Hudson River
PCBs SUPERFUND SITE

Draft Engineering Performance Standards
Peer Review Copy

Part 1: Performance Standard for Dredging Resuspension

October 2003

Prepared for:

U.S. Army Corps of Engineers, Kansas City District
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On Behalf of: U.S. Environmental Protection Agency, Region 2

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Volume 1 of 4

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To All Interested Parties:

The U.S. Environmental Protection Agency (EPA) is pleased to release the *Draft Engineering Performance Standards - Peer Review Copy* for the Hudson River PCBs Superfund Site (Site).

EPA's February 2002 Record of Decision for the Site calls for the independent peer review of the engineering performance standards for dredging-related resuspension, dredging residuals, and dredging productivity. Eastern Research Group, Inc. (ERG), an EPA contractor, has established a peer review panel to independently review and ensure that the engineering performance standards for the Site cleanup are technically adequate, properly documented, and satisfy quality requirements. ERG is responsible for administering the peer review and selecting the independent experts for the peer review panel.

EPA released the *Draft Engineering Performance Standards – Public Review Copy*, for public review on May 14, 2003 and accepted public comments on this document from May 14, 2003 through July 14, 2003. EPA is separately responding to comments received on the *Draft Engineering Performance Standards – Public Review Copy.* Copies of all comments received by EPA, as well as EPA's responses, will be provided to the peer reviewers and will be placed in the information repositories established for the site. Copies also will be available online at EPA's web site for the Hudson River PCBs Site (www.epa.gov/hudson).

A briefing meeting for the peer reviewers has been scheduled for October 15-16, 2003 in Saratoga Springs, NY. At the meeting, the peer reviewers will listen to presentations by EPA, other interested agencies, and the public on the engineering performance standards, take a tour of the Upper Hudson, and hear the charge questions that are the focus of their review. Electronic versions of the Draft Engineering Performance Standards and other documents related to the peer review are available on EPA's project Web site.

For questions about the *Draft Engineering Performance Standards*, please contact Alison A. Hess, EPA, at (212) 637-3959.

Sincerely yours,

George Pavlou, Director
Emergency and Remedial Response Division

Draft Engineering Performance Standards – Peer Review Copy
Hudson River PCBs Superfund Site
Executive Summary
October 2003

In February 2002, the United States Environmental Protection Agency (USEPA) issued a Record of Decision (ROD) for the Hudson River PCBs Superfund Site (Site). The ROD calls for targeted environmental dredging of approximately 2.65 million cubic yards of PCB-contaminated sediment from the Upper Hudson River (approximately 40 river miles) in two phases over a six-year period, and monitored natural attenuation of the PCB contamination that remains in the river after dredging.

In the ROD, USEPA identified five remedial action objectives, which are as follows:

- Reduce the cancer risks and non-cancer health hazards for people eating fish from the Hudson River by reducing the concentration of PCBs in fish;
- Reduce the risks to ecological receptors by reducing the concentration of PCBs in fish;
- Reduce PCB levels in sediments in order to reduce PCB concentrations in river (surface) water that are above applicable or relevant and appropriate requirements for surface water;
- Reduce the inventory (mass) of PCBs in sediments that are or may be bioavailable; and
- Minimize the long-term downstream transport of PCBs in the river.

In selecting its cleanup remedy, USEPA required that performance standards for resuspension during dredging, production rates during dredging, and residuals after dredging (together called the "Engineering Performance Standards") be established. This decision was made to address comments received from members of the public who expressed a wide spectrum of views on the project. Some suggested that the environmental dredging could "do more harm than good" and take much longer than stated, while others were concerned that the ROD was not sufficiently comprehensive in its requirements for the environmental cleanup. USEPA required these performance standards in its final cleanup decision to promote accountability and ensure that the cleanup meets the human health and environmental protection objectives set forth in the ROD.[1]

This document presents the draft Engineering Performance Standards for public review and comment. For each performance standard, it discusses the major ways performance is measured, the techniques used to assess performance, the supporting analyses for the

[1] Other performance standards will address public concerns related to potential impacts of the cleanup on the surrounding community, such as air emissions, navigation, and noise. These are being developed separately.

recommendations (including case studies), and some of the major interactions among the performance standards.

Consistent with the ROD, the Engineering Performance Standards were developed in consultation with New York State, the National Oceanic and Atmospheric Administration and the U.S. Fish and Wildlife Service. (New York State is developing substantive water quality certification requirements for the environmental dredging pursuant to the federal Clean Water Act; USEPA will review the requirements when they become available for any implications with respect to the Engineering Performance Standards). USEPA's consultants included a team of senior scientists and engineers who developed the standards, which then were reviewed by a separate team of recognized technical experts. General Electric Company reviewed a near-final version of the draft standards. Comments from these organizations were considered in preparing this Public Review Copy of the Draft Engineering Performance Standards.

Following the close of the public comment period, the Draft Engineering Performance Standards were revised as appropriate and are now released to the public as this Draft Engineering Performance Standards – Peer Review Copy. The standards will be peer reviewed by a panel of independent experts, modified as appropriate to address the peer reviewers' recommendations, and then implemented during the Phase 1 dredging. The results from the first season of dredging (Phase 1) will be used to evaluate the project's progress compared to the assumptions in the ROD in order to determine whether there are any necessary adjustments to the dredging operations in the succeeding phase (Phase 2) or to the standards. The report evaluating the dredging with respect to the Phase 1 standards also will be peer reviewed. USEPA will use the peer reviewers' recommendations to help determine whether the dredging plan is feasible in achieving the human health and environmental protection objectives of the ROD. The Engineering Performance Standards will be refined or adjusted, if necessary, for the remaining dredging seasons (Phase 2).

Based on the analyses performed to develop the standards, USEPA believes that the standards are consistent with the human health and environmental protection objectives of the ROD. USEPA has determined:

- Compliance with the Resuspension Standard will limit the concentration of Total PCBs in river water one mile or more downstream of the dredging area to levels that are acceptable for potable water under the requirements of the Safe Drinking Water Act;

- Resuspension of PCBs in compliance with the Resuspension Standard will have a negligible adverse effect on Tri+ PCB concentrations in Hudson River fish, as compared to a scenario assuming no dredging-related PCB releases;[2]

[2] A negligible effect is defined, in this case, as a predicted Tri+ PCB concentration in Upper Hudson fish of 0.5 mg/kg or less, and in Lower Hudson River fish of 0.05 mg/kg or less, within 5 years after the completion of dredging in the Upper Hudson.

- Compliance with the Control Level of the Resuspension Standard is expected to result in a Total PCB load (mass) transported downstream during remedial dredging that is similar to the range of Total PCB loads detected during recent baseline (*i.e.*, pre-dredging) conditions, as documented by weekly measurements from 1996 to 2001;

- The Residuals Standard specified in the ROD (approximately 1 mg/kg Tri+ PCBs prior to backfilling) is achievable based on case studies of other environmental dredging projects and can be applied in the Upper Hudson on an area-wide average basis;

- The Productivity Standard will result in completion of the dredging within the six dredging seasons called for in the ROD, based on an example conceptual schedule for project implementation; and

- The three Draft Engineering Performance Standards, including their respective monitoring programs, are achievable individually and in combination. The standards appropriately balance their points of interaction, allowing flexibility during design and implementation while ensuring protection of human health and the environment. For example, the requirements concerning additional dredging attempts in the Residuals Standard must consider the requirements for dredging production in the Productivity Standard.

A summary of each of the three Draft Engineering Performance Standards is presented below, followed by discussion of some of the major interactions among the Standards.

Performance Standard for Dredging Resuspension

Objectives

The Performance Standard for Dredging Resuspension (*i.e.*, Resuspension Standard) is designed to limit the concentration of PCBs in river water such that water supply intakes downstream of the dredging operations are protected, and to limit the downstream transport of PCB-contaminated dredged material. The attendant water quality monitoring program will be implemented to verify that the objectives of the Resuspension Standard have been met during dredging. The analytical results obtained from the water quality monitoring will be compared to the Resuspension Standard and associated lower action levels to monitor and control resuspension through appropriate actions. Such actions could include, as appropriate, expanding the monitoring program, notifying public water suppliers, implementing operational or engineering improvements, and, if necessary, temporarily halting the dredging.

The ROD requires the development of a Resuspension Standard but does not set forth any framework or numerical value for the Standard. The Resuspension Standard and a series of tiered action levels were developed based on extensive modeling, review of environmental dredging case study data, and evaluation of applicable or relevant and appropriate requirements (ARARs) identified in the ROD for PCBs in river water.

Statement of the Resuspension Standard

Resuspension Standard

Under the Resuspension Standard, the maximum allowable Total PCB concentration in the water column is 500 nanograms per liter (ng/L) (*i.e.*, 500 parts per trillion) at any far-field monitoring station, regardless of the source of the PCBs. This concentration is the USEPA Safe Drinking Water Act Maximum Contaminant Level (MCL) for PCBs in drinking water supplies.[3] Potential sources include dredging, tender and tugboat movements, materials handling, and PCBs from upstream and non-dredging sources. Dredging is only allowed to proceed when concentration of Total PCBs in the river water at any Upper River far-field station is 500 ng/L or less.

Action Levels

Action levels were developed to help identify potential problems and to guide appropriate responses, such as preventive actions or engineering improvements, as necessary, as a means of avoiding an exceedance of the Resuspension Standard. As shown in Table ES-1 below, there are three action levels leading up to the Resuspension Standard, which are designated “Evaluation Level,” “Concern Level,” and “Control Level.” The monitoring requirements become more stringent at each level to increase the types and quantity of data available to interpret the river’s response to the dredging. If the monitoring shows an exceedance at the Evaluation or Concern Level, engineering solutions are suggested. If the monitoring shows an exceedance at the Control Level, implementation of an engineering solution is required.

[3] The New York State MCL is also 500 ng/L.

Table ES-1: Resuspension Standard and Action Levels

Action Level	Parameter	Required Action
Evaluation Level	• 300 g/day Total PCB load or 100 g/day Tri+ PCB load as a 7-day running average (far-field) • 100 mg/L 6-hour running average net suspended solids increase or average net increase in the daily dredging period if the dredging period is less than 6 hours (near-field, 300 m, River Sections 1 & 3) • 60 mg/L 6-hour running average net suspended solids increase or average net increase in the daily dredging period if the dredging period is less than 6 hours (near-field, 300 m, River Section 2) • 700 mg/L net suspended solids average 3-hour continuous (near field, 100 m and channel-side) • 12 mg/L 6-hour running average net suspended solids increase or average net increase in the daily dredging period if the dredging period is less than 6 hours (far-field)	Monitoring Contingencies Engineering Evaluations (recommended) Engineering Solutions (recommended)
Concern Level	• 350 ng/L Total PCBs as a 7-day running average (far-field) • 600 g/day Total PCB load or 200 g/day Tri+ PCB load as a 7-day running average (far-field) • 100 mg/L net suspended solids daily average for the dredging period (greater than 6 hours) or 24 hours (near-field, 300 m, River Sections 1 & 3) • 60 mg/L net suspended solids daily average for the dredging period (greater than 6 hours) or 24 hours (near-field, 300 m, River Section 2) • 24 mg/L net suspended solids daily average for the dredging period (greater than 6 hours) or 24 hours (far-field)	Monitoring Contingencies Engineering Evaluations Engineering Solutions (recommended)
Control Level	• 350 ng/L Total PCBs as a 4-week running average (far-field) • 65 kg/year Total PCB or 22 kg/year Tri+ PCB load during the Phase 1 dredging season (far-field) • 600 g/day Total PCB load or 200 g/day Tri+ PCB load as a 4-week running average (far-field)	Monitoring Contingencies Engineering Evaluations Engineering Solutions
Resuspension Standard	500 ng/L Total PCBs (confirmed far-field occurrence)	Temporarily Halt Dredging Monitoring Contingencies Engineering Evaluations Engineering Solutions

The Evaluation Level is based on PCB load (net mass loss) criteria and suspended solids concentrations. The PCB load criteria are 300 g/day Total PCBs (and 100 g/day Tri+ PCBs), which approximates the amount that could reasonably be distinguished from baseline conditions. These amounts are approximately three times the best engineering estimate of mass loss from the dredging operation at full production as reported in the ROD. The near-field suspended solids concentration criteria were derived for each River Section of the Upper Hudson to correspond to a far-field PCB concentration of 350 ng/L Total PCBs. There is a corresponding far-field suspended solids criterion derived for a far-field concentration of 500 ng/L Total PCBs, the Resuspension Standard. Consistent with the ROD, the Evaluation Level, Control Level and Concern Level each require the collection of site-specific data in Phase 1 that will be used to determine whether adjustment to the dredging operations or to the standards are needed in Phase 2. Once these data have been evaluated, it may be appropriate to eliminate the Evaluation Level in the Resuspension Standard for Phase 2.

The Concern Level includes both a PCB concentration and load-based criteria. The concentration criterion is a seven-day running average exceedance of 350 ng/L Total PCBs (*i.e.*, 70% of the 500 ng/L Resuspension Standard, which is a reasonable warning threshold). The load criteria are structured similarly, with a one-week exceedance of 600 g/day Total PCBs (and 200 g/day Tri+ PCBs). This daily load rate is based on a total project load of up to 650 kg Total PCBs over the duration of the dredging as estimated from various engineering and modeling analyses.[4] The near-field suspended solids concentration criteria were derived for each River Section of the Upper Hudson to correspond to a far-field PCB concentration of 350 ng/L Total PCBs, but the threshold duration of the concentration criteria is longer. There is an associated far-field suspended solids criterion derived to correspond to a far-field PCB concentration at twice the Resuspension Standard (*i.e.*, 1000 ng/L).[5]

The Control Level criteria for PCB concentration and load are similar in form to those for the Concern Level, but the threshold duration of the concentration criteria is increased. In this case, the concentration criterion is a four-week running average concentration of 350 ng/L Total PCBs. The load criteria, likewise, consist of a four-week exceedance of 600 g/day Total PCBs (and 200 g/day Tri+ PCBs). There are no increased suspended solids criteria associated with the Control Level (*i.e.*, the Control Level is not triggered by suspended solids concentrations alone).

Near-field and Far-field Monitoring Stations

The Resuspension Standard requires water quality monitoring at both "near-field" stations (located within a few hundred meters of the dredging operation) and "far-field" stations (to be established at fixed locations in the Upper and Lower Hudson River, primarily dams and bridges). Monitoring is required at all far-field stations during Phase 1 (two stations upstream of the project area, four stations in the Upper River, two stations in the Lower River and one station in the Mohawk River at Cohoes). The Resuspension Standard of 500 ng/L Total PCBs is applied to the PCB concentration data collected at any far-field station that is at least 1 mile downstream of the dredging area. The data collected at both near-field and far-field stations are compared to the action level criteria.

Water quality impacts that are detected only in the immediate dredging area, including within containment barriers that the Contractor may employ around the dredging area, are not covered by the Resuspension Standard. Some resuspension within the dredging areas is likely unavoidable regardless of the type of dredging equipment used, and is of concern only to the extent it transports PCBs downstream.

[4] The daily rate is based on attainment of the recommended target cumulative volume as specified in the Productivity Standard, and should be prorated according to the production rate planned in the Production Schedule to be submitted annually to USEPA.

[5] This higher level recognizes the high degree of uncertainty in the suspended solids measurement. Additional PCB sampling prompted by this level will be used to confirm compliance with the Resuspension Standard.

Routine Monitoring Program[6]

The routine water quality monitoring program consists of PCB sampling and analysis at the far-field stations and the collection of suspended solids data at the near-field and far-field stations every three hours. The routine monitoring program is specific with respect to the details and frequency of the sample collection, potential development of continuous field monitoring techniques for suspended solids, requirements for representative discrete and composite sampling schemes at the far-field stations (Upper and Lower Hudson), and the number and configuration of near-field suspended solids sampling stations. Monitoring results will be made available to USEPA upon receipt from the laboratories. Corrective actions and analytical results will be summarized in weekly reports to USEPA.

Contingencies

Monitoring Contingencies

If an action level is exceeded, monitoring contingencies are required at both near-field and far-field stations. The monitoring contingencies consist of increased sampling frequency and more rapid laboratory turn-around of analytical data at the sampling locations, compared to the routine monitoring program. The monitoring contingency is intended to provide additional data to better characterize the developing changes and trends in water quality. The Resuspension Standard allows the monitoring program to revert to routine frequencies and normal turnaround times when conditions have decreased below the action levels for specific durations.

Engineering Contingencies

If the Evaluation Level is exceeded, the Resuspension Standard suggests that an engineering evaluation be undertaken and that a range of engineering contingencies be considered.

If the Concern Level is exceeded, the Resuspension Standard requires that an engineering evaluation be undertaken and suggests a range of engineering contingencies. However, at the Concern Level, implementation of an engineering solution is discretionary.

If the Control Level is exceeded, the Resuspension Standard requires implementation of an engineering solution, with the exact engineering solution to depend on the specific circumstances encountered in the field and an interpretation of the monitoring data collected in connection with the action level exceedance.

If the Resuspension Standard is exceeded, all dredging operations must be temporarily halted pending the results of an engineering evaluation and selection of an engineering solution in consultation with USEPA.

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[6] The term "routine" refers to a level of monitoring appropriate to this project to be conducted while the dredging operation is in compliance with the Resuspension Standard and all action level criteria.

The suggested engineering evaluations and solutions include examination of boat traffic patterns, additional evaluation of sediment pipelines for leaks, implementation or modification of silt barriers and may include, for the Control Level, temporarily halting the dredging operations.

Public Water Supply Monitoring and Contingencies

The Resuspension Standard provides for notification to downstream public water suppliers when the Total PCB concentration at the Waterford far-field station is predicted to be 350 ng/L or greater. The monitoring and notification required by the Resuspension Standard is in addition to monitoring and notification requirements that will be developed separately for the Community Health and Safety Plan for the remedial work activities.[7]

Supporting Analyses and Assumptions

A large number of analyses were conducted in developing the Resuspension Standard, including the action levels. Some of the most important analyses are summarized below.

Dissolved-Phase PCB Releases

Case studies regarding environmental dredging projects provide different conclusions regarding the importance of dissolved-phase PCBs in the absence of a release of suspended solids. Some data from the Fox River in Wisconsin suggest that relatively large dissolved-phase releases of PCBs are possible during dredging without an associated release of contaminated sediments (suspended solids). In contrast, field measurements of dissolved and particle-associated PCBs collected during environmental dredging at the New Bedford Harbor site in Massachusetts suggest that dissolved phase PCB releases are not significant.

In developing the Resuspension Standard, analyses were conducted to evaluate possible mechanisms for dissolved-phase PCB releases during dredging of the Upper Hudson. These analyses sought to consider the likelihood and magnitude of potential dissolved-phase effects. Potential releases of dissolved-phase PCBs, via 1) release of contaminated porewater from the dredged sediment surface and 2) a release of contaminated solids into the water column, were quantitatively modeled to estimate a range of potential PCB contaminant loads that could be experienced. The modeling indicated that the amount of dissolved-phase PCBs likely to be introduced into the system is relatively small compared to baseline concentrations (*i.e.*, without dredging).

[7] 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. The plan will include a section that outlines the actions to be followed should monitoring of contaminants show contaminant levels above certain levels to be identified in the plan.

Modeling

USEPA's peer-reviewed fate and transport models and bioaccumulation models (HUDTOX and FISHRAND) were used to simulate concentrations of PCBs in the water column, sediment, and fish in the Upper Hudson that could result from resuspension during the remedial dredging. The Farley model, along with FISHRAND, was used to simulate conditions in the Lower Hudson. The modeling efforts examined the impact of allowing the dredging to proceed at the action levels (both PCB concentrations in the water column and PCB mass loads). The model results indicate that the PCB water column concentrations and the PCB mass loads would have a negligible impact on PCB concentrations in Hudson River fish as compared to a scenario with no dredging-related releases (see footnote 2). Using the model results, the impact to human health and ecological receptors were calculated consistent with USEPA's site-specific risk assessments.

Analyses of Baseline Water Quality Data

In developing the Resuspension Standard, analyses were conducted using historical Hudson River water quality data to distinguish between the pre-dredging baseline concentrations of PCBs and suspended solids in the water column and PCB concentrations expected due to resuspension during dredging. Data collected since 1996 as part of GE's ongoing weekly sampling program were statistically evaluated to derive the monthly mean concentration of PCBs and the variance for the months of the dredging season (*i.e.*, May through November). The findings indicate maximum PCB concentrations during May and June of each year. Subsequent sensitivity analyses also indicate that the Total PCB loads specified in the Concern and Control Levels are similar to the range of existing baseline loads experienced by the river system. The baseline data to be collected prior to Phase 1 dredging will be used to refine these statistical analyses.

Performance Standard for Dredging Residuals

Objectives

The Performance Standard for Dredging Residuals (*i.e.*, Residuals Standard) is designed to detect and manage contaminated sediments that may remain after initial remedial dredging in the Upper Hudson River. The ROD calls for removal of all PCB-contaminated sediments in areas targeted for dredging, and anticipates a residual of approximately 1 mg/kg Tri+ PCBs (prior to backfilling). The "residual sediments" may consist of contaminated sediments that were disturbed but escaped capture by the dredge, resuspended sediments that were redeposited/settled, or contaminated sediments remaining below the initial dredging cut elevations (*e.g.*, due to uncertainties associated with interpolation between core nodes of the design sediment sampling program or insufficient core recovery).

The Residuals Standard requires the implementation of a post-dredging sampling and analysis program to detect and characterize PCB concentrations in the residual sediments.

The post-dredging sediment data are compared to the anticipated residual of approximately 1 mg/kg Tri+ PCBs stated in the ROD and a group of statistical action levels developed for the Residuals Standard. The approach to be taken to manage the residual sediments (including re-dredging) is then selected depending on the statistical analyses of the post-dredging data. The use of statistical analyses to evaluate environmental datasets is a scientifically accepted practice.

Statement of the Residuals Standard

Sampling and Analysis

The Residuals Standard requires the collection of surface sediment samples following dredging and after USEPA has confirmed that the design cut-lines have been achieved. Based on engineering judgment, the dredging is assumed to proceed within work areas that are similar to the median size of the targeted areas identified in the ROD. Therefore, a 5-acre "certification unit" was considered for the post-dredging sampling program and the subsequent statistical evaluation of the post-dredging surface sediment data. The Residuals Standard specifies that each certification unit be sampled for compliance directly after it is dredged, so that appropriate actions can be taken as the project progresses. In each 5-acre certification unit, sediment samples representing the 0-6 inch depth interval below the dredged sediment surface are to be obtained from 40 grid nodes and analyzed for Tri+ PCBs. The analytical results from those samples will be compared to the action levels in the Residuals Standard, and the required actions taken.[8]

Action Levels and Required Responses

The Residuals Standard requires the review of: 1) the Tri+ PCB concentrations in all 40 individual sediment samples within each 5-acre certification unit, 2) the mean Tri+ PCB concentration of the certification unit, 3) the median Tri+ PCB concentration of the certification unit, and 4) the average of the mean Tri+ PCB concentrations of a 20-acre joint evaluation area (certification unit under review and the three units within 2 mile stretch of river). The following responses are required for Phase 1 of the dredging project. Adjustments may be made before finalizing the Residuals Standard for Phase 2 based on analyses of the post-dredging sediment data collected during Phase 1. For example, if justified, the joint evaluation area may be increased to 40 acres for Phase 2.

1. Backfill (where appropriate) and Demobilize: At certification units with an arithmetic average residual concentration less than or equal to 1 mg/kg Tri+ PCBs, no sediment sample result greater than or equal to 27 mg/kg Tri+ PCBs, and not more than one sediment sample result greater than or equal to 15 mg/kg Tri+ PCBs, backfill (where appropriate) and demobilize from the certification unit.

[8] The Residuals Standard does not preclude collection of samples from deeper intervals, which may be cost-effective.

2. Jointly Evaluate 20-acre Area: At a certification unit with an arithmetic average residuals concentration greater than 1 mg/kg Tri+ PCBs and less than or equal to 3 mg/kg Tri+ PCBs, no sediment sample result greater than or equal to 27 mg/kg Tri+ PCBs, and not more than one sediment sample result greater than or equal to 15 mg/kg Tri+ PCBs, jointly evaluate a 20-acre area.

   For 20-acre evaluation, if the area-weighted arithmetic average of the individual means from the certification unit under evaluation and the 3 previously dredged certification units (within 2 miles of the current unit) is less than or equal to 1 mg/kg Tri+ PCBs, backfill may be placed (with subsequent testing required). Otherwise, the certification unit must be re-dredged (see #4 below for actions required during and following re-dredging) or a sub-aqueous cap constructed. Re-dredging or capping is to be conducted at the specific areas within the certification unit that are causing the non-compliant mean concentration. If the certification unit does not comply with #1 or #2, above, after two re-dredging attempts, contingency actions may be implemented in lieu of further re-dredging attempts, as described in #5, below.

3. Re-dredge or Construct Sub-aqueous Cap: At a certification unit with an arithmetic average residuals concentration greater than 3 mg/kg Tri+ PCBs but less than or equal to 6 mg/kg Tri+ PCBs, no single sediment sample result is greater than or equal to 27 mg/kg Tri+ PCBs, and not more than one sediment sample result is greater than or equal to 15 mg/kg Tri+ PCBs, re-dredge or construct a sub-aqueous cap. The choice of two options is provided to maintain flexibility and productivity (*e.g.*, some areas may not be conducive to dredging). If re-dredging is chosen, the surface sediment of the re-dredged area must be sampled and the certification unit re-evaluated. If the certification unit does not meet the objectives of #1 or #2, above, following two re-dredging attempts, contingency actions may be implemented in lieu of further re-dredging attempts, as described in #5, below.

4. Re-dredging Required: For areas of elevated Tri+ PCB concentrations within a certification unit with an arithmetic average residuals concentration greater than 6 mg/kg Tri+ PCBs or to address individual sampling point(s) with concentrations greater than or equal to 27 mg/kg Tri+ PCBs or more than one sampling point with concentrations greater than or equal to 15 mg/kg Tri+ PCBs, re-dredging is required.

   Sampling at depths greater than 6 inches will be triggered by an arithmetic average residual concentration of greater than 6 mg/kg Tri+ PCBs. The spatial extent of this sampling at greater depth will be determined by the median Tri+ PCB concentration. If the median concentration in the certification unit is greater than 6 mg/kg Tri+ PCBs, collection and analysis of additional sediment samples is required from deeper intervals over the entire certification unit (*e.g.*, 6-12 inch, 12-18 inch, etc.) as necessary to re-characterize the vertical extent of PCB contamination. If the median concentration is 6 mg/kg Tri+ PCBs or less, characterization of the vertical extent of contamination is required only in the areas within the certification unit that are contributing to the non-compliant mean concentration. Additional sampling to characterize the vertical extent of contamination is contemplated only once.

The Residuals Standard provides a mechanism for calculating the horizontal extent of re-dredging. All re-dredging attempts are to be designed to reduce the mean Tri+ PCB concentration of the certification unit to 1 mg/kg Tri+ PCBs or less. If after two re-dredging attempts, the arithmetic average Tri+ PCB concentration in the surface sediment still is greater than 1 mg/kg, then contingency actions are to be implemented as stated in #5, below.

5. Contingency Actions: At areas where two re-dredging attempts do not achieve compliance with the residuals criteria, as verified by USEPA, construct an appropriately designed sub-aqueous cap, where conditions allow.

A flow chart illustrating implementation of the *Performance Standard for Dredging Residuals* is shown in Figure ES-1. The flow chart options are summarized in Table ES-2.

TABLE ES-2
SUMMARY OF DRAFT RESIDUALS STANDARD

Case	Certification Unit Mean (mg/kg Tri+ PCBs)	No. of Sample Results where 27 > *result* ≥15 mg/kg Tri+ PCBs	No. of Sample Results ≥ 27 mg/kg Tri+ PCBs	No. of Re-Dredging Attempts Conducted	Required Action (when all conditions are met)*
A	$x_i \le 1$	≤ 1	0	N/A	Backfill certification unit (where appropriate); no testing of backfill required.
B	N/A	≥ 2	N/A	< 2	Redredge sampling nodes and re-sample.
C	N/A	N/A	1 or more	< 2	Redredge sampling node(s) and re-sample.
D	$1 < x_i \le 3$	≤ 1	0	N/A	Evaluate 20-acre average concentration. If 20-acre average concentration ≤ 1 mg/kg Tri+ PCBs, place and sample backfill. If 20-acre average concentration > 1 mg/kg, follow actions for Case E below.
E	$3 < x_i \le 6$	≤ 1	0	< 2	Construct sub-aqueous cap immediately OR re-dredge.
F	$x_i > 6$	N/A	N/A	0	Collect additional sediment samples to re-characterize vertical extent of contamination and re-dredge. If certification unit median > 6, entire certification unit must be sampled for vertical extent. If certification unit median ≤ 6, additional sampling required only in portions of certification unit contributing to elevated mean concentration.
G	$x_i > 6$	N/A	N/A	1	Re-dredge.
H	$x_i > 1$ (and 20-acre average > 1)	≥ 2	≥ 1	2	Construct sub-aqueous cap (if any of these mean/sample result conditions are true) and two re-dredging attempts have been conducted OR choose to continue to re-dredge.

*Except for Case H, where any of the listed conditions will require cap construction.

Preference for Dredging

The selected remedy includes dredging of contaminated sediment, using PCB inventory as the primary means to target removal areas. The Residuals Standard of approximately 1 mg/kg Tri+ PCBs (prior to backfilling) is achievable based on case studies of other environmental dredging projects and can be applied on an area-wide average basis. However, review of case studies also indicates that, for some isolated areas, residual concentrations subsequent to the initial dredging attempt may exceed the 1 mg/kg Tri + PCB standard. The non-compliant residuals will likely be associated with difficult-to-dredge bottom conditions such as bedrock outcrops and boulder fields. As a result, in limited areas of the Upper Hudson River, it may be difficult to achieve the Residuals Standard. The capping contingency was added as an option to address this scenario.

Capping of the existing PCB inventory was assessed as a remedial action alternative in the 2000 Feasibility Study, but was not selected as the most appropriate remedy, largely because it does not provide the same degree of reliability as dredging. This finding was due to the potential for defects or damage to the cap, thereby reducing its effectiveness relative to dredging while still requiring the sediment handling, processing, and disposal activities needed for dredging. The option for capping allowed in the Residuals Standard differs significantly from the remedial action alternative that was evaluated in the Feasibility Study in that the design dredging cut lines must be met and the targeted PCB inventory removed before this option can be considered (*i.e.*, the capping contingency in the Residuals Standard is not a stand-alone remedial action alternative). Capping performed under the Residuals Standard would not be used to sequester significant PCB inventory and, because the mass of PCBs to be isolated is greatly reduced, the reliability of a cap placed for the purpose of isolating residual contamination is less critical. Were the cap breached in this situation, the potential spread of contamination would be much less because of the much lower contaminant mass and potential for mixing (dilution) with the surrounding capping material.

Although application of a sub-aqueous cap has been added as an option in the Residuals Standard, there is a decided preference for dredging alone. Capping is less reliable for long-term control than dredging, and there are long-term operation and maintenance requirements associated with capping. Factors for deciding if an area should be capped and preparation of the site-specific cap design must include the river conditions (sediment texture, water depth, location in the channel, compatibility with habitat, etc.) as well as cost and impact on productivity. The option for capping is not meant to compensate for any deficiency in the dredging design or operations. USEPA will be fully apprised of the decision-making for areas to be capped in accordance with the requirements of the Standard as represented in Figure ES-1. Through the required submittal of Certification Unit-specific closure reports, USEPA will review the residual sampling data collected for the areas, confirm that the dredging cut lines have been met, review field notes, and review and approve each site-specific cap design. A limit on the amount of area that can be capped without obtaining approval from USEPA may be added to the standard for Phase 2, based on information gathered during Phase 1.

Supporting Analyses and Assumptions

Certification Unit Sample Size and Sampling Grid

USEPA's 2002 "Guidance for Choosing a Sampling Design for Environmental Data Collection" provides methods to determine the number of samples required to estimate the mean contaminant concentration of a given area. Evaluation of the 1984 Upper Hudson River sediment data (which is the most comprehensive to date), case study residuals data from other environmental dredging projects, and USEPA statistical guidance supported the use of 40 samples to characterize each 5-acre certification unit.

The 40 samples are to be collected from a regular triangular grid, which equates to a sample spacing of approximately 80 feet. The residuals sampling grid is to be offset from the design support sediment sampling grid by 40-60 percent of the grid spacing. Criteria for relocating sampling points, when necessary, are provided in the Residuals Standard. The Residuals Standard accommodates the application of the sampling grid to certification units that differ in size from the conceptual 5-acre unit. This flexibility is provided to address circumstances in which the remedial dredging may result in certification units of varying sizes (*e.g.*, due to the installation of silt barriers, if used).

Action Level Development

The action levels originated with the statement in the ROD that anticipates a residual in dredged areas of approximately 1 mg/kg Tri+ PCBs (before backfilling). Statistical thresholds were developed to evaluate residuals sampling data and trigger responses, a common scientifically accepted practice for interpreting environmental data. The thresholds consist of action levels for the area-weighted mean concentration (upper confidence limits, or UCLs) and action levels for individual sample results (prediction limits, or PLs). Both UCLs and PLs are measures of the probability that a sample result belongs to a sample population that has a specific mean; consistent with the ROD, the desired mean for Upper Hudson River residuals is 1 mg/kg Tri+ PCBs or less).

Since no residual sediment data exist for the Upper Hudson River (and will not exist until after remedial dredging is initiated), UCLs and PLs were calculated based on residual sediment data from other environmental dredging projects. The values derived for the Residuals Standard are: 3 mg/kg Tri+ PCBs (95% UCL), 6 mg/kg Tri+ PCBs (99% UCL), 15 mg/kg Tri+ PCBs (97.5% PL), and 27 mg/kg Tri+ PCBs (99% PL). These criteria are used to evaluate the degree to which the residual of approximately 1 mg/kg Tri+ PCBs specified in the ROD is attained in a particular certification unit, and to trigger appropriate actions for managing residual sediments.

Requirement for Collection of Additional Core Samples

The Residuals Standard requires the collection of additional sediment samples where the initial mean Tri+ PCB concentration (0-6 inch interval) for the certification unit is greater than 6 mg/kg. Residual sediments with a Tri+ PCB concentration above the 99% UCL indicates the dredge was still removing material from a contaminated stratum. In this case, it is possible that additional contaminated sediment "inventory" remains to be removed. The median concentration is used as a criterion to determine whether deeper sediment samples (*e.g.*, 6-12 inch, 12-18 inch, etc. as necessary to define the vertical extent of contamination) must be collected from all 40 sampling points in the certification unit or, as appropriate, from smaller sub-areas where isolated or clustered elevated nodes are causing the mean concentration to exceed the requirements of the standard. Following the collection and evaluation of the deeper sediment samples, new cut-lines must be established and re-dredging conducted to reduce the residual concentrations.

Required Number of Re-dredging Attempts

To maintain dredging productivity, and noting that case studies of other environmental dredging projects report diminishing returns for successive re-dredging in an attempt to obtain the remedial objectives, the number of required re-dredging attempts was set at two attempts. Re-dredging attempts are dredging efforts conducted to reduce residual concentrations, and by definition occur subsequent to the USEPA's confirmation of attainment of the initial design cut elevations to remove inventory. The Construction Manager may also choose to conduct additional re-dredging attempts, based on cost considerations or knowledge of the dredging area, with the intent of reducing the mean Tri+ PCB concentration in the certification unit to 1 mg/kg or less Tri+ PCBs.[9]

Based on the Phase 1 results and the second peer review, USEPA may modify the required number of redredging attempts (or the triggers for engineering contingencies and capping, described below).

Engineering Contingencies and Capping

In the event that the dredging operations after two or more dredging attempts cannot achieve the Residuals Standard of a mean concentration of 1 mg/kg Tri+ PCBs or less, engineering contingencies must be implemented, including the construction of a sub-aqueous cap, where conditions permit, over the recalcitrant area to address the residual PCB contamination.

Where further dredging is not practicable, the sub-aqueous cap is intended to support recovery of the Hudson River ecosystem following removal of inventory, similar to the function of the backfill. The type of backfill and capping material will vary to account for the river conditions and ecological setting. This will be an important consideration for the remedial design with regard to habitat issues, and may require the design of multi-layer caps that address both residuals isolation and habitat recovery.

The installation of a sub-aqueous cap is likely to further reduce residual concentrations of PCBs and may require additional dredging to accommodate the cap thickness. While not expected, should conditions encountered in the navigation channel require the installation

[9] This option is limited to circumstances where no project delays affecting the ability to meet the Productivity Standard will be incurred.

of a sub-aqueous cap, sufficient dredging may be required to install the cap and an upper, armored layer below the navigation depth. The armored layer would act as an indicator during future navigational dredging in the channel to prevent damage to the cap.

In order to avoid delays to the remediation, prototype capping specifications for typical river conditions and ecological settings will need to be developed during the remedial design phase. These prototypes can then be readily customized for the situations encountered during remediation. General cap design criteria and relevant USEPA and USACE guidance documents for cap design are identified in the Residuals Standard. The specific design details of the capping contingency are to be addressed in the design phase of the Hudson River PCBs Site remediation. USEPA will review the submitted design for conformance with the requirements of the ROD and the engineering performance standards.

The cost of cap construction and maintenance should be balanced by the Construction Manager, in consultation with USEPA, against the cost of additional re-dredging attempts and their respective impacts on the schedule. Following the completion of Phase 1, the areas capped (if any) during Phase 1 will be evaluated to review the decisions that were made given river conditions in the capped areas and impacts on productivity. Using the information gathered during Phase 1 and the data gathered during the design sampling (*e.g.*, subbottom profiling results), a limit on the amount of area that can be capped without prior approval from USEPA may be added to the standard for Phase 2, if warranted.

