response to changes in water column sample composition (*e.g.,* congener pattern, oil phase, dissolved vs. suspended contamination, etc.). Split sample precision should be considered when selecting operational changes. This proposed change will not impact water supplies because Waterford and Halfmoon have an alternate connection to Troy, and Stillwater (which draws its water from an aquifer adjacent to the river) has treatment.	Avoid unnecessary operational shutdowns and improve productivity.
Maintain the water column Control Level of 350 ng/L for discretionary use by EPA to	N/A	During Phase 1, few operational changes were made prior to exceeding the 500 ng/L threshold. Exceeding the	Provide early action to avoid operational shutdowns and maintain productivity.

Table ES-1. Proposed Changes to the Performance Standards (cont'd)

Proposed Change to Standard	Proposed Numerical Criteria	Rationale	Impact on Other Standards
require (as opposed to merely recommend) appropriate operational changes.		500 ng/L threshold may be avoided by proactive adjustments to the operation.	
Residuals			
Reduce the number of cases from 8 to 4 primary response categories.	The four maintained cases are: 1. The standard is met or almost met 2. Residuals are present 3. Inventory is present 4. Recalcitrant residuals or inventory is present	The intention is to simplify and streamline the standard based on Phase 1 results. Four of the cases included in the Residuals Standard were not encountered during Phase 1 and are not likely to be encountered during Phase 2.	This may have some benefit to resuspension and productivity by shortening the time for CU closure.
Remove the 20-acre averaging option and backfill testing requirement.	N/A	The conditions where the 20-acre averaging could be applied did not occur during Phase 1 and are unlikely to occur in Phase 2.	This will have some benefit to resuspension and productivity by avoiding longer times for CU closure.
Eliminate use of the 99% UCL (6 mg/kg criterion) as a basis to decide CU sampling requirements.	N/A	Rather than use 6 mg/kg criterion to trigger sampling at depth, full penetration and analysis of all 6-inch core segments in a minimum 24-inch core (unless bedrock or dense clay is encountered) will be required for all post-dredging cores due to Phase 1 experiences with missed inventory and underestimated DoC.	This will improve productivity by eliminating multiple, unnecessary re-dredging passes and sampling rounds to address missed inventory.
Permit capping without formal petition to EPA only after completion of the first pass and at least 1 additional dredging pass targeting only the top 6 inches of material. In other	No numerical criteria are changed for this revision. This applies only to Case 4 – Recalcitrant Residuals or Inventory Present	The Residuals Standard contemplated limited capping as a contingency to address residuals in the presence of difficult bottom conditions. The option for capping is not meant to compensate for any deficiency in	When underestimates of DoC have been remedied, re-dredging to capture inventory will be reduced, improving productivity and reducing resuspension. The targets

Table ES-1. Proposed Changes to the Performance Standards (cont'd)

Proposed Change to Standard	Proposed Numerical Criteria	Rationale	Impact on Other Standards
words, in order for capping to be permitted, the inventory must have been removed as confirmed by post-dredging coring and an additional pass targeting just 6 inches (residuals) must have been performed.		dredging design. However, during Phase 1, capping was sometimes employed primarily to isolate inventory and this should be avoided in Phase 2.	within the Productivity Standard are designed to accommodate some re-dredging.
Confirm DoC in post-dredging cores.	Two contiguous segments less than 1.0 mg/kg Total PCBs are required to confirm that DoC is known.	During Phase 1, there were situations where sediment cores were observed to reach a value of less than 1.0 mg/kg in a single 0 to 6-inch segment only to see concentrations rise again deeper in the profile.	This is an important component of defining DoC, thereby minimizing the number of dredging passes in order to maintain productivity targets and minimize resuspension.
Simplify identification of non-compliant nodes for reviewing dredging pass results.	Target average value of 1.0 mg/kg Tri+ PCB, using only the ranked, measured nodal values in a simple accumulating average.	As implemented in Phase 1, locations that appeared to be compliant with the standard on one pass caused the mean to exceed the Residuals Standard threshold after later passes, requiring re-dredging (or capping) in the previously compliant location. This problem is eliminated by this simplified process.	This will make the second dredging pass laterally more extensive, capturing inventory more quickly, leading to faster closure of CUs to maintain productivity and minimize resuspension.
Simplify identification of re-dredging or capping boundaries.	The area associated with non-compliant nodes extends to the periphery of compliant nodes or to the edge of the CU. Where a compliant node is surrounded by non-	In Phase 1, a sophisticated algorithm was a source of much discussion and often resulted in unusual dredging geometries. A more conservative approach is needed in light of poor spatial correlation and DoC	Simplified geometry will shorten the design and decision period between dredging passes leading to faster closure of CUs to maintain productivity and