Joint Evaluations and Backfill Testing

The concept of a 20-acre joint evaluation was developed to maintain flexibility where the mean residual concentrations in selected 5-acre certification units are only slightly higher than 1 mg/kg Tri+ PCBs. The size of the joint evaluation area was chosen based on USEPA's peer-reviewed fate, transport and bioaccumulation models for the Upper Hudson River (HUDTOX and FISHRAND), which were used to evaluate recovery of the Upper Hudson following remediation. The models used river segments in the Thompson Island Pool that are similar in size to the 20-acre joint-evaluation areas. The benefits of targeted remedial dredging projected by the USEPA models hold if the mean residuals concentration is 1 mg/kg Tri+ PCBs or less on average, over 20-acre areas.

If a certification unit has a mean residuals concentration of greater than 1 mg/kg Tri+ PCBs but less than or equal to 3 mg/kg Tri+ PCBs, and the average concentration in the 20-acre joint evaluation area that contains the certification unit is 1 mg/kg Tri+ PCBs or less, backfill may be placed without a re-dredging attempt. In this case, testing of the backfill after placement is required.

The backfill testing is to be accomplished by collecting surface sediment samples (0-6 inches) of the backfill after it is placed, using the same grid spacing used for the residual sediment sampling. Each 0-6 inch backfill sample is to be analyzed for PCBs. The mean concentration of PCBs in the backfill samples must be 0.25 mg/kg Tri+ PCBs or less. If this criterion is not met, the non-compliant areas of the backfill layer must be removed via dredging, replaced, and retested until the criterion is achieved. Alternately, in some areas it may be possible to place additional backfill material. However USEPA approval is required for this option.

Performance Standard for Dredging Productivity

Objective

The Performance Standard for Dredging Productivity (*i.e.*, Productivity Standard) is designed to monitor and maintain the progress of the dredging to meet the schedule stated in the ROD. The project schedule stated in the ROD has a six-year duration and consists of the first dredging season designated "Phase 1" (initial dredging at a reduced scale) followed by five dredging seasons collectively designated "Phase 2" (each with dredging at full production to remove the remainder of the contaminated sediments identified for removal). The Productivity Standard specifies the cumulative volume of sediment to be dredged during each dredging season, based on the current estimate of 2.65 million cubic yards of sediment to be removed.

Statement of the Productivity Standard

Required and Recommended Cumulative Annual Dredging Volumes

The Productivity Standard requires compliance with minimum cumulative volumes of sediment for each dredging season and targets larger volumes for the first five dredging seasons, as provided in Table ES-3 below. The minimum cumulative volume of sediment to be removed, processed and shipped off-site by the end of each dredging season is the quantity shown in the "Required Cumulative Volume" column. The targeted cumulative volumes allow for the work to be designed for completion at a somewhat faster rate, so that a reduced volume remains in the sixth and final dredging season. This recommended approach provides additional time to address any unexpected difficulties within the schedule called for in the ROD. The targeted cumulative dredging volumes are shown in the "Target Cumulative Volume" column.

Table ES-3: Productivity Requirements and Targets

Dredging Season[1]	Required Cumulative Volume (cubic yards)	Target Cumulative Volume (cubic yards)
Phase 1 (Year 1)	Approx. 240,000	265,000
Phase 2 (Year 2)	720,000	795,000
Phase 2 (Year 3)	1,200,000	1,325,000
Phase 2 (Year 4)	1,680,000	1,855,000
Phase 2 (Year 5)	2,160,000	2,385,000
Phase 2 (Year 6)	2,650,000[2]	2,650,000[2]

(1) The overall completion schedule, if appropriate, should be adjusted to be consistent with the total volume of sediment to be dredged as determined by USEPA during remedial design (for example, based on the findings of the design support sediment characterization program).
(2) Represents total estimated in-situ volume to be removed as per the ROD, exclusive of any amounts generated by re-dredging to meet the Residuals Performance Standard.

Monitoring and Recordkeeping

The Productivity Standard requires the Contractor managing the dredging project to track and report progress to the USEPA. The recordkeeping, in addition to and as verified by USEPA or its representatives in the field, will become the basis for measuring compliance with the Productivity Standard By March 1 of each year, the Contractor shall provide USEPA with a schedule showing cumulative volumes planned to be removed each month during the upcoming dredging season (*i.e.*, Production Schedule). The production schedule should consider the targeted cumulative volumes and must meet or exceed the requirements of the Productivity Standard (or as revised in accordance with USEPA-approved design documents).

Monthly and annual productivity progress reports shall be submitted to USEPA. Monthly productivity progress reports will be compared to the production schedule submitted by the Contractor and will be the primary tool for assessing whether the project is on schedule. Annual production progress reports, prepared at the conclusion of each dredging season, will be used to evaluate compliance with the Productivity Standard.

The monthly and annual reports will summarize daily records of the dredging locations, approximate production and number of operating hours of operation for each dredge, estimates of in-situ sediment volumes removed, and the weight of dewatered sediments and estimated mass of PCBs shipped off-site.

Action Levels and Required Responses

The Productivity Standard's action levels and responses are summarized in Table ES-4 below.

Table ES-4: Action Levels and Required Responses

Action Level	**Description**	**Response**
Concern Level	Monthly production rate falls 10% below scheduled rate.	Notify USEPA and take immediate steps to erase shortfall in production over next two months.
Control Level	Production falls below scheduled production by 10% or more for two or more consecutive months.	Submit an action plan explaining the reasons for the production shortfall and describing the engineering and management actions taken or underway to increase production and erase shortfall by end of the dredging season.
Standard	Annual cumulative volume fails to meet required production requirements.	Action to be determined by USEPA.

In any dredging season, if the planned monthly cumulative production falls below the scheduled amount by 10 percent or more, the Contractor shall identify the cause of the shortfall to USEPA and take immediate steps (adding equipment and crews, working extended hours, modifying the plant and equipment or approach to the work, or other) to erase the cumulative shortfall over the following two months or by the end of the dredging season, whichever occurs sooner. Any steps taken to increase production shall conform to all other Performance Standards established for the project. Significant changes to operating procedures or equipment, such as use of an entirely different dredging technology or means of processing the dredged sediments prior to shipment, will require USEPA approval.

If the monthly productivity falls below the scheduled productivity by 10 percent or more for two or more consecutive months, the Contractor shall provide a written action plan to the USEPA explaining the reasons for the production shortfall and describing the engineering and management steps taken or underway to erase the shortfall in production during that dredging season.

If an annual production shortfall occurs, USEPA will determine the appropriate action to address non-compliance with the Productivity Standard. USEPA will also evaluate the circumstances that led to the annual shortfall, if encountered, when assessing compliance.

Supporting Analyses and Assumptions

Conceptual Project Schedule

To evaluate the feasibility of the required and target cumulative annual volumes specified in the Productivity Standard (refer to Table ES-3), a detailed conceptual critical path schedule was developed using Primavera Systems, Inc. software. A number of conservative assumptions were made regarding means and methods that could be used during the dredging project in order to demonstrate that the Productivity Standard is achievable. The Productivity Standard, however, does not require that the remedial design adhere to the assumptions and work sequence used to develop the Productivity Standard conceptual schedule. The schedule output indicates that both the required and the target cumulative volumes developed for the Productivity Standard are reasonable and achievable. Selected examples of the supporting analyses and assumptions used to develop the schedule are summarized below.

Removal Volume

The Productivity Standard is based on the removal of approximately 2.65 million cubic yards of sediment, as stated in the ROD. This volume may be revised upward or downward based on the results of the design support sediment characterization program. The Productivity Standard requires adjustment if the final targeted dredging volume differs by more than 10% from the current estimate.

Construction Schedule and Dredging Season

The Productivity Standard is based on a construction period for the project of six (6) years (including Phases 1 and 2, as stated in the ROD) and assumes that there will be a minimum of 30 weeks available each year to conduct dredging operations, unconstrained by any work hours limitations. To implement this schedule, coordination would be required with the New York State Canal Corporation to extend their routine hours and season of operation.

Dredging Equipment

Both mechanical and hydraulic dredges were considered during the development of the conceptual schedule. Smaller specialty equipment was also considered for use near shorelines, in shallow water, and in difficult locations (such as shallow bedrock areas). Estimated dredging volumes were developed by river section and dredge type for the schedule. The conceptual schedule included only the use of a mechanical dredge as a conservative approach, since mechanical dredging is typically a slower process. The schedule assumes that dredging can take place in multiple river sections simultaneously, with the dredging generally progressing from upstream to downstream within each river section.

Work Elements and Sequence

The conceptual schedule assumptions address the potential elements and sequence of the dredging work. The assumptions include, but are not limited to, the following:

- Silt barriers, while not required by the Productivity Standard, were assumed to be installed for all dredging work outside the navigation channel. The assumed silt barriers consist of segments of steel sheet piling installed at the upstream and downstream limits of the work area, connected by high density polyethylene (HDPE) curtains with floatation booms and weighted at the bottom. This assumption is conservative with respect to the schedule, which accounts for the time necessary to install and remove the silt barriers.

- Silt barriers are removed only after backfill and shoreline stabilization where appropriate, has been completed.

- Backfilling and shoreline stabilization at each area dredged in a particular season is completed prior to demobilization at the end of each dredging season.

- Work is conducted in a generally upstream to downstream sequence within a given river section.

Sediment Processing/Transfer Facility

The conceptual schedule of the Productivity Standard assumed the establishment of one land-based sediment processing/transfer facility, located at the northern extreme of the 40-mile long project area. Conceptual design calculations were prepared regarding railroad sidings, transportation of scows loaded with dredged sediments via the canal system, and other transportation issues to evaluate whether the dredged sediment volumes to be removed could be transferred, processed (*e.g.*, dewatered), and shipped off-site at an appropriate rate (compared to the required and target production rates). The assumption of one facility was made to be conservative with respect to the schedule, in that it requires sufficient time for sediments removed from any location within the Upper Hudson to be transported to one location. A less conservative assumption would entail two facilities, as was assumed for purposes of evaluating engineering feasibility of the remedy. Note, however, that the assumption does not reflect a worst case based on available information, which would be one facility at or below the southern extreme of the project area.

Interactions Among Performance Standards

The development of the Performance Standards included consideration of the degree to which they are interrelated. Some of the major points of interaction between the Standards, and issues identified as being significant to the compliance with all the standards, are summarized below. The design of the project should be optimized in consideration of these interactions.

- The Resuspension Standard controls PCB mass loss during dredging. It is important to note that PCB mass loss is intrinsically linked to dredging productivity, in that ongoing project activities (dredging, vessel traffic, installation and removal of barriers, if used, and debris removal) will contribute to PCB mass loss. The Resuspension Standard Concern Level and Control Level are triggered if the average daily Total PCB mass loss exceeds 600 g/day for more than a one-week, or four-week stretch, respectively.[10] Non-compliance with the Productivity Standard beyond the six (6) year schedule will increase the total project PCB mass loss. If unforeseen difficulties require extensions to the schedule, the daily allocation of PCB mass loss will have to be commensurately lowered during the remainder of the dredging project to maintain the PCB mass loss of 650 kg upon which the Resuspension Standard action levels are based. Achievement of the target cumulative annual volumes in the Productivity Standard is strongly encouraged to minimize the total project-related downstream transport of PCBs.

- Balancing the limits on PCB concentrations in the water column in the Resuspension Standard and the cumulative annual volumes in the Productivity Standard requires careful planning during equipment deployment considering, for example, the impacts of the number and types of equipment selected, location of dredging areas, and the monthly baseline variation in PCB water column concentrations. This is an area where Phase 1 monitoring is expected to contribute significantly to the understanding of how to efficiently proceed with dredging and maintain compliance with the Performance Standards.

- The Residuals Standard requires characterization of residual sediments, which may include redeposited/settled sediments. To avoid recontamination of a satisfactorily completed certification unit, the Productivity Standard assumes that dredging generally will proceed from upstream to downstream within each River Section. The Resuspension Standard modeling also indicates that the dredge may create a deposit of resuspended sediments slightly downstream of each dredging area, providing further incentive for work to proceed generally from upstream to downstream.

- The Productivity Standard includes a conceptual sequence of work and schedule for the dredging work to validate the feasibility of the required and target cumulative annual dredging volumes. The conceptual sequence of work and schedule necessarily included, among other elements, the time needed to comply with the requirements of the Residual Standard for sampling and analysis of each certification unit, possibly two re-dredging attempts and/or sub-aqueous cap

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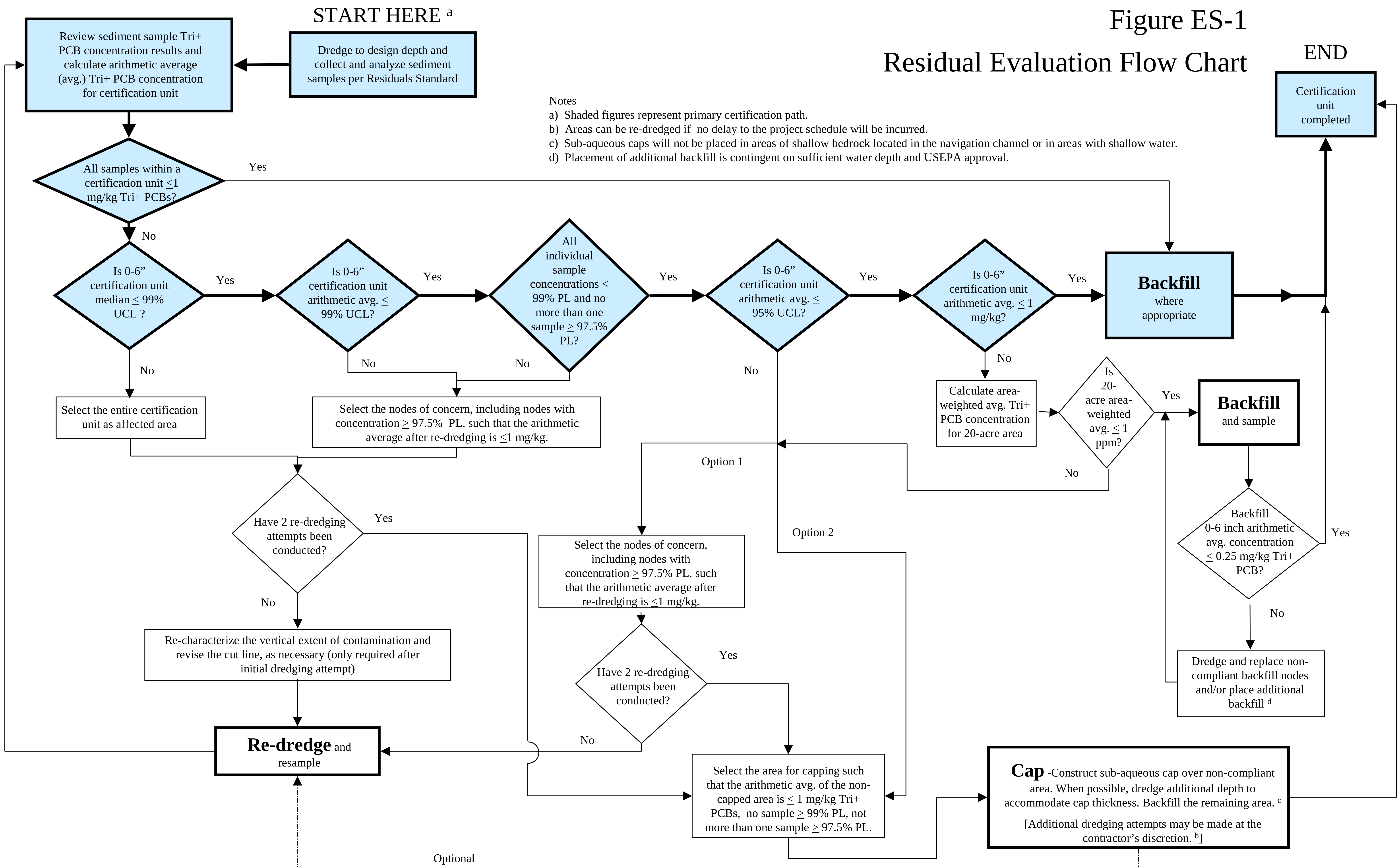
[10] The daily rate is based on attainment of the recommended target cumulative volume as specified in the Productivity Standard, and should be prorated according to the production rate planned in the Production Schedule to be submitted annually to USEPA.

construction, and placement of backfill (where appropriate) prior to demobilization. For instance, USEPA conservatively assumed that re-dredging could require half of the total time spent on the initial dredging. However, if significantly more time is needed for re-dredging than was estimated in the conceptual schedule, it may affect the ability to meet the overall productivity standard. Understanding that these work elements contribute to the project duration, flexibility was designed in the Residuals Standard (*e.g.*, provisions for 20-acre joint evaluations during Phase 1, options for immediate capping where the certification unit mean is only slightly greater than the objective of 1 mg/kg Tri+ PCBs, and provisions for successively closing portions of a certification unit as dredging progresses) to maintain productivity. The experience and information gained during Phase 1 of dredging will be the subject of the second peer review. This peer review will evaluate the project performance in Phase 1, so that any necessary refinements and adjustments can be made to the dredging operations or standards, including the Productivity Standard, prior to the second phase of dredging.

Figure ES-1
Residual Evaluation Flow Chart



Introduction
Draft Engineering Performance Standards – Peer Review Copy
Hudson River PCBs Superfund Site

Overview

In February 2002, the United States Environmental Protection Agency (USEPA) issued a Record of Decision (ROD) for the Hudson River PCBs Superfund Site (Site). The ROD calls for targeted environmental dredging of approximately 2.65 million cubic yards of PCB-contaminated sediment from the Upper Hudson River (approximately 40 river miles) in two phases over a six-year period, and monitored natural attenuation of the PCB contamination that remains in the river after dredging.

In the ROD, USEPA identified five remedial action objectives, which are as follows:

- Reduce the cancer risks and non-cancer health hazards for people eating fish from the Hudson River by reducing the concentration of PCBs in fish;
- Reduce the risks to ecological receptors by reducing the concentration of PCBs in fish;
- Reduce PCB levels in sediments in order to reduce PCB concentrations in river (surface) water that are above applicable or relevant and appropriate requirements for surface water;
- Reduce the inventory (mass) of PCBs in sediments that are or may be bioavailable; and
- Minimize the long-term downstream transport of PCBs in the river.

In selecting its cleanup remedy, USEPA required that performance standards for resuspension during dredging, production rates during dredging, and residuals after dredging (together called the "Engineering Performance Standards") be established. This decision was made to address comments received from members of the public who expressed a wide spectrum of views on the project. Some suggested that the environmental dredging could "do more harm than good" and take much longer than stated, while others were concerned that the ROD was not sufficiently comprehensive in its requirements for the environmental cleanup. USEPA required these performance standards in its final cleanup decision to promote accountability and ensure that the cleanup meets the human health and environmental protection objectives set forth in the ROD.[1]

This Public Review Copy of the Draft Engineering Performance Standards document is published in four volumes. The standards are presented in three parts, each contained in a single volume; an Appendix is contained in the fourth volume. Each part discusses one performance standard: *Part 1* discusses the Performance Standard for *Dredging*

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[1] Other performance standards will address public concerns related to potential impacts of the cleanup on the surrounding community, such as air emissions, navigation and noise; these are being developed separately.

Resuspension, Part 2 provides the Performance Standard for *Dredging Residuals*, and *Part 3* contains the Performance Standard for *Dredging Productivity*. Each of these parts includes a concise statement of the standard, discussion on the development approach, supporting analyses, and rationale used to derive the performance standard. Each part further provides a plan for refinement of the standard to account for additional data that may be obtained subsequent to publishing the standard, as well as to address evaluation of Phase 1. The Appendix contains a review of pertinent information derived from case studies of other environmental dredging projects considered in developing the draft Engineering Performance Standards. Some of the information was derived from research of the literature and public web sites, while additional information was developed from interviews with project managers and technical staff.

Consistent with the ROD, the Engineering Performance Standards were developed in consultation with New York State, the National Oceanic and Atmospheric Administration and the U.S. Fish and Wildlife Service. (New York State is developing substantive water quality certification requirements for the environmental dredging pursuant to the federal Clean Water Act; USEPA will review the requirements when they become available for any implications with respect to the Engineering Performance Standards). USEPA's consultants included a team of senior scientists and engineers who developed the standards, which then were reviewed by a separate team of recognized technical experts. General Electric Company reviewed a version of the draft standards previous to this one. Comments from these organizations were considered in preparing a Public Review Copy of the Draft Engineering Performance Standards.

Following the close of the public comment period on July 14, 2003, the Draft Engineering Performance Standards was revised to create the Draft Engineering Performance Standards – Peer Review Copy. This version of the standards will be peer reviewed by a panel of independent experts, modified as appropriate to address the peer reviewers' recommendations, and then implemented during the Phase 1 dredging. The results from the first season of dredging (Phase 1) also will be peer reviewed, and the Engineering Performance Standards will be refined or adjusted, if necessary, for the remaining dredging seasons (Phase 2).

It is important to note that the standards developed herein are intended only for application to the remedial environmental dredging of the Upper Hudson River called for in USEPA's 2002 ROD for the Hudson River PCBs Superfund Site at this juncture in time. The standards are not intended to provide general or universal guidance for environmental dredging. Other projects and locations may have specific features differing from those of the Hudson River, and the standards presented here may not be applicable to those projects.

Site Background

The Hudson River PCBs Superfund Site encompasses the Hudson River from the Fenimore Bridge in Hudson Falls (River Mile [RM] 197.3) to the Battery in New York Harbor (RM 0), a stretch of nearly 200 river miles (about 320 km). The Upper Hudson

River portion of the Site extends from the Fenimore Bridge to the Federal Dam at Troy (RM 153.9), a distance of just over 43 river miles. To facilitate effective project management and address Site complexities, the Upper Hudson River has been further divided into three major sections: River Sections 1, 2 and 3. River Section 1 extends from the former Fort Edward Dam just north of Rogers Island (RM 194.8) to the Thompson Island (TI) Dam (RM 188.5), a stretch of the river also known as the Thompson Island Pool; River Section 2 extends from the TI Dam to the Northumberland Dam (RM 183.4), which includes a 2.3-mile, non-navigable stretch of the river from the TI Dam to the Fort Miller Dam; and River Section 3 extends from the Northumberland Dam to the Federal Dam. Upstream of River Section 1 is a river segment between the Fenimore Bridge and the former Fort Edward Dam, a distance of about 2.5 river miles.

During an approximately 30-year period ending in 1977, General Electric (GE) used PCBs in its capacitor manufacturing operations at its Hudson Falls and Fort Edward, NY facilities. PCB oils were discharged both directly and indirectly from these plants into the Hudson River. This included both non-permitted and permitted discharges. Even after GE received a permit in 1975, permit exceedances occurred. Estimates of the total quantity of PCBs discharged directly from the two plants into the river from the 1940s to 1977 are as high as 1,330,000 pounds (about 605,000 kg).

Many of the PCBs discharged to the river adhered to sediments and accumulated downstream with the sediments as they settled in the impounded pool behind the former Fort Edward Dam, as well as other depositional areas farther downstream. Because of its deteriorating condition, the Fort Edward Dam was removed in 1973. Five areas of PCB-contaminated sediments were exposed due to the lowering of the river water level when the Fort Edward Dam was removed. These five areas are known as the Remnant Deposits. During subsequent spring floods, PCB-contaminated sediments from the Fort Edward Dam area were scoured and transported downstream.

In 1984, USEPA completed a Feasibility Study (FS) and issued a Record of Decision (ROD) for the site (the 1984 ROD). The 1984 ROD contained the following components:

- An interim No Action decision with regard to PCBs in the sediments of the Upper Hudson River;
- In-place capping, containment, and monitoring of exposed Remnant Deposits (in the area of RM 195 to 196) from the former impoundment behind the Fort Edward Dam, stabilization of the associated river banks and revegetation of the areas; and
- A detailed evaluation of the Waterford Water Works treatment facilities, including sampling and analysis of treatment operations to see if an upgrade or alterations of the facilities were needed.

Although commercial uses of PCBs ceased in 1977, GE's Fort Edward and Hudson Falls plants continue to contaminate the Hudson River with PCBs, due primarily to releases of PCBs via bedrock fractures from the GE Hudson Falls plant. In September 1991, GE detected an increase in PCB concentrations at the Upper Hudson River water sampling stations being monitored as part of the construction monitoring program associated with Remnant Deposits capping. GE ultimately attributed the higher levels to the collapse of a wooden gate structure within the abandoned Allen Mill located adjacent to the river bank near the GE Hudson Falls plant. As reported by GE, the gate structure had diverted water from a tunnel that had been cut into bedrock, thereby preventing oil-phase PCBs originating at the GE Hudson Falls plant, that had migrated to the tunnel via subsurface bedrock fractures, from flowing into the river. From 1993 to 1995, GE removed approximately 45 tons of PCBs from the tunnel under NYSDEC jurisdiction. In 1994, GE documented the presence of PCB-contaminated oils in bedrock seeps at Bakers Falls adjacent to its Hudson Falls plant. GE has instituted a number of mitigation efforts that have resulted in a decline, but not cessation, of PCBs entering the river through the seeps.

The 1984 ROD did not address the PCB-contaminated oil leaking through bedrock in the vicinity of the GE Hudson Falls plant, which was not known to USEPA at the time. GE is conducting remedial activities at the GE Hudson Falls Plant Site under an Order on Consent between the New York State Department of Environmental Conservation (NYSDEC) and GE. The changing upstream loading from the Hudson Falls site must be accounted for in any evaluation of PCB levels within the Hudson River. In addition, the GE Fort Edward Plant outfall area is likely a continuing source of PCBs to the Hudson River , although the Fort Edward outfall area currently is being remediated by the New York State Department of Environmental Conservation pursuant to state law.

In December 1989, USEPA announced its decision to initiate a detailed Reassessment Remedial Investigation/Feasibility Study (RI/FS) of the interim No Action decision for the Upper Hudson River sediments. This was prompted by the five-year review required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), technical advances in sediment dredging and treatment/destruction technologies, as well as a request by NYSDEC for a re-examination of the 1984 decision. The February 2002 ROD is the result of the Reassessment.

Engineering Performance Standards Development

This document presents the development of the performance standards required by the ROD and discusses the major measure(s) of performance in each case, the technique(s) used to assess performance, the supporting analyses for the recommendations (including case studies), and major possible interactions among the performance standards.

To develop meaningful performance standards, it was necessary to envision a likely sequence of work for the major elements of the remediation project. It is understood that this "model sequence" may require adjustment as the remedial design is prepared. The model sequence of work outlined below is based on information in the ROD and emphasizes the points where the performance standards will interact with the work.

1. Extensive sediment sampling and analyses are conducted to identify locations where the Tri+ PCB mass per unit area (MPA) is 3 g/m^2 or greater in River

Section 1 and 10 g/m^2 or greater in River Section 2. In River Section 3, identification of target areas is based on removal of selected sediments with high concentrations of PCBs, high erosional potential and potential for uptake by biota. This information, in conjunction with other field investigation data, is used to determine target area boundaries for dredging and to delineate dredging "cut-lines." The dredging cut-lines are to be designed to remove all PCB-contaminated sediments within a particular targeted area (*i.e.*, the dredged bottom surface concentration is anticipated to be below 1 mg/kg).

2. Regular water column sampling and analysis is conducted to evaluate the PCB and total suspended solid (TSS) concentrations in the Hudson River prior to dredging (background concentrations).
3. Upon commencement of remediation, environmental dredging is employed to remove contaminated sediments from the targeted areas. Water quality monitoring is conducted continuously according to the requirements of the Dredging-Related Resuspension Performance Standard. Contingency actions are implemented to control resuspension releases if the action levels in the standard are contravened.
4. On completion of dredging in a particular targeted area, post-dredging sediment sampling is conducted according to the requirements of the Dredging Residuals Performance Standard to confirm that residual PCB concentrations are less than or equal to the anticipated residual concentration of approximately 1 mg/kg, as specified by the ROD. Contingency actions are implemented if sediment sample results from a particular targeted area are non-compliant. Following verification, backfill is placed where appropriate and shoreline stabilization is completed.
5. The progress of the dredging project is monitored according to the requirements of the Dredging Productivity Performance Standard. Contingency actions are implemented if the dredging production rate deviates significantly from that required by the performance standard.
6. At the completion of the first dredging construction season (Phase 1), remedial operations are assessed for compliance with the various performance standards. If necessary, adjustments to the remedial operations and performance standards are recommended, evaluated by the peer review panel, and implemented.
7. Phase 2 dredging commences and continues through project completion. Extensive monitoring (including that required to establish compliance with the performance standards) continues throughout the life of the project. Adjustments to the remedial operations and performance standards may also be implemented during Phase 2 consistent with the peer-reviewed approach.
8. Property restoration and decommissioning of the processing/transfer facility location(s) are conducted as expeditiously as practicable following completion of dredging and backfill activities. Habitat replacement and associated monitoring are performed in accordance with the approved plan.

Based on the analyses performed to develop the standards, USEPA believes that the standards are consistent with the human health and environmental protection objectives of the ROD. USEPA has determined:

- Compliance with the Resuspension Standard will limit the concentration of Total PCBs in river water one mile or more downstream of the dredging area to levels that are acceptable for potable water under the requirements of the Safe Drinking Water Act;

- Resuspension of PCBs in compliance with the Resuspension Standard will have a negligible adverse effect on Tri+ PCB concentrations in Hudson River fish, as compared to a scenario assuming no dredging-related PCB releases;[2]

- Compliance with the Control Level of the Resuspension Standard is expected to result in a Total PCB load (mass) transported downstream during remedial dredging that is similar to the range of Total PCB loads detected during recent baseline (*i.e.*, pre-dredging) conditions, as documented by weekly measurements from 1996 to 2001;

- The Residuals Standard specified in the ROD (approximately 1 mg/kg Tri+ PCBs prior to backfilling) is achievable based on case studies of other environmental dredging projects and can be applied in the Upper Hudson on an area-wide average basis;

- The Productivity Standard will result in completion of the dredging within the six dredging seasons called for in the ROD, based on an example conceptual schedule for project implementation; and

- The three Draft Engineering Performance Standards, including their respective monitoring programs, are achievable individually and in combination. The standards appropriately balance their points of interaction, allowing flexibility during design and implementation while ensuring protection of human health and the environment. For example, the requirements concerning additional dredging attempts in the Residuals Standard must consider the requirements for dredging production in the Productivity Standard.

Performance Standard for Dredging Resuspension

The Performance Standard for Dredging Resuspension (*i.e.*, Resuspension Standard) is designed to limit the concentration of PCBs in river water such that water supply intakes downstream of the dredging operations are protected, and to limit the downstream transport of PCB-contaminated dredged material. The attendant water quality monitoring program will be implemented to verify that the objectives of the Resuspension Standard have been met during dredging. The analytical results obtained from the water quality monitoring will be compared to the Resuspension Standard and associated lower action levels to monitor and control resuspension through appropriate actions. Such actions

[2] A negligible effect is defined, in this case, as a predicted Tri+ PCB concentration in Upper Hudson fish of 0.5 mg/kg or less, and in Lower Hudson River fish of 0.05 mg/kg or less, within 5 years after the completion of dredging in the Upper Hudson.

could include, as appropriate, expanding the monitoring program, notifying public water suppliers, implementing operational or engineering improvements, and, if necessary, temporarily halting the dredging.

The ROD requires the development of a Resuspension Standard but does not set forth any framework or numerical value for the Standard. The Resuspension Standard and a series of tiered action levels were developed based on extensive modeling, review of environmental dredging case study data, and evaluation of applicable or relevant and appropriate requirements (ARARs) identified in the ROD for PCBs in river water. Thresholds for increased monitoring and engineering controls provide a basis for design and evaluation of a contingency plan in the event of a contravention of the action levels. Once a baseline monitoring program has been finalized and implemented for the project, new water quality data will be collected and evaluated. The improved understanding of baseline conditions will be used to prepare a more thorough description of the relationships between water quality parameters and to further refine or adjust the Resuspension Standard (primarily the associated monitoring program), as necessary, based on the peer-reviewed approach. A plan is presented for refinement of the standard and the associated monitoring program, both as a result of availability of ongoing baseline monitoring data prior to Phase 1, and following completion and evaluation of Phase 1.

Performance Standard for Dredging Residuals

The Performance Standard for Dredging Residuals (*i.e.*, Residuals Standard) is designed to detect and manage contaminated sediments that may remain after initial remedial dredging in the Upper Hudson River. The ROD calls for removal of all PCB-contaminated sediments in areas targeted for dredging, and anticipates a residual of approximately 1 mg/kg Tri+ PCBs (prior to backfilling). The "residual sediments" may consist of contaminated sediments that were disturbed but escaped capture by the dredge, resuspended sediments that were re-deposited/settled, or contaminated sediments remaining below the initial dredging cut elevations (*e.g.*, due to uncertainties associated with interpolation between core nodes of the design sediment sampling program or insufficient core recovery).

The Residuals Standard requires the implementation of a post-dredging sampling and analysis program to detect and characterize PCB concentrations in the residual sediments. The post-dredging sediment data are compared to the anticipated residual of approximately 1 mg/kg Tri+ PCBs stated in the ROD and a group of statistical action levels developed for the Residuals Standard. The approach to be taken to manage the residual sediments (including re-dredging) is then selected depending on the statistical analyses of the post-dredging data. The use of statistical analyses to evaluate environmental datasets is a scientifically accepted practice.

The development of the residuals performance standard was accomplished using information from remedial dredging project case studies, and consideration and implementation of statistical data evaluation tools. The standard also encompasses contingency options in the event of non-compliance, and the development of an approach to refine the standard following analysis and interpretation of Phase 1 data.

Performance Standard for Dredging Productivity

The Performance Standard for Dredging Productivity (*i.e.*, Productivity Standard) is designed to monitor and maintain the progress of the dredging to meet the schedule stated in the ROD. The project schedule stated in the ROD has a six-year duration and consists of the first dredging season designated “Phase 1” (with dredging at a reduced scale) followed by five dredging seasons collectively designated “Phase 2” (each with dredging at full production to remove the remainder of the contaminated sediments identified for removal). The Productivity Standard specifies the cumulative volume of sediment to be dredged during each dredging season, based on the current estimate of 2.65 million cubic yards of sediment to be removed. Following the completion of Phase 1, the data obtained from the monitoring program will be analyzed to determine if refinements to the Productivity Standard or changes to the Phase 2 remedial program are necessary.

Structure and Content of the Engineering Performance Standards

As stated above, the Engineering Performance Standards are presented in three parts, one for each of the three standards. To provide a comprehensive and consistent presentation of each standard, each part is subdivided into four sections, as follows:

Section 1 – Statement of the Performance Standard

This section provides a concise statement of the standard and associated lower-tier action levels with no rationale or background explanation. It simply states the standard as it is to be implemented during the dredging program.

Section 2 – Technical Basis of the Performance Standard

This section contains three major subsections describing the technical basis for development of the standard.

Background and Approach

The objectives, development processes, and methodology used in the development of these standards are presented in this section. A brief summary of the scope for the development of the standard is included in this section. Summaries of several case studies that are similar in nature to this project are also presented.

Supporting Analyses

This section analyses the available information for its applicability to this project. This section includes the statistical evaluations and modeling required in order to derive the standard. Evaluations of baseline monitoring data or performance data from previous case studies, as well as any conceptual design activities, that give substance to the derivation of the standard are provided.

Rationale for Determination of the Standard

Based on the supporting analyses performed, a determination is made as to what the performance standard should be, and the rationale for this determination is discussed. Analysis of case studies, along with reasoning and explanation of decisions and judgments made to arrive at the standard is provided in this section.

Section 3 – Implementation of the Performance Standard

This section is a full presentation of the standard, including conceptual information to be provided to assist the user to interpret application of the standard in unforeseen circumstances. Action levels, including the standard proper, along with monitoring requirements and the basis for engineering controls and contingencies to be required at each level, are laid out in detail.

Section 4 - Plan for Refinement of the Performance Standard

This section contains a plan for refinement of the standard that may be appropriate due to ongoing collection of baseline data, or to discovery of additional case studies that shed new light on the development of the standard prior to implementation of Phase 1. In addition, the plan will address the means by which data developed during monitoring of Phase 1 operations and impacts will be used to refine or adjust the standard prior to and during Phase 2.

Within each Section, the presentation may vary from Standard to Standard, in order to suit the needs of that particular Standard.

Key Project Personnel and Roles

In order to facilitate development of engineering performance standards that are consistent with the state-of-the-art dredging technologies and methods, scientific and statistical analysis, and the current level of knowledge about the Hudson River system, Malcolm Pirnie assembled a technical team of highly qualified professionals, many of whom had been involved with the Reassessment RI/FS for the site, or previous work on the river on behalf of New York State. In addition, the quality review normally conducted internally was delegated to a diverse team of technical experts assembled from a broader pool of candidates, recognized in their respective fields, and functioning independently of the technical team developing the standards.

Technical Team

The technical effort was divided among three teams corresponding to the three standards to be developed. Key senior members of the technical team are presented below.

Bruce Fidler, P.E. – Engineering Performance Standards Development Leader

Mr. Fidler obtained his master's degree in civil and sanitary engineering in 1979 and has more than 23 years experience in environmental engineering and hazardous waste remediation. He has been involved with the Hudson River PCBs Superfund Site since 1991, virtually the entire period of the Reassessment RI/FS and subsequent design-phase work. While with TAMS Consultants, Inc., Mr. Fidler led various pre-feasibility evaluations and served as Project Manager for Phase 3 of the Reassessment, including preparation of the Feasibility Study and the summary of the selected remedy presented to USEPA's National Remedy Review Board, and the final Reassessment Responsiveness Summary incorporating over 73,000 comment documents received from the public. Having joined Malcolm Pirnie in early 2002, Mr. Fidler is now providing consultation on various aspects of the design period activities in addition to leading the engineering performance standards development effort.

Edward Garvey, Ph.D., P.G. – Resuspension Standard Team Leader

Dr. Garvey is a senior environmental geochemist with TAMS Consultants, Inc., an Earth Tech Company. He has over 22 years of experience in environmental geochemistry, with additional experience in human health risk assessment and hydrogeology. His educational training includes a Ph.D. in geochemistry, a M.A. in geological sciences and a B.E. in chemical engineering. Dr. Garvey is a registered geologist/geochemist in the Commonwealth of Pennsylvania. Dr. Garvey's experience includes over 19 years of study specific to the Hudson River, including his Ph.D. dissertation and his efforts since 1991 as the chief scientist on the Hudson River PCBs Reassessment RI/FS for USEPA. For the Reassessment RI/FS, Dr. Garvey planned and directed the collection of environmental data, including extensive, multi-year sediment and water column sampling programs, coordinated the efforts of various scientists and consultants, and prepared several major reports on the investigation. His work on this project has produced several technical papers as well as many technical presentations on the fate of PCBs in the environment. In his role as the Resuspension Standard Team Leader, Dr. Garvey brings extensive experience on the geochemical interpretation of sediment contamination data and its implications for long-term PCB transport.

Neven Kresic, Ph.D. – Residuals Standard Team Leader

Dr. Kresic has more than 20 years of teaching, research and consulting experience in surface water and groundwater assessment, engineering and remediation for U.S. and international clients. He has designed site characterization and environmental sampling plans, and performed data analysis and evaluation of remedial design alternatives at numerous CERCLA, Resource Conservation and Recovery Act (RCRA) and other industrial sites throughout the US. His areas of expertise include subsurface modeling, geostatistical, probabilistic and stochastic analyses of spatial and time data series, and groundwater remediation. Dr. Kresic is a professional geologist and hydrogeologist, and teaches short professional courses in geographic information systems (GIS), Groundwater Modeling and Groundwater Remediation for the National Ground Water Association.

John Mulligan, P.E. – Productivity Standard Team Leader

Mr. Mulligan earned his master's degree in sanitary engineering from the School of Public Health at the University of North Carolina in 1967 and has over 35 years of experience in civil and environmental projects including a number of hazardous waste remediation projects involving dredging and disposal of contaminated sediments. He became involved in the Hudson River PCB project in 1974 when he served as Malcolm Pirnie's project engineer on the design of a new water main crossing the Hudson. This was required to replace existing mains damaged by the removal of the former Fort Edward Dam, and involved removing timber cribs from the former dam pool, and stabilizing the sediment deposits left behind the old dam when the water level fell. From 1975 through 1991, he served as Malcolm Pirnie's Project Manager for the preparation of studies and designs for the NYSDEC aimed at remediating the PCB contamination of the river sediments. In more recent years, Mr. Mulligan has designed a dredging project to remove and dewater PCB-contaminated sediments from the St. Lawrence River for General Motors Corp. and assisted in the design of the demonstration project for the remediation of PCB-contaminated sediments at Deposit N in the Fox River near Green Bay, WI.

Donald J. Hayes, Ph.D., P.E. – Consulting Expert

Dr. Hayes has been working with environmental aspects of dredging, dredged sediment disposal, and contaminated sediment management for over 20 years. He has published extensively in these areas. He also contributed to a number of guidance documents and authored software used to evaluate contaminated sediments management alternatives. He is especially recognized for his expertise in water quality impacts associated with dredging operations. Dr. Hayes served on the National Academies of Engineering Committee on Contaminated Marine Sediments and co-authored the resulting report. He is currently actively working on seven contaminated sediment projects and has contributed to many more projects over the past few years; many of these are Superfund projects. He previously contributed to the Reassessment Feasibility Study for this Site, as well as the final Reassessment Responsiveness Summary. Dr. Hayes worked as a research Civil Engineer at the USACE's Waterways Experiment Station for over 10 years and has been in academia for the past 11 years. Dr. Hayes received his Ph.D. in Environmental Engineering and Water Resources Planning and Management in 1990.

In addition to the expertise contributed by these team members, modeling for the project was conducted by LimnoTech, Inc. (HUDTOX model) and Menzie-Cura & Associates, Inc. (FISHRAND model).

Quality Review Team

Quality reviews for the project are being performed by a team of experts that functions independently of the technical team. Reviewers include the following:

Kenneth J. Goldstein, C.G.W.P - Quality Review Team Coordinator

Area of Expertise: Residuals Sampling

Mr. Goldstein is a professional hydrologist/hydrogeologist at Malcolm Pirnie, with over 20 years experience in contaminant hydrogeology and contaminant fate and transport. He has designed work plans, field sampling plans and quality assurance plans and directed numerous sampling and analytical programs for physical and chemical characterization of sediments, soil and groundwater.

Mr. Goldstein was responsible for the sampling and characterization of dredge spoil deposits and contaminated sediments in the Upper Hudson River through the late 1980s and early 1990s. In addition, Mr. Goldstein developed field sampling plans and performed sediment sampling on the Raritan River, Jamaica Bay, and Eastchester Bay. He has performed statistical and geospatial analysis of sediment quality data and physical characterization data. Mr. Goldstein's current focus is on remediation of contaminated media using in-situ remedial technologies.

Jonathan B. Butcher, Ph.D., P.H.

Areas of Expertise: Residuals, Resuspension, Reassessment RI/FS History

Dr. Jonathan Butcher is an environmental engineer and Professional Hydrologist with TetraTech, Inc., who has worked on the Reassessment RI/FS for the Hudson River PCBs Site since soon after its commencement. He has provided technical support in four key areas: (1) contaminant fate and transport modeling for PCBs within the river water and sediment; (2) predictive modeling of bioaccumulation of PCBs in fish; (3) data validation and reconciliation for historical data collection efforts, and (4) sampling design and statistical and geostatistical analyses of sample data.

Dr. Butcher developed the Phase 1 PCB fate and transport model application and Phase 2 model specifications for the study, and was responsible for internal model review during the FS. He developed a bivariate bioaccumulation factor method to predict PCB burdens in fish in systems where the water column and sediment fractions are not in equilibrium, and collaborated on development of mechanistic and stochastic bioaccumulation models. He was also responsible for an innovative study of the environmental partitioning behavior of PCB congeners in Hudson River water and sediments.

Dr. Butcher has taken a lead role in the review of GE's alternative modeling analyses of PCBs in the Hudson, and has developed methods for translating historical Aroclor quantitation results to a common Tri+ PCB basis. He has published several peer-reviewed papers on key scientific aspects of this work.

Gregory Hartman, P.E.

Areas of Expertise: Sediment Remediation, Environmental Dredging, Dredging Residuals

Mr. Hartman is a licensed Professional Engineer in Oregon and Washington, and is currently a consultant with the firm of Dalton, Olmsted & Fuglevand in Kirkland, WA. Mr. Hartman has a B.S. in Civil Engineering, and an M.S. in Coastal and River Engineering. He has 34 years experience working in the Coastal and Waterway Industry. As a Civil Engineer in the Navigation Division of the Portland District USACE, he was Chief of Dredging Operations, and gained direct working experience as a dredger. Since 1978 Mr. Hartman has been a consultant, working on coastal and river projects in the United States and overseas.

Mr. Hartman has taught the USACE Dredging Fundamentals Short Course every year since 1982. He has also taught courses intermittently on Dredge Cost Estimating, Dredge Contract Administration, and Dredge Inspectors Course to the USACE, and Dredge Remediation and Confined Disposal Site Design for the University of Wisconsin Short Course on Understanding Contaminated Sediment.

Mr. Hartman is Past President and Past Chairman of the Board for the Western Dredging Association, and Retired Board Member of the World Dredging Association. He is on the Board of Industry Advisors for the World Dredging, Mining and Construction Magazine. Relevant experience includes the remediation of the St. Paul Waterway in Tacoma, WA and the development, design and construction oversight for the Sitcum Waterway Remediation Project in the Port of Tacoma. Mr. Hartman was Dredge Consultant for various projects including: the design and contract oversight of navigation dredging and PCB remediation on the US Navy Puget Sound Shipyard in Bremerton, WA; Pilot Study 2000, to dredge PCBs for the New Bedford, MA remediation; preliminary design for remediation of PCBs in Fox River, WI; sediment remediation in Greens Bayou, TX and; Hylebos Waterway PCB remediation design and construction in Tacoma, WA.

Michael R. Palermo, Ph.D., P.E.

Areas of Expertise: Sediment Remediation, Environmental Dredging, Residuals

Dr. Palermo is a Research Civil Engineer and Director of the Center for Contaminated Sediments at the U.S. Army Engineer Research and Development Center, Waterways Experiment Station, where he manages and conducts research and applied studies concerning dredging and dredged material disposal and remediation of contaminated sediments. He has authored numerous publications in the area of dredging and dredged material disposal technology and remediation of contaminated sediments. He was the lead author of the USACE technical guidance for dredged material capping and the lead author of the USEPA ARCS program guidance for in-situ capping for sediment remediation. Dr. Palermo also serves on several technical advisory panels for superfund projects involving contaminated sediments.

Dr. Palermo is a Registered Professional Engineer and a member of the Western Dredging Association and the International Navigation Association. He is also Associate Editor for the Journal of Dredging Engineering. He received his B.S. and M.S. degrees in Civil Engineering from Mississippi State University and his Ph.D. degree in Environmental and Water Resources Engineering from Vanderbilt University.

William N. Stasiuk, Ph.D., P.E.

Areas of Expertise: Water Quality, Public Water Supply, Risk Assessment

Dr. Stasiuk is a Licensed Professional Engineer at Malcolm Pirnie, with experience in dealing with sites contaminated with PCBs. In 1975, he helped coordinate the NYSDEC's technical case in the original enforcement action against GE regarding Hudson River contamination. He directed the public health response to PCB contamination in the West Glens Falls, NY residential area in 1979 and the subsequent remedial action.

As Director of the Center for Environmental Health within the New York State Department of Health (NYSDOH) from 1985 through 1996, Dr. Stasiuk provided direction to the Bureaus which carried out exposure investigations, risk assessments and health studies at all contaminated sites in New York State. He was directly responsible for the post-cleanup assessment and further remedial actions leading to the reoccupancy of the Binghamton State Office Building. He provided oversight of assessment, response and remedial actions at the State University at New Paltz PCB contamination incident.

Also with NYSDOH in the late 1960s, Dr. Stasiuk was instrumental in development of a mathematical water quality model for the Hudson River from Corinth to the Battery. He also organized, staffed and supervised the first Toxic Substances Control Unit in NYSDOH in 1979, and assisted in development of drinking water standards for organic compounds, including PCBs. He was the NYSDOH's representative on the NYS Superfund Management Board.

In addition to providing executive direction to the Bureau of Water Supply (part of the Center for Environmental Health), Dr. Stasiuk's water supply experience includes serving from 1996-2000 as Deputy Commissioner and Director of the Bureau of Water Supply in the New York City Department of Environmental Protection, which is responsible for the New York City water supply system.

Quality Review Team Roles and Responsibilities

The above team of experts, collectively referred to as the Quality Review Team (or QRT), was charged with reviewing and evaluating the scope of work and approach for the development effort as well as a series of draft deliverables leading up to publication of the standards for review by the public and the peer review panel. The team members performed their reviews individually, but then sought to reach consensus and provide unified guidance to the technical team to the extent possible. All comments received from the QRT were considered carefully by the technical team and implemented in consultation with USEPA.

Although each of the five members of the QRT has a particular specialty (or specialties) relating to the project as indicated above, each was asked to review all three standards in the course of his work. The intention of this approach was to provide consistent review and evaluation of all standards individually and to provide evaluation of the interactions among the standards. While each of the QRT members has reviewed the standards[3], and concurs with their form and content, each has been operating solely within the framework of this project and not with the intention of providing generic or universal guidance on performance standards development related to other projects or sites.

Disclaimer Applicable to the Engineering Performance Standards Development

As indicated above, the standards developed herein are intended only for application to remedial environmental dredging of the Upper Hudson River called for in USEPA's 2002 ROD for the Hudson River PCBs Superfund Site at this juncture in time. The standards are not intended to provide general or universal guidance for environmental dredging. Other projects and locations may have specific features differing from those of the Hudson River, and the standards presented here may not be applicable to those projects.

[3] Gregory Hartman, PE was unavailable to review later drafts of the standards documents as issued for public comment and peer review, but participated in review of the technical approach, as well as internal drafts. He also addressed specific questions and issues posed by members of the technical team during preparation of later drafts.

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ATTACHMENTS

1.0 Statement of the Performance Standard for Dredging Resuspension

The Performance Standard for Dredging Resuspension, hereafter referred to as the Resuspension Standard, is designed to minimize polychlorinated biphenyls (PCBs) exported from sediment during remedial dredging and to protect downstream water quality. This standard, as described in this document, is to be applied during the Phase 1 remediation. The standard will be revised as necessary at the end of Phase 1 based upon knowledge gained from the first year of the remediation for application to Phase 2. Adjustments to this standard may also be made during Phase 1, if sufficient information is obtained during Phase 1 to identify these changes.

PCB export associated with dredging-related activities, as it applies to this 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, by tender and tugboat movements, barge transport, materials handling and other remedial activities. It is important to note that this definition requires both the disturbance and the downstream transport of PCBs. Thus, this definition governs the export of PCBs from the remedial dredging areas to downstream river sections and the Lower Hudson River. It does not include water quality impacts that do not result in downstream transport away from the immediate area of remedial activity. Resuspension within engineered control barriers (*e.g.*, silt curtains) is not regulated by this standard other than the extent to which this resuspension results in unacceptable downstream transport of PCBs beyond the barriers. The Resuspension Standard framework specifies criteria for both formulations of PCBs used throughout the Reassessment RI/FS: Total PCBs; and Tri+ PCBs[1].

Monitoring requirements for the public water supplies as well as the procedure for notifying operators 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.

This document is organized into four main sections, as briefly described below:

- Section 1 – Statement of the Performance Standard for Dredging Resuspension. This section provides a concise statement of the standard and its major provisions (*i.e.*, the standard and action levels, monitoring requirements and engineering contingencies) and includes this introduction.

- Section 2 – Technical Basis for the Performance Standard. This section describes the rationale for the selection of the standard and action levels. It also provides the definitions of the basic terms used in defining the standard.

- Section 3 – Implementation of the Performance Standard. This section describes how the standard will be implemented in terms of required monitoring and measurements as well as the required engineering contingencies.

[1] Total PCBs refers to the sum of all measurable PCB congeners in a sample, while Tri+ PCBs refers to the sum of PCB congeners containing three or more chlorine atoms.

- Section 4 – Plan for Refining the Performance Standard. This section describes the basis for modifying the standard and the types of modifications that may be anticipated.

In addition to these main components, this document also contains seven attachments (Attachments A through G) providing the details of the calculations and analyses that were developed to support the standard.

1.1 Resuspension Standard

In the formulation of the performance standard, several action levels were established so that remediation-related problems can be quickly identified and corrected before criteria are exceeded which would require temporarily halting the dredging operations. The Resuspension Standard is presented in terms of a standard threshold and three action levels. The Resuspension Standard for water quality is the maximum allowable concentration of PCBs in the river (500 ng/L). Failure to comply with this threshold requires that operations be temporarily halted until the exceedance can be rectified. Exceedance of the action levels will warrant additional monitoring and engineering improvements up to and including temporary halting of operations.

The Resuspension Standard includes criteria for both PCBs and suspended solids for both near-field and far-field conditions, which are defined as follows:

- Near-field conditions are those within a few hundred meters of the remedial operation. Only suspended solids criteria are applicable to the near-field stations.

- Far-field conditions are those at specific, permanent monitoring locations that are located at least one mile downstream of the remedial operation. Both PCBs and suspended solids criteria are applicable to the far-field stations.

Detailed definitions of near-field and far-field are presented in Sections 2 and 3 of this document. In addition, as discussed in Section 2, the performance standard for resuspension addresses both long-term and short-term impacts in terms of long-term and short-term criteria. In general, short-term criteria are for the protection of public water supplies, while long-term criteria are intended to help secure the long-term recovery of the river and its biota.

1.1.1 Resuspension Standard

The Resuspension Standard threshold is the maximum Total PCB concentration in the water column at any time at the far-field monitoring stations. This concentration is the federal maximum contamination limit, or MCL, for drinking water supplies, 500 ng/L Total PCBs.[2] Remedial activities may proceed only when the ambient Total PCB concentration (PCBs from all sources) is less than 500 ng/L. For the purpose of this standard, exceedance of the Resuspension Standard threshold requires a confirmed occurrence of 500 ng/L Total PCBs at a far-field station.

[2] The New York State MCL is also 500 ng/L.

In the event that remedial operations move to a location less than one mile upstream of a far-field monitoring point, the next downstream far-field station becomes the representative far-field station for the operation.

1.1.2 Action Levels

Action levels have been developed in order to identify and correct remediation-related problems well before the Resuspension Standard threshold is reached. The action levels cover operations in the immediate vicinity of remedial operations (near-field) and at the fixed monitoring locations (far-field), so that water quality responses to the remedial operation, site conditions and engineering controls can be quickly identified. These action levels include both load and concentration criteria, and apply to suspended solids, Total PCBs, and Tri+ PCBs.

There are three tiers of action levels: Evaluation Level; Concern Level; and Control Level. Analyses prepared for the FS and this document suggest that the remediation can reasonably be accomplished without exceeding the Evaluation Level criteria. The criteria for the Concern Level were established at two times the Evaluation Level criteria, and are set at levels that indicate the possibility of exceedance of the MCL at downstream public water supplies and that could impact the long-term recovery if maintained indefinitely. The Control Level criteria are similar to the Concern Level in terms of concentrations and load levels, but are applied to longer threshold durations of the elevated concentrations or loads.

Increases in monitoring are required as each successive action level is exceeded. Engineering solutions are suggested for the first two action levels (Evaluation Level and Concern Level), but are mandatory at the third (Control Level).[3] The PCB criterion for the Evaluation Level is based on mass loss (units of g/day) only. The Concern and Control Levels include both PCB mass loss and PCB concentration criteria. Suspended solids criteria are specified for the Evaluation and Concern Levels. Table 1-1 summarizes the resuspension criteria for the three action levels.

1.2 Routine Monitoring Program

Routine monitoring is required to evaluate compliance with both the Resuspension Standard threshold and the action levels. Routine monitoring data are compared to the resuspension criteria listed in Table 1-1. As long as the water column conditions are in compliance with all criteria, the dredging operation is considered to be under control (*i.e.*, operating as designed) and no additional monitoring (beyond continued routine monitoring) is required.

This section (1.2) describes routine (minimum) monitoring requirements at both the far-field and the near-field monitoring locations. If the resuspension criteria are exceeded, monitoring and engineering contingencies may be implemented as summarized briefly in Section 1.3, below.

[3] The Concern Level has a mandatory engineering study but not a mandatory engineering solution.

1.2.1 Far-Field Monitoring

Far-Field Monitoring Locations

A total of nine far-field monitoring stations are included in the routine monitoring program. These stations consist of:

- Four far-field monitoring locations downstream from the main remediation areas: Thompson Island Dam (river mile [RM] 188.5), Schuylerville (RM 181.3), Stillwater (RM 168.3), and Waterford (RM 156.5).

- Two upstream baseline stations in the Upper Hudson: Bakers Falls (RM 197.3) and Rogers Island (RM 194.4).

- Two Lower Hudson River stations: Albany (approximately RM 140) and Poughkeepsie (RM 77).

- One monitoring station will also be required on the Mohawk River at Cohoes to independently estimate PCB loads from the Mohawk watershed. This station will be used in conjunction with the measurements at the Lower Hudson monitoring locations to aid in identifying the fraction of any PCB load increase that may be derived from the Mohawk River as opposed to the Upper Hudson remedial activities.

Far-Field Monitoring Parameters and Frequency

The basic monitoring program for the Resuspension Standard in the Upper River consists of far-field PCB measurements collected daily at the four Upper Hudson far-field stations and Rogers Island; and far-field suspended solids samples collected every three hours, 24 hours a day (*i.e.*, eight samples a day). Continuous recording devices may be substituted for the discrete suspended solids samples, once a semi-quantitative relationship between the continuous measuring devices and the discrete measurements has been demonstrated. Sampling required at Bakers Falls is less frequent. The routine monitoring program also includes the deployment of integrating samples (*e.g.*, Isco samplers) to collect bi-weekly (every two weeks) samples for PCB congener analysis at the four Upper Hudson far-field stations and Rogers Island. Table 1-2 outlines the parameters and frequency of monitoring at the Upper Hudson far-field stations during routine monitoring.

Far-field stations in the Lower Hudson will also require routine monitoring. Sampling at these stations will include sample collection for all parameters listed in Table 1-2, but only at a single center-channel station and at a lower frequency. A far-field station at the Mohawk River will be monitored at the same frequency as the two Lower Hudson River stations, sampling across the river cross-section.

1.2.2 Near-Field Monitoring

Near-Field Monitoring Locations

Near-field monitoring locations are associated with individual remedial operations and move as the remedial operation moves. A remedial operation can include debris removal, dredging, backfilling or a combination of these activities if surrounded by a resuspension control barrier. Each remedial operation requires five routine monitoring locations, which are arranged as shown in Figure 1-1: one upstream station; one side channel station; and three downstream stations. If barriers are installed to control resuspension, a sixth station will be required inside the barrier.

Near-Field Monitoring Parameters and Frequency

Near-field monitoring requirements consist of grab samples for suspended solids analysis at all near-field monitoring locations at a frequency of once every three hours. As with the far-field monitoring discussed previously (Section 1.2.1), continuous monitoring sensors can replace discrete samples for comparison to the resuspension criteria if a semi-quantitative relationship with the discrete samples has been demonstrated. Under the routine monitoring program, suspended solids will then be measured continuously by probes mounted on buoys around the remedial operations and discrete samples for suspended solids will be collected daily at each station. Results will be continuously transmitted to the dredge operator to provide real-time feedback of the operation.

1.3 Engineering and Monitoring Contingencies

The performance standard provides monitoring and engineering in the event that the action levels are exceeded. The specifics of the contingency to be implemented depend on a variety of factors, including the location in the river where the exceedance occurs, the extent or magnitude of the exceedance, and the criterion exceeded.

1.3.1 Monitoring Contingencies

In the event that the action levels are exceeded, monitoring contingencies will be required at both the far- and near-field stations. The far-field monitoring contingency requirements differ from station to station, depending on the location of remediation, the location of the far-field station (Upper or Lower Hudson River), and the magnitude of exceedance. The near-field and Lower Hudson River monitoring contingencies are more straightforward with only two conditions: routine, or non-routine.

Far-Field Stations

The monitoring contingencies for the Upper Hudson River are presented in Table 1-2. For non-routine monitoring, the sampling frequency will vary depending on the location of the remediation. Table 1-2 presents the monitoring contingencies if the remediation is being conducted more than one mile upstream of the Thompson Island Dam (TI Dam). The monitoring contingencies for the Lower Hudson River are presented in Table 1-3.

Near-Field Stations

The monitoring requirements for the near-field stations are presented in Table 1-4. If the suspended solids action level is exceeded at any point, suspended solids samples will be collected every three hours at each station with the exceedance. Exceedance of any action level for suspended solids will require monitoring for suspended and dissolved phase PCB congeners, suspended solids, and related parameters at the nearest representative downstream far-field station at the frequency indicated in Table 1-2.

Criteria for reverting to lower monitoring levels are provided in Section 3.

1.3.2 Engineering Contingencies

Engineering contingencies will be implemented to reduce the levels of contaminant export in the event that the resuspension criteria are exceeded. For Evaluation Level exceedances, engineering evaluations and engineering improvements are recommended, but not required. When the Concern Level, Control Level, or the Resuspension Standard threshold criteria are exceeded, engineering evaluations and implementation of engineering solutions are required.[3] Only the monitoring contingencies and temporary halting of operations for exceedance of the Resuspension Standard threshold are prescribed by the standard. Contingencies that may be considered for each action level and the Resuspension Standard threshold are discussed in Section 3.

1.4 Minimum Monitoring and Record-Keeping Requirements

Weekly progress reports will be submitted to the USEPA Site Manager, according to a schedule to be defined by the Agency, for the Agency's use in determining compliance with the Performance Standard for Resuspension. The reports will 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 will be provided to USEPA separately within a week of completion. Laboratory data shall be made available to USEPA upon receipt from the laboratory. Data from continuous reading instruments must be made available to USEPA within 12 hours of collection. Because of the need to rapidly respond to the exceedance of the 500 ng/L Total PCBs level, exceedances of this concentration shall be reported to USEPA within 3 hours of data receipt. Data logging requirements for both near-field and far-field suspended solids must be sufficient so as to begin increased PCB sampling with 6 hours of the actual exceedance, as required by the action level exceeded.

1.5 Finalization of the Resuspension Standard

An outline for the approach for the revision of the Resuspension Standard is presented in Section 4 of this document, listing possible areas of revision for Phase 1 and Phase 2. To a large extent,

[3] The Concern Level has a mandatory engineering study but not a mandatory engineering solution.

revisions prior to Phase 1 operations will involve improvements to baseline concentration estimates (e.g., from the three years of additional data from the Baseline Monitoring Program which will be available prior to the initiation of the Phase 1 dredging) and adjustments to reflect dredging schedules different than that assumed here. Revisions for Phase 2 will most likely involve adjustments to monitoring requirements with a possible reduction in frequency and intensity of some sampling components, as well as further adjustments to the load-based concentration thresholds to better reflect the actual dredge operation and production schedule.

2.0 Technical Basis of the Performance Standard for Dredging Resuspension

2.1 Background and Approach

2.1.1 Record of Decision

As part of USEPA's responsibilities during the remedial design for the Hudson River PCBs site, the agency will develop the Engineering Performance Standard that addresses the release and downstream transport of PCBs due to dredging operations. As specified in the Hudson River Record of Decision (ROD [USEPA, 2002a]):

> *Performance standards will address (but may not be limited to) resuspension rates during dredging… These performance standards will be enforceable, and based on objective environmental and scientific criteria. The standards will promote accountability and ensure that the cleanup meets the human health and environmental protection objectives of the ROD. (ROD, page 88)*

This standard is to be applied during the Phase 1 dredging effort and revised as necessary at the end of Phase 1 to reflect knowledge gained from the first year of dredging activities, as stated in the ROD:

> *…The information and experience gained during the first phase of dredging will be used to evaluate and determine compliance with the performance standards. Further, the data gathered will enable EPA to determine if adjustments are needed to operations in the succeeding phase of dredging, or if performance standards need to be reevaluated. (ROD § 13.1, page 97)*

The need for a performance standard concerning the release and downstream transport of PCBs was recognized in the ROD:

> *…Although precautions to minimize resuspension will be taken, it is likely that there will be a localized temporary increase in suspended PCB concentrations in the water column and possibly in fish PCB body burdens. (ROD § 11.5, page 85)*

This Resuspension Standard provides criteria to minimize the release of PCBs that are consistent with the rates of release anticipated in the ROD, while at the same time facilitating the removal of PCB-contaminated sediments from the river bottom. Like the residual and productivity performance standards, the ultimate goal of this standard is to:

> *…ensure that dredging operations are performed in the most efficacious manner, consistent with the environmental and public health goals of the project. (ROD § 11.5, page 85)*

The ROD also identifies several applicable or relevant and appropriate requirements (ARARs), and recognizes the need to conform with these federal and state requirements for water quality. These guidelines were considered, to the extent appropriate.

2.1.2 Definitions

Dredging is fundamentally a sub-aqueous earthmoving action. Just as ground-based earthmoving operations generate dust, dredging results in sediment particles being released into the water column. And just as air currents spread dust from a construction site, ambient water currents transport resuspended sediments downstream. Resuspended sediments with particulate-associated PCBs increase water column PCB concentration, just as contaminated dust particles contribute to the total concentration of airborne contaminants.

In order to clearly describe the PCB release and downstream transport related to dredging, the following terms have been defined in terms of the operation and distance downstream:

- ***Resuspension production rate***. Dredging-related disturbances suspend PCB-bearing sediments in the water column. The rate at which this occurs is the *resuspension production rate.*

- ***Resuspension release rate***. Since most of the sediments to be remediated in the Upper Hudson are fine sands, a significant fraction and often the majority of the small amount of material that escapes the dredge will settle in the immediate vicinity of the dredge. Materials that remain in the water column are then transported away by river currents. The rate of sediment transport in the immediate vicinity of the dredge is defined as the *resuspension release rate.*

- ***Dissolved-phase PCBs***. As suspended solids are transported away from the dredge, they will continue to settle, while at the same time releasing a portion of their PCB burden into the water column where the PCB is no longer bound to a solid particle. PCBs located within the water column but not bound to a solid particle are defined as *dissolved-phase PCBs* (smaller than 0.7 microns).

- ***Particulate PCBs***. As suspended solids are transported away from the dredge, they will continue to settle, while at the same time PCBs bound to the solid particles will be released into the water column. PCBs that are not released into the water column and continue to be bound with the suspended solids are defined as *particulate PCBs.*

Most of this settling takes place within a few hundred yards of the dredge. Given the extensive area of remediation in the Upper Hudson and its focus on depositional areas, it is expected that much of the material settling in the vicinity of the dredge will be collected during subsequent dredging passes.

- ***Resuspension export rate***. Beyond roughly 1 mile, further PCB removal from the water column by particle settling becomes small and most of the PCBs in the water column are likely to travel long distances before being removed or captured by baseline geochemical processes such as volatilization or aerobic degradation. The rate at which PCBs are transported beyond 1 mile is defined as the *resuspension export rate.* It is this rate of PCB loss, with its potential for downstream impacts, that is the focus of the resuspension discussion in the ROD.

- ***PCB loss due to resuspension***. For the purposes of this performance standard, *PCB loss due to resuspension*, as stated in the ROD, is defined as the resuspension export rate just described. The standard addresses the net export of PCBs resulting from any activity related to the removal of PCB-contaminated sediments from the river bottom. This definition includes PCB export resulting from the dredging operation itself, as well as the export of PCBs due to dredging-related boat movements, materials handling, and other activities. This definition requires both the disturbance and the downstream transport of PCBs from the source. Thus, the standard does not directly address the resuspension release rate or the resuspension production rate. These rates are considered only indirectly to the extent that these rates produce an export of PCBs beyond a distance of 1 mile downstream of dredging activity. Similarly, resuspension within engineered control barriers (*e.g.*, silt curtains) is not regulated by this standard, other than the extent to which resuspension within the barriers results in unacceptable export of PCBs downstream.

- ***Net export of PCBs to the Lower Hudson***. The *net export of PCBs to the Lower Hudson* is defined as the PCB resuspension export rate at the Waterford-Lock 1 Station, *i.e*., the load of PCBs at this location that is attributable to dredging-related activities. The Waterford-Lock 1 station was selected because it is downstream of the target areas identified in the Feasibility Study (FS) (USEPA, 2000b) but upstream of the Mohawk River, which was shown to be a source of PCBs to the Lower Hudson River (USEPA, 1997). The Federal Dam, which is the lower boundary of the Upper River, was not chosen because this location is downstream of the Mohawk River.

It is important to note that resuspension of sediments also results from other natural processes (*e.g.*, bioturbation and high-flow events) and anthropogenic processes (*e.g.*, the movement and actions of other vessels in the river). For instance, sediments are resuspended by propeller action during recreational boating activities or commercial shipping. Resuspension and any ensuing PCB export via these processes are accounted for by use of the baseline monitoring water column PCB concentrations in the development of the action levels.

In recognition of the nature of PCB release via resuspension, the Resuspension Standard addresses two areas with respect to dredging: the near-field area and the far-field area.

- ***Near-field area.*** The *near-field area* is defined as the region in the immediate vicinity of the remedial operation, nominally extending from 100 feet upstream to 1 mile downstream of the remedial operation. This area represents the region of the water column most directly impacted by the remedial operation. The production of suspended solids by the dredge yields a resuspension release rate that controls local PCB levels in the water column. Resuspension and settling superimposed on the flowing river result in heterogeneous water column conditions in this area, making monitoring difficult. Each remedial operation has its own near-field area, although they can readily overlap, if deployed in the same vicinity.

- ***Far-field area,*** The *far-field area* is the region well downstream of the remedial operations, beginning no less than 1 mile downstream of the dredging operation.

> Typically, by this distance downstream, the majority of particle settling related to dredging-related activities is expected to have occurred. Additionally, the river has traveled a sufficient distance downstream that water column conditions can be expected to be relatively homogeneous and, therefore, can be sampled in a representative manner with a manageable level of effort. At this point, PCBs in the water column resulting from dredging constitute the resuspension export rate and are considered to be available to contaminate downstream regions.

2.1.3 Contaminants of Concern in Addition to PCBs

Although much of the data collected for the Hudson River focuses on PCBs because these were selected as the contaminants of concern during the RI/FS, other contaminants (including dioxins and metals) may also be of concern in sections of the river. This performance standard does not address thesecontaminants. New York State is developing substantive water quality certification requirements for the environmental dredging pursuant to the federal Clean Water Act. The water column concentrations of compounds with certification requirements will be monitored during the remediation.

2.1.4 Remedial Design Consideration

Development of the performance standard for PCB loss due to resuspension will be done prior to the acquisition of the design support sampling, baseline monitoring sampling and the remedial design. As such, some broad and basic assumptions about the remedial design are required in order to construct the standard. The performance standard does not dictate the specifics of the remedial design other than to specify that the design must be able to achieve the performance standard. The equipment and procedures selected by the design team will be constrained in no other way by this standard. As an example, the limits on the spread of resuspended sediments that may be afforded by the use of silt curtains or other barriers will not be considered in the development of the standard. The design team will determine if these measures are required. Technologies and procedures that may be utilized to control resuspension are described and are based on an examination of the results from case studies and the analyses prepared for the Hudson River FS.

2.1.5 Case Studies

The preparation of the Draft Standard for Dredging-Related Resuspension included a review of previous monitoring programs associated with environmental dredging efforts. Review of historical case studies was conducted for both PCBs and suspended solids (turbidity or suspended solids). These studies provided a useful perspective on both the extent of dredging-related releases, as well as the techniques used to monitor the dredging operation. While the standard was developed to be specific to the conditions of the Hudson River, these historical studies provided useful data used to support the selected criteria and requirements.

The PCB resuspension analysis that was completed for the Responsiveness Summary of the Record of Decision (USEPA, 2002a) provides detailed information on specific studies of PCB release. This work has been augmented here by the inclusion of a review of dredging-related turbidity issues. The applicable information from the case studies is summarized as appropriate under Section 2.2, Supporting Analyses. A discussion of the case studies can be found in Appendix A to the Draft Engineering Performance Standard (provided under separate cover). A brief summary of project information for the case studies reviewed for this standard is presented in Table 2-1.

2.2 Supporting Analyses

Supporting analyses were conducted during preparation of the Resuspension Standard to address and resolve issues pertaining to the impact of dredging and PCB transport from the dredge area to downstream locations. These analyses were completed to gather information and to gain an understanding on the following issues:

- What levels of turbidity or suspended solids have been observed at other environmental dredging sites? (Section 2.2.1)

- Does a correlation exist between suspended solids, turbidity and PCBs, so one can be a surrogate indicator of the other? (Section 2.2.1)

- What levels of PCB release have been observed at other environmental dredging sites? (Section 2.2.2)

- What are the baseline levels and variability of suspended solids and Total PCBs in the Hudson River water column? (Section 2.2.3)

- What is the upper bound baseline contaminant concentration per month or per season in the Hudson River? (Section 2.2.3)

- How will releases due to dredging be quantified relative to the ongoing releases from the sediments? (Section 2.2.4)

- How does the anticipated solids release from dredging compare to the baseline levels? (Section 2.2.4)

- By what mechanisms will dissolved PCBs be released and how does this compare with particulate PCB levels? (Section 2.2.5)

- Does the release of dissolved PCBs represent a significant impact that may occur from dredging? (Section 2.2.5)

- What would be considered a significant release (*i.e.*, resuspension export rate) from the dredging operation? (Section 2.2.6)

- How may potential releases affect human health and ecological risks? (Section 2.2.6)

- How much PCB may be released during dredging (*i.e.*, resuspension production and release rates)? (Section 2.2.7)

- At what rate will resuspended sediment settle out of the water column? (Section 2.2.7)

- How far downstream will the settling of resuspended material occur? (Section 2.2.7)

- How much material will be deposited and what is impact on the deposition areas outside of the targeted (dredged) areas? (2.2.7)

- Where should monitoring be conducted to measure PCB mass loss from dredging? (Sections 2.2.1 and 2.2.6)

- How far from the dredge should water quality monitoring be conducted and what parameters should be measured? (Sections 2.2.1 and 2.2.7)

To address these issues, supporting analyses were completed to define a basis on which the standard could be established. Several of these issues were addressed as part of the analyses completed for the ROD. Other issues required further analysis. This section briefly summarizes these analyses and the conclusions drawn. Extensive descriptions of the analyses completed specifically for this standard can be found in the attachments (Attachments A to G) to this document.

2.2.1 Turbidity and Suspended Solids at Other Sites

An evaluation was conducted to gather data concerning turbidity and suspended solids from completed dredging projects as well as current and design-phase dredging projects. The review of the available sites is extensively documented in Appendix A (Volume 4 of 4). Dredge sites previously researched during preparation of the Hudson River FS report and the Hudson River Responsiveness Summary report were also included in this study. Among the issues addressed by this evaluation are the following:

1. What levels of turbidity or suspended solids have been observed at other dredging sites?

2. Does a correlation exist between suspended solids, turbidity and PCBs, so that one can be a surrogate indicator of the other?

3. How far from the dredge should water quality monitoring be conducted and what parameters should be measured?

These issues are specifically addressed in Sections 2.2.1.1 to 2.2.1.3, respectively. Table 2-1 provides a brief summary of the various sites where dredging-related turbidity or suspended solids data were available.

2.2.1.1 Reported Levels of Turbidity and Suspended Solids

In most dredging studies, turbidity was the main monitoring parameter. In several instances, data were also collected to correlate turbidity with suspended solids, with varying degrees of success. As to the absolute values of turbidity or suspended solids reported, most studies only noted the instances where conditions exceeded the site-specific criteria. This information is useful in that it can provide some examples of turbidity extremes related to dredging. In most instances, the main area of turbidity or suspended solids monitoring was conducted in the near-field, as defined previously. This is discussed further in Section 2.2.1.3. In general, probe measurements or sample collection were most often performed within 1,000 feet of the dredging operation, although data were also obtained further away.