Table ES-1. Proposed Changes to the Performance Standards (cont'd)

Proposed Change to Standard	Proposed Numerical Criteria	Rationale	Impact on Other Standards
	compliant nodes, the area associated with the compliant node is dredged to the average depth of the surrounding non-compliant nodes. Generally, 3 compliant nodes are required to define an area that does not require re-dredging.	uncertainty.	minimize resuspension.
Identify nodes with high probability of exceeding the Residuals Standard threshold early in the CU dredging process to mitigate uncertainty in DoC estimation.	Target concentration of 1.0 mg/kg Tri+PCB, permitting only a mean of 1.49 after the last pass.	As implemented in Phase 1, locations that appeared to be compliant with the standard on one pass later caused the mean to exceed the Residuals Standard threshold after later passes, requiring re-dredging (or capping) in the previously compliant location. Areas identified in this manner will meet the true threshold of 1 mg/kg, regardless of the outcome of subsequent re-dredging attempts at the non-compliant locations.	This will make the second dredging pass laterally more extensive, capturing inventory more quickly, leading to faster closure of CUs to maintain productivity and minimize resuspension.
Avoid capping in the navigation channel whenever possible. If it is necessary, however, design and implement such that the top of cap allows for a minimum of 14 feet of draft to allow for future maintenance dredging by the NYS Canal Corporation	Caps must allow 14 feet of draft in navigation channels.	Capping was not expected in the navigation channel. However, during Phase 1 the installation of a subaqueous cap was required in and around Rogers Island. The caps in the navigation channel were placed such that the navigation depth of 12 feet was met. The 12-foot depth, however,	Because sediments deposited in the established navigation channel historically dredged to a depth of 14 feet are expected to be softer and readily dredged, except possibly where debris exists, this is expected to have a

Table ES-1. Proposed Changes to the Performance Standards (cont'd)

Proposed Change to Standard	Proposed Numerical Criteria	Rationale	Impact on Other Standards
(NYSCC).		does not account for the need to conduct maintenance dredging of sediments that become naturally deposited on top of the cap. The tops of any caps placed in the navigation channel in Phase 2 must be at least 14 feet deep in order for NYSCC to maintain adequate channel depths.	minimal impact on productivity.
Eliminate the concepts of 'inventory pass' and 'residuals pass' from the Residuals Standard. Consider all passes simply as dredging passes.	N/A	Rarely in Phase 1 was subsequent dredging after the first pass exclusively done to remove inventory or residuals. The categorization of particular dredging passes, which has no impact on implementation of the Residuals Standard, became a distraction during project discussions.	No impacts are expected.
Productivity			
Add a provision to extend the time frame for Phase 2 at the discretion of EPA.	Every reasonable effort will be made to maintain the 5-year duration of Phase 2. EPA may allow 1 or 2 additional years if conditions require.	This change allows EPA to adjust the project schedule if necessary to accommodate conditions beyond the control of EPA and GE, such as extreme flows, force majeure, or the discovery of significant additional inventory to be removed; as well as possible resuspension impacts, which are the subject of ongoing analysis by EPA.	The project will still be required to meet a PCB load threshold based upon the amount of mass to be removed and protection of the Lower Hudson River.
Recalculate the annual required and target dredging volumes to reflect the revised Phase 2 removal volume.	<u>Required volume:</u> Yrs 1 to 4 - 475,300 CY/Yr Yr 5 - 475,300 CY* Avg. daily - 3,378 CY	This modification is consistent with the design intent of the standard and is based on a Phase 2 schedule of 5 years and the current estimate of	The project will still be required to meet a PCB load threshold based upon the amount of mass to be