With regard to turbidity criteria, the review of case studies indicated that typical turbidity criteria were established at levels between 25 and 50 nephelometric turbidity units (NTUs) above background levels. However, although many studies noted that turbidity monitoring was conducted during dredging operations, no turbidity threshold was provided in the reports nor were data available for review. Instead, the reports concluded that turbidity never exceeded background levels. However, useful information on turbidity levels was obtained from some sites, as discussed below.

- For New Bedford Harbor remediation in the lower harbor area, the turbidity standard was set at 50 NTUs above background levels, 300 feet from the dredge. It was indicated that the 50 NTU standard was reached infrequently and further action was not needed since this level was not detected 600 feet from the dredge.

- At the General Motors (GM) Central Foundry Division site (St. Lawrence River, New York), the turbidity threshold was set at 28 NTUs. Turbidity measurements were periodically taken upstream and downstream of the dredge. When the value downstream exceeded the upstream value by 28 NTUs, real-time turbidity measurements continued until the exceedance ended. Prolonged exceedances required modifications to the waterborne remediation activities until the problem was rectified. During dredging at the GM Massena site, 18 out of 923 turbidity samples exceeded the action level of 28 NTUs above background (ranging from 31 to 127 NTUs). These exceedances were observed at a depth of 1 feet below the water surface (except for one measurement at 9 feet). The duration of the exceedance was generally reported to be two to eight minutes, with two exceedances that lasted for 15 minutes and 45 minutes, respectively.

Both the reported values and the near-field turbidity criteria suggest maximum turbidity values around 25 to 50 NTUs above baseline conditions. Few sites routinely reported all of their data, making further conclusions as to turbidity levels difficult. Suspended solids data were even more rare, and in most cases were assumed to correlate with turbidity.

2.2.1.2 Correlations Among Turbidity, Suspended Solids and PCBs

Information with regard to turbidity, suspended solids and Total PCB data and associated correlations was examined where available. Little data were available for most sites. However, for three dredging projects, an attempt was made to correlate collected data and draw a conclusion. In all three instances, however, the correlations were between turbidity and suspended solids. No correlations were reported between PCBs and either the turbidity or suspended solids parameter.

At the GM Massena site, bench scale tests were conducted prior to dredging to develop a relationship between suspended solids and turbidity. The following correlation was developed for overall conditions, including elevated suspended solids results (*i.e.*, >300 milligrams per liter [mg/L]):

$$\text{Turbidity (NTU)} = 7.3745+(0.611058 \times SS) + (0.00094375 \times SS^2);\ r^2=0.941$$

where: SS = the suspended solids concentration in mg/L.

Based on a regression analysis completed on the data set generated from the bench scale tests to determine if a relationship existed between suspended solids and turbidity at lower concentrations (*i.e*., when suspended solids values are less than 60 mg/L and turbidity values are less than 60 NTUs), the above equation was simplified to the following relationship by applying a linear fit curve to the plotted data set at lower concentrations, as indicated previously:

$$SS\ (mg/L) = [0.63 \times (\text{Turbidity})] + 6.8;\ r^2 = 0.43$$

where: Turbidity = the turbidity reading in NTU.

Using this relationship, it was concluded that a turbidity value of 28 NTUs corresponded to a suspended solids concentration of less than 25 mg/L. It should be noted that this relationship was the basis of the turbidity standard of 28 NTUs set for the dredging project. It can be concluded, in essence, that GM Massena's threshold was not only to maintain a turbidity of less than 28 NTUs, but it was also to maintain a suspended solids concentration of 25 mg/L or less.

At the Cumberland Bay remediation site (Lake Champlain, New York), a technical specification set for the contractor was the development of a site-specific correlation between suspended solids and turbidity. This relationship was expected to yield action levels for the more easily measured parameter, turbidity, which in turn could be readily correlated to suspended solids action levels during the dredging operation. To accomplish this task, the contractor performed bench scale tests prior to initiating dredging. The end result was that a reliable suspended solids - turbidity correlation could not be determined. This was attributed to unforeseen factors related to algae blooms and light refraction, which caused turbidity to vary in a way that could not be directly correlated to suspended solids.

A similar series of bench scale tests were conducted prior to dredging at the Fox River Deposit N dredging site (Kimberly, Wisconsin). In addition to the tests correlating turbidity with suspended solids, studies were conducted to determine sediment resuspension and settling rates. This test was conducted by submerging a 1-foot-thick aliquot of Deposit N sediment under 5 feet of river water. The system was then agitated by applying forced air into the system. Water samples were then collected for turbidity and suspended solids analyses and sediment settling rates were observed within this system, The results of this study produced the following relationship between turbidity and suspended solids:

$$SS = -1.27 + 1.313 \times Turbidity; \quad r^2 = 0.98$$

Where:	SS	= suspended solids in mg/L, and
	Turbidity	= turbidity in NTU.

As a result of this relationship, suspended solids were estimated in the field during dredging based on real time turbidity measurements.

Given the success observed for the two riverine sites, it may be possible to generate a site-specific relationship for the Hudson River during Phase 1 or with a laboratory test prior to Phase 1.

2.2.1.3 Turbidity and Suspended Solids Monitoring

At the dredging projects examined, the locations of near-field monitoring generally included water quality monitoring stations upstream of the dredge, downstream of the dredge and to the side of the dredge (a side-stream station). At sites where containment such as sheet piling or turbidity barriers were deployed, monitoring stations were placed at the aforementioned locations outside of the containment area. Inside the containment area there were generally no monitors, or if there were monitors, they did not have a specific threshold level to adhere to but, rather, were used to evaluate the dredge operation itself. At sites where dredging was not contained, the monitor was located an average of 300 feet from the dredge. Monitoring locations for several of the larger sites examined are described below.

- At the New Bedford Harbor Hot Spot dredging site, water quality monitoring stations were situated 300 feet from the dredge. This 300-ft radial area was referred to as the "mixing zone," an area where environmental impacts were not directly monitored. There were no set threshold levels within the 300-ft area surrounding the dredge, as it was assumed that solids settling out within this radius from the dredge would not result in an adverse impact to the harbor. However, beyond 300 feet, it was assumed that solids would have the potential to impact downstream resources.

- Another project at New Bedford Harbor, the dredging of the lower harbor, utilized the concept of the 300-ft mixing zone as well. For this project, a turbidity threshold of 50 NTUs was set at the 300 feet distance from the dredge, as noted previously, In the event that 50 NTUs were detected or exceeded at this location, additional turbidity monitoring was required 300 feet from this limit, or 600 feet from the dredge, to confirm the reading and assess the magnitude of the plume.

- Many of the Commencement Bay dredging projects, located off the coast of Washington State, also utilized the concept of the mixing zone. No containment was used, due to the tidally influenced waterways; however, monitoring was conducted at the limit of the mixing zone, which was typically established 300 feet from the dredge to ensure compliance with state and federal waterway regulations,

- At the Grand Calumet River, Indiana remediation site, monitoring is planned at locations both upstream and downstream of the dredge, at a distance of 300 feet.

- During dredging operations at the GM Massena site, water quality monitoring stations were positioned between 200 and 400 feet downstream of the sheet piling that enclosed the remedial operations.

Much of the available data on turbidity and suspended solids monitoring is focused in the near-field region, where turbidity measurement is the primary parameter. Monitoring locations are typically located 300 feet from the operation, with additional monitoring performed at greater distances on a less-frequent basis. These locations appear to have been selected based on professional judgment. Monitoring at these locations appears to have successfully measured the suspended solids transport from the vicinity of the remedial operations.

2.2.2 PCB Releases at Other Dredging Sites

PCB releases at other dredging sites were extensively explored as part of the RS for the ROD (see the White Paper entitled "Resuspension of PCBs During Dredging," Master Comment/Response 336740 [USEPA, 2002a]). As part of this review, three sites were found to have sufficient PCB data to permit an examination of the rate of PCB release (see Table 2-2). Since the completion of the RS, no other sites have been found that have data to support a similar analysis. For two of these sites, GE Hudson Falls and New Bedford Harbor Hot Spots, monitoring around the location was sufficient to permit an estimate of the mass of PCB transported away from the site (*i.e.*, out of the near-field region). This loading information was combined with information regarding the mass of PCBs removed to provide an estimate of the fraction of PCB lost. As noted in the White Paper, the rates of loss observed for these sites (0.36 and 0.13 percent, respectively) are in close agreement with the estimate presented in the FS for the Hudson River based on a dredging release model (*i.e.*, 0.13 percent).

As discussed at length in the White Paper, there were specific issues on sample collection techniques and sampling locations that compromised the data from the Fox River study in terms of developing a flux estimate. The percent loss estimated for this site was 2.2%. In particular, the close proximity of the monitoring location to the dredging operation during portions of the study (less than 0.25 mile) was a significant factor impacting the data. These results suggest that much greater separation between source and sampling location is needed in order to correctly represent dredging-related losses. Nonetheless, the rate of loss estimated by the US Geological Survey (USGS) for this site was considered in the modeling analysis in the RS, as well as later in this document, even though the magnitude of loss estimated is considered to be an overestimate.

2.2.3 Hudson River Water Column Concentration Analysis

Extensive study of PCB levels in the Hudson River was conducted during the Reassessment RI/FS; however, these analyses were focused on understanding the sources of existing loads and concentrations within the river. For the purposes of establishing a standard for PCB losses due to resuspension, it became necessary to develop a basis for distinguishing between dredging-related and pre-existing baseline conditions. To this end, an analysis of the mean and variation of monthly conditions in the Upper Hudson was conducted using data obtained primarily through the ongoing Post-Construction Remnant Deposits Monitoring Program conducted by GE under a consent decree with USEPA. These data were also combined with flow data routinely recorded by USGS to provide estimates of PCB loads in the Upper Hudson.

The analyses, which are presented in Attachment A, were primarily intended to address the following two issues:

- What are the baseline levels and variability of suspended solids and Total PCBs in the Hudson River water column?

- What is the upper bound baseline contaminant concentration per month or per season in the Hudson River?

By establishing baseline concentrations and loads as well as the inherent variability of these parameters, it becomes possible to discern the additional contributions of PCBs originating with the remedial operations. That is, by establishing baseline conditions, deviations from these conditions can be identified and attributed to dredging-related releases as appropriate.

The following section briefly summarizes Attachment A of this report. The quantitative answers to the two issues above are found in the tables of the attachment and are not repeated here.

Post-1996 data collected by GE in the ongoing weekly sampling program were used in the baseline calculations since they represent the most comprehensive water column dataset and probably best reflect the current conditions in the Hudson River. Baseline conditions for suspended solids and Total PCB data were analyzed from this data set.

Three of GE’s monitoring stations were analyzed for these purposes: Rogers Island (Ft. Edward), Thompson Island Dam (TI Dam), and Schuylerville. Results for both the PRW2 and the TID-West stations at Thompson Island Dam were examined separately. The data from Rogers Island is considered characteristic of concentrations and loads originating upstream of the remediation area. The TI Dam and Schuylerville stations represent conditions within the remediation area and represent important far-field monitoring locations. Although these data are extensive, the data may not be completely representative of the river conditions because of the sampling and analytical methods employed.

The examination was limited to the months of May through November, representing the expected dredging season. The data were examined on a monthly basis, in recognition of the significant month-to-month variation in conditions, documented in the Reassessment RI/FS (*e.g.*, see Appendix D1 of the FS). The analysis included the statistical characterization of each month for each station, establishing a basis for estimation of the mean and the variance of the population as a whole. Correlations with flow were examined as well and applied when significant and useful. (Minor correlations with flow were ignored if the magnitude of the change in concentration or load was small.)

Using these statistics, the following values were established for each month and station for both PCBs and suspended solids:

1. The arithmetic average for a particular month.

2. The 95th percentile upper confidence limit (95% UCL) on the average value for the month.

Data for adjacent months were combined when no significant difference was found between means and seasonal conditions were deemed similar (*e.g.*, May and June, October and November). The formula applied to estimate these factors was dependent on the underlying distribution of the data (*i.e.*, normal, lognormal or non-parametric). These results are summarized in Table 2 of Attachment A of this document. June yielded the maximum concentrations in suspended solids at all stations, while maximum PCB concentrations were observed in both May and June. Maximum upper confidence limits for suspended solids also occurred exclusively in June, whereas maximum upper confidence limits for PCBs were less systematic.

The baseline concentrations and loads presented in Attachment A can be used as a basis to evaluate dredging resuspension. Daily Total and Tri+ PCB measurements will be obtained at the far-field stations. Results obtained during dredging operations that represent concentrations less than the average concentration or between the average and the 95% UCL baseline are not statistically different from the baseline variability of the river system and do not demonstrate resuspension releases in excess of targets. Intermittent releases of PCBs above the UCL baseline will not have a significant impact, so long as the average rate of release remains below the 95% UCL for the month plus some allowable increment as evaluated by the seven-day running average and remains below the average for the month plus some allowable increment as evaluated by the four-week running average.

In a similar manner suspended solids will also be used to identify dredging-related releases. In this instance, continuous or multiple daily measurements will be used to estimate the net suspended solids increase between the far-field monitoring points and upstream of the dredging operations. Net suspended solids increases beyond mean baseline increases will be considered indicative of dredging-related releases. Dredging-related releases are allowable to the limits specified in the standard, as described in Section 1.

These baseline concentrations will be used to evaluate suspended solids and PCB measurements collected during dredging. In general, it can be stated that any measurement made during dredging which exceeds these baseline concentrations indicates a dredging-induced release of solids and PCBs. Water column concentrations may on occasion be elevated above the upper confidence limits due to baseline processes, but it is unlikely that the concentrations will be elevated above these levels for sustained periods of time without an obvious cause (such as a flood event).

Each far-field station requiring monitoring to satisfy the standard will also be monitored during the Baseline Monitoring Program. These baseline data will be used to revise the estimates of the averages and 95% UCLs at all stations and will form the basis for identifying dredging-related releases in Phase 1.

2.2.4 Resuspension Sensitivity Analysis

During the dredging operation, adequate monitoring will be essential to demonstrate that the resuspension criteria are adhered to and to verify that minimal downstream transport of PCBs occurs. An analysis was conducted to examine the impacts of plausible dredging releases relative to the estimated monthly baseline concentrations. Ultimately, this analysis was needed to address portions of the following issues:

- How will releases due to dredging be quantified relative to the ongoing releases from the sediments?
- How does the anticipated solids release from dredging compare to the baseline levels?

Two analyses are summarized in this section that have a direct bearing on this analysis. In Attachment A, baseline concentrations and variances were examined for two of the main far-field monitoring stations, the TI Dam and Schuylerville. This analysis established an average monthly concentration and an upper bound on monthly mean concentrations. These data were then used in an analysis to estimate monthly loads for PCBs. A second important piece of information may be found in Section 2.2.2, with respect to the estimated fractions of PCB mass that may be exported during dredging. Values in case studies listed in Table 2-2 correspond to 0.13, 0.36, and 2.2 percent of the PCB mass removed. These values can be translated into an absolute mass export rate for the Upper Hudson remediation, as follows:

$$F_{dredge} = \frac{M_{UH}}{5\,yrs \times 7\frac{mo}{yr} \times \frac{30\,days}{1\,mo} 14\frac{hr}{day}} \times L_{dredge} \times \frac{1{,}000\,g}{1\,kg}$$

where:	F_{dredge}	=	dredging resuspension export rate (or flux) in g/hr,
	M_{UH}	=	mass of PCBs in the sediments of the Upper Hudson to be removed by dredging (69,800 kg or 150,000 lbs) in kg,
	5 yrs	=	period of remediation (half year production in first and last dredging seasons with four full-production-rate years in between),[1]
	7 mo/yr	=	dredging season per year,
	30 days/mo	=	days per month,
	14 hr/day	=	expected mean dredging period per day,
	L_{dredge}	=	dredging resuspension export rate as a fraction of removal (unitless).

[1] This removal rate represents the target removal schedule in the Productivity Performance Standard.

By this formula, the three percentages given above (0.13, 0.36, and 2.2 percent) translate to PCB export rates of 6, 17, and 104 grams per hour (g/hour) of dredge operation, respectively. These values are comparable in magnitude to the nominal baseline daily flux of PCBs during the dredging season, generally ranging from 20 to 80 g/hr.[2] Thus the lower end of the possible export rates will be difficult to observe relative to the magnitude and variability of baseline fluxes as demonstrated in the variations discussed in Attachment A. In light of this observation, three nominal resuspension export rates were explored in this analysis, 0.5, 1.0, and 2.5 percent. These translate to 24, 47, and 119 g/hr respectively (or nominally 300, 600, and 1,600 g/day on a 14 hour/day basis).

Recognizing the anticipated range in river conditions over the dredging season, the analysis was conducted for Total PCBs in the Upper Hudson River over a wide range of river flow rates (2,000 to 10,000 cubic feet per second [cfs]). The suspended solids increase in the water column was estimated based on the volume of sediment removed, the density of the sediment, the dredging-induced resuspension export rate, flow rate and length of the dredging season. Similarly, the Total PCB increase in the water column was computed as a function of the mass of Total PCBs to be removed, the dredging-induced resuspension export rate, river flow rate and length of the dredging season. These results are presented in Attachment B of this performance standard. Because dredging-related export is calculated as a net addition of PCB or suspended solids (mass per unit time), the additional flux is independent of the river flow but the estimated increase in water column concentration will vary inversely with flow. For these estimates, dredging releases were not considered to be flow-dependent, but to result from spillage, equipment handling, etc., all of which are independent of flow.

These estimated increases in concentration were then translated into a dredging-induced suspended solids and Total PCB concentrations in the river system. This was computed by adding the system's baseline variation of suspended solids and Total PCB concentrations (the estimated baseline concentrations) to the estimated increase in concentration (loading) as a result of solids loss from the dredging operation. Comparison of these potential in-river suspended solids and Total PCB concentrations were evaluated against the estimated suspended solids and Total PCB monthly baseline concentrations to determine the level of "significant" increase in the river system over baseline concentrations that signals an unacceptable dredging-related impact.

This analysis was completed for both monitoring stations at the TI Dam and for the Schuylerville monitoring station. Attachment B provides a detailed analysis for each monitoring station. The analysis identified periods of the dredging season wherein 600 g/day PCB export rate loading from the dredging operation would increase the Total PCB water column levels to a concentration just below 350 ng/L, at the Schuylerville monitoring station. These elevated Total PCB water column concentrations were estimated for the months of May and June during low-flow conditions at the Schuylerville monitoring stations. Similar values were estimated for the TID-PRW2 station. Concentrations exceeding 350 ng/L were calculated for the TID-West station at low flow. In all three instances, however, the data may not be truly representative of the river conditions at the location, in light of concerns over collection techniques. Thus, any conclusions drawn from the data are tentative.

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[2] This range is based on a range of flows from 3,000 to 5,000 cfs and a water column concentration of 75 to 150 ng/L, typical of conditions in the TI Pool in June and July.

With the exception of estimated Total PCB concentrations during the months of May and June during low-flow conditions, it was concluded that 300 g/day and 600 g/day releases of Total PCB due to dredging will correspond, overall, with a Total PCB concentration in the water column of less than 300 ng/L Total PCBs on average, indicating that concentrations can be maintained below the 350 ng/L criterion of the Concern and Control Levels. Generally, this analysis identified problematic times of year during the dredging season wherein extra care will need to be taken to maintain minimal releases from the dredge to avoid exceedance of the Total PCB concentration resuspension criteria. These results also suggest that, during the months of May and June, less-contaminated areas might be chosen for remediation in favor of more highly contaminated areas, if low-flow conditions occur.

A sensitivity analysis was conducted on the annual PCB loading baseline to evaluate the impact associated with a dredging-induced PCB loading into the water column. This analysis was completed to evaluate whether the remediation of the Upper Hudson via dredging will have a measurable impact on the annual PCB loads. The baseline annual PCB loading was estimated for each of the monitoring stations for the period of 1992 through 2000 and compared to the dredging-induced PCB loading, assuming a PCB export rate of 300 g/day, 600 g/day, and 2,300 g/day (the latter value corresponding to load conditions at the Resuspension Standard threshold for Total PCBs of 500 ng/L). The dredging-induced PCB loading for each of these scenarios was computed as a function of the volume of sediment removed, the Total PCB concentration on the solids, the induced Total PCB flux and the section of the river being remediated, assuming that dredging work would occur seven days per week and that the increase in concentrations would occur only during the 14-hour-per-day working period. This analysis is presented in Attachment B of this document.

Comparison of the baseline annual PCB loading to the dredging-induced PCB loading for the three scenarios indicated that a well-controlled dredging project (the export of 300 g/day Total PCBs from dredging) would release less than 65 kg per year Total PCBs into the river as a result of the remediation and that a 600 g/day Total PCB export rate from dredging would result in an annual loading of about 130 kg per year Total PCBs. The Resuspension Standard threshold would result in an annual loading of 500 kg/year into the river. It can be seen that these rates of mass loss begin to become significant relative to the baseline annual loads. It was concluded that an annual dredging-induced 65 kg/year Total PCB loading is a relatively small fraction of the baseline load to the river in most years, and that the Total PCB load induced by the Resuspension Standard threshold is similar to PCB loadings which occurred in the early 1990s. This rate of export will be controlled through limits on the annual and monthly rates of dredging-induced PCB export to prevent excessive PCB loss when the baseline PCB concentrations are low and the concentration criteria would allow higher export rates.

It is concluded from this analysis that the PCB concentration and load criteria established for the Resuspension Standard and action levels are protective of the river system and would generate Total PCB concentrations typically within the baseline variability of the river system.

2.2.5 Dissolved-Phase Releases

Evidence has been reported from the Fox River study (USGS, 2000) to suggest that a large dissolved-phase release of PCBs is possible in the absence of any apparent increase in the water column loading of suspended solids. As a result, theoretical analyses were conducted to assess the potential mechanisms by which dissolved PCBs could be released into the water column. An attempt was then made to quantify the potential release of PCBs in the dissolved phase. The following issues were explored through theoretical analyses to estimate a quantity of PCBs that may be released into the river system in the dissolved phase:

- By what mechanisms will dissolved PCBs be released and how does this compare with particulate PCB levels?

- Does the release of dissolved PCBs represent a significant impact that may occur from dredging?

To some degree, resuspended solids lost from the dredge will release their PCB burden into the dissolved phase as the solids concentrations attempt to establish equilibrium. PCBs will continue to move from the particulate phase on the resuspended solid to the dissolved phase in the water column until a steady state is reached, a process that is otherwise known as establishing equilibrium. Once equilibrium is reached, the PCB concentration on the resuspended solid can be estimated, as well as the concentration of PCBs in the dissolved phase. This then allows the impacts of resuspension downstream of the dredging area to be determined, since the PCB flux from the dredging area has been quantified. In addition, the quantity of dissolved phase PCBs released into the water column may have a significant impact on the water column quality, depending on the concentration and quantity of the dissolved-phase release.

There are two basic pathways by which dissolved-phase PCB concentrations can be released into the water column. The first pathway is through direct releases of porewater to the overlying water column as a result of the dredge's making a cut into the sediment. The second pathway by which dissolved PCBs may enter the water column is directly from a solids release/loss into the water column from dredging. Once solids are displaced into the water column, PCBs begin to partition from the particulate phase to the dissolved phase in an attempt to reach equilibrium within the system. In the event that the suspended solids added to the water column are of sufficient mass and contamination level, the dissolved-phase concentration will rise markedly. These analyses are described in detail in Attachment C to this document. A summary of the analyses assumptions, methodology, and conclusions are presented below.

The first theoretical model analyzed was the three-phase partitioning model, which was examined to evaluate conclusions drawn from PCB-loss calculations estimated for dredging conducted at the Fox River dredging sites. Specifically, the reported fraction of total mass loss as dissolved phase during dredging was approximately 1 percent of the total mass removed (USGS, 2000).

The three-phase partitioning model presented here assumes that the contaminant, PCBs, reaches equilibrium among particulate, truly dissolved, and dissolved organic carbon (DOC)-bound phases. This model was employed on a mass of contaminant per volume of sediment basis. The three-phase partitioning model was evaluated using the Hudson River data. Detail analysis and parameters used for this model can be found in Section 2 of Attachment C.

It was determined, using the three-phase equilibrium model, that the Hudson River sediment porewater contains very little of the in-situ sediment PCB mass. More specifically, the three-phase partitioning model indicated that the dissolved phase represents 0.002 percent of the Tri+ fraction of PCBs relative to the sediment-bound PCB fraction of 99.998 percent. For the mono- and di-homologue fractions, the dissolved phase represents 0.004 percent as compared to the sediment-bound PCB fraction of 99.996 percent

These percentages of dissolved-phase PCBs per sediment-bound PCBs were then used to estimate the number of porewater volumes that would need to be displaced to achieve a 1 percent mass loss, as reported from the Fox River case study. The number of porewater volumes is computed as the proportion of water-to-sediment volume or the desired mass to be lost (1 percent) over the mass available in a single porewater volume (either 0.002 percent for Tri+ or 0.004 for mono- and di-homologue). This computation estimated that 420 volumes of porewater would need to be released for the Tri+ fraction, or 210 cubic yards of water per cubic yard of sediment, assuming the sediment are half water and half sediment. For the mono- and di-homologue fraction, approximately 250 porewater volumes would need to be released, or 125 cubic yards of water, assuming the sediment is half water and half sediment. It was concluded from this analysis that a direct loss of PCBs to the water column from the dissolved phase through the porewater would be highly unlikely, because such a large volume of water must be displaced to result in a measurable release of dissolved PCBs.

Another analysis conducted consisted of the application of the two-phase partitioning model to estimate the distribution of the dissolved-phase PCBs to the total concentration of PCBs in the water column due to dredging, This analysis was conducted to evaluate if it is sufficient to simply measure whole-water PCBs during dredging or if the dissolved phase must also be measured if it is representative of a significant concentration. This model assumes equilibrium exists between the dissolved-phase fraction and the suspended phase fraction.

Data collected in the GE float surveys show that sediments continue to release PCBs to the water column throughout the year even when low-flow conditions exist and no observable resuspension is occurring in the system. Thus, for this analysis, a scenario was assumed in which a suspended solids concentration of 1 mg/L would be temporarily added to the system as a result of dredging. It was thought that evaluating the magnitude of PCBs in the water column for this scenario would allow for a preliminary evaluation as to whether the effects of dredging could be distinguished from the baseline river conditions. In fact, the estimated fraction of dissolved phase PCBs estimated for the dredging-induced scenario in which suspended solids was released into the water column was similar to background concentrations. The fraction of dissolved phase to total water column PCB concentration for both background and after dredging is similar, on the order of 0.9, It was concluded that it is not possible to distinguish the effect of dredging by simply comparing the fraction of the dissolved phase increase in the water column.

Both analyses presented above assume that the solids and dissolved phase PCBs reached equilibrium. Recent studies have indicated that full chemical equilibrium may not be reached since the desorption rates of hydrophobic chemicals from sediment tends to be slow. It is thought that the residence time of a resuspended particle in the water column from dredging is relatively short (*i.e.*, on the order of hours). Assuming a few hours residence time, it is not likely that the PCBs will reach equilibrium. In response to this concern, a literature review was conducted to obtain desorption equilibrium and kinetics of PCBs so this analysis could be carried out and evaluated.

The PCBs desorption rate constants reported in the literature are homologue-based, except for those of Carrol *et al*. (1994), who used an untreated PCB that was comprised of 60 to 70 percent mono- and di-chlorinated biphenyls. The desorption rate constants were determined to vary between 4.2×10^{-4} to 0.2 hr^{-1}. The reported rate constants correspond to a half-life of approximately 3 to 1,700 hours and equilibrium times of 26 hours to 980 days. Given the length of time that it takes the PCBs to reach equilibrium, as described by these rate constants, it was concluded that it is highly unlikely that there will be large amounts of dissolved-phase PCBs released as a result of dredging. To validate this statement, the reported desorption rate constants were applied to the Hudson River sediment and dredging conditions. Applying these values into a kinetic rate equation, it was estimated that the dissolved-phase PCB released due to dredging may range from 7.6×10^{-5} to 3.2 ng/L, which is approximately 0.04 to 18 percent of the whole-water PCB concentration. These estimates indicate that the amount of dissolved-phase PCBs introduced into the system will be relatively small and comparable to background concentrations.

Field Data

The theoretical analyses conclude that the release of a large amount of dissolved-phase PCBs is unlikely to occur as a result of dredging. It is possible to assess these results using field measurements of dissolved and suspended PCB concentrations in the water column during dredging, using the case study data. Measurements of dissolved- and particulate-phase PCBs were collected during the Pre-Design Field Test conducted at the New Bedford Harbor during August 2000 (USACE, 2001).

The particulate PCB and suspended solids measurements taken during the dredging at New Bedford Harbor show patterns of concentrations similar to what would be expected during the remediation. At the point of dredging, the particulate PCB concentrations are elevated about ten times over the upstream conditions, but by 1,000 feet downstream the concentration were just above the highest measured upstream concentration. Turbidity levels drop off quickly with distance to upstream monitoring point conditions. The dissolved phase PCB concentrations at the dredge are again about ten times larger than the upstream concentrations but these concentrations drop off quickly into the range of the upstream samples. The upstream PCBs concentrations are about 60 percent dissolved. At the dredge this percentage drops to below 20 percent indicating that PCBs released via dredging are primarily solids-bound. Downstream of the dredge the percent of dissolved phase is more variable but remain less than the 60 percent fraction at the upstream location. This variability in the downstream samples is mirrored in the particulate PCB and suspended solids measurements.

These results of this study are consistent with a mechanism of PCB release through the suspension of contaminated solids. This conclusion is more convincing in light of the high concentrations New Bedford Harbor (860 ppm on average in the top 0 to 1 foot segment) relative to the Hudson River (approximately 50 ppm on average in the Thompson Island Pool).

2.2.6 Far-Field Modeling

To study the long-term impacts of dredging, far-field modeling was used to simulate water column, sediment and fish Tri+ PCB concentrations in the Upper and Lower Hudson River as a result of the dredging operation. The far-field model was applied to determine the following:

- What would be considered a significant release (*i.e.*, resuspension export rate) from the dredging operation?

- How may potential releases affect long-term human health and ecological risks?

- What would be the short-term impact of an accidental release on the public water supply?

The modeling efforts were focused on examining the impact of running the dredging operation at the specified action levels in the Resuspension Standard. The water column, sediment and fish Total PCB concentrations were forecasted using USEPA's peer-reviewed, coupled, quantitative models for PCB fate, transport and bioaccumulation in the Upper Hudson River, called HUDTOX and FISHRAND, which were developed for the Reassessment RI/FS. HUDTOX was developed to simulate PCB transport and fate for the 40 miles of the Upper Hudson River from Fort Edward to Troy, New York. HUDTOX is a fate and transport model, which is based on the principle of conservation of mass. The fate and transport model simulates PCBs in the water column and sediment bed, but not in fish. For the prediction of the future fish PCB body burdens, the FISHRAND model was used. FISHRAND is a mechanistic time-varying model incorporating probability distributions. It predicts probability distributions of expected concentrations in fish based on mechanistic mass-balance principles, an understanding of PCB uptake and elimination, and information on the feeding preferences of the fish species of interest. Detailed descriptions of HUDTOX and FISHRAND models can be found in the Revised Baseline Modeling Report (USEPA, 2000c).

For the Lower Hudson River, the Farley *et al*. (1999) fate and transport model was used. The water and sediment concentrations from the Farley fate and transport model were used as input for FISHRAND to generate the PCB body burden estimates for fish species examined in the Lower Hudson.

As part of the modeling effort for the Resuspension Standard, the following scenarios were simulated using HUDTOX, FISHRAND, and Farley models:

- Dredging scenario with no resuspension release rate (HUDTOX run number d004),

- Dredging scenario with a net increase in Total PCB mass export of 300 g/day at the far-field monitoring stations (run number sr02). This essentially simulates the Evaluation Level of the Resuspension Standard,

- Dredging scenario with a net increase in Total PCB mass export of 600 g/day at the far-field monitoring stations (run number sr01); corresponds to Concern or Control Level of the Resuspension Standard, and

- Dredging scenario with a maximum Total PCB concentration of 350 ng/L at the far-field monitoring stations (run number sr04); corresponds to Concern Level or Control Level of the Resuspension Standard.

- Dredging scenario with an accidental release during the 600 g/day dredging operation conditions.

A list of completed model runs used in this report is provided in Table 2-3. Unlike the previous modeling efforts performed for the Responsiveness Summary for the ROD (USEPA, 2002a), the model simulations completed for the Performance Standard track the sediment being resuspended as a result of dredging. The dredging scenarios with resuspension release were simulated with additional solids and Tri+ PCB loading to the model segments. In addition to simulating the "best estimate" of PCB resuspension release during dredging, the dredging schedule was shifted from 2004 to 2006, as seen in the start years listed in Table 2-4.

The resuspension scenarios above are specified as the PCB export rate at the far-field monitoring stations. Due to the nature of the HUDTOX model structure, PCB loads cannot be readily specified at far-field locations (*i.e.*, specifying the resuspension export rate). Rather, the input of PCBs is specified as an input load at a location within the river, equivalent to a resuspension release rate. In order to create a correctly loaded HUDTOX run, it is first necessary to estimate the local resuspension release rate from the dredging operation; that is, the rate of Total PCB and solids transport at the downstream end of the dredge plume. At this location most of the solids that are going to settle out will have settled out and the suspended solids will more closely resemble those simulated by HUDTOX. Unfortunately, there is no direct way to establish the relationship between the resuspension release and export rates prior to running the models. To estimate the suspended solids flux input loading term for HUDTOX, a near-field model was developed (TSS-Chem) which is based in part on the work by Kuo and Hayes (1991). The Total PCB input loading term for HUDTOX (the resuspension release rate) was derived iteratively so as to obtain the desired PCB export rate at the far-field monitoring location. The resuspension release rate was obtained by checking the resuspension export rate (output from HUDTOX) until the model output gave the desired Total PCB export rate. Once the resuspension release rate that created the desired resuspension export rate was obtained, the corresponding suspended solids flux associated with the Total PCB release rate was estimated using TSS-Chem model. Detailed descriptions of the TSS-Chem and HUDTOX models and their use are provided in Attachment D.

A complete discussion on the effects of different formulations for suspended solids flux input to the model is provided in Appendix D. From this study, it was concluded that the PCB export rate is not particularly sensitive to the amount of solids (suspended solids flux) loaded with the PCBs. A scenario with no solids added to the model segments increases the Total PCB export rate minimally (less than 15 percent) compared to the scenario with the suspended solids flux added derived from the one-mile plume scenario of the TSS-Chem model.

Figures 2-1 through 2-3 present comparisons of predicted HUDTOX Tri+ PCB concentrations in the water column at various locations throughout the Upper Hudson River for the monitored natural attenuation (MNA), no resuspension and three action level scenarios over a 70-year forecast period.

The effect of running the dredging operations at the Evaluation Level (300 g/day) and the Concern Level (600 g/day) on predicted water column Tri+ PCB concentrations is largely confined to the six-year active dredging period (2006 through 2011). Outside of the period of scheduled dredging (2012 and later), impacts on water column Tri+ PCB concentrations are minimal. However, running the dredging operations at the Control Level (350 ng/L or 1,600 g/day) results in significantly higher water-column concentrations during the dredging period and slightly elevated water column concentrations for approximately 10 years after completion in River Section 3 only.

To answer the question of what would be considered a significant release (*i.e.*, resuspension export rate) from the dredging operation, the cumulative Tri+ PCB load at Waterford as forecasted by HUDTOX was used. Figure 2-4 shows the Tri+ PCB load forecasts for several load conditions. The lower bound will be the ideal conditions of dredging, where there is no sediments being spilled (no resuspension) and the upper bound will be the MNA scenario. The 300 g/day scenario was only simulated through 2020. From the figure, it was shown that the Tri+ PCB load for this scenario crosses the MNA by the completion of dredging (2011). The HUDTOX forecast for the Tri+ PCB load from the 600 g/day scenario remained higher than the MNA for a little longer, approximately four years after completion of dredging operations (2015). However, HUDTOX forecasts showed that Tri+ PCB cumulative loads for both 300 g/day and 600g/day scenarios will be lower than the MNA. This suggests that these two scenarios would yield acceptable loads to the Lower River. HUDTOX results for the 350 ng/L scenario showed that cumulative Tri+ PCB loads will go below the MNA cumulative loads for the 70-year forecast period. This suggests that by running the dredging operations at the Control Level (350 ng/L) for the entire program, significantly more Tri+ PCB mass will be transported to the Lower River relative to the MNA scenario, yielding an unacceptable amount of release.

Similar conclusions can be drawn for the Total PCB load estimates, although longer periods are estimated until the 300 g/day and 600 g/day dredging scenarios cross the MNA trajectory. These forecasts are considered less certain, however, since the models do not directly simulate Total PCB, but rather Tri+ PCB. The Total PCB estimates are based on estimates of Tri+ to Total PCBs in the resuspended sediments (see ROD Responsiveness Summary White Paper – Relationship Between Tri+ and Total PCBs for more details [USEPA, 2002]).

In addition to giving an indication of significant release, the results from HUDTOX runs may also give an indication of the water column concentrations for the different dredging scenarios. Figures 2-5 through 2-7 show the whole water, dissolved phase, and particulate phase Total PCB concentration for the 300 g/day, 600 g/day, and 350 ng/L scenarios during the dredging period (2006 to 2011).

The HUDTOX model predicted that by running the dredging operations at the Evaluation Level (Total PCB flux of 300 g/day), the mean whole water column Total PCB concentrations at the TI Dam would be less than 160 ng/L. At Schuylerville and Waterford, the HUDTOX model predicted that the whole water column concentrations would average less than 120 and 80 ng/L, respectively (Figure 2-5). The water column Total PCB concentrations as a result of running the dredging operations at 600 g/day would be higher than those of the 300 g/day scenario, as expected. The mean whole water Total PCB concentrations at the TI Dam during the dredging period (2006 to 2011) for the 600 g/day scenario are predicted to be less than 250 ng/L except for few days in June 2008 (Figure 2-6). The whole water Total PCB concentrations at the Schuylerville and Waterford monitoring stations are predicted to be lower than 200 and 150 ng/L, respectively. For the 350 ng/L scenario, as expected, the HUDTOX forecast shows that on average, the whole water Total PCB concentrations will be approximately 350 ng/L (Figure 2-7). The predicted Total PCB concentrations in the water column during River Section 2 dredging are higher than 350 ng/L because the forecast flow used in the model during that dredging period (August 16 to November 30, 2009), is about 15 percent lower than the historical average flow based on the USGS data. Therefore, the higher concentrations are expected. However, the average concentration during the entire dredging period for River Section 2 (August 16 to November 30, 2009 and May 1 to August 15, 2010) is around 380 ng/L.

The annual species-weighted fish body burdens for human fish consumption at RM 189, 184, and 154 are shown in Figure 2-8. The fish concentrations used are the species-weighted averages, based on Connelly *et al*. (1992), and are considered to represent a reasonable ingestion scenario among the three fish species consumed to any significant extent by human receptors (anglers): largemouth bass (47 percent); brown bullhead (44 percent); and yellow perch (9 percent) (USEPA, 2000a). FISHRAND fish body burdens forecasts for the MNA, no resuspension, 350 ng/L Total PCB, and 600 g/day Total PCB scenarios were plotted in the figure. The 300 g/day scenario was not simulated since the Tri+ PCB loads to the Lower River are lower than both the 600 g/day and 350 ng/L scenarios. FISHRAND modeling results for the Upper River show that the impact of the 600 g/day scenario on fish tissue concentrations is largely confined to the dredging period in River Sections 1 and 2 (Figure 2-8), similar to the water column results from the HUDTOX model. In River Section 3, the impact to the fish tissue concentrations lasts about three years beyond the dredging period to approximately 2014. The forecast results from the different dredging scenarios indicated that the impacts to fish tissue concentration would largely be short-term (*i.e.*, confined to the years during the dredging period) for River Section 1, even for the 350 ng/L scenario. The impact of the 350 ng/L scenario is slightly longer lasting in River Section 2 compared to that for River Section 1 (Figure 2-8). Long-term human health and ecological risks are discussed in the following section.

Human Health and Ecological Receptor Risks

This section compares long-term risks (*i.e.*, after completion of dredging) from consumption of PCB contaminated fish to anglers and ecological receptors (as represented by the river otter [*Lutra canadensis*]) under the no resuspension, 350 ng/L Total PCB, 600 g/day Total PCB, and monitored natural attenuation scenarios. Risks were calculated with exposure durations beginning one year after the year in which dredging will be completed in the each section of the river and the average of the upper river (Table 2-4). Exposure durations (*e.g.*, 40 years for evaluating cancer risks to the reasonably maximally exposed [RME] adult angler, 7 years for evaluating non-cancer health hazards to the RME adult angler) and all other risk assumptions, locations, toxicity values, receptors, and fate, transport, and bioaccumulation models used here are the same as those used for baseline conditions throughout the Hudson River PCBs RI/FS in the Revised Human Health Risk Assessment, the Revised Baseline Ecological Risk Assessment, the Feasibility Study, and the Record of Decision Responsiveness Summary reports.

The fate and transport and bioaccumulation of PCBs in the upper river were predicted as Tri+ PCB concentrations using the HUDTOX and FISHRAND models. PCB contamination in fish tissue from the Hudson River has been shown to consist almost exclusively of Tri+ PCB, with average values ranging from 98 percent to nearly 100 percent (USEPA, 2002). As the Revised HHRA and ERA (USEPA, 2000a and 2000e, respectively) have shown ingestion of fish to account for most of the risk to human and ecological receptors, the use of Tri+ PCB for risk assessment modeling requires no revisions for comparison to available toxicological literature for PCB effects expressed as total PCB or Aroclors. The Tri+ PCB group includes the PCB compounds that are most toxic to fish, wildlife, and humans and is considered to capture the majority of toxicity associated with PCB compounds.

Table 2-5 presents annual species-weighted fish fillet Tri+ PCB concentrations in the Upper Hudson River, as compared to the risk-based remediation goal (RG) for the protection of human health of 0.05 mg/kg PCBs in fish fillet, based on non-cancer hazard indices for the RME adult fish consumption rate of one half pound meal per week (this level is protective of cancer risks as well). Other target concentrations presented are 0.2 mg/kg PCBs in fish fillet, which is protective at a fish consumption rate of one half-pound meal per month, and 0.4 mg/kg PCBs in fish fillet, which is protective of the central tendency (CT) or average angler who consumes one half-pound meal every two months.

The time to reach human health fish target concentrations of 0.2 mg/kg Tri+ PCB and 0.4 mg/kg Tri+ PCB in the Upper Hudson River was shorter for all resuspension scenarios as compared to monitored natural attenuation in the upper river as a whole and in River Sections 1 and 2 (Table 2-6). In River Section 3, all active remediation scenarios achieved the RG of 0.05 mg/kg Tri+ PCB prior to MNA. The greatest differences seen in the time to achieve fish target concentrations between the active remediation scenarios and MNA were seen in River Section 1, where the MNA scenarios took up to 17 years longer to achieve some target concentrations, while the smallest differences were seen between scenarios in River Section 3.

Using fish fillet concentrations based upon the three resuspension scenarios (*i.e.*, no resuspension, 350 ng/L, and 600 g/day) human health fish consumption cancer risks and noncancer hazards show at least a 50 percent reduction in the upper river as a whole, Section 1 (River Mile 189), and Section 2 (River Mile 184) compared to monitored natural attenuation for both RME and average exposures (Tables 2-7 and 2-8). Risk reductions in Section 3 were seen for the no resuspension and 600 g/day scenarios as compared to monitored natural attenuation, but not for the 350 ng/L Total PCB scenario.

Based on site-specific angler surveys, the Human Health Risk Assessment (USEPA, 2000a) determined that Mid-Hudson River anglers have a different diet than anglers in the upper river, consisting of 53 percent brown bullhead, 15 percent largemouth bass, 1.4 percent yellow perch, 7.6 percent white perch, and 23 percent striped bass. Striped bass concentrations were not modeled for resuspension scenarios and therefore human health cancer risks and noncancer hazards for Mid-Hudson River anglers could not be calculated. To provide an estimate of relative risks amongst the resuspension scenarios, angler intake was calculated using fish concentrations from the FISHRAND model. Striped bass intake was proportionally divided between the remaining fish species (i.e., 69 percent brown bullhead, 19 percent largemouth bass, 2.0 percent yellow perch, and 10 percent white perch) and white perch concentrations from the FISHRAND Model were used in the absence of Farley Model data. Calculated fish exposure concentrations were used only for comparison between alternatives and do not represent predicted intake concentrations based on mid-river angler consumption patterns. As expected, fewer differences were seen between the resuspension scenarios in the lower river than in the upper river. Long-term cancer risks and non-cancer hazards differed by a maximum of 32 percent. The no resuspension and 600 g/day Total PCB scenarios showed the greatest risk reductions as compared to monitored natural attenuation scenario. The 350 ng/L Total PCB showed lower and sometimes no reductions in risk, owing to elevated concentrations of PCBs predicted in fish tissues for several years following dredging operations (Figure 2-9).

Risks to ecological receptors, as represented by the river otter, were evaluated by examining largemouth bass whole fish PCB concentrations. In the Upper Hudson River the lowest-observed-adverse-effect-level (LOAEL) target levels were reached within the modeling timeframe for the upper river as a whole and in Section 3 for all scenarios (Table 2-9). In the upper river as a whole, all resuspension scenarios reached the LOAEL target level of 0.3 PCBs mg/kg 17 years prior to the MNA scenario (Table 2-10). Ecological target levels were not reached within the modeling timeframe for Sections 1 and 2 of the river. In Section 3, all scenarios reached the LOAEL target level within five years of one another.

Largemouth bass PCB concentrations in the Lower Hudson River were lower under all resuspension scenarios than under the monitored natural attenuation scenario (Table 2-11). The LOAEL PCB target concentration in largemouth bass was reached 4 to 11 years sooner under the various resuspension scenarios than under monitored natural attenuation in various sections of the lower river (Table 2-12).

Resuspension may temporarily increase PCB concentrations locally, resulting in slight increases in fish PCB concentrations. However, human health noncancer hazards and cancer risks and ecological risks were calculated to be well below those under the monitored natural attenuation scenario. Minor differences were seen between the various resuspension scenarios indicating the human health and environmental impacts from dredging are predicted to be minimal, particularly since levels of resuspension approaching the performance criteria are expected to occur on an intermittent, rather than continuing basis.

Accidental Release-Short-Term Impacts

HUDTOX was used to model an accidental release scenario. The purpose of modeling this scenario was to demonstrate the short-term and long-term impacts to the public water intakes downstream of the incident. The following accidental release scenario was analyzed:

A hopper barge containing 870 tons of silty sand (barge capacity is 1000 tons, with 87 percent sediment and 13 percent water) from River Section 2 is damaged and releases the entire load in the area just above Lock 1. The contents fall in a mound and no effort is made to remove or contain the material. Over a period of one week, the entire load is swept downstream. The sediment had been removed by mechanical dredging. The background concentrations are at the 600 g/day Total PCB flux at the River Section 3 monitoring location. For this scenario, there will be an additional release of 113,000 kg/day suspended solids, with a baseline condition of 20,000 kg/day for a one-week period (from July 1 through 7, 2011). This scenario is quite conservative in that the average concentration from River Section 2 is higher than in the TI Pool because areas with mass per unit area greater than 10 g/m^2 are targeted in this river section whereas, in the TI Pool, areas greater than 3 g/m^2 are targeted. The hopper barge was used because it has a larger capacity than the deck barge (200 tons) that was also proposed in the FS. The location of the accident is just above the public water intakes at Halfmoon and Waterford, minimizing any reductions to the water column concentration resulting from settling and dilution. Because the sediment was removed by a mechanical dredge nearly the entire weight is attributed to sediment with little dilution with water. The already elevated water column concentrations result in water column concentrations at the public water intakes greater than the MCL. This scenario is also conservative, in that a spill of this magnitude would probably be contained within hours of the release.

HUDTOX provided the whole water, particulate bound and dissolved phase PCB concentrations in the water column. The model predicted that the accidental release scenario results in a short-term increase of the whole water Total PCB above the MCL in the water column at Waterford (Figure 2-10). However, the highest dissolved phase Total PCB concentration was less than 350 ng/L (Figure 2-10). Instantaneous attainment of PCB equilibrium between the dissolved and suspended phases is assumed by HUDTOX. As a result, the dissolved phase PCB concentrations are overestimated by HUDTOX, providing an additional conservative assumption.

While the Total PCB concentration entering the public water intake would be in excess of the federal and state MCL, it is likely that the concentration in the influent would be greatly reduced by minimal treatment because approximately 850 ng/L of the total 1,150 ng/L Total PCB peak concentration would be attributed to the suspended phase. Assuming that the bulk of the contaminated suspended solids would be removed by filtration, the delivered concentration without further treatment would be closer to the dissolved phase PCB concentration of 300 ng/L. Thus, the water output from the plant would still meet the Federal MCL of 500 ng/L.

As noted above, the dissolved phase PCB concentrations estimated by HUDTOX are already biased high. The dissolved phase PCB concentrations would probably be further reduced by activated carbon treatment, which is currently implemented at the Waterford public water intake. This analysis suggests that the concentration reaching the public would be substantially less than the MCL even in the event of an accidental release in the vicinity of the intakes. While this analysis suggests that the planned operations are unlikely to impact the public water supplies in the event of an accident, further consideration on the protection of public water supplies and the requisite monitoring will be given in the development of a community health and safety plan (CHSP).

2.2.7 Near-Field Modeling

Two models (CSTR-Chem and TSS-Chem) were developed to estimate the conditions within 1 mile downstream of the dredge head. These near-field models were used to estimate the suspended solids and Total PCB plumes resulting from resuspension of solids. The models were useful in identifying the most appropriate location for the placement of water column monitoring stations in the near-field and provided an estimate of solids transported into the far-field. In addition, the TSS-Chem model was used to estimate the effects of settled material on sediment concentrations within the near-field.

CSTR-Chem and TSS-Chem Applicability

CSTR-Chem and TSS-Chem models were developed and utilized for the near-field modeling effort to estimate the transport and concentration of suspended solids and Total PCBs from the dredge head to the far-field region (approximately 1 mile downstream of the dredge head). CSTR-Chem is used to model the area immediately around the dredge. The input for this model is the subsequent resuspension rate. Since solids will settle within this area, the solids flux out will not be equal to the resuspension production rate of solids. The rate at which solids exit the immediate dredge area is termed the source strength. The source strength represents the solids available for downstream transport and is the input for the TSS-Chem model. However, since the TSS-Chem model simulates a point source and CSTR-Chem has a non-zero width, the two models cannot be directly linked. Despite the disconnection, however, CSTR-Chem can still be used to provide a basis for assumptions concerning the source strength, mainly the dissolved PCB concentration and the silt fraction for input to TSS-Chem.

The TSS-Chem model consists of two components, a Gaussian plume transport model that describes the dispersion and settling of the particles downstream and a geochemical component that uses two-phase partitioning of PCBs from solids into the dissolved phase taking into account a kinetic desorption rate. TSS-Chem utilizes the same solids transport equations as DREDGE (Kuo and Hayes, 1991), outlined in Appendix E.6 of the FS and the Resuspension White Paper of the ROD, for a mechanical dredge. The TSS-Chem model was used to estimate PCB water column conditions downstream of the dredge across the width of the river up to a distance of one mile. TSS-Chem is useful for the near-field downstream transport of solids and PCBs but is inadequate in estimating the net contribution of solids, and dissolved and suspended phase PCB to the water column in the immediate vicinity of the dredging operations (*i.e.,* relating the resuspension production rate to the source strength). For this purpose, the CSTR-Chem model was developed.

The CSTR-Chem model is based on an ideal reactor configuration consisting of a continuous stirred tank reactor (CSTR). This construct represents a means to simplify the mathematical modeling of constituent concentrations in the immediate vicinity of the dredge head. CSTR-Chem assumes that a constant flow influent with a known constant concentration (*i.e.*, upstream river water) is instantaneously mixed as it enters a confined, well-mixed tank (the region immediately around the dredge head). Physical and chemical reactions occur while the water is within the ideal tank and the tank effluent is at the same flow as the influent and at the uniform concentration within the tank. The CSTR concept is most appropriate to the analysis of dredging operations because turbulence in the area of the dredge, coupled with ambient flows, may be assumed to produce mixed conditions similar to that in an ideal tank reactor. A complete discussion of the CSTR-Chem and TSS-Chem model development is presented in Attachment D.

One of the important input parameters in the CSTR-Chem and TSS-Chem models is the desorption rate constant. The conclusions drawn from CSTR-Chem and TSS-Chem models depend on an accurate desorption rate constant assumption. An extensive literature review on the PCB desorption rate constant was conducted for the Resuspension Standard and is presented in Attachment C. Due to lack of knowledge on the amount of “labile” (fast) and “non-labile” (slow) fractions in the dredged material, only fast desorption rate constants are considered in this study in order to provide a conservative (upper bound) estimate of the amount of PCBs that partition into the dissolved phase. The rate of desorption used for TSS-Chem and CSTR-Chem is 0.2 hr^{-1}. This desorption rate was applied to the difference between the PCB concentration of the suspended sediments and the equilibrium concentration by allowing more PCBs to remain in the water column with the existing soluble PCB concentration. The two-phase partitioning equations are provided in more detail in Attachment D.

Applicability of the CSTR-Chem model depends upon the presence of near-field conditions that can reasonably be represented as well-mixed and it is important that the diameter of the cylindrical area that is approximated as a CSTR should reflect the extent to which well-mixed conditions exist. For the purposes of this analysis, a CSTR width of 10 meters is used. Buckets that may be used in the Hudson River project are generally 2 to 3 m in diameter closed and somewhat more open. It was assumed that velocities induced by bucket movement could extend across most of a 10 m width used in this analysis.

The CSTR-Chem results suggest that under transient partitioning conditions, which are expected within the CSTR, the PCB releases from dredging operations will generally be less than 1 percent dissolved. The model results also suggest there is no significant loss of silt particles from the settling within the CSTR. The results of the CSTR-Chem model were used to develop the assumptions made concerning the source strength of the TSS-Chem model. The results indicated that:

- When the dissolved fractions estimated by the CSTR-Chem was input into the TSS-Chem, the results did not significantly vary from runs that had no initial dissolved phase.

- The silt fraction within the sediments is the only parameter that significantly affected the TSS-Chem PCB flux at one mile.

Incorporating these model observations, the TSS-Chem model was used to simulate the near-field dredging operations, from just beyond the dredge head to a 1 mile distance downstream. A more detailed discussion on the relationship between the TSS-Chem model assumptions and the CSTR-Chem is provided in Attachment D.

Near-field Model Results

Near-field modeling was performed to address the following issues:

- How much PCBs may be released during dredging?
- How far from the dredge should water quality monitoring be conducted?
- At what rate will resuspended sediment settle out of the water column?
- How far downstream will the settling occur?
- How much material will be deposited and what is the impact on the deposition areas outside of the targeted (dredged) areas?

TSS-Chem was used to estimate solids and PCB loads for input to the HUDTOX model. Conditions at one mile were taken for input to the HUDTOX model, recognizing the difference in model scales. As outlined in Appendix E.6 of the FS and White Paper: Resuspension of PCBs During Dredging (336740) of the RS, the average resuspension rate is based on a combination of field data from other sites and a resuspension model. The downstream transport rates (source strengths) only apply to silts and finer particles (65 percent of cohesive and 20 percent of non-cohesive sediments for the Hudson River) within the sediment. The use of only silts does not significantly affect the PCB flux estimates since the silt resuspension rate (which is essentially equal to the silt source strength) is the driving source term for the PCB flux downstream

The production rates for the average source strength calculations were based on a total of five full production dredging seasons, using the estimated amount of sediment removal necessary and the time limitations involved. Each source strength estimate was run through TSS-Chem to calculate the resulting flux and concentration increases at one mile. The production rates, source strengths, and results are shown in Table 2-13. The average source strength was estimated at approximately 0.7 to 0.9 kg/s. For the various river sections these source strengths corresponded to PCB fluxes of approximately 80 to 210 g/day at one mile. The variation in the PCB fluxes for the different river sections is mainly caused by the different sediment concentrations. The highest flux is from dredging activities in River Section 2, which has a sediment concentration roughly 2.2 times greater than River Section 1.

The TSS-Chem model was used to simulate the solids transport in the water column due to dredging operations up to 1 mile downstream. Simulations were performed for the 300 g/day, 600 g/day, 350 ng/L and 500 ng/L scenarios. The results suggest that the water column at 1 mile downstream of the dredge head has a significant amount of dissolved phase but the suspended solids phase is still dominant (Figure 2-11). The fraction of dissolved phase Total PCB is greater for scenarios with lower amounts of solids introduced to the water column (lower resuspension rates and source strengths) (Table 2-13). For example, for the 300 g/day scenario (which has the lowest SS flux range from 0.3 to 1.3 kg/s at the dredge head) the TSS-Chem predicted that the fraction of dissolved phase Total PCBs 1 mile downstream of the dredge head ranges from 0.2 to 0.4 (Table 2-13). The 500 ng/L scenario has the highest amount of solids introduced to the water column (ranges from 3 to 9 kg/s at the dredge head). For this scenario the TSS-Chem model results showed that the fraction of dissolved phase Total PCB in the water column ranges only from 0.05 to 0.1.

According to the TSS-Chem model results, the suspended solids concentration decreases and the width of plume increases as the solids are transported downstream. The suspended solids concentration at 300 m downstream is about one quarter to one third of the concentration at 50 m downstream while the width of the plume at 300 m downstream is about twice of the plume width at 50 m downstream. The greater width of the plume at 300m suggests that this location may be easier to monitor using a stationary, continuous reading suspended solids sensor. It is also likely that by this distance downstream water column concentrations of suspended solids will be more homogeneous. As a result, 300 m downstream of the dredge head was chosen to be the primary near-field monitoring location, is an attempt to balance between the wider, more homogeneous plume conditions farther downstream and the easier identification of the center of the plume.

The time that the particles remain suspended is primarily a function of the sediment type. Generally silt particles will remain suspended longer than coarse particles. In the near-field models, the rate at which particles fall through the water column is determined by the particle settling velocity. Different settling velocities are defined for fine and coarse particles in the models. A summary of settling velocities from various studies is provided in Attachment D. For most of the studies Stokes' Law was the theoretical basis for estimating the settling velocity of sand particles. This approach is appropriate for discrete particles that do not aggregate and was applied to the coarse material in the near-field models.

Stokes' Law only applies to discrete particles settling and does not account for flocculation during settling. Flocculation increases the rate at which silts settle from the water column, but the rate of flocculation depends on site-specific conditions and sediment properties. Therefore silt settling velocities presented in QEA's report (1999) for Hudson River sediments were used in the near-field models, since these values were derived for Hudson River conditions and included the effects of flocculation.

The TSS-Chem results indicate that with a flow rate of 4,000 cfs, approximately 30 m downstream from the dredge head most of the coarse material has settled to the bottom of the river. At this distance, the coarse material is less than 0.1 percent of the net suspended solids from dredging. Since the coarse material settles much faster than the silts it does not contribute significantly to PCB loads and concentrations at 1 mile. The results also suggest that there is a significant amount of settling within 1 mile downstream of the dredge head. The amount of Total PCBs being introduced to the water column from the dredge head is reduced by approximately 80 percent in River Section 1 and approximately 70 percent for River Sections 2 and 3 at 1 mile downstream of the dredge head (Table 2-13). For example, in River Section 1, when the amount of Total PCB added to the water column due to dredging is 1,700 g/day, the load at 1 mile is approximately 400 g/day.

PCB Deposition Immediately Downstream at the Dredge Operations

If the suspended solids that settle onto the riverbed during transport downstream are contaminated, PCB mass and concentration will be added to the surrounding downstream areas. Using the modeled suspended solids concentrations in the water column downstream of the dredge, with the associated PCB concentration on the suspended solids, it is possible to estimate the increase in PCB mass in these areas. The increase in mass per unit area and the length-weighted average concentration of the top six-inch bioavailable layer were used to measure the effect of the settled material. Since these areas are outside of the target areas, the settled particles are not scheduled for removal.

The spatial distribution of the settled contamination will vary according to the shape of the target area and the rate of dredging. For this estimate, the target area is assumed to be 5 acres, 200 feet across and approximately 1,100 feet long, because the areas of contamination are typically located in the shoals of the river and are narrow. From the FS, a time needed to dredge a 5-acre area with 1 m depth of contamination would take 15 days operating 14 hours per day. It is assumed that the dredge will move in 50 feet increments across and down the target area. With these assumptions, the dredge will relocate approximately every two hours. To simulate the deposition of settled material, the amount of PCB mass per unit area, the mass of the settled material and the thickness of the settled material that is deposited in two hours downstream at each modeled location is added on a grid as the dredge moves across and down the area.

The TSS-Chem results for each river section and action levels were used to estimate the additional mass per unit area and length-weighted average concentration approximately 2 acres downstream of the target area. The remediation could operate continuously at Evaluation Level and Concern Level, but not Control Level. The results are shown in Table 2-14.

The length-weighted area concentrations were calculated assuming that the PCB concentration in the sediment underlying the settled material is 1 mg/kg. The ROD defines 1 mg/kg as the acceptable residual concentration. In the two acres below the target area in River Section 2 for example, the concentrations range from 2 to 9 mg/kg. These increases suggest that dredging should proceed from upstream to downstream if no silt barriers are in place so that settled material can be captured by the dredge inside the target areas. Also, silt barriers may be needed to prevent the spread of contamination to areas downstream of the target areas have already been dredged or are not selected for remediation. This settled material is likely to be unconsolidated and may be easily resuspended under higher flow conditions.

2.2.8 *Relationship Among the Resuspension Production, Release, and Export Rates*

During dredging operations, it is necessary to specify the near-field load to the water column that would yield the targeted export rates (*i.e*., resuspension criteria) at the far-field stations. In order to estimate these loads, computer models were utilized to provide a relationship between the far-field and the near-field dredging-induced PCB transport and loss. The TSS-Chem and HUDTOX models were used to represent and link the resuspension production (at the dredge-head), release and export rates. The resuspension release rate (and source strength) in the region from the dredge to a distance of one mile is represented by the TSS-Chem model. The resuspension export rate in the region beyond one mile is represented by HUDTOX.

The TSS-Chem and HUDTOX models were used to examine the amount of sediment being suspended in the water column at the dredge-head, the suspended solids and Total PCB flux at 1 mile downstream of the dredge-head and the Total PCB flux at the far-field monitoring stations for the 300 g/day, 600 g/day, and 350 ng/L scenarios. Table 2-13 shows the resuspension production, release and export rates for the simulations. Because HUDTOX predicted different rates of export for different reaches of the river given the same PCB release rate, the TSS-Chem model was run under different conditions so as to yield a consistent output from HUDTOX (*e.g.,* 600 g/day, 350 ng/L) for all river sections. From the results it was predicted that in order to create an export rate of 300 g/day of Total PCB at the TI Dam, the amount of Total PCBs in bulk sediments that need to be suspended is approximately 900 to 1,700 g/day depending on the location of the dredge-head to the monitoring stations. The farther the dredge is from the far-field monitoring location, the greater the amount of solids and PCBs that would need to be suspended into the water column (Table 2-13). In order to get the same result, the resuspension production rates that create an export rate of 300 g/day are on the order of 2 to 3 percent of the removal rate of Total PCB via dredging. In River Section 2, the amount of Total PCB in the bulk sediment that needs to be suspended to the water column to create the 300 g/day Total PCB flux is approximately 1,000 g/day. The resuspension production rate of Total PCBs that creates the 300 g/day of Total PCB flux in River Section 3 is approximately 1300 g/day when the dredge-head is farther away from the far-field monitoring location and around 1000 g/day when the dredge-head moves closer (downstream) to the monitoring station. Overall, the Total PCB resuspension export fraction relative to the PCB resuspension production rate for the 300 g/day scenario is estimated to range from 0.17 to 0.34.

For the 600 g/day Total PCB flux scenario, the amount of Total PCB mass that would need to be suspended into the water column in River Section 1 ranges from 3,000 to 4,000 g/day (on the order 5 to 6 percent of the removal rate of Total PCB). In River Section 2, to obtain an export rate of 600 g/day, approximately 2,000 g/day of Total PCB mass would need to be suspended to the water column (approximately 2 percent of the Total PCB removal rate via dredging). For River Section 3, approximately 2,000 to 3,000 g/day of Total PCB mass would need to be suspended into the water column to create an export rate of 600 g/day Total PCB flux (on the order of 2 percent of the Total PCB removal rate via dredging). Overall, the Total PCB export fraction relative to the PCB resuspension production rate for the 600 g/day scenario is estimated to range from 0.17 to 0.31, similar to that for the 300 g/day scenario.

The 350 ng/L Total PCB concentration at the far-field monitoring stations scenario was also simulated. The Total PCB fluxes at the TI Dam, Schuylerville and Waterford that would represent the 350 ng/L are 1,200, 2,000, and 2,300 g/day, respectively. The resuspension production rates that correspond to the 350 ng/L Total PCB concentration at TI Dam are approximately 6,000 to 7,600 g/day (approximately 10 to 13 percent of the Total PCB removal rate via dredging). For River Section 2, the resuspension production rates are approximately 7,000 to 8,300 g/day (approximately 6 to 7 percent of the Total PCB removal rate via dredging). In River Section 3, approximately 8,400 to 11,000 g/day of Total PCB mass would need to be suspended to the water column to create an export rate of 350 ng/L Total PCB concentrations. These resuspension production rates are approximately 19 to 24 percent of the Total PCB removal rate via dredging. The Total PCB export fraction for this scenario ranges from 0.16 to 0.28.

The 500 ng/L condition was only simulated by TSS-Chem model, without a subsequent HUDTOX model forecast. As a result, the Total PCB fluxes at the far-field monitoring stations were extrapolated based on the 500 ng/L input conditions and the results of the previous HUDTOX simulations. The TSS-Chem results for the 500 ng/L scenario suggest that the Total PCB export fraction of the resuspension production rate ranges from 0.16 to 0.29 (*i.e.*, 16 to 29 percent of the PCB mass removed would have to be spilled to yield a 500 ng/L condition in the river). In River Section 1, to obtain 500 ng/L Total PCB concentration at the far-field monitoring station, TSS-Chem estimated that approximately 10,000 to 13,000 g/day of Total PCB mass would need to be suspended into the water column. This Total PCB mass corresponds to approximately 17 to 23 percent of the Total PCB removal rate via dredging. For River Section 2, the resuspension production rates are approximately 9,300 to 11,000 g/day (approximately 8 to 9 percent of the Total PCB removal rate via dredging). In River Section 3, approximately 13,000 to 16,600 g/day of Total PCB mass would need to be suspended into the water column to create an export rate of 500 ng/L Total PCB concentrations.

These model calculations yield an important conclusion concerning criteria developed for the Resuspension Standard. While the model analysis of the concentrations and loads that comprise the standard show relatively little long-term impact on downstream receptors and conditions, the amount of sediment spillage required to attain these levels is quite large. Spillage at these levels is unlikely and certainly well beyond what is expected for standard environmental dredging practices. Based on these analyses, compliance with the Resuspension Standard appears to be attainable, including the lowest action criteria.

2.2.9 Review of Applicable or Relevant and Appropriate Requirements (ARARs)

The evaluation of potentially applicable Federal and State water quality standards for the purpose of the performance standard development was based on work previously done for the Record of Decision (ROD) for the Hudson River PCBs Site (USEPA, 2001; Section 9.2). In the ROD, seven chemical-specific ARARs for PCBs were identified:

500 ng/L Federal MCL [40 CFR § 141.61] and NYS MCL [10 NYCRR, Chapter I, Part 5, Section 5.1.52, Table 3];

90 ng/L	NYS standard for protection of human health and drinking water sources [6 NYCRR Parts 700 through 706];
30 ng/L	Federal Water Quality Criterion (FWQC) criteria continuous concentration (CCC) for saltwater [Aroclor-specific 40 CFR § 131.36];
14 ng/L	Federal Water Quality Criterion (FWQC) criteria continuous concentration (CCC) for freshwater [Aroclor-specific 40 CFR § 131.36];
1 ng/L	Federal Ambient Water Quality Criterion for Navigable Waters [40 CFR § 129.105(a)(4)];
0.12 ng/L	NYS standard for protection of wildlife [6 NYCRR Parts 700 through 706]; and
0.001 ng/L	NYS standard for protection of human consumers of fish [6 NYCRR Parts 700 through 706].

Of these criteria, USEPA waived the three lowest concentration standards (0.001 ng/L to 1 ng/L) due to technical impractibility (ROD; Statutory Determinations; p. vi), as it is technically impractical to reach these concentration levels in the Hudson River with the continuing input from the upstream sources. As long as the water column concentrations are below the federal and state MCL (500 ng/L), protection of human health will be achieved. Only the 500 ng/L total PCB standard is not regularly exceeded by the at the main stem Upper Hudson River stations downstream of Rogers Island under existing (baseline) conditions; therefore, the other ARARs were not applied in the development of the Resuspension Standard. No other chemical-specific criteria were identified as ARARs or TBCs (To-Be-Considered criteria) in the ROD or the Phase 3 RRI/FS Phase 3 Feasibility Study Report (USEPA, 2000b).

Additional surface water quality criteria were considered for parameters that may be impacted by the remediation. These parameters are pH, dissolved oxygen (DO), and turbidity. NYS guidelines [6 NYCRR Parts 700 through 706] set the following standards:

pH	6.5 to 8.5 for Class A surface water;
DO	not less than a daily average of 6 mg/L for trout bearing waters; not less than 5 mg/L for non-trout bearing waters; and
Turbidity	No criteria for surface water

Specific resuspension criteria have not been established for these water quality parameters. The water quality parameter data will be used for comparison to the continuously monitored data at both the near-field and far-field stations. These standards may be used as resuspension criteria in Phase 2, if warranted.

2.2.10 Summary of Supporting Analyses

Numerous analyses were done in support of this performance standard. Review of case studies have provided examples for the way the issue of resuspension of contaminated material has been handled at other sites leading to development of the elements of this standard: resuspension criteria, monitoring and engineering contingencies. The calculations described suggest that the standard will be protective of the environment and human health, if complied with, and that it will be achievable. The context for these analyses will be evident in discussion of rationale (Section 2.3). A brief synopsis of the supporting analyses follows.

Turbidity and Suspended Solids at Other Sites

A surrogate measurement of suspended solids concentrations such as turbidity may become an important real time indicator of PCB concentration levels, if it is proven in Phase 1 that the primary mechanism of contaminant release from the remediation is resuspension of sediment. Turbidity measurements are instantaneous whereas analyses for suspended solids or PCBs are more time consuming and limit the time available to warn downstream water supplies in the event of an exceedance of the standard. Case studies were reviewed to provide an indication of turbidity and suspended solids concentrations in the water column and the thresholds that were established at these sites to limit resuspension. Because suspended solids measurements are needed for comparison to resuspension criteria, a correlation must be developed between suspended solids and a surrogate before a surrogate measurement could be used for this purpose. Review of case studies and literature indicates that such correlations are site-specific, have been established at other sites and could potentially be developed for the Hudson River. The case studies described the configuration of monitors relative to the remedial operations. This information was considered when specifying the near-field monitoring locations required by the standard.

PCB Releases at Other Sites

The case studies also provided information with which to calculate the amount of PCB released from other dredging sites. The rate of loss provides another indication of what a reasonable load-based resuspension criterion would be. These estimates of loss can also be used to determine the average increase in water column concentration during the remediation. Estimated rates of contaminant loss from other sites are 0.13, 0.36 and 2.2 percent.

Hudson River Water Column Concentration Analysis

Approximately five years of baseline water column PCB concentrations are available. Although there are concerns over the quality of these data, resulting from the sampling methods and analytical methods used, estimates of the average and highest expected water column PCB can be made. These values can be compared to the PCB concentration-based resuspension criteria directly to indicate if in some months, the PCB concentration may routinely approach the standard, even without the added impact of the suspension. The results indicate that the average PCB water column concentrations will be less than the concentration-based resuspension criteria, although in some months it is expected that the criteria would be exceeded on occasion.

Resuspension Sensitivity Analysis

The resuspension sensitivity analysis was built on the Hudson River water column concentration analyses by adding the estimated increase in concentration for a given increase in PCB load on to the estimated baseline PCB water column concentrations. This analysis suggests that the load-based resuspension criteria will not routinely elevate the water column concentration over the concentration-based criteria. The results indicate that the average PCB water column concentrations during dredging will be less than the concentration-based resuspension criteria, although in some months it is expected that the criteria would be exceeded on occasion.

Dissolved-Phase Releases

Concerns were raised during the public comment period for the Hudson River ROD that dissolved-phase PCB concentrations could be significant during remediation of PCB contaminated sediment and a release of this kind could not be detected by a surrogate measure such as suspended solids or turbidity. The calculations described in Section 2.2.5 indicate that a release of this kind would not be possible without an associated suspended solids release, because the bulk of the PCB contamination is bound to the sediment and there is not a sufficient amount of PCBs dissolved in the porewater to cause a substantial release.

Far-Field Modeling

The impacts of allowing the remediation to continue at the levels indicated by the resuspension criteria were determined through model simulation. The fate, transport and bioaccumulation models developed during the Reassessment RI/FS phase were used for this purpose. The results indicate that operation at the total PCB load-based resuspension criteria, which are the only criteria at which the remediation could operate for extended periods of time, will result in short-term impacts to the environment during the remediation, but will have little impact on the fish tissue concentrations post-dredging. An accidental release scenario in the vicinity of the Upper Hudson River public water intakes indicated that although the concentrations entering the intake would be greater than the MCL, minimal water treatment would be sufficient to reduce the concentrations below the MCL.

Near-Field Modeling

Models of surface water concentrations in the vicinity of the dredge were developed to: determine the amount of PCBs released from the dredging operation; predict the downstream water column concentrations; calculate the area in which the resuspended material would settle and the increase in PCB concentration in that area; and identify the appropriate locations for near-field monitoring. The modeling indicated that the PCBs released by the dredge would be largely suspended phase. The amount of dissolved PCBs increase to a limited extent as the plume traveled downstream, but this process is slow because of the small coefficient of desorption. The relative amount of dissolved phase to suspended phase PCBs increases as the solids settle. Settling of contaminated material downstream of the dredge has the potential to raise surface concentrations substantially. This would be of concern if the area were not subsequently dredge and may indicate the need for containment, if this is verified. The locations of the far-field and near-field monitoring points relative to the remedial operations and the suspended solids near-field resuspension criteria are suggested by the results of these models.

Relationship Among the Resuspension Production, Release, and Export Rates

The Total PCB load-based resuspension criteria were based on engineering judgement and the balance of several factors. These factors include the best engineering estimate of resuspension production and export, the minimum detectable PCB load increase, the load defined by the water column concentration criteria, the impact of load on fish tissue recovery and the delivery of Total PCBs and Tri+ PCBs to the Lower Hudson. The selection process for the load-based criteria are described in detail in Section 2.2.8. A series of models was used to examine the relationship among the resuspension production, release, and export rates. The model calculations yield an important conclusion concerning the relationship between the resuspension production rate and the performance standard criteria. While the model analysis of the concentrations and loads that comprise the standards show relatively little long-term impact on downstream receptors and conditions, the amount of sediment spillage required to attain these levels is quite large. Spillage at these levels is certainly well beyond what is likely given standard environmental dredging practices.

Review of Applicable or Relevant and Appropriate Requirements (ARARs)

Federal and state surface water quality guidelines were reviewed to determine if these regulations would provide a concentration level that was achievable during the remediation and protective of human health. The Federal and state MCL of 500 ng/L total PCBs met these criteria.