Table ES-1. Proposed Changes to the Performance Standards (cont'd)

Proposed Change to Standard	Proposed Numerical Criteria	Rationale	Impact on Other Standards
	Avg. monthly - 86,420 CY Target volume: Yrs 1 to 4 - 528,100 CY/Yr Yr 5 - 264,100 CY* Avg. daily - 3,745 CY Avg. monthly - 96,020 CY *or remaining inventory	remaining inventory to be removed (~2.4 million CY).	removed and protection of the Lower Hudson River.
Count sediment volumes removed during residuals dredging and when dredging missed inventory toward meeting required and target volumes listed in the Standard.	N/A	GE requested, and EPA approved, a change for Phase 1 to count missed inventory, and it should be carried forward into Phase 2, as well as residuals dredging volumes. Since there is some uncertainty in the remaining inventory to be dredged for Phase 2, since overcuts may be required to address uncertainty in the existing DoC information, and since all dredging activities will contribute to resuspension losses, these dredged volumes should be counted toward the productivity targets.	No impacts are expected.

RESUSPENSION STANDARD FINDINGS

- The Resuspension Standard functioned as designed during Phase 1, and monitoring data collected were used to temporarily halt dredging operations when the 500 ng/L criterion was exceeded on three occasions.
- Dredging operations and processes can be improved and streamlined to increase productivity and reduce resuspension.
- At Thompson Island, Lock 5, and Waterford, the 7-day running average net loadings for Total PCBs and Tri+ PCBs were exceeded. The total Phase 1 PCB load control levels were also exceeded. However, EPA's goal of a maximum 1 percent loss rate to the Lower Hudson River was achieved.
- The monitoring data on PCB concentrations in the river water show no dredging impacts to water quality in the Lower Hudson River.
- River water concentrations of PCBs returned to pre-dredging levels in the Upper Hudson River once all in-river activities ended.
- Fish tissue impacts were limited to the vicinity of dredging. The current data do not indicate that dredging had an effect on PCB levels in fish more than 2 to 3 miles downstream of the Thompson Island Pool.
- EPA anticipates that any dredging-related, localized body burden increases of PCBs in fish that are observed in the short term will rapidly return to baseline levels, and continue to decline thereafter following remediation.
- Several factors contributed to the resuspension of PCBs, including: PCB mass and volume removal, vessel traffic, disturbance of exposed contaminated surface sediments, backfill processes, and efficiency of dredge bucket use.
- The data do not demonstrate 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, lending further support to this finding.
- PCBs in the vicinity of the dredging operations were dominated by dissolved and PCB-bearing oil (NAPL) phases. Suspended solids concentrations were not a good predictor for Total PCB transport downstream of the dredging operations.
- The PCB load criterion of 650 kg established at the time of the ROD should be revised upward to reflect the following observations: baseline loads to the Lower Hudson are about 3 times greater than EPA's model predicted; the surface sediments are not being buried and their concentrations are 3 times higher than predicted by the model; and the amount of PCBs to be removed is 2 to 3 times higher than estimated in the ROD. These factors all indicate that the currently expected short-term PCB releases will be more than offset by the long term improvements in PCB load and exposure resulting from the remedy.