2.3 Rationale for the Standard

2.3.1 Development of the Basic Goals and Resuspension Criteria

The performance standard for PCB losses due to resuspension is unique among the engineering performance standards in that the basic criteria are not numerically enumerated in the ROD. Unlike the Production and Residuals Standards whose basic goals are enumerated there (*i.e.*, approximately 2.65M cubic yards in six years and 1 mg/kg Tri+ PCB, respectively), the performance standard for PCB losses due to resuspension must justify both its ultimate numerical goals as well as the required implementation.

The remedial action objectives provide the ultimate basis for the development of the Resuspension Standard. As discussed in the 2002 ROD,

> *[the] RAOs address the protection of human health and protection of the environment. (ROD § 9.1, page 50)*

The RAO specifically addressed by this Resuspension Standard is the following:

> *Minimize the long-term downstream transport of PCBs in the river. (ROD § 9.1, page 51)*

In the ROD, the goal of the Resuspension Standard for PCB losses is defined in the following context:

> *…Analysis of yearly sediment resuspension rates, as well as resuspension quantities during yearly high flow events, shows the expected resuspension due to*

> *dredging to be well within the variability that normally occurs on a yearly basis. The performance standards and attendant monitoring program, that are developed and peer reviewed during design, will ensure that dredging operations are performed in the most efficacious manner, consistent with the environmental and public health goals of the project. (ROD § 11.5, page 85)*

And again,

> *…Sampling and monitoring programs will be developed and implemented during the design, construction and post-construction phases to…determine releases during dredging…. These monitoring programs will include sampling of biota, water and sediment such that both short-and long-term impacts to the Upper and Lower Hudson River environs, as a result of the remedial actions undertaken, can be determined and evaluated. EPA will increase monitoring of water supply intakes during each project construction phase to identify and address possible impacts on water supplies drawn for drinking water. The locations, frequency and other aspects of monitoring of the water supplies in the Upper and Lower Hudson will be developed with public input and in consultation with New York State during remedial design. (ROD § 13.3, page 99)*

Controlling the export of PCBs during the remediation will keep the water column concentrations close to current baseline levels and, by extension, keep fish tissue concentrations close to baseline levels during the remediation. In short, the goal of the standard is to:

> **Minimize PCB losses during dredging to reduce risks to human and ecological health by controlling PCB exposure concentrations in drinking water and fish tissue.**

2.3.1.1 Development of Water Column Concentration Criteria for PCBs

The most important ARAR for drinking water supplies is the federal maximum contamination limit, or MCL, for drinking water supplies, 500 ng/L Total PCBs[5]. This ARAR establishes the first of two objectives for the Resuspension Standard:

Objective 1 (Drinking Water): Maintain PCB concentrations in raw water at drinking water intakes at levels less than the federal MCL of 500 ng/L.

Objective 1 establishes a numerical limit on PCB concentrations in the Upper Hudson. Adherence to this level provides assurance that no public water supplies will be adversely impacted by the remediation, regardless of its ability to treat PCB-bearing water. Most of the WTPs potentially affected by the remediation have treatment systems that can reduce the concentration of PCBs in the finished water, although the current degree of reduction is

[5] The New York State MCL is also 500 ng/L.

unknown. For this reason, this standard will take the more conservative approach and not rely on this capability. Instead, this standard will seek to maintain acceptable water column concentrations in the raw water.

Based on this objective, PCB export must be sufficiently controlled so as to prevent exceedance of the 500 ng/L Total PCBs level at the water supply intakes at Waterford and Halfmoon, NY, the first public water supply intakes downstream of the remedial areas. While dilution and degradation can be expected to reduce PCB concentrations in the water column during transit from River Sections 1 and 2 to the public water intakes, these processes cannot be relied upon while dredging in River Section 3. Thus, dredging in River Section 3 requires that PCB export due to dredging not result in water column concentrations in excess of the federal MCL. As a conservative approach for the protection of the water supplies, this same concentration level (500 ng/L) is applied at all far-field monitoring locations and is the standard for water column concentrations (Resuspension Standard threshold).

An action level criterion was also derived from Objective 1. Although the 500 ng/L level represents a level not to be exceeded, there is need for an action level, below the MCL. Specifically, it is desirable to keep water column concentrations below the federal MCL while still meeting the productivity goals of the remedial operation. To this end, a second concentration limit of 350 ng/L Total PCBs was established. This value represents 70 percent of the MCL value and serves as a trigger for additional monitoring. Engineering review and improvements are required if the average concentration increase is 350 ng/L or higher for four weeks. These activities are required to identify and correct any potential problems that may cause a subsequent exceedance of the federal MCL, warranting a possible disruption in the operations and requiring contingency actions on the part of the municipal water suppliers. This concentration threshold was defined as one of the Concern Level and Control Level criteria.

Compliance with these resuspension criteria at the far-field stations attains the objective and protects public water supplies during the remedial efforts. These criteria are designed to limit short-term impacts, since the river will deliver any resuspended PCBs to the downstream water supplies at Waterford and Halfmoon in a matter of days. However, the ROD clearly is also concerned with the impacts to fish and downstream consumers of fish. This concern requires a longer perspective, since fish integrate their exposure to PCBs over both time and area. Thus fish tissue concentrations are likely to be more impacted by a long, steady loss of PCBs than a single large release event. A second objective can be defined specific to this issue, as discussed in the following section.

2.3.1.2 Development of Primary Criteria for PCB Loads

Objective 2 (Fish Tissue): Minimize long term net export of PCBs from dredged areas to control temporary increases in fish tissue concentrations.

Objective 2 addresses the need to limit the impact of the remediation itself on the anticipated recovery of river after the remedial dredging is completed. This objective recognizes that the export of PCBs during dredging has the potential to slow the rate of recovery for fish body burdens and related exposures if it is sufficiently large. However, this objective also recognizes that it is primarily the long-term release of PCBs that has the potential to create an adverse impact. Short-term releases can be tolerated so long as the long-term average continues to satisfy the criteria. In general, short-term releases are of the time scale of hours to days while long-term releases are considered in terms of several weeks to months or longer. Thus, from the perspective of the 2002 ROD, the short-term releases are manageable so long as they do not compromise eventual recovery of the river. As noted in the ROD:

> *Although precautions to minimize resuspension will be taken, it is likely that there will be localized temporary increases in suspended PCB concentrations in the water column and possibly on fish PCB body burdens. (ROD § 11.5, page 85)*

This objective can be approached from two perspectives: an ideal rate of PCB export and an acceptable maximum export rate. The ideal rate is obviously no PCB release at all. However, this is also unattainable. The case study analysis presented in Section 2.2.2 and the resuspension analysis presented in the Responsiveness Summary (2002 ROD) provide some useful target values, however. The two sites examined in Section 2.2.2, the GE Hudson Falls remediation and the New Bedford Harbor Hot Spot remediation, achieved net PCB export rates of 0.36 and 0.13 percent, respectively, relative to the mass of PCBs removed. These percentages translate to Total PCB resuspension export rates of 240 and 86 g/day of operation or 50 and 18 kg/yr on an annual basis for the remediation of the Hudson, respectively. These annual values represent only a small fraction of the annual baseline load of 260 to 400 kg/yr observed for the period 1996-2002 (see Figure 7 of Attachment B). Export at this level is unlikely to have any discernable impact on fish tissue concentrations, given the baseline variability.

In developing the load criteria for the standard, several different perspectives were examined to make the standard meaningful (*i.e.,* not too high) and achievable (*i.e.,* not too low). These include the following:

1. Best engineering estimate of resuspension production and export,
2. Minimum detectable PCB load increase,
3. Load defined by the water column concentration criteria of 350 and 500 ng/L Total PCBs,
4. Impact of load on fish tissue recovery, and
5. Delivery of Total PCBs and Tri+ PCBs to the Lower Hudson (*i.e.*, Waterford load).

Each of these perspectives has the potential to provide some level of constraint on the selection of a PCB load criterion. Each is discussed below.

<u>Best Engineering Estimate of Resuspension Production and Export.</u> The analysis performed in Appendix E.6 of the Feasibility Study and in the Responsiveness Summary provided an initial engineering estimate of the rate of PCB release from the dredge operation. The analysis estimated a resuspension production rate and a resuspension release rate, yielding an estimated Total PCB export rate of approximately 86 g/day (18 kg annually) or 0.13 percent of the PCB mass to be removed from the river bottom (69,800 kg).

In the preparation of the Resuspension Standard, the initial model analysis of suspended solids transport has been expanded and improved to more realistically represent conditions as well as to account for the kinetics of PCB dissolution. These results were discussed above in Section 2.2.7. (A detailed discussion is provided in Attachment D.) These analyses confirm the results initially presented in the Feasibility Study. The current analysis estimates a PCB export rate only slightly greater than the original estimate, at 90 g/day (19 kg annually[6]) or about 0.14 percent of the PCB mass to be removed. Based on these results, a best engineering estimate of 19 kg per dredging season was selected as the target load value.

Although a target level of 90 g/day would appear a desirable target (the analysis presented in the Feasibility Study shows this loading rate to have a negligible[7] impact on the recovery of fish tissue concentrations throughout the river), it is important to note that this value does not account for activities other than the dredge operation itself. Boat movements, debris removal, barrier installation and removal, and other activities related to the dredging operation all have the potential to release PCBs but are difficult to quantitate. Hence a set of criteria is needed to define reasonable upper limits for dredging-related releases based on estimated impacts to the river. Much of the analysis described in Section 2.2 was completed with the intention of providing input to the selection of these limits.

<u>Minimum Detectable PCB Load Increase</u> An important limitation in selecting the PCB load criteria is the ability to measure the net increase in load due to dredging activities. Several considerations must be addressed in this regard. The selection of the far-field locations as the main PCB monitoring locations is a direct result of this concern. Baseline loads of PCBs originating from the sediments are similar in magnitude to those expected from dredging. Much of the sediment initially added to the water column will rapidly settle, releasing little or no PCBs. Hence the ability to detect a net PCB load increase in the poorly mixed region around the dredge operation (*i.e.*, at the near-field monitoring stations) is difficult and highly uncertain. For this reason, PCB monitoring will be conducted well away from the dredging operation (*i.e*., far-field monitoring), where the net PCB load should be more stable and can be detected over baseline conditions.

As discussed in Section 2.2.4 and Attachment B, this approach does have a limit on the ability to measure PCB export at a far-field station. Based on the historical variability observed in the available data, it is unlikely that PCB export below 300 g/day (65 kg annually[8]) can be differentiated from baseline conditions. This value then provides a minimum observable PCB export rate or load. Notably, the target load for PCB export due to dredging given above falls below the detectable load rate. Thus, if the target PCB criterion is reached, there will be no measurable increase in PCB export. From a monitoring perspective, the target for dredging is no observable increase in PCB load above baseline.

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[6] The target PCB export rate of 19 kg/year represents a daily resuspension export rate of 90 g/day, assuming a 210-day dredging season (May through November) and seven days per week of operation. This is conservative in that operations less than seven days per week would result in higher daily export rates.
[7] A negligible impact in the Upper Hudson is defined as a forecast fish tissue concentration difference relative to the no-resuspension dredging scenario of 0.5 mg/kg or less within 5 years after the cessation of dredging.
[8] This rate of PCB export corresponds to slightly less than 0.5 percent of the estimated mass of PCBs to be removed.

Load Defined by the Water Column Concentration Criteria of 350 and 500 ng/L Total PCBs The federal MCL provides a means to obtain an upper bound on the annual and daily load rate. If daily Total PCB concentrations remain at a monthly average concentration of 500 ng/L throughout the dredging season, the PCB export load can be calculated from the difference between 500 ng/L and the average baseline concentration for the month. This calculation yields an export rate of about 2,300 g/day (500 kg annually[9]). The 350 ng/L Total PCB resuspension criterion also provides a basis for a loading estimate. To maintain a monthly average concentration of 350 ng/L Total PCBs, the resuspension export rate must be approximately 1,600 g/day (340 kg annually[10]). For the purposes of this standard, the Control Level is expected to be the maximum operating condition since concentrations above this level will require engineering improvements to reduce the releases. From this consideration, 1,600 g/day (340 kg annually) represents the likely maximum annual load that can be derived from the water column concentration criteria.

Impact of Load on Fish Tissue Recovery The ability to measure a net increase in PCB export relative to baseline conditions and the water concentration criteria provides potential bounding criteria for an acceptable export rate. However, it is still necessary to demonstrate that export rates at these levels do not substantively alter the recovery period of the river as measured by the decline in PCB concentrations in fish tissue. The model simulation for the best engineering estimate for resuspension presented in the Responsiveness Summary is the basis for comparison[11]. To investigate this, a series of model forecasts were conducted at resuspension release rates (near-field) and resuspension export rates (far-field) derived from the load considerations given above. The model runs dealing with long-range forecasts are summarized in Section 2.2.6. The near-field model analysis is summarized in Section 2.2.7. A complete discussion of the supporting model analyses is provided in Attachment D. Table 2-15 lists the completed model runs along with brief descriptive information.

Due to the inherent nature of the HUDTOX model structures, PCB loads cannot be readily specified at far-field locations. Rather, the input of PCBs is specified as an input load at a location within the river, equivalent to a resuspension release rate. For the supporting model runs, the resuspension release rate was derived iteratively, by estimating the resuspension release rate (input to the model) and then checking the resuspension export rate (the model output) until the model output met the desired criteria. This was necessary in order to make the model match the potential control criteria at the planned monitoring locations. These iterations also took into account the different river sections, with their corresponding target sediment properties (*i.e.*, silt fraction), PCB concentrations and hydrodynamics. The simulations also account for the changes in dredging location as the remediation progresses. For example, to simulate the 350 ng/L Total PCB condition (*i.e.*, the Control Level threshold for the entire dredging program), it was necessary to load approximately 1,550 g/day Total PCBs and 56,000 kg/day of sediment in Section 1, 2,300 g/day Total PCBs and 35,000 kg/day of sediment in Section 2 and 2,800 g/day

[9] This rate of PCB export corresponds to about 3.8 percent of the PCB mass to be removed.

[10] This rate of PCB export corresponds to about 2.4 percent of the PCB mass to be removed.

[11] Since the completion of the Feasibility Study, various factors and considerations have lead to a suggested start date for the remediation of 2006, instead of 2004 as originally planned. Since the best estimate simulation prepared for the Feasibility Study was barely discernable above the "no resuspension" simulation, the simulations prepared here were simply compared against a revised "no resuspension" result, reflecting the later start date. The 90 g/day best estimate condition was not rerun.

Total PCB and 94,500 kg/day of sediments.[12] These PCB and sediment loads reflect the differences in PCB concentration, river flow and monitoring locations among the three sections. PCB and sediment loads had to be further varied to reflect the year-to-year movements of the dredges within each section. As would be expected, less resuspension was necessary to achieve a specified PCB concentration or load at the far-field station the closer the dredge was to the station.

Model simulations for the 350 ng/L Total PCBs scenario were run to examine the impact of this criterion on the recovery of the river, using the recovery of fish tissue concentrations as the main measure (see Figures 2-8 and 2-9). This scenario showed some fish body burden increases during dredging but negligible[13] changes to fish tissue trajectories during the post-dredging period. After noting the negligible impact of the 350 ng/L scenario, there was no need to run a 300 g/day scenario since its impact would clearly be much less. A 600 g/day Total PCBs scenario was run, based on its selection as a load criterion (see below). As expected, the 350 ng/L scenario has a greater impact than the 600 g/day scenario. However, both model runs indicate negligible[14] changes in fish tissue concentrations in regions downstream of the dredging. Within five years of the completion of dredging there is little discernable impact from the dredging releases based on the fish tissue forecasts. The model results suggest that compliance with the water concentration criteria previously developed (*i.e.*, 350 ng/L and 500 ng/L) will also minimize dredging impacts to the long-term recovery of the river.

<u>Delivery of Total PCBs and Tri+ PCBs to the Lower Hudson</u> In addition to the recovery of the river as measured by fish tissue concentrations, impacts to the river due to dredging can also be gauged by the absolute mass of PCBs released. For this comparison, both Total PCBs and Tri+ PCBs are considered. The emphasis is placed on the estimated Tri+ PCB releases, however, since this is the fraction of PCBs that is bioaccumulative. This fraction is also far better understood from the perspective of sediment inventory as well as geochemical processes (the USEPA models simulate Tri+ PCBs). As noted above, the main consideration in developing a load standard is to minimize the release of PCBs. For this reason, the cumulative PCB load at Waterford, as forecast by the HUDTOX model, provides a useful gauge of any suggested loading standard. In this instance, the ideal condition is that given by the no resuspension scenario for the selected remedy. The upper bound would be the load delivered by the original Monitored Natural Attenuation scenario (MNA). The forecast for acceptable load criteria would fall between the MNA and the no resuspension scenario.

The Tri+ PCB load forecasts for several load conditions are presented in Figure 2-4. The lowest curve, representing the least amount of PCBs transported downstream, represents the no resuspension scenario. MNA is also indicated on the figure. Because of the dredging-related

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[12] To put the suspended solids values in perspective, at a nominal flow rate of 4,000 cfs and 2 to 4 mg/L of suspended solids, the Hudson transports 20,000 to 40,000 kg of solids per day, respectively.

[13] A negligible impact in the Upper Hudson is defined as a forecast fish tissue concentration difference relative to the no-resuspension dredging scenario of 0.5 mg/kg or less within 5 years after the cessation of dredging. In the Lower Hudson, it is defined as a forecast fish tissue concentration difference relative to the no-resuspension dredging scenario of 0.05 mg/kg or less within 15 years after the cessation of dredging. Note that in the Lower Hudson, fish tissue concentration forecasts always agree within 0.5 mg/kg except for one year during the dredging period for the 350 ng/L scenario at River Mile 152.

[14] See footnote 13.

PCB releases, all scenarios except no resuspension exceed the MNA forecast during the dredging period. Unlike the lower PCB release scenarios (see the upper diagram in Figure 2-4), the forecast curve corresponding to the 350 ng/L criteria never crosses over the MNA curve, indicating that setting the loading standard on the basis of this water concentration criterion would deliver significantly more Tri+ PCB mass to the Lower Hudson than MNA. The 300 g/day scenario (run to 2020) crosses the MNA curve just before the cessation of dredging. While this scenario was not run for the full forecast period, it is evident that the Tri+ PCB load level for the 300 g/day scenario would deliver much less Tri+ than the MNA. Also shown on the figure is a forecast curve for a Tri+ PCB load for the 600 g/day scenario[15]. This curve also crosses the MNA forecast, just after the completion of dredging. On the basis of this analysis, both a 300 and a 600 g/day load standard would yield acceptable Tri+ PCB loads to the Lower Hudson.

The impacts of the possible load criteria were also examined for Total PCBs, as illustrated in the lower diagram of Figure 2-4. These Total PCB curves are considered less certain, since the EPA models were developed to simulate Tri+ PCBs and not Total PCBs. Nonetheless they provide some guidance. The results from this analysis also show an unacceptably high Total PCB load to the Lower Hudson, based on the 350 ng/L criterion. Both the 300 and the 600 g/day forecasts show less total load delivered to the Lower Hudson than MNA, although the equivalence points occur later in time. The 600 g/day forecast crosses about 20 years after the completion of dredging. The overall load difference between the 600 g/day scenario and MNA is relatively small such that an increase in the daily load to 700 g/day would probably exceed the MNA curve. Given the uncertainties in the Total PCB estimates, the Tri+ PCB forecasts are considered the more reliable gauge among these scenarios.

Selection of a Load-Based Criterion Taking into account the various considerations described above, it is clear that the target load of 90 g/day is not measurable, and the load equivalent to 350 ng/L delivers an unacceptably large mass of PCBs to the Lower Hudson. None of the load scenarios chosen as criteria yield an unacceptable impact on fish tissue concentrations so this gauge is not useful here. Consideration of loads to the Lower Hudson provides the greatest limitation on selecting a load criterion but it is somewhat uncertain for Total PCBs.

While no exact value results from this analysis, it is clear that the loading standard must fall between the ability to measure it (*i.e.*, 300 g Total PCBs/day detection threshold) and the 350 ng/L-based load of 1600 g/day, which results in unacceptable loads to the Lower Hudson. The 600 g/day load, representing 130 kg annually, appears to provide a "best" fit for this criteria. It is twice the load detection threshold and therefore measurable. It is less than the 350 ng/L – 1,600 g/day condition and results in acceptable Tri+ and Total PCB load increases to the Lower Hudson.[10] In term of absolute loads, the 130 kg/year represents slightly more than a 40 percent increase in the mean annual load at Schuylerville (300 kg/yr for 1998-2002). Added to this value, the load increase would yield 430 kg/yr, which is just beyond the observed range at Schuylerville between 1998 and 2002 (180 – 410 kg/yr). Relative to TI Dam loads, this load increase represents a 40 to 90% increase in the observed loads (TID West and TID-PRW, respectively) for 1996 to 2002. More importantly though, this load represents a nearly seven-

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[15] This load is equivalent to 130 kg/year or slightly less than 1 percent of the estimated mass of PCBs to be removed.

[10] As was noted previously, the Total PCB load is not considered a robust constraint due to its uncertainty.

fold increase relative to the best engineering estimate of 90 g/day, thus providing a reasonable allowance for other dredging related releases (*e.g.*, boat traffic and debris removal). Yet as noted above, this load increment would have negligible[17] impacts on the long-term river recovery, generating only brief (1-2 year) increases in fish tissue concentrations relative to the MNA scenario. Based on these considerations, the value of 600 g/day has been selected as the primary load criterion. 600 g/day is equivalent to 650 kg load loss over the entire remediation and 65 kg in Phase 1 assuming half the targeted production rate will be achieved.

Because Tri+ PCBs are the most important component of Total PCBs for the recovery of fish tissue concentrations, a load criterion is desired for this parameter as well. This criterion is simply derived from the Total PCB load criterion and the observation that the Total PCB to Tri+ PCBs ratio in the sediments is approximately 3:1. Since sediments are the main form of release of PCBs, it is expected that the net addition of Tri+ PCBs will be one third that of Total PCBs, yielding a primary criterion for Tri+ PCBs of 200 g/day.

The last consideration for selecting the load-based criteria is the time frame over which these apply. Taking into consideration the long-term nature of the load impacts and the likely high degree of short-term variability, the criteria should be based on longer-term conditions in order to avoid major disruptions to the operation due to short-term exceedances. For this reason, the Control Level load criterion will be measured over four-week periods by constructing a running average of Tri+ and Total PCB loads at all far-field stations for the entire dredging season. A shorter time frames of 7-days will be applied for the Concern Level and the Evaluation Level.

2.3.2 Rationale for a Tiered Approach

The actions levels (Evaluation Level, Concern Level and Control Level) were developed to facilitate a steady level of remedial activities while still providing environmental protection. The tiered approach is intended to require additional sampling and engineering controls as PCB levels rise above those predicted by the best engineering analysis. This tiered approach provides action levels to trigger monitoring contingencies and implementation of additional engineering controls and thereby avoid a complete cessation in the operation. It is the intention of this standard to both minimize PCB losses and facilitate uninterrupted remedial operations.

In this approach, monitoring requirements will increase as the lower action levels are exceeded to provide data to clarify the nature of the PCB losses. These data can then be used to direct engineering control improvements while dredging operations continue unabated. The monitoring requirements will have no effect on dredging operations and productivity since they do not affect the equipment and crews involved.

<u>PCB Considerations</u>

In developing the tiers of the standard, the need to control PCB export must be balanced with the need to comply with the federal standard. As extensively discussed in Attachments A and B, baseline water column PCB concentrations vary from month-to-month, necessarily complicating

[17] A negligible effect in the Upper Hudson is defined as a forecast fish tissue concentration difference relative to the no-resuspension dredging scenario of 0.5 mg/kg or less within 5 years after the cessation of dredging.

the structure of the standard. Based on these concerns, the PCB component of the Evaluation Level is a flux-based action level. The Concern Level has both flux-based and concentration based PCB criteria. Exceedance of absolute concentrations for the flux-based criteria at the Evaluation Level is not a concern in this instance and the standard is focused on control of PCB export and potential long-term impacts to the recovery of the river. The Concern Level and Control Level have both PCB load and PCB concentration criteria. For the Control Level, the load components are intended to require additional engineering controls since PCB loads have not been previously brought into compliance under the Evaluation Level and Concern Level. The length of the time for the exceedance (four weeks) reflects the concern that PCB loads have been well above the expected condition for a long period and that the annual PCB load may exceed the primary load criterion.

The PCB concentration-based criterion of 350 ng/L is included in the Concern Level and Control Level to address the concern over exposure to PCBs via public water supplies as the MCL is approached. The duration for the exceedance is one week based on a seven-day average in acknowledgement of the anticipated variability in water column conditions. As previously discussed, the federal MCL of 500 ng/L Total PCBs represents an absolute maximum concentration, the exceedance of which will cause the temporary halting of the remedial operations. The Control Level at 350 ng/L Total PCBs for four-weeks based on the four-week mean concentration will be the effective maximum allowable level, since exceedance of this level means that the absolute maximum is being approached and that extra efforts are required to control PCB export. By requiring operations to maintain water column conditions below this value (350 ng/L Total PCBs), the Control Level provides a relatively large window of protection, decreasing the likelihood of a 500 ng/L event. When concentrations exceed 350 ng/L Total PCBs on average for four-weeks or more, contingency-based action and engineering improvements become mandatory until riverine conditions falling below the Control Level are achieved. Notably, months with high baseline concentrations will have relatively little “room to spare” and may require tight controls on the dredging operations to comply with this criterion. Exceedance of the Control Level may prompt temporary cessation of operations as deemed necessary by EPA.

The monitoring and engineering requirements of the Control Level reflect the gravity of the exceedances. Extensive monitoring requirements and mandatory engineering controls are needed at this level to quickly identify the problems and render a solution, thereby avoiding a cessation of the dredging operation.

Exceedance of the Resuspension Standard threshold (500 ng/L Total PCBs) will require a cessation of operations if the exceedance is confirmed by samples collected the following day. By developing control criteria in this fashion, there should have been at least three attempts (one for each of the three lower action levels) to understand and control any resuspension problem. At this point (exceedance of the Resuspension Standard threshold), temporary halting of operations is required since conditions are clearly not as anticipated and may have significant consequences.

Suspended Solids Considerations

While PCB concentrations and loads are clearly the most important focus of this standard, determination of PCB conditions in the river is time-consuming with a significant lag between the collection of samples and the availability of preliminary (draft) data. For this reason, it is desirable to measure and monitor parameters that correlate with PCBs and can be determined readily. Suspended solids, in particular, fit this requirement and have been selected for monitoring as well. Suspended solids measurements are reflective of short-term conditions since they will vary rapidly in response to sediment disturbances. For this reason the suspended solids criteria will be derived from the water column concentration criteria described in Section 2.3.1.1. Acceptable suspended solids concentrations were developed for both near-field and far-field conditions.

To further support the development of the suspended solids criteria, near-field conditions were simulated using a Gaussian plume model (TSS-Chem) to estimate the impact of various resuspension release rates. This analysis, summarized in Section 2.2.7 and described in Attachment D, indicates that resuspension release rates corresponding to PCB loads of 300 to 2,000 g/day are rapidly reduced in the near-field region, with resulting PCB export rates at the far-field stations 2 to 6 times less. This analysis included an estimation of kinetically controlled PCB desorption, suggesting relatively minimal rates of dissolved phase PCB release in the immediate vicinity of the dredge. In the region between 10 and 1000 m downstream of the dredge, PCB loads steadily diminish while gradually decreasing the fraction borne by suspended matter relative to the dissolved phase. At the point of departure from the near-field region, PCB loads are primarily dissolved phase but overall the loads are substantively reduced compared to the immediate dredge area. The conclusions from this analysis include the observation that downstream export of PCBs (at one mile beyond the dredge operation) is unlikely to exceed the 300 g/day Total PCB control level on a regular basis. Furthermore, the analysis of suspended solids release and PCB desorption presented in Section 2.2.5 and Attachment C indicates the PCB release within the dredging region is controlled by the resuspension process alone. The creation of dissolved phase releases by processes other than PCB desorption from suspended solids is highly unlikely, further supporting the focus of this performance standard on solids-related release mechanisms. This assumption will be tested by the separate phase PCB analyses required by the contingency monitoring in the event that PCB levels exceed various action levels.

Suspended solids criteria were developed for the Evaluation and Concern Levels to provide a means to more rapidly identify an issue with river conditions. In most instances, suspended solids exceedances will necessitate additional PCB monitoring, which in turn should identify if the PCB criteria are being exceeded. While these suspended solids criteria will require additional monitoring, the PCB concentrations, and not the suspended solids concentrations, will trigger the need for additional engineering controls. The additional monitoring will be limited to the far-field monitoring requirements for the nearest representative far-field station with the sampling timed to capture the plume causing the exceedance. Near-field suspended solids sampling frequency will remain at three-hour intervals regardless of the action level exceeded.

Near-field Suspended Solids Criteria

Derivation of the suspended solids action levels is described in detail in Attachment D and briefly summarized here. The near-field suspended solids action levels were derived using the TSS-Chem model to simulate suspended solids conditions corresponding to the PCB concentration resuspension criteria. For the Evaluation and Concern Level, suspended solids thresholds represent an average suspended solids concentrations 300 m downstream of the dredge that would yield a Total PCB concentration exceeding 350 ng/L at the far-field station. The same suspended solids values are used for both action levels; only the duration of the exceedance varies between the levels. This was done to simplify the monitoring while still identifying significant events. A location of 300 m downstream was selected since the model suggests a plume width of 50 m and a relatively homogeneous water column at this distance. At this distance, it should be easy to reliably maintain a sensor in the plume and also minimize moment-to moment variability in suspended solids measurements. If barriers are installed, this station will be placed 150 m downstream of the barrier.

Additional monitoring will be required at a location closer to the dredge to provide the operator with real time information on the effectiveness of the dredge operations and the suspended solids controls. A distance of 100 m downstream of the dredge was selected as sufficiently downstream to provide some level of mixing and smoothing of the suspended solids signal while still being close enough to provide rapid feedback to the dredging operation. Feedback may be crucial in identifying operations or actions that cause excessive turbidity, but can be controlled to minimize water quality impacts. Another station will be located 10 m to the side of the dredge nearest the channel. At these locations, a sustained concentration of 700 mg/L suspended solids will trigger an exceedance of the Evaluation Level. If barriers are in place, these stations will not have an associated resuspension criterion. In all cases, adjustment of the monitoring locations will be considered if alternate sites can be shown to be more effective to the monitoring goals.

Unlike the PCB criteria, the near-field suspended solids criteria should be prorated among all the active dredge operations in a given area, but for Phase 1, the concentration criteria for the suspended solids will apply to each operation individually.

Far-field Suspended Solids Criteria

Far-field suspended solids criteria were developed for the Evaluation and Concern Levels, reflecting the decreased sensitivity of suspended solids measurements at the far-field monitoring station. The suspended solids at the far-field stations are derived from the far-field PCB standards. The far-field suspended solids criterion was developed by simply calculating the amount of suspended solids which can result in a net increase of PCB concentration above the primary PCB criterion assuming that the PCB concentration on the suspended solids is the same as on the dredged sediment. As a conservative measure, the 500 ng/L far-field Total PCBs standard was used. Assuming the baseline level of PCB concentration is approximately 100 ng/L, the net PCB concentration increase will be 400 ng/L. As stated in the Responsiveness Summary, the average PCB concentration on the dredged sediment across the three river sections is about 34 ppm. Based on these values, the increase in suspended solids concentration above baseline is calculated to be about 12 mg/L. This increase in suspended solids concentration must occur across the entire river and not just within the dredge plume for the associated PCB concentration increase to occur. This level (12 mg/L suspended solids increase) is close to natural variability, however. Considering the uncertainty in the calculation assumptions as well as the natural variability in suspended solids concentration, a value twice 12 mg/L, *i.e.*, 24 mg/L was also selected. As a result, the Concern Level uses 24 mg/L as the far-field suspended solids criterion. The Evaluation Level uses approximately half of this value (12 mg/L), with a shorter duration. The periods of exceedance are the same as those for the near-field suspended solids action levels. The increased monitoring requirements will be limited to the far-field station with the exceedance with the sample collection timed in order to capture the plume.

Due to the variable conditions within the river over time, some action levels may conflict with one another, particularly in May and June when baseline concentrations are relatively high. In these instances, the Concern or Control Level criteria for Total PCB concentration may be exceeded even though the Total PCB load does not exceed the Concern Level criteria. The concentration-based action levels will govern since these are intended to provide protection for the downstream public water supplies and therefore represent the more protective criteria in these instances. Similarly, the suspended solids criteria may identify potentially important PCB concentration or load conditions that are not verified by subsequent PCB sampling and analysis. This is recognized in the standard by requiring confirmation of the action level exceedance with results from increased PCB monitoring at the nearest far-field station before implementing monitoring contingencies at downstream stations. In all cases exceedances of the action level criteria by any parameter (*i.e.*, Total PCBs, Tri+ PCBs or suspended matter) will spur additional monitoring requirements.

2.3.3 Monitoring Rationale

This section presents the overall rationale for the monitoring program. Further details, including support for the monitoring frequency requirements can be found in Attachment G.

As noted in the ROD (USEPA, 2002a), the export of PCBs from the dredging area to regions downstream is the ultimate concern of this performance standard since it affects both fish and public water supplies. Thus the most important monitoring stations are those that monitor the rate of PCB export downstream. This increase in PCB export can be best and most easily measured at sufficient distance downstream of the dredging operation to allow the river to homogenize the water column inputs from dredging. This distance should also be sufficient to avoid the inclusion of solids suspended during dredging that will settle in close proximity to the dredging operation and thus not represent a source to regions downstream. Based on historical evidence as well as concerns highlighted by the Fox River study (USGS, 2000), these stations will be used for direct comparison with the Resuspension Standard criteria only when the stations are at least one mile downstream of the dredging operations.

Since the dredging program extends over nearly 30 miles, with potentially impacted downstream water supplies as far away as 100 miles from the TI Dam, the far-field monitoring program will consist of several major monitoring locations that can be readily and regularly occupied to obtain water column samples for PCB analysis. It is important to measure the PCB concentrations and the PCB mass loading from each of the river sections. In addition to showing how much mass is exported from each of the river sections, the size of the region subjected to the PCB export can be determined. Additionally, water treatment plants downstream can be notified in the event of a large release.

2.3.3.1 Far-Field Concerns

Because of the importance of the Hudson River as a public water supply and the need to assure public safety, daily samples will be collected at all far-field monitoring stations. Discrete samples will be collected from each station to represent the entire river cross section (*e.g.*, an equal-area representation of the river's cross section). The samples must be collected to represent the dredging period. That is, samples from an affected water parcel at each far-field station must be collected. Without consideration for time-of-travel between the remedial operations and the representative far-field station, false low values may be obtained and potentially large releases may go unidentified even though samples will be collected daily under routine monitoring. The daily discrete routine monitoring will include the following variables:

- Total PCBs (whole water[18], congener-specific, low detection limits)
- Suspended Solids
- Dissolved Organic Carbon
- Organic Carbon on Suspended Solids (Weight loss on ignition on suspended solids or similar)
- Temperature
- pH
- Dissolved Oxygen
- Conductivity

In situ probes are required for the following:

- Turbidity
- Suspended solids with a particle counter

The discrete samples for PCBs are clearly required to document compliance with the far-field action level criteria and the Resuspension Standard threshold. The suspended solids, dissolved organic carbon and organic carbon on suspended solids are all needed to support the interpretation of the PCB data, particularly when action levels are exceeded. The continuous reading parameters are needed as supporting information to confirm a minimal impact of dredging on water quality.

The daily discrete monitoring parameter analytical methods must be sufficiently sensitive to avoid non-detect values at most stations and provide data that can characterize PCB concentrations during both routine and unusual conditions. As discussed in further detail in the next section, the frequency and type of samples will be adjusted as action levels are exceeded. For example, the frequency of PCB sampling will be increased to as often as four times per day.

[18] Whole water samples require separation of dissolved and suspended matter fractions for separate extraction. Extracts may be combined into a single analysis.

Other sampling techniques, such as the separate measurement of dissolved and suspended phase PCBs, will be required as well.

In addition to the daily discrete sample collection, two other forms of sampling will be included at these stations. Specifically, continuous suspended solids monitoring (by means of turbidity and particle counters) and the use of an integrating PCB sample (*e.g.*, an Isco sampler) will also be required. The turbidity monitoring will be conducted continuously and recorded on a regular basis for use within the same day. This device will provide a real time measure that may be correlated with suspended solids once sufficient data are obtained, potentially identifying any dredging-related release of solids and by inference the associated PCBs concentration.

An integrating PCB sampler will be required as well to provide an alternate measurement basis for water column PCB concentrations. These sampling techniques provide a useful integration of water column loads over time and can be compared to historical measurements (to be collected during the remedial design) or simply to the prior months' data. The data from the integrating PCB sample can be used to document changes in PCB export from the dredging operations to the extent the changes occur in between daily discrete samples. The results can be compared to the more quantitative but instantaneous daily measurements of PCB concentration to generate a rough estimate of PCB transport. More importantly, these samplers provide a long-term integration of PCB load, monitoring the relatively long periods of time between the daily sampling events. This information serves to confirm that river conditions as captured by the daily discrete samples are representative of general river conditions. These samplers do not provide real time data but rather confirm that the discrete samples are providing a useful measure of average conditions. These samplers will be deployed in a manner similar to the regular water column points, (*i.e.*, multiple points in the river cross section will be sampled to obtain a representative sample where possible). These samples will be collected biweekly at the five Upper River main stem stations from Rogers Island to Waterford.

2.3.3.2 Near-Field Concerns

Local variation prevents useful monitoring of PCB in the immediate vicinity (near-field) of the dredging operation. From the float studies conducted by GE in the late 1990s, it is clear that the PCB concentrations in the water column can increase greatly over relatively short distances from exposure to the contaminated sediments. Near-field downstream monitoring of the PCB concentrations could not distinguish between the contribution resulting from resuspension during dredging and the contribution from the sediments. Additionally, the time lag between sample collection and the availability of PCB data (normally at least 24 hours even with an accelerated turnaround time) preclude the use of PCB measurement as a real time monitor of dredging operations.

The near-field monitoring program is designed to provide a real time measure of conditions around the dredging operation. It is designed recognizing that the far-field monitoring program cannot provide direct feedback to the dredge operators concerning the day-to-day operation of the equipment and engineering controls. For this reason, near-field monitoring will entail continuous measurement of turbidity by (using) electronic sensors (see Attachment F) to allow real time response to changing conditions and dredge operator activities. Electronic sensors for suspended solids will be supplemented by the required three-hour discrete samples.

The near-field monitoring program is not intended to provide quantitative measures of PCB loss from the dredging operations but rather to provide a more sensitive qualitative measure of the possible impacts of various dredging activities. These results will be used in coordination with far-field turbidity, suspended solids and PCB monitoring, so that acceptable levels of near-field turbidity can be developed from the net effects observed downstream.

The near-field monitoring program will include suspended solids and turbidity monitoring both upstream and downstream of the dredging operation, so that dredging-related turbidity and associated suspended solids can be identified. Sensor deployment will entail a network of sensors in a river cross-section, typically five sensors deployed longitudinally around the dredge. The distances downstream of the dredging operation have been determined based on information available in the literature as well as the results of the near-field modeling analysis described in Attachment D. In addition to direct sensor measurements, daily particle counter suspended solids measurement will also be collected to provide analytical confirmation of the sensors.

The near-field monitoring program provides the best opportunity to obtain real time results that can be used to guide the dredging operations as well as to identify those activities that may result in unacceptable releases of PCBs from the sediments. While PCB monitoring is the ultimate measure of downstream impacts, the real time turbidity and suspended solids monitoring provides the best means of minimizing suspended solids and PCB release.

While the use of turbidity or suspended solids monitoring provides valuable real time data, there are some issues that need to be considered in the design of the monitoring program and interpretation of the data. Besides the straightforward issues of sample accuracy and representativeness, the installation of backfill concurrent with the dredging operation may serve to confound the turbidity and suspended solids signals. To the extent that backfill creates large amounts of turbidity, it is possible that the contribution of dredging-related turbidity or suspended solids may be indiscernible. The expected close proximity of dredging and backfill operations will make it difficult to estimate the suspended solids load upstream of dredging but downstream of the backfilling. Thus, measurement of the local impact of dredging by suspended solids monitoring may be compromised. This is addressed to the extent possible by placing a suspended solids and turbidity monitoring station just upstream of each dredging operation. Additionally, it is expected that backfilling operations will not always coincide with dredging, thus simplifying the suspended solids monitoring. Further refinement of the near-field and far-field suspended solids criteria is anticipated at the completion of Phase 1, and possibly during Phase 1 if appropriate.

In summary, both PCB and suspended solids monitoring have limitations that affect their usefulness. For PCBs, it is the time lag between sampling and the availability of the data as well as the baseline release of PCBs that limit the measurement sensitivity. For suspended solids, it is the near-field heterogeneity as well as the impact of backfilling resuspension that confound the measurement. Nonetheless, these measures taken together can provide a rigorous basis on which to monitor downstream transport and compliance with the Resuspension Performance Standard.

2.3.4 Summary of Rationale

The rationale for the performance standard for PCB loss due to resuspension has its basis in the goals outlined in the ROD. The need to protect downstream fish and fish consumers and the need to protect public water supply intakes define the objectives for the standard. Action levels were derived from consideration of ARARs for the site and RAOs from the ROD as well as the ability to detect a net increase in PCB loads. These criteria were shown by modeling analysis to produce little change in downstream fish tissue recovery, further supporting their use as action levels. Specifically, PCB releases commensurate with 500 ng/L had no substantive impact on the fish recovery once dredging operations were completed. Ultimately the RAO concerning the transport of PCBs to the Lower Hudson provided the lowest upper bound on the acceptable amount of PCB loss (*i.e.*, 600 g/day or 650 kg over the entire period of dredging). Additional action levels were needed to provide a tiered series of action levels with an increasing amount of contingencies as the various action levels are exceeded. The criteria, monitoring requirements and engineering contingencies are all designed with the intention of identifying and correcting minor problems in the dredging operation while keeping the dredging operation functioning smoothly and steadily.

Due to the variable conditions within the river over time, the Total PCB concentrations may be greater than 350 ng/L even though the load-based criteria are not exceeded. This results from elevated baseline conditions and is most likely to occur in May and June. The concentration-based action levels will govern since these are intended to provide short-term protection for the downstream public water supplies and therefore represent the more protective criteria in these instances. It is also possible that the suspended solids criteria may indicate elevated PCB concentrations that are not verified by subsequent PCB sampling and analysis. This is recognized in the standard by requiring confirmation of the exceedance with PCB concentration data at a representative far-field station before requiring implementation of engineering evaluations or monitoring contingencies at downstream far-field stations.

3.0 Implementation of the Performance Standard for Dredging Resuspension

The Resuspension Standard consists of the standard threshold and associated action levels, monitoring requirements and engineering requirements. The implementation of the action levels is described in Section 3.1. Considerations for using a continuous monitoring device to measure suspended solids for comparison to the resuspension criteria is discussed in Section 3.2. Monitoring requirements including measurement techniques, monitoring locations and other specifics are described in Section 3.3. For engineering contingencies, the engineering evaluations, technologies for controlling releases that may be implemented and the requirements of the standard regarding engineering contingencies are described in Section 3.3.

Flowcharts depicting the implementation of the Resuspension Standard are provided in Figures 3-1, 3-2 and 3-3 for the near-field suspended solids criteria, far-field Total PCBs and far-field suspended solids. These flowcharts present the interaction between the three aspects of the standard: action levels, monitoring and engineering controls.

3.1 Resuspension Criteria

Details of the implementation of the standard are provided in this section. The requirements and criteria of the standard are presented in tabular form in Table 1-1. Implementation of the Resuspension Standard will necessarily require monitoring for the parameters of concern. Daily measurements of suspended solids and PCB concentrations can be compared with the appropriate action level or the Resuspension Standard threshold. Load-based criteria require more than a simple measure of concentration, since flow must be incorporated in the load estimate. 7-day and 4-week running averages of Total PCB and Tri+ PCB loads must be routinely calculated at each of the Upper Hudson River far-field stations. Note that in the event that dredging occurs in more than one river section, effectively creating two "nearest" far-field stations, this standard is applied in the same manner to both stations. That is, load-based and concentration criteria apply to both stations equally. Given the various uncertainties in load estimation, no "pro-rating" of the standard for the upper station will be required, although the dredge operators should consider doing so, as needed. This also means that either station can dictate response actions.

PCB load-based criteria for the various periods of time will be based on different statistical treatments of the data, in recognition of the greater certainty provided by long-term trends (*i.e.*, 4-week averages) relative to the shorter averaging period. The criteria will be based on the results of the three-year Baseline Monitoring Program, which is scheduled to begin in 2003. Historical data collected prior to the baseline period will be used to the extent possible. Estimates of flow will be derived from USGS gauging stations currently operating in the Upper Hudson, along with data from additional stations developed for this monitoring program (*e.g.*, Schuylerville). As noted above, the load-based criteria will also be adjusted to reflect the anticipated dredging period length with the maximum allowable net release of 650 kg Total PCBs[1] or 220 kg Tri+ PCB over baseline for the duration of the remediation.

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[1] The daily rate is based on attainment of the recommended Target Cumulative Volume as specified in the Productivity Standard, and should be prorated according to the production rate planned in the Production Schedule to be submitted annually to USEPA.

Each of the action levels has associated load-based criteria. To simplify review of the monitoring results and avoid additional computations during the remediation, the load-based criteria will be converted to look-up tables of concentrations that correspond to various load-based levels as a function of river flow and month. Examples of these tables for Total PCBs at the Schuylerville station are included as Tables 3-1, 3-2 and 3-3 for the Evaluation Level, Concern Level and Control Level far-field net Total PCB load, respectively. The tables were developed using the existing GE data for this location. However, as mentioned above, the existing water column data from the Upper Hudson are limited in applicability,[2] and were used to provide a preliminary set of values for these tables. Final values for these tables for both Total PCBs and Tri+ PCBs will be developed from the Baseline Monitoring Program. Exceedance of the final values to be developed for these tables from the Baseline Monitoring Program for a given month and given flow will constitute exceedance of the corresponding action level.

For all flux estimates, the load calculation may be corrected for contributions originating upstream of the remediation area (*i.e.*, above Rogers Island) in the event that loads from this region are above the levels typically observed. That is, if loads at Rogers Island rise beyond the 95 percent prediction level for Rogers Island for the corresponding measurement period (*e.g.*, day, week or month), then the downstream load calculations may be corrected by subtracting the difference between the 95 percent prediction level for Rogers Island and the actual value at Rogers Island from the load calculated for the downstream station.

In the event that dredging operations move to a location less than one mile upstream of a far-field monitoring point, the next downstream far-field station becomes the representative far-field station for the operation. The nearer far-field station will continue to be monitored for the purpose of judging the adequacy requirement that far-field stations must be at least one mile downstream from the remediation, but these data will not be used to judge compliance with the standard. These data will be used to judge the condition that the far-field station must be more than one mile from the remedial operations for the monitoring data to be comparable to the resuspension criteria.

For exceedence of suspended solids criteria, the impacted water column must be sampled to determine the concentration of PCBs in the plume. Suspended solids and turbidity measurements collected from the representative far-field station will document that the sample has been collected from the plume.

Equations are provided in the sections below for comparing the monitoring results to the resuspension criteria. Half the detection limit will be substituted for nondetect values in the formulas.

[2] The single point monitoring locations at Thompson Island Dam and Schuylerville are not adequate (*i.e.*, not sufficiently representative of river conditions) for the purposes of estimating recent baseline load conditions. A cross-sectional composite sample, as will be obtained during both the baseline monitoring and the remedial monitoring programs for this purpose.

3.1.1 Evaluation Level

3.1.1.1 Far-Field Net Total PCB Load

The net increase in Total PCB mass transport due to dredging-related activities at any downstream far-field monitoring station exceeds 300 g/day for a seven-day running average.

The far-field net Total PCB load is a load-based criterion (300 grams per day), as opposed to a concentration-based action level (PCB concentration criteria (ng/L)), and is calculated after taking into account the pre-existing baseline loads of Total PCBs. This criterion applies only to the monitoring stations of the Upper Hudson, where a PCB load can be readily estimated. The formula to estimate the dredging-related release using the seven-day running average concentration under routine monitoring is as follows:

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

where: F_7 = Seven-day average load of Total PCBs at the far-field station due to dredging-related activities in g/day,

$\overline{C_{ffs}}$ = Flow-weighted average concentration of Total PCBs at the far-field station as measured during the prior seven-day routine discrete sampling in ng/L. For once per day sampling, this is given as:

$$\overline{C_{ffs}} = \frac{\sum_{j=1}^{7} C_{ffs\,j} \times Q_j}{\sum_{j=1}^{7} Q_j} \qquad (3\text{-}2)$$

where: C_{ffs} = The Total 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 = The daily average flow at the far-field station for day j,

$\overline{C_{bl}}$ = Estimated 95 percent upper confidence limit of the arithmetic mean baseline concentration of Total PCBs at the far-field station for the month in which the sample was collected, in ng/L. Initial estimates for these values are given in Table 3-4. This value is determined from baseline monitoring data and represents the upper bound for the average concentration at the far-field station in the absence of dredging. In the condition that the 95 percent UCL varies within the 7-day period of interest (*e.g.*, at the end of a month), time-weighted average 95 percent UCL is calculated as the sum of each day's 95 percent UCL dividing by the number of days.

Q_7	=	Seven-day average flow at the far-field station, determined either by direct measurement or estimated from USGS gauging stations, in cfs, and
T_{d7}	=	Average period of dredging operations per day for the seven-day period, in hours/day, as follows:

$$T_{d7} = \frac{\sum_{j=1}^{7} T_{d_j}}{7} \qquad (3\text{-}3)$$

where: T_{d_j} = The period of dredging operations for day j in hours.

If F_7 is 300 g/day Total PCBs or greater, this is considered to be an exceedance of the Evaluation Level. This formula is intended to identify a mean loading of Total PCBs due to dredging in excess of the action level. The upper confidence limit of the water column PCB concentrations at each station and month is chosen to represent baseline concentrations ($\overline{C_{bl}}$), because this is a comparison to the average condition for a short duration. The confidence limit indicates the probability or likelihood that the interval contains the true population value. Because the seven-day average value will be compared to the monthly mean, it is appropriate to estimate the range of values that may contain the mean. Values that fall outside this range are unlikely to be part of the original population of baseline values and therefore they are likely to represent a dredging-related release of PCBs. Note that this and all PCB load standards may be adjusted for production rate as described in Section 3.1.3.5.

3.1.1.2 Far-Field Net Tri+ PCB Load

The net increase in Tri+ PCB mass transport due to dredging-related activities at any downstream far-field monitoring station exceeds 100 g/day day for a seven-day running average.

Equations 3-1, 3-2 and 3-3 will be used to calculate the far-field net Tri+ PCB load at each Upper River mainstem station on a daily basis by substituting the daily Tri+ PCB concentrations and baseline Tri+ PCB 95th percent UCL values in place of the Total PCB concentrations. Baseline Tri+ PCB concentrations have not been calculated for this report, but the Tri+ PCB 95th percent UCLs will be calculated using the data collected during the Baseline Monitoring Program. If F_7 is 100 g/day Tri+ PCBs or greater, this is an exceedance of the Evaluation Level.

3.1.1.3 Far-Field Average Net Suspended Solids Concentration

The sustained suspended solids concentration above ambient conditions at a far-field station exceeds 12 mg/L. To exceed this criterion, this condition must exist on average for 6 hours or a period corresponding to the daily dredging period *(whichever is shorter). Suspended solids are measured every three hours by discrete samples.*[3]

The net increase in suspended solids concentration between far-field stations will be calculated during the daily dredging period for each main stem Upper River far-field station. If the suspended solids concentration is estimated continuously using turbidity as a surrogate, the 6-hour running average net increase will be calculated throughout the daily dredging period. If the suspended solids concentration is measured by discrete samples at 3-hour intervals, the net increase will be calculated throughout the day for each 6-hour interval as the data become available from the laboratory. The suspended solids data must be available within three hours of sample collection (3-hour turnaround time). The net increase in suspended solids is calculated as follows:

$$\text{Net Increase in Suspended Solids (mg/L)} = C_{avg} - C_{baseline} \qquad (3\text{-}4)$$

where:

C_{avg} = Average suspended solids concentration for the time interval at the far-field station, and

$C_{baseline}$ = Baseline arithmetic average suspended solids concentration for the same far-field station and month the will be based on the Baseline Monitoring Program results.

Suspended solids contributions from the tributaries will appear to be dredging-related increases in suspended solids. This criterion may be waived if the increase in suspended solids can be traced to meteorological events. The baseline concentrations at each station will be developed from the results of the Baseline Monitoring Program.

The Evaluation Level is exceeded if the net increase in suspended solids concentration is 12 mg/L or greater. Sample collection will be timed to measure the concentration of PCBs in the impacted water column. Exceedance of this criterion prompts Evaluation Level sampling at one far-field station. The station will be chosen to measure the Total PCB concentration in the suspended solids plume in order to determine if additional actions need to be taken. The frequency of this sampling will be equivalent to that defined in Table 1-2 for the representative stations (TI Dam and Schuylerville). Only the grab sample will be collected for this purpose.

3.1.1.4 Near-Field Net Suspended Solids Concentration 300 m Downstream

The sustained suspended solids concentration above ambient conditions at a location 300 meters downstream (i.e., near-field monitoring) of the dredging operation or 150 meters downstream from any suspended solids control measure (e.g., silt curtain) exceeds 100 mg/L for River Sections 1 and 3 and 60 mg/L for River Section 2. To exceed this criterion, this condition must exist on average for

[3] Continuous reading probe may be substituted if a semi-quantitative relationship between the probe reading and the discrete suspended solids samples.

six hours or for the daily dredging period (whichever is shorter). Suspended solids are measured every three hours by discrete samples.[4]

The net increase in suspended solids concentration between the upstream near-field station and the downstream near-field stations will be calculated during the daily dredging period for each remedial operation. Without barriers, these near-field stations will be located approximately 300 m downstream of the dredge. With barriers, these stations will be located approximately 150 m downstream of the barrier. If the suspended solids concentration is estimated continuously using turbidity as a surrogate, the 6-hour running average net increase will be calculated throughout the daily dredging period. If the suspended solids concentration is measured by discrete samples at 3-hour intervals, the net increase will be calculated throughout the day for each 6 hour interval as the data become available from the laboratory. The suspended solids analysis will require a 3-hour turnaround time. The net increase in suspended solids is calculated as follows:

$$NetIncreaseInSS_{near-field} = C_{avg} - C_{up} \tag{3-5}$$

where:

C_{up}	=	The arithmetic average upstream near-field station concentration over the time interval and
C_{avg}	=	The arithmetic average downstream concentration over the time interval. Samples will be collected from two stations located 300 m downstream. The average concentration from each location over the time period will be calculated separately and the higher average concentration will be chosen for use in this equation.

In River Sections 1 and 3, a net increase in suspended solids concentration 100 mg/L or higher, constitutes an Evaluation Level exceedance. In River Section 2, a net increase in suspended solids concentration 60 mg/L or higher, is considered to be an Evaluation Level exceedance. Exceedance of this criterion prompts Evaluation Level sampling at the nearest representative far-field station. Sample collection will be timed to measure the concentration of PCBs in the impacted water column.

Each near-field 300 m station (150 m station with barriers) will be compared to either 100 mg/L or 60 mg/L, depending on the location of the remediation during Phase 1, while the behavior of the system is tested. In Phase 2, when multiple dredging operations are conducted simultaneously within the same section of the river, the sum of the concentrations measured at the near-field station may be compared to the criteria, because this approach is in keeping with the development of the criteria. This criterion may be waived if the increase in suspended solids can be traced to meteorological events.

[4] Continuous reading probe may be substituted if a semi-quantitative relationship between the probe reading and the discrete suspended solids samples.

3.1.1.5 Near-Field Net Suspended Solids Concentration 100 m Downstream and the Side Channel Station Without Barriers

The sustained suspended solids concentration above ambient conditions at the near-field side channel station or the 100 meters downstream station exceeds 700 mg/L. To exceed this criterion, this condition must exist for more than three hours on average measured continuously or a confirmed occurrence of a concentration greater than 700 mg/L. Suspended solids are measured every three hours by discrete samples.

Without barriers, the average suspended solids concentration over the time period at the upstream near-field stations for a remedial operation will be subtracted from the average suspended solids concentration over the same time period at the 100 m downstream station to get the net suspended solids concentration. Also, the average suspended solids concentration over the time period at the upstream near-field stations for a remedial operation will be subtracted from the average suspended solids concentration over the same time period at the side channel station to get the net suspended solids concentration.[5] If the suspended solids concentration is estimated continuously using turbidity as a surrogate, a 3-hour average net suspended concentration of 700 mg/L or higher is an exceedance. If the suspended solids concentration is measured by discrete samples at 3-hour intervals, two consecutive samples of 700 mg/L or higher is an exceedance. Exceedance of this criterion prompts Evaluation Level sampling at the nearest representative far-field station. Sample collection will be timed to measure the concentration of PCBs in the impacted water column.

The net suspended solids concentration at each near-field 100 m station or side channel station will be compared to 700 mg/L while the remediation is in Phase 1. In Phase 2, when multiple dredging operations are conducted simultaneously within the same section of the river, the sum of the concentrations measured at the near-field 100 m stations (or side channel station) may be compared to 700 mg/L, because this approach is more in conformance with the development of the criterion. This criterion may be waived if the increase in suspended solids can be traced to meteorological events.

3.1.2 Concern Level

3.1.2.1 Far-Field Total PCB Concentration

The net increase in Total PCB mass transport due to dredging-related activities at any downstream far-field monitoring station exceeds 350 ng/L for a seven day running average.

The arithmetic average of the past seven days will be calculated on a daily basis for each of the Upper River mainstem far-field stations. For each station, a day will be represented by a single

[5] Note that this standard also applies to the 300 m station in the unlikely event that a 700 mg/L event occurs at that location, but does not affect the 100 m and side channel stations.

value. If more than one sample is collected in a day for a station, the arithmetic average of the Total PCB measurements for a station will be used as a single day's concentration in the 7 day average. If the arithmetic average of the Total PCB concentration is 350 ng/L or higher at a far-field station, this is considered to be an exceedance of the Concern Level.

3.1.2.2 Far-Field Net Total PCB Load

The net increase in Total PCB mass transport due to dredging-related activities at any downstream far-field monitoring station exceeds 600 g/day on average over a seven day period.

The far-field net Total PCB load will be calculated using Equations 3-1, 3-2 and 3-3. If the 7-day Total PCB load is 600 g/day or higher, this is considered to be an exceedance of the Concern Level.

3.1.2.3 Far-Field Net Tri+ PCB Load

The net increase in Tri+ PCB mass transport due to dredging-related activities at any downstream far-field monitoring station exceeds 200 g/day on average over a seven day period.

Equations 3-1, 3-2 and 3-3 will be used to calculate the far-field net Tri+ PCB load at each Upper River mainstem station on a daily basis by substituting the daily Tri+ PCB concentrations and baseline Tri+ PCB 95th percent UCL values in place of the Total PCB concentrations. Baseline Tri+ PCB concentrations have not been calculated for this report, but the Tri+ PCB 95th percent UCLs will be calculated using the data collected during the Baseline Monitoring Program. If F_7 is 200 g/day Tri+ PCBs or greater, this is considered to be an exceedance of the Concern Level.

3.1.2.4 Far-Field Average Net Suspended Solids Concentration

The sustained suspended solids concentration above ambient conditions at a far-field station exceeds 24 mg/L. To exceed this criterion, this condition must exist for a period corresponding to the daily dredging period (6 hours or longer) or 24 hours if the operation runs continuously (whichever is shorter) on average. Suspended solids are measured every three hours by discrete samples.[6]

The net increase in suspended solids concentration between far-field stations will be calculated on a daily basis for each mainstem Upper River far-field station as soon as the data become available (within 3 hours of sample collection). The net increase in suspended solids concentration will be estimated for the daily dredging period (longer than 6 hours) or 24 hours if dredging is continuous. Suspended solids will be measured with discrete grab samples or with a

[6] Continuous reading probe may be substituted if a semi-quantitative relationship between the probe reading and the discrete suspended solids samples is developed.

surrogate continuous measurement such as turbidity, if a correlation between the parameters that is satisfactory to USEPA is established. Equation 3-4 can be used to calculate the net increase in suspended solids for the time period of concern.

Suspended solids contributions from the tributaries will appear to be dredging-related increases in suspended solids. This criterion may be waived if the increase in suspended solids can be traced to meteorological events.

The Concern Level is exceeded if the net increase in suspended solids concentration is 24 mg/L or greater. Sample collection will be timed to measure the concentration of PCBs in the impacted water column. Exceedance of this criterion prompts Concern Level sampling at one far-field station. The station will be chosen to measure the Total PCB concentration in the suspended solids plume in order to determine if additional actions need to be taken. The frequency of this sampling will be equivalent to that defined in Table 1-2 for the representative stations (TI Dam and Schuylerville). Only the grab sample will be collected for this purpose.

3.1.2.5 Near-Field Net Suspended Solids Concentration 300 m Downstream

> *The sustained suspended solids concentration above ambient conditions at a location 300 meters downstream (i.e., near-field monitoring) of the dredging operation or 150 meters downstream from any suspended solids control measure (e.g., silt curtain) exceeds 100 mg/L for River Sections 1 and 3 and 60 mg/L for River Section 2. To exceed this criterion, this condition must exist for a period corresponding to the daily dredging period (6 hours or longer) or 24 hours if the operation runs continuously (whichever is shorter) on average. Suspended solids are measured every three hours by discrete samples.*[7]

The net increase in suspended solids concentration between the upstream near-field station and the downstream near-field stations will be calculated during the daily dredging period for each remedial operation. Without barriers, these near-field stations will be located approximately 300 m downstream of the dredge. With barriers, these stations will be located approximately 150 m downstream of the barrier. The net increase in suspended solids concentration will be estimated for the daily dredging period (longer than 6 hours) or 24 hours if dredging is continuous. Equation 3-5 can be used to calculate the net increase in suspended solids for the time interval of concern.

In River Sections 1 and 3, a net increase of 100 mg/L or higher in suspended solids concentration is considered to be a Concern Level exceedance. In River Section 2, a net increase of 60 mg/L or higher in suspended solids concentration is considered to be a Concern Level exceedance. Exceedance of this criterion prompts Concern Level sampling at the nearest representative far-field station. Sample collection will be timed to measure the concentration of PCBs in the impacted water column.

[7] Continuous reading probe may be substituted if a semi-quantitative relationship between the probe reading and the discrete suspended solids samples is developed.

Each near-field 300 m station (150 m station without barriers) will be compared to either 100 mg/L or 60 mg/L depending on the location of the remediation during Phase 1 while the behavior of the system is tested. In Phase 2, when multiple dredging operations are conducted simultaneously within the same section of the river, the sum of the concentrations measured at the near-field stations may be compared to the criterion, because this approach is in conformance with the development of the criterion. This criterion may be waived if the increase in suspended solids can be traced to meteorological events.

3.1.3 Control Level

3.1.3.1 Far-Field Net Total PCB Concentration

> *The Total PCB concentration at any downstream far-field monitoring station exceeds 350 ng/L on average for four weeks.*

The arithmetic average of the past four weeks will be calculated on a daily basis for each of the Upper River mainstem far-field stations starting four weeks into the dredging season. For each station, a day will be represented by a single value. If more than one sample is collected in a day for a station, the arithmetic average of the Total PCB measurements for a station will be used in calculating the 4-week arithmetic average. If the 4-week arithmetic average Total PCB concentration is 350 ng/L or higher at a far-field station, this is considered to be an exceedance of the Control Level.

3.1.3.2 Far-Field Net PCB Seasonal Load Loss

> *The net increase in PCB mass transport due to dredging-related activities measured at the downstream far-field monitoring stations exceeds 65 kg/year Total PCBs or22 kg/year Tri+ PCBs.*

The model projections indicate that no more than 650 kg dredging related Total PCBs or 220 kg dredging related Tri+ PCBs will be exported during the period of remediation. This is pro-rated according to the anticipated rate of PCB inventory removal for a season (see Section 3.1.3.5). During Phase 1, it is anticipated that one-tenth of the PCB inventory will be targeted for removal. Therefore, only one-tenth of this allowable Total PCB load (65 kg) or Tri+ PCB load (22 kg) will be the maximum allowable release of PCBs during Phase 1 assuming the target production rate is met. Assuming the target productivity schedule is followed, this value rises to 130 kg/yr Total PCBs or 44 kg/yr Tri+ PCBs.

3.1.3.3 Far-Field Net Total PCB Load

The net increase in Total PCB mass transport due to dredging-related activities at any downstream far-field monitoring station exceeds 600 g/day on average over a four week period.

The far-field net Total PCB load will be calculated weekly for each main-stem Upper River station. The formula to estimate the dredging-related release using the four-week running average concentration under routine monitoring is as follows:

$$F_4 = \left(\overline{C_{ffs}} - \overline{C_{bl}}\right) \times Q_4 \times T_{d_4} \times \frac{0.02832 m^3}{ft^3} \times \frac{3600 s}{hr} \times \frac{1 g}{10^9 ng} \times \frac{1000 L}{m^3} \tag{3-6}$$

where: F_4 = 4-week average load of Total PCBs at the far-field station due to dredging-related activities in g/day.

$\overline{C_{ffs}}$ = Flow-weighted average concentration of Total PCBs at the far-field station as measured during the prior 4 weeks routine discrete sampling in ng/L. For once per day sampling, this is given as:

$$\overline{C_{ffs}} = \frac{\sum_{j=1}^{n} C_{ffs\,j} \times Q_j}{\sum_{j=1}^{n} Q_j} \tag{3-7}$$

where: $C_{ffs\,j}$ = The Total 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.

$Q_{i\,j}$ = The daily average flow at the far-field station for day j.

n = Number of days in the 4-week period

For integrating samplers, this is given as

$$\overline{C_{ffs}} = \frac{\sum_{j=1}^{n} C_{ffs\,j} \times Q_j}{\sum_{j=1}^{n} Q_j} \tag{3-8}$$

where: $C_{ffs\,j}$ = The Total PCB concentration for each sampler

$Q_{i\,j}$ = Sum of the daily average flow during the implementation of each sampler.

n = Number of samplers within four weeks

$\overline{C_{bl}}$ = time-weighted arithmetic mean baseline concentration of Total PCBs at the far-field station during the prior four weeks. As given in Table 3-4, the arithmetic mean baseline concentration varies month by month. The time-weighted average concentration is calculated as the sum of each day's baseline average concentration dividing by the number of days.

Q_4 = Four weeks average flow at the far-field station, determined either by direct measurement or estimated from USGS gauging stations, in cfs.

T_{d4} = Average period of dredging operations per day for the four weeks period, in hours/day, as follows:

$$T_{d_4} = \frac{\sum_{j=1}^{n} T_{d\,j}}{n} \qquad (3\text{-}9)$$

where: Td_j = The period of dredging operations for day j in hours.

n = Number of days in the 4-week period.

If F_4 is 600 g/day Total PCBs or greater, this is considered to be an exceedance of the Control Level. This formula is intended to identify a mean loading of Total PCBs due to dredging in excess of the action level. The average of the water column Total PCB concentrations for each station and month is chosen to represent baseline concentrations ($\overline{C_{bl}}$), because this is a comparison to the average condition for an extended period of time. While it is appropriate to use the UCL for a seven-day period, the more conservative average value is appropriate for the larger data set in the four-week period.

3.1.3.4 Far-Field Net Tri+ PCB Load

The net increase in Tri+ PCB mass transport due to dredging-related activities at any downstream far-field monitoring station exceeds 200 g/day for a four week running average.

Equations 3-6, 3-7, 3-8 and 3-9 will be used to calculate the far-field net Tri+ PCB load at each Upper River main-stem station on a daily basis by substituting the daily Tri+ PCB concentrations and baseline Tri+ PCB arithmetic mean concentration in place of the Total PCB concentrations. Baseline Tri+ PCB concentrations have not been calculated for this report, but the Tri+ PCB average concentration will be calculated using the data collected during the Baseline Monitoring Program. If F_4 is 200 g/day Tri+ PCBs or greater, this is considered to be an exceedance of the Control Level.

3.1.3.5 Adjustment to the Load-Based Thresholds

The production rate will be reviewed on a weekly basis. The allowable Total PCB load loss for the season will be adjusted if this target rate is not met using the following equation:

$$AllowableSeasonalTotalPCBLoss(kg) = \frac{m}{M} \cdot 650(kg) \qquad (3\text{-}10)$$

where:

m	=	Total PCB mass anticipated to be dredged in a season (kg) and
M	=	Total PCB mass to be dredged in the remediation (kg), 69800 kg as estimated in FS (USEPA, 2001).

The allowable 7-day and 4-week Total PCB load loss thresholds will be revised if the production rate varies from the anticipated value or the operation schedule differs from that assumed for this report. The equation for estimating the allowable Total PCB load loss is as follows:

$$Load_{TPCB,allowable} = \frac{m_{dredged}}{P_{t\arg et} * T} * Load_{threshold} \quad (3\text{-}11)$$

where:

m_{dredge} = Total PCB mass dredged within a period, kg

$P_{t\arg et}$ = Targeted production rate, kg/hour. This is given as:

$$P_{t\arg et} = \frac{M}{T_d * D_{year} * Y} \quad (3\text{-}12)$$

where:

M	=	Total PCB mass targeted to be dredged in the remediation (kg), 70,000 kg as estimated in FS (USEPA, 2001).
T_d	=	assumed average period of dredging operations per day, 14 hours/day.
D_{year}	=	assumed number of days in one dredging season, 210 days/season.
Y	=	number of dredging seasons during the remediation.

$Load_{threshold}$ = Total PCB load thresholds specified in action levels, such as 300 g/day and 600 g/day.

The load calculation may be corrected for contributions originating upstream of the remediation (*i.e.*, above Rogers Island) in the event that loads from this region fall above levels typically observed. If loads at Rogers Island rise beyond the 95th percentile for the seven-day and 4-week measurements, the downstream load calculations may be corrected by subtracting the difference between the 95th percentile value and the actual value at Rogers Island from the load calculated for the downstream station.

3.1.4 Resuspension Standard Threshold

Resuspension Standard threshold is a confirmed occurrence of 500 ng/L Total PCBs, measured at any main stem far-field station. To exceed the standard threshold, an initial result greater than or equal to 500 ng/L Total PCBs must be confirmed by the average concentration of four samples collected within 48 hours of the first sample. The standard threshold does not apply to far-field station measurements if the station is within one mile of the remediation.

3.2 Semi-Quantitative Relationship Between Suspended Solids and Turbidity

As a part of the monitoring program, continuous reading suspended solids or turbidity meters are required at the near-field and far-field stations. The program also requires discrete grab samples to be collected every three hours. The following discussion covers the development of a semi-quantitative relationship between suspended solids and turbidity. It is expected that this relationship will allow for a substantial decrease in discrete suspended solids sampling while also providing continuous information on suspended solids.

PCB concentrations cannot be determined easily and quickly in the field. PCB laboratory analyses are time-consuming and costly and, in the near-field, the dredging related contribution would not be easily distinguishable from the baseline contributions from the sediments. It is expected that suspended solids can ultimately serve as a surrogate for dredging-related PCB contributions, because the primary mechanism of release is expected to be resuspension of contaminated sediment unaccompanied by a significant dissolved phase PCB release. (The monitoring requirements, especially the contingency monitoring with split phase, will determine if this is true.) Suspended solids analyses will also become costly if collected at a high frequency at each remedial operation and the results will not be available for three hours. Turbidity is easily and rapidly measured with real time monitoring devices. In order to use turbidity measurements effectively, a correlation between the suspended solids concentrations and turbidity readings will be developed that is site specific and accounts for the differing turbidity responses from buried and surficial sediments. Without a correlation between turbidity and suspended solids, the turbidity monitoring cannot be compared to the resuspension criteria.

Site-specific relationships between suspended solids and turbidity have been developed for other sites. This is discussed in Section 2.2.1 and the results of a literature search are presented in Attachment F-1. Because correlations have been found between suspended solids and turbidity at other sites, it is likely that a semi-quantitative relationship between these parameters can be developed for the Hudson River.

A study conducted by USACE (Thackston and Palermo, 2000) indicates that the correlations observed between turbidity and suspended solids are site-specific. There is not a universal correlation between turbidity and suspended solids, among turbidity measurements made on different water-sediment suspensions, or between measurements taken on the same sample using different instruments. Existing correlations between turbidity and suspended solids have been developed in the laboratory using whole sediment samples. Generally, any sample used to produce a correlation curve between suspended solids and turbidity must be suspension-specific, not just site-specific. The sample must approximate the suspension to be represented in size, number, shape and type of the particles.

Establishing a semi-quantitative relationship between suspended solids and turbidity in the near-field and far-field is not required, but it is strongly recommended that this effort be undertaken. With this relationship, the turbidity measurements would provide a real time indication of PCB concentrations possibly leading to a reduction in sampling frequency for PCBs in Phase 2. The development of a relationship also has the potential to reduce suspended solids monitoring in Phase 1 while actually improving the level of knowledge of PCB and suspended solids release.

3.3 Monitoring Plan

A description of the monitoring plan is provided in this section. Measurement techniques, monitoring locations, parameters, sampling frequency and requirements of the standard are provided. Attachment F provides a description of measurement techniques for the continuous monitoring requirements. Some of the more stringent aspects of this monitoring program, such as higher frequency sampling and short turnaround can be relaxed if the public water supplies are sufficiently protected by additional water treatments or alternate water supplies throughout the remediation. A clear rationale for each element of the monitoring plan is provided in Attachment G.

3.3.1 Measurement Technologies

Sampling techniques and technologies have been reviewed to select the appropriate technologies to obtain the monitoring data needed to confirm adherence to the standard. The far-field monitoring will build on the Baseline Monitoring Program implemented during the remedial design period (2003 – 2005). The near-field monitoring will have a reduced set of parameters and has little relation to previous sampling efforts. Some additional components will be required to give a full picture of the conditions during dredging (e.g., continuous monitoring for PCBs), but will not be assessed against the action levels in Phase 1.

Instruments that provide an instantaneous measure of water column conditions will be used for the following parameters:

- Turbidity
- Dissolved oxygen
- Temperature
- pH
- Conductivity
- Suspended Solids Particle Counters

Continuous measurement of water column conditions will be made for:

- Turbidity
- Suspended Solids Particle Counters
- Integrating Sampler for PCBs (continuous sampler)

The analytical methods will need to be sensitive enough to measure water column concentrations at each station. This is most important for PCBs. For Total and Tri+ PCBs, a congener-specific method with a detection limit low enough to detect expected PCB congener concentrations at Bakers Falls, Rogers Island, and Waterford is required (*i.e.*, 0.05 ng/L per congener). The same analytical methods must be used at each station throughout the program.

3.3.2 Monitoring Programs

Far-Field Monitoring

The far-field stations will be used to monitor water column conditions in the Upper and Lower Hudson River. These results are needed for comparison to the baseline water column concentrations to estimate the magnitude of any dredging-related release. Due to the anticipated extent of remediation and associated barge traffic, dredging-related releases may not be limited to a single area and so monitoring of multiple stations is anticipated throughout the dredging period. The parameters of primary interest are PCBs and related parameters including turbidity, suspended solids, DOC and Suspended OC. Turbidity and suspended solids will be used as indicators of dredging-related releases assuming the mechanism for increased PCB concentrations associated with dredging will be resuspension of contaminated sediment. DOC and Suspended OC describe the dissolved and suspended matter distribution of PCBs in the water column. These parameters also may be useful in determining the source of elevated concentrations.