RESIDUALS STANDARD FINDINGS

- Phase 1 removed as much or more PCB mass and volume than called for in the ROD, even though 8 CUs or areas were not addressed.
- The Total PCB mass and volume removed were roughly 1.5 times higher than the original estimates in the design for the areas dredged. More PCB mass and volume were discovered than anticipated.
- Operations and processes (depth of contamination, efficient dredging passes, sampling, analysis, and time to closure of dredged areas) can be improved and streamlined to increase productivity and reduce resuspension.
- The PCB sediment inventory in the Phase 1 CUs was reduced by 98 percent, excluding CU-1, meeting the ROD goal of 96-98 percent removal. This is largely due to the Residuals Standard's post-dredging sampling requirements, which detected contaminated sediment inventory that was not encompassed by the initial dredging cut lines.
- Efficient dredging and closure of areas in Phase 1 were hampered by an inaccurate estimate of the depth of the contaminated sediment inventory. Multiple dredging passes were required to remove the contaminated sediments. This adversely affected resuspension and productivity.
- The Residuals Standard was designed to remove most of the contaminated sediments in the first dredging pass. The impact of the poorly defined depth of contamination resulted in removing only 49 percent of the actual inventory by volume and only 58 percent of actual inventory by mass in the first dredge pass.
- Because the initial dredging pass did not remove the full contaminated sediment inventory and multiple dredging passes were required in each CU to address 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 have been reduced had the depth of contamination been robustly re-characterized following the initial dredging pass.
- Each dredging pass successfully reduced sediment PCB concentrations.
- 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. Deposits of contaminated wood debris should be removed entirely, where encountered, as a component of the dredging project management.
- The uncertainty in depth of contamination should be addressed by setting the dredging cut line to the bottom of the first six-inch core segment (rather than the top) with a Total PCB concentration less than or equal to 1 mg/kg and adding 3 inches for uncertainty in dredging precision. An overcut of 3 inches should be added to subsequent passes targeting 6 inches.

PRODUCTIVITY STANDARD FINDINGS

- The volume of contaminated sediments dredged during Phase 1 (approximately 280,000 CY) exceeded the required volume (200,000 CY) by 40 percent and also exceeded the targeted volume (265,000 CY); this volume was removed from 10 of the 18 certification units (CUs) targeted for dredging in Phases 1 (the remaining 8 CUs will be dredged in Phase 2).
- In addition, approximately 80 percent more PCBs (20,000 kg) were removed than targeted for the 10 CUs dredged during Phase 1 (11,000 kg)
- The targeted volume of sediments to be removed on a monthly basis during Phase 2 (86,000 CY) can be attained through improvements in operations.
- The maximum monthly dredging production rate achieved during Phase 1 was approximately 78,000 CY (GE estimate), only 12 percent less than the Phase 1 requirement of 89,000 CY. The production rate was largely limited by an inability to unload scows (barges) arriving at the dewatering site at the rate that they were filled by the dredges.
- More than 4,700 hours (more than a quarter of the available dredging hours) were lost while dredges sat idle waiting for scows to be unloaded. Had empty scows been available, the maximum monthly dredging rate could have exceeded 110,000 CY.
- Pre-design sampling failed to provide an accurate definition of the depth of contamination in areas dredged in Phase 1. In the 10 CUs that were completed during Phase 1, approximately 1.8 times more sediment was removed than was estimated for them in the design. Phase 2 volumes are expected to increase by about 1.5 times over GE's original design.
- Productivity was also slowed by the need to re-define dredge cut lines multiple times in most CUs and to make additional passes to remove previously unidentified contaminated sediments (inventory) below the original cut lines.
- Higher-than-anticipated rates of PCB resuspension resulted in a loss of approximately 1,000 hours (only 6%) of available dredging time during Phase 1.
- The volume of sediment remaining to be dredged in Phase 2 has been revised based on the Phase 1 observations and is now estimated at approximately 2.4 million CY. Approximately 475,000 CY per year will have to be dredged to complete this work in a 5-year time frame.
- Dredging productivity requirements for Phase 2 can be met through changes in the scow unloading operation, a loosening of tight tolerances for meeting design cut lines, and other design and operational changes.