The far-field Upper Hudson River sampling will entail the measurement of PCB congeners, suspended solids and organic carbon by taking discrete, cross-sectional grab samples. These measurements are needed to assess the impacts of the dredging operations and to provide a basis for a warning system for the downstream water intakes. The required sampling in the Lower Hudson River is similar to the far-field Upper Hudson River sampling, but is more limited in the extent and frequency of sampling. Data from these samples will identify increased impacts to the Lower Hudson River from dredging and be compared to resuspension criteria.

Unless stated otherwise, the monitoring and sampling at each station will be performed using equal discharge increment (EDI) or equal width increment (EWI) sampling techniques. The EDI or EWI methods usually result in a composite sample that represents the discharge-weighted concentrations of the stream cross-section for the parameter that is being monitored or sampled. The EDI and EWI methods are used to divide a selected cross-section of a stream into increments having a specified width. The term vertical refers to that location within the increment at which the sampler or the measurement probe is lowered and raised through the water column. EWI verticals are located at the midpoint of each width increment. EDI verticals are located at the centroid, which is a point within each increment at which stream discharge is equal on either side of the vertical. If properly implemented, EDI and EWI methods should yield identical results. These sampling methods will be applied for all parameters measured in the water column.

Continuous integrating samplers will be required at each of the Upper Hudson River stations between Fort Edward and Waterford. These samplers will be used throughout the dredging program to integrate PCB loads and concentrations over time, providing a measure of PCBs releases between the discrete samples. By integrating data over time intervals in the periods between the discrete water column samples, this information will enable the identification of dredging related releases, including the dissolved phase PCB, that cannot otherwise be identified by examining surrogate measurements (such as suspended solids). The Phase 1 results may be used to develop resuspension criteria for Phase 2.

The continuous suspended solids monitoring consists of monitoring suspended solids using direct reading laser diffraction based particle counters or turbidity monitors correlated to suspended solids at 5 main-stem Upper Hudson River stations between For Edward and Waterford. Suspended sediment data that will be collected during the baseline/pre-dredge phase will be used to develop a database that will document spatial and seasonal naturally occurring variations in the suspended solids loading in the Upper Hudson River. This database will then serve as a baseline that will be compared with measurements made during construction of the remedy to determine the impacts of the remedial action and, if necessary, provide a warning system for downstream water intakes in the Hudson River.

Suspended solids and flow will be monitored continuously at the main-stem stations of the far-field Upper Hudson River between Fort Edward and Waterford. Suspended solids measures are needed to provide real time information on suspended solids during dredging. These data are also needed to establish the anticipated normal range of suspended solids conditions for the local suspended solids monitoring to be performed in the vicinity of the dredge during remediation. Suspended solids will be collected every three hours, 24 hours per day, unless an acceptable correlation between turbidity and suspended solids is developed during the baseline monitoring period. If turbidity can be used a surrogate for suspended solids, the number of suspended solids measurements required by the performance standard at the far-field stations will be greatly reduced. The flow rate at each location is needed for comparison of the discrete sample measurements to the load-based criteria. The net suspended solids concentrations will be compared to resuspension criteria.

Particle counters will be installed at four main stem stations: TI Dam, Schuylerville, Stillwater, and Waterford. This will potentially provide an additional means of relating a continuous, real time measurement to suspended solids.

Monitoring parameters required by the performance standard, but not compared to resuspension criteria, are:

- Temperature
- pH
- Conductivity
- Dissolved Oxygen

The remediation could alter the surface water quality in the vicinity of the dredge. DO will be monitored, because high suspended solids could exert a demand on oxygen levels which is potentially damaging to biota in the region of the dredge. These values will be compared to baseline values to determine if the surface water quality has altered significantly. Conductivity and pH measurements provide a measure of quality assurance for the data. The pH values can be compared to the New York state surface water standard. Temperature will be monitored because PCB concentrations are partially dependent on water column temperature.

Near-Field Monitoring

Suspended solids will be continuously measured at the near-field monitoring locations surrounding the dredges (and other remedial operations) using turbidity as a surrogate. Turbidity monitoring is required to address two goals of the Phase 1 standard: to provide a real time measure of conditions surrounding the dredging operation; and to provide feedback to the dredge operator. The real time measure provides an immediate signal to the dredge operator in the event of an unexpected release. It also provides the dredge operator with feedback, providing information on the amount of resuspension resulting from various dredge manipulations. Using this information, the dredge operator is expected to optimize the manipulations of the dredge to avoid unnecessary resuspension.

Depth-integrated water column samples will be collected every three hours at each near-field monitoring location and analyzed for suspended solids. These data will be used for compliance with the near-field suspended solids concentration criteria. If a semi-quanititative relationship between turbidity and suspended solids can be established by a laboratory study, the continuous turbidity readings can be used in place of the laboratory analyses and only one sample for laboratory analysis of suspended solids collected from each near-field monitoring station per day. The daily measurements will be used as a confirmation of, or correction to, the correlation. The requirement that the suspended solids be measured manually each day allows the continuous monitors to be routinely checked for problems such as bio-fouling and damage, as well as verifying the adequacy of the correlation.

Daily particle counter measurements will be required at each near-field monitoring location. This will provide an additional means of relating a real time measurement to suspended solids.

3.3.3 Monitoring Locations

Far-field Monitoring

The following stations comprise the far-field monitoring stations for the Upper Hudson River:

- Thompson Island Dam (River Mile [RM] 188.5).[8]
- Schuylerville (RM 181.3).
- Stillwater (RM 168.3).
- Waterford (RM 156.5).

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[8] The Thompson Island Dam station will be a true cross-sectional station, as opposed to the historical TID West or PRW2 stations.

Two upstream baseline stations will be monitored in the Upper Hudson River:

- Bakers Falls (RM 197.3).
- Rogers Island (RM 194.4).

The Bakers Falls and Rogers Island stations represent baseline conditions for the remediation area and thus need to be monitored regularly to avoid confusion between dredging-related releases and those that may have occurred upstream. The frequency of monitoring at Bakers Falls will be less than that at Rogers Island, if the Bakers Falls station continues to exhibit low baseline levels of PCB and suspended solids relative to Rogers Island conditions.

In the Lower Hudson River, the following stations will be monitored:

- Albany (approximately RM 140).
- Poughkeepsie (RM 77).

In addition to these Lower Hudson River stations, a monitoring station will also be required on the Mohawk River at Cohoes to estimate PCB loads from the Mohawk watershed. This station will be used in conjunction with the measurements at the Lower Hudson River monitoring locations to aid in identifying the fraction of any PCB load increase from the Mohawk River, as opposed to the Upper Hudson River remedial activities.

The daily (and any continuous) measurements at the far-field stations must reflect the river cross section at the monitoring location by using either an equal-discharge-increment (EDI) or equal-width-increment (EWI) sampling technique (USGS, 2002). At least five locations will be monitored in each cross section. Discrete samples in the cross section may be composited, but continuous reading devices (*i.e.*, turbidity) are required at multiple locations in the cross section.

Near-Field Monitoring Locations

Near-field monitoring locations are associated with individual dredge operations and move as the dredging operation moves. Each remedial operation requires five monitoring locations, which are arranged as shown in Figure 1-1 and described as follows:

- One station located approximately 100 m upstream of the dredging operation will monitor water quality conditions entering the dredging area to establish ambient background conditions.

- One station located 10 m to the channel side of the dredging operation will monitor local boat traffic impacts.

- One station located 100 m downstream of the dredging operation or 50 m downstream of the most exterior silt control barrier will monitor the dredge plume.

- Two stations located 300 m downstream of the dredging operation or 150 m downstream of the most exterior silt control barrier will monitor the dredge plume.

If silt control barriers are installed, the five stations will be placed outside of the barrier. A sixth location within is required in the controlled area downstream of the dredge. While there is no standard for this inner station, it is needed to develop a relationship between conditions inside the silt barriers and the near-field monitoring stations just downstream. The distances from the remedial operations are approximate and the location of the near-field stations may be changed in the field to better capture the plume, if USEPA approves the change. It is acknowledged that the location of remedial operations and silt barriers will be determined during the design. As a result, the location of the near-field monitoring stations can only be anticipated in this standard, but will be reviewed as a part of the design. Work plans developed for the remediation must specify a means of verifying that the downstream monitors are placed to capture the plume. With changing river conditions and movement of the dredge, periodic adjustment of the monitor locations will be required.

3.3.4 Frequency and Parameters

The parameters and frequency of sampling required by the Resuspension Standard are presented in Tables 1-2, 1-3 and 1-4 for routine monitoring and each action level. The parameters required are constant throughout, but the sampling method or analytical technique may differ in some instances. The sampling frequency varies by station and action level.

Far-field Monitoring Parameters and Frequency

Table 3-5 presents the relevant information for each parameter that will be monitored as part of the far-field Upper Hudson River program. PCB congeners will be analyzed using the Green Bay method or an equivalent method. Attachment F-2 provides a synopsis of PCB analytical methods and associated detection limits. Laboratory analysis of suspended solids will be conducted using a method equivalent to ASTM method 3977-97. The entire sample collected will be used for the suspended solids and PCB analyses.

All measurement techniques require sufficient sensitivity in order to avoid non-detect values at most stations. For PCB congeners, low detection limits will be required at Bakers Falls, Rogers Islands and Waterford. Discrete sample must be collected from a potentially impacted water parcel as it passes the station, although samples from different stations do not need to be timed to correspond to the same water parcel.

The type of integrating sampler will be determined during design. Analysis for DOC, suspended OC and suspended solids will be required in addition to PCB congeners for these samples, if this is appropriate for the type of sampler chosen.

Whole water samples for PCB analysis will be filtered at the laboratory, the PCBs extracted on the dissolved and suspended phases separately using matrix-specific extraction and cleanup methods used for the Reassessment RI/FS or similar methods demonstrated to be capable of achieving equivalent extraction efficiencies. Justification for this approach is provided in Attachment F-3. Analyses will be done on the entire sample collected to avoid misrepresenting the fraction of PCBs in the suspended phase.

Routine monitoring of the six Upper River main-stem stations will consist of grab samples and continuous monitoring. Non-routine monitoring will require the same analyses, but the sampling method and frequency will vary with the station and action level. Grab samples will be composited from five samples in the cross-section using the EDI sample collection method. Continuous monitors will be located in five locations in the cross-section, if possible.

At Bakers Falls, one whole water PCB sample will be collected per week. DOC, suspended OC and suspended solids will be measured for these samples. The surface water quality parameters to be measured are turbidity, temperature, pH, conductivity, and dissolved oxygen. Routine and non-routine monitoring are the same for this station. Laboratory results must be available within 72 hours of the collection of the sample. This station will be sampled from only one location in the cross-section.

At Rogers Island, one whole water PCB sample will be collected per day. DOC, suspended OC and suspended solids will be measured for these samples. Surface water quality parameters to be measured continuously are turbidity, temperature, pH, and conductivity. Dissolved oxygen measurements will be made along with each grab sample collected for suspended solids. Samples will be collected for suspended solids every three hours and 24 hours per day. An integrating sampler will be deployed continuously for two-weeks throughout the construction season. Laboratory results for grab samples must be available within 72 hours of the collection of the sample, except for suspended solids results which must be available within three hours. Routine and non-routine monitoring are the same for this station. The monitoring frequency at Rogers Island may be reduced to weekly for all parameters except suspended solids, if the data will not be used to monitor for releases from the upstream sources that could be interpreted as releases from the remediation. Reduction in frequency at this station will require approval from USEPA.

USEPA has not yet identified the location of the Phase 1 dredging. Assuming that the remediation will be limited to the northern end of the TI Dam during Phase 1, there will be two representative stations that are sampled with a shorter turnaround and a higher frequency for monitoring contingencies. These stations are the TI Dam and Schuylerville stations. Stillwater and Waterford stations will be monitored to measure the PCB concentrations entering the Upper Hudson River public water treatment plants in Halfmoon and Waterford. The monitoring will also be used to confirm or adjust the means by which Total PCB concentrations for the Waterford station have been estimated based on the concentrations at the upstream stations. This information will be important during Phase 1 to understand the behavior of the system, but the frequency of sampling at these downstream locations will most likely be reduced in Phase 2.

Routine monitoring for the four Upper River far-field stations from the TI Dam to Waterford will be identical to the monitoring at Rogers Island with two exceptions. Suspended solids will be continuously monitored with a particle counter at these stations. Grab sample laboratory results for parameters other than suspended solids must be available within 24 hours of the collection of the sample for the TI Dam and Schuylerville.

Non-routine monitoring at the two representative stations (TI Dam and Schuylerville) will increase in frequency for the PCB, DOC, suspended OC and suspended solids samples and the PCB analyses will be on the dissolved and suspended phases instead of whole water. For the Evaluation Level, the samples will be collected twice a day. For the Concern Level, the samples will be collected three times a day. For the Control Level and Resuspension Standard threshold, the samples will be collected four times a day, but will be composited from samples collected hourly over 1 six-hour period. The deployment period for the integrating sampler will also vary. For the Evaluation Level, the deployment period is the same as for routine monitoring. For the Concern and Control Levels, the integrating sampler will be deployed for periods of one week. For the Resuspension Standard threshold, the integrating sampler will be deployed for one day periods.

The sampling frequency and turnaround time for the farthest downstream stations (Stillwater and Waterford) is unchanged from routine monitoring at these stations for the Evaluation Level. The sampling method changes for the Concern and Control levels from discrete grab samples to daily integrating samples to capture the average concentration in what could be a rapidly changing environment. The grab sample analytical results will be required within 72 hours for the Concern Level and 24 hours for the Control Level. The shorter turnaround for the Control Level is warranted because the Total PCB concentration could be approaching the Resuspension Standard threshold or the PCB load loss to the Lower Hudson River has exceeded the allowable rate for an extended period of time. For the Resuspension Standard threshold, these stations will be sampled four times a day for whole water PCBs, DOC, suspended OC and suspended solids as well as the surface water quality measurements with the results required from the laboratory within 24 hours of the sampling time. In addition, an integrating sampler will be deployed for one day periods.

The turnaround time for PCB analyses from the integrating sampler will only be specified where the information is needed quickly for comparison to the resuspension criteria. For the Resuspension Standard the turnaround times will be 24-hours for the two representative far-field stations (TI Dam and Schuylerville stations) and the stations farther downstream (Stillwater and Waterford stations). For the Concern and Control Levels at Stillwater and Waterford, the turnaround times will be 72-hours and 24-hours, respectively.

These monitoring contingencies are for remediation of River Section 1 more than one mile upstream from the TI Dam. The monitoring contingencies would be different for remediation conducted River Section 2 and 3. In general, the two stations downstream of the dredging will have the parameters, frequency, sampling methods and turnaround times associated with the TI Dam and Schuylerville as described above. Stations below these stations will have the parameters, frequency, sampling methods and turnaround times associated with Stillwater and Waterford as described above. If the remediation is conducted in more than one river section, more than two stations are representative. If there were an accidental release in a section that was not undergoing remediation at that time, the two stations at least one mile downstream of the accidental release would be representative until the situation was resolved. Representative stations must always more than one mile downstream from the source of the resuspended material.

In the event that a far-field suspended solids resuspension criterion is exceeded, a far-field station would be monitored for PCBs. Exceedance of Evaluation Level criteria will prompt far-field Evaluation Level discrete sample monitoring requirements. Exceedance of Concern Level criteria will prompt far-field Concern Level monitoring discrete sample monitoring requirements. This additional far-field sampling will be limited to the nearest downstream representative far-field station or the next downstream station, depending on the location of the plume causing the exceedance. Sample collection will be timed to capture the plume. The frequency, parameters and sampling methods will be the same as those defined for the TI Dam and Schuylerville in Table 1-2.

If the monitoring requirements change because of exceedance of a resuspension criterion or reverting to lower action levels, the deployment period of the continuous integrating samplers may change before completion of the period. If the deployment period is reduced, the sample already collected will be sent for analysis. If the deployment period is extended, the sampling period can be extended to match the new requirements.

Lower Hudson River and the Mohawk River at Cohoes

Far-field stations in the Lower Hudson River and at one location in the Mohawk River will require routine monitoring. Sampling at these stations will include the analysis of PCBs congeners, DOC, suspended OC and suspended solids. The samples will be whole water, not split phase. Surface water quality measurements for turbidity, temperature, pH, conductivity and dissolved oxygen will be made with a probe. The results of the analyses will be required within 72-hours. Samples will be collected every four weeks under routine monitoring. (This low frequency is contingent on the results of the Baseline Monitoring Program showing Total PCB concentrations less than 100 ng/L on average to allow a margin of safety for the public water supplies.) The Mohawk River station will be sampled using EDI or EWI, but only at a single center-channel station is required for the Lower Hudson River stations.

Non-routine monitoring at these locations will be triggered by an estimated Total PCB concentration of 350 ng/L or higher at Waterford or Troy. The first round of non-routine monitoring will be timed to capture the parcel of water that triggered the non-routine Lower Hudson River and Mohawk River monitoring.

The concentration is estimated using the following equation:

$$C_{Lower\ \ Hudson} = C_{Far-field} \times \frac{Q_{Far-field}}{Q_{Troy}}$$

where:

C_{Troy}	=	Estimated water column concentration Troy.
$C_{Far\text{-}field}$	=	Measured water column concentration at the far-field station, typically Thompson Island Dam or Schuylerville.

$Q_{Far\text{-}field}$	=	Instantaneous flow at the far-field station (cfs) at the time of sample collection.
Q_{Troy}	=	Instantaneous flow over Federal Dam at Troy

Near-field Monitoring

Table 3-6 presents the relevant information for each parameter that will be monitored as part of the near-field program. Each near-field station will have continuous monitoring for turbidity, temperature and conductivity for one hour prior to beginning remedial operations and continue for at least two hours after the operation ceases or until baseline conditions are confirmed by two consecutive one-hour measurements. This applies to the five stations required if there are no barriers installed, and to all six stations if barriers are installed. The information from these monitors will provide immediate feedback to the dredge operator. Daily particle counter measurements at each station will be required in Phase 1.

As discussed in Section 3.2, a correlation between suspended solids and turbidity may or may not be sought and found. Without the correlation, depth-integrated samples will be collected from each near-field station (5 or 6 per remedial operation) every three hours with the results of the analysis available within three hours. These results will be compared to the resuspension criteria. One sample from each near-field station will be collected one-hour prior to beginning the remedial operations at a location. After completing the remedial operation, at least two samples collected one hour apart will be used to confirm that the suspended solids concentrations have stabilized. (This will require the sampling to continue for at least another 4 to 5 hours because of the 3-hour turnaround time on the analyses.) More samples will be required if the suspended solids concentrations have not stabilized two hours after completing the remedial operation. If the remediation is halted due to hazardous conditions such as thunderstorm, the near-field monitoring to show that the suspended solids concentrations have stabilized will not be required.

Turbidity or another continuously monitored parameter can be used to establish the ambient conditions, estimate suspended solids concentrations for comparison to the resuspension criteria and confirm that the suspended solids concentrations have stabilized following completion of the remedial operation if a satisfactory correlation to suspended solids can be demonstrated. One sample from each near-field station will be required per day if a continuous measurement is a surrogate for suspended solids.

If a continuous measurement is used as a surrogate for suspended solids, routine and non-routine monitoring in the near-field are identical. If a continuous measurement is used for comparison to the resuspension criteria and a station has a action level exceedance, depth-integrated samples will be collected for suspended solids with the results available within three hours for the station with the exceedance. Exceedance of Evaluation Level criteria will prompt far-field Evaluation Level monitoring. Exceedance of Concern Level criteria will prompt far-field Concern Level monitoring. This additional sampling will be limited to the nearest downstream representative far-field station and timed to capture the plume from the remedial operation. The frequency, parameters and sampling methods will be the same as those defined for the TI Dam and Schuylerville in Table 1-2.

Additional sampling in the near-field may be conducted as a part of the engineering evaluations. Samples for PCB analysis may be collected in the vicinity of the dredges or in other areas affected by the remediation. The same sampling and analytical methods will be used for comparison to the near-field and far-field data.

3.3.5 Reverting to Lower Action Levels

Any reduction in monitoring requires approval from USEPA before the changes are made. USEPA may approve a reduction in the level of monitoring when the following occurs for Total PCB criteria:

- For the exceedance of a Concern Level concentration threshold level, two days of values below the action level are required before the contingencies can be relaxed.
- For the exceedance of a Evaluation or Concern Level seven-day running average load-based criterion, the running average load level must fall below the action level for one week before the contingencies can be relaxed.
- For the exceedance of the Control Level 4-week running average load-based criterion and concentration threshold, 15 days of values below the action level are required before the contingencies can be relaxed.
- Following exceedance of Resuspension Standard threshold, temporary halting of in-river operations and modification of the remedial operation, Control Level monitoring requirements will commence unless otherwise instructed by USEPA.
- Routine monitoring will resume in the Lower Hudson after non-routine monitoring has confirmed that the concentrations in the Lower Hudson are below 350 ng/L Total PCBs and the estimated concentration at Waterford and Troy have fallen below 350 ng/L Total PCBs for at least two days.

USEPA may approve a reduction in the level of monitoring when the following occurs for suspended solids criteria:

- Following exceedance of suspended solids criteria, the suspended solids concentrations must fall below the action level for one day before the contingencies can be relaxed.

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

3.4 Engineering Contingencies

For the Hudson River remediation, engineering contingencies must be considered for the dredging operation in the event that the action levels are exceeded. Engineering contingencies will be recommended for consideration when the Evaluation or Concern Levels are exceeded by any measure (suspended solids or PCB, near-field or far-field). Engineering contingencies will be required and implemented if the Total PCB or Tri+ PCB concentrations exceed the Control Level or the Resuspension Standard (500 ng/L Total PCBs) based on monitoring results at the far-field stations. In the event of exceeding the Control Level or the Resuspension Standard threshold, an adjustment to the remedial operation is mandatory. However, for the lower tier action levels (the Evaluation and Concern Levels), an adjustment to the operation is optional.

Additional monitoring is mandatory when any of the action levels criteria parameter (*i.e.,* Total PCBs, Tri+ PCBs or suspended solids) is exceeded. Engineering evaluations of the source of the exceedance are also required when any of the Concern Level, Control Level or the Resuspension Standard threshold is exceeded.

The performance standard requires increased monitoring contingencies, engineering evaluations, and modification of remedial operations for exceedance of the action levels. Section 3.3 describes the monitoring contingencies. This section describes the engineering evaluations, suggested technologies to control resuspension, and the requirements of the standard in this regard. These engineering evaluations and technologies are described in general terms here, but will be specified during the remedial design and possibly modified during the remedial operation.

Recommended and required engineering contingencies are listed below for each action level and the Resuspension Standard threshold.

Evaluation Level Evaluate and identify any problems. Examine boat traffic patterns near the dredges. Examine sediment transfer pipelines for leaks. Recommend engineering evaluations near the dredges and barges. Other engineering evaluations recommended as well. Recommend PCB sample collection in the near-field or other areas of the operation as a part of an engineering evaluation.

Concern Level Engineering evaluation mandatory if the exceedance is caused by high PCB concentration at the far-field station. Evaluate and identify any problems. Consider the use of shallower barges, suspended sediment control barriers, or silt curtains. Modify dredge operations. Perform engineering evaluations near the dredges and barges.

Control Level Mandatory engineering evaluation and continual adjustments to dredging operations until the Concern Level or better is attained. Evaluate and identify any problems. Consider change in silt barriers or dredge type. Consider implementing silt barriers, if not already in use. 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. Temporary cessation of operations may be required. The initial engineering solutions must be implemented within 10 days of exceeding this action level.

Resuspension Standard

Mandatory cessation of all operations in the river if PCB concentration levels in excess of 500 ng/L Total PCBs are confirmed by next day's samples. Restart requires engineering evaluation and USEPA approval. The evaluation should be completed with 10 days of shut down.

3.4.1 Engineering Evaluations

The engineering evaluation includes the study of all dredge-related operations and supporting components. This includes the review of the dredging operation, barrier installation and sediment transportation system. Except for the Evaluation Level, engineering evaluation are required for exceedance of Concern Level, Control Level, and Resuspension Standard. Study is recommended but not required for an Evaluation Level Exceedance. Exceedance of the suspended solids criteria must be confirmed by PCB measurements before actions other than increased monitoring are required. The evaluation and review of the dredging operation should include additional turbidity measurements in the vicinity of the dredge, barge, pipeline, etc. and will be conducted to evaluate the possible source and mechanism causing the exceedance. An engineering evaluation will include the following as needed:

- Examination of the containment barrier, if it is in use, for leaks and stability;
- Examination of the sediment transport pipeline, if a hydraulic dredge is used;
- Examination of the barge loading system and barge integrity, if barges are used;
- Examination of the turbidity associated with the sediment transport barges and other support vehicles; and
- Analysis of near-field water column samples for Total PCBs, as well as analysis of samples from other locations such as along the sediment transport pipeline, the channel, etc.

The evaluation will be briefly documented in a report with approach, results and conclusions for submittal to USEPA. Submittal of a report is mandatory in cases where USEPA must approve modifications to the remediation or give approval to resume operations following temporary halting of remedial operations.

3.4.2 Implementation of Control Technologies

Engineering contingencies consisting of the implementation of specific control technologies recommended for consideration in the event of an exceedance of the Control Level or Resuspension Standard are listed below. The contingencies are for remedial operations. A more detailed description of these technologies is provided in Attachment E to the Resuspension Standard. It is also noted that the use of these contingencies was primarily suggested by the review of relevant case studies (Appendix A of the Preliminary Performance Standard Report) as well as from research done during preparation of the Hudson River FS Report (USEPA, 2000b).

Remedial Operations

Barriers and modifications to operations and equipment are the principal methods that may be useful in reducing the suspended solids and PCB concentrations downstream of the dredging operation.

Barriers

Barrier types reviewed in Attachment E include:

- Fixed Structural Barriers such as sheet piling;
- Non-Structural Barriers such as silt curtains and silt screens;
- Portable Barriers Systems such as the Portadam™ and Aqua-Barrier™ systems;
- Air Gates; and
- Control Zone Technology.

If a barrier system has been implemented, but action levels are still exceeded, further steps that can be considered include:

- Monitor or inspect the barrier for leaks;
- Identify and correct problems with the installation;
- Change the barrier material to a more effective material such as HDPE;
- Install multiple layers of barriers; and
- Fasten the barrier to the river bottom.

Operation and Equipment Modifications

Operation and equipment modifications that may reduce the generation of suspended sediments include:

- Limiting/reducing boat speeds to reduce prop wash;
- Restricting the size of boats that can be used in certain areas;
- Loading barges to less than capacity where necessary to reduce draft;
- Use of smaller, shallow draft boats to transport crew members and inspection personnel to and from the dredges;
- Selection of an alternate dredge with a lower resuspension rate;
- Selection of another means of placing backfill/capping materials; and
- Scheduling changes to the dredge plan/pattern to avoid remediation of highly contaminated areas during times of year when background PCB concentrations are high.

3.4.3 Requirements of the Standard

The standard provides a series of action levels by which the severity of the dredging-related release can be measured and quantified. As an action level is exceeded, engineering evaluations, the implementation of engineering solutions will be suggested or required, based on the level of the exceedance. This tiered level of enforcement is set up to allow for the remediation to be conducted continuously without operation near the Resuspension Standard threshold and subsequent temporary halting of remedial operations due to a confirmed exceedance.

In summary, the Resuspension Standard requires the following:

Action Level	Monitoring Contingencies Required*	Engineering Evaluation Required	Engineering Contingencies Required
Evaluation	Yes	Recommended	No
Concern	Yes	Yes**	No
Control	Yes	Yes	Yes
Resuspension Standard Threshold	Yes	Yes	Yes

* Monitoring requirements for suspended solids exceedances limited for the far-field monitoring to only one or two stations, in order to capture the PCB concentrations in the impacted water column.

** Required only for PCB exceedance at a far-field station, recommended for suspended solids exceedance.

3.4.4 Settled Contaminated Material and the Need for Resuspension Barriers

The near-field modeling results presented in Section 2.2.6 and Attachment D indicate that a substantial amount of the suspended solids will settle in the immediate vicinity of the dredge. In particular, coarse-grained sediments settle very rapidly and so will most likely be captured by a subsequent dredging pass. However, fine-grained sediments remain in the water column sufficiently long to settle in the next several hundred meters to one to two miles downstream of the dredge. While modeling analysis does not show these additions to be significant in terms of long-distance transport, the redeposited sediments do potentially create small regions of elevated contamination just outside the remedial areas. This could elevate the PCB concentration of the river bed surficial sediments downstream of the remediation to concentration levels that are unacceptable even for the least stringent PCB load-based action level (300 g/day).

The potential for redeposition leads to the conclusion that, where appropriate, resuspension barriers of some type should be considered to contain the resuspended material within the target areas, thereby reducing the spread of contaminated material. The need for these controls is suggested by evidence obtained from the dredging on the Grasse Rive. Rising concentrations of Cesium 137 and PCB in the surface layer sediment downstream were observed as part of the post-dredge sampling of the Grasse River Non-Time Critical Removal Action (NTCRA). As shown in Figure 3-4, Cesium 137 increases in the uppermost layers of all 4 cores collected downstream of the dredging operation. The surface layer sediment represents the most recently deposited material. In term of natural variation, the concentration for Cesium 137 is not expected to increase since its source (atmospheric weapons testing) no longer exists. This significant increase is consistent with the release and redeposition of older sediments containing high levels of Cesium 137 as a result of dredging operations. The relatively thin layer suggests this is not a significant redeposition on the scale of miles (the distance among the cores) but does demonstrate its occurrence. PCBs do not show as much response as Cesium 137 but evidence of a recent PCB release is clear in one core (18M). This core shows significantly elevated PCB concentrations at the surface, also consistent with a suspended solids release. The elevated PCB levels associated with this core may also reflect its generally higher PCB levels in recently deposited sediments, suggesting that the location may collect more of the fine-grained, PCB contaminated sediments than the other coring locations. Notably triple silt barriers were used at this site, but the barriers were not fastened to the river bottom, potentially permitting resuspended material to travel beneath the barriers and move downstream. While these data cannot be construed as proof, they do suggest that the calculations prepared on suspended solids settling warrant further consideration. Without barriers, some form of sediment monitoring outside of the target areas may be required. Sediment monitoring for this purpose will be included as a part of the design, if needed.

These data also suggest dredging should generally proceed from upstream to downstream or the associated redeposition will recontaminate remediated areas. Where resuspension barriers are used, the water flow rate within the barriers is expected to be greatly reduced, thereby significantly reducing this problem. Use of these barriers, however, may require the sampling of all surface sediments contained within the barriers, unless some other means is taken to prevent contamination of non-target area.

4.0 Plan for Refinement the Performance Standard for Dredging Resuspension

There will be two opportunities to modify the Resuspension Standard following the completion of the peer review process:

- Before Phase 1; and
- Between Phase 1 and the start of Phase 2.

Additional modifications may be made to the standard during Phase 2, if appropriate.

Prior to Phase1, the baseline monitoring water column program and remedial design sediment sampling will be completed. The additional data collected after the issuance of the standard will improve the ability to measure exceedances of the standard, but are not expected to change the main criteria of the standard itself. The acceptable rate of PCB loss or the acceptable water column concentrations is not expected to be adjusted as the result of additional data since these criteria are based on forecast impacts and risks.

The ongoing water column monitoring program is expected to be enhanced during the Baseline Monitoring Program during the remedial design period. Some modifications to the sampling program may include using cross-section-based sampling (*e.g.*, EDI or EWI) to collect more representative samples, an improved suspended solids analytical method in place of the current total suspended solids method, a PCB congener method with lower detection limits and additional monitoring stations. This is expected to provide at lease three years of additional data prior to the start of construction. These water column monitoring data will be considered in the refinement of the performance standard criteria, since the data will improve the knowledge of baseline conditions. These data will be used to better populate the monthly data distributions used to estimate the average and baseline level of variability of the PCB and suspended solids concentrations. In turn, better estimates of the baseline condition will aid in identifying dredging-related releases during remediation.

As a part of the remedial design, GE is collecting sediment samples throughout the Upper River in order to more precisely define the extent of contamination. This data will be used to revise the estimate of mass to be removed during the remediation. Load-based criteria will be reviewed, if the mass of PCBs to be removed is significantly different from previous estimates.

The data collected during Phase 1 will provide a second opportunity to review the performance standard. These data will be examined and the performance standard revised, if appropriate for use in Phase 2. In particular, correlations between suspended solid and turbidity; suspended solids and PCB concentrations, and grab sample PCB concentrations and integrating sampler should be examined to make maximum use of these monitoring data and possibly reduce the scale of the monitoring effort while still being protective of the environment and human health.

An outline for the approach for refinement of the Resuspension Standard is presented below describing how new information obtained during the remedial design phase, during Phase 1, and if appropriate, during Phase 2 can be reflected in the performance standard criteria. Table 4-1 lists some potential changes to each element of the standard.

Refinement Prior to Phase 1

Prior to Phase 1, the baseline monitoring water column data will be used to improve the estimates of the baseline concentrations and upper confidence limits (UCL) that form the basis of the action levels. The other component of the action levels, the water column concentrations corresponding to the PCB load criteria (*i.e.*, 300 g/day Total PCB mass loss [Evaluation Level] and 600 g/day Total PCB mass loss [Concern and Control Levels], see Tables 1-2 to 1-4), will be adjusted according to the finalized operating and production schedule as presented in the remedial design.

The baseline data will also be used to examine the current distribution of PCBs between the dissolved phase and suspended matter phase. In the event that PCB or suspended solids concentrations exceed the action levels during the remediation, the distribution of dissolved and suspended phase PCBs observed during baseline conditions will form a basis for comparison. These comparisons should aid in identifying the sources and mechanisms responsible for the action level exceedances.

The baseline monitoring data will be used, along with the historical data, to refine the action levels. In addition to providing three more years of data at the three monitoring stations sampled in previous years, the Baseline Monitoring Program includes sampling at Stillwater (RM 163.5) and Waterford (RM 156.5). The baseline average and UCL values will be calculated for these stations based on the baseline monitoring data. The values for the historical stations (TI Dam and Schuylerville) may differ substantially from the data collected to date, because the method of sampling and the analytical method for suspended solids will change at these stations. The baseline samples will be collected in a manner that will provide a representative sample, potentially changing the average and UCL values calculated to date. The analysis of baseline data available at this time is presented in Attachment A.

The acceptable mass of PCBs exported as a result of dredging was added to the baseline concentrations to derive the values presented in Tables 3-1 to 3-3. The magnitude of the increase in concentration is based on the assumption of a 14-hour per day, seven day per week dredging schedule.[1] These values will be adjusted if the hours and days of operation differ from the assumed values during Phase 1 or Phase 2 according to the method defined in Attachment B. The concentration thresholds for the load-based criteria will change further if the productions schedule deviates from the target level.

[1] The increase in concentration is based on adding the dredging-related release at a constant rate during the 14 hour per day operation. The calculated threshold concentration is intended to describe a sample collected from the river during this period. If the dredging operation operates for shorter or longer periods in a day or per week, the daily addition must be adjusted such that the average daily load remains at the action level value.

An outline of tasks to be performed prior to Phase 1 to determine best estimates of the baseline water column levels is provided below:

1. Compare the TID-West and TID PRW2 results with the TID cross-sectional results. Determine if there is a correlation between the historical data and the Baseline Monitoring Program data.

2. Compare the Schuylerville vertical composite results with the Schuylerville cross-sectional results. Determine if there is a correlation between the historical data and the Baseline Monitoring Program data.

3. Calculate the average and UCL values according to the method outlined in Attachment A for all stations. Include the historical data in the analysis, if possible.

4. Incorporate the increase in PCB mass over baseline levels (*i.e.*, 300 g/day and 600 g/day) and calculate or revise the acceptable concentration criteria while also reflecting any changes to the operation or production schedule relative to those assumed for this report.

5. Analyze the ratio of dissolved phase and suspended phase PCB concentrations in the water column during baseline for comparison to measured water column concentrations during the remediation.

6. The amount of PCBs to be dredged will be estimated using the pre-design sediment sample data. The PCB load-based standard will need to be revised if the amount of PCBs to be removed increases significantly (by a factor of two or more) than previously estimated in the RI/FS. The revisions to the standard resulting from this finding, if any, will not necessarily be simple and may require additional analysis to assess the long-term effects of the remediation.

7. PCB load limits will be revised, if the schedule differs from the assumed 14-hours per day, seven days per week basis.

Refinement Post-Phase 1

After completion of Phase 1, refinements to the monitoring program or other components of the Resuspension Standard that may be needed include:

1. Total PCB mass loss for the 300 g/day and 600 g/day criteria will be adjusted according to the operating schedule if there are changes from the 14- hours per day, seven days per week schedule assumed in this report. These criteria will be adjusted according to the production schedule if there are changes from the target level.

2. Near-field suspended solids action levels may be adjusted, taking into consideration the far-field suspended solids and PCB concentrations that correspond to the actual near-field suspended solids concentrations observed during dredging.

3. A reduction in sampling frequency will be considered.

4. The 350 ng/L PCB concentration for the action levels may be reduced if it does not provide a sufficient margin of safety for the public water supplies.

5. The suspended solids far-field and near-field concentration limits may be adjusted using the Phase 1 suspended solids and PCB results.

6. Turnaround times for PCBs and suspended solids may be adjusted, depending on the degree of compliance with the standard among other factors.

7. Near-field station locations may be adjusted based on the experience from Phase 1. Fewer stations may be required for Phase 2 once the behavior of the system has been tested.

8. Implementation of engineering contingencies (as described in Attachment E) may be required to limit the effects of resuspension. Additional monitoring or revisions in monitoring may be required to evaluate the effectiveness of these contingencies.

9. The Evaluation Level may by eliminated.

Further refinements similar to these may also be indicated by monitoring results acquired during Phase 2. In particular, remedial operations in River Sections 2 and 3 may be sufficiently different that adjustments are warranted. Such adjustments will be considered and reviewed by the USEPA at the appropriate time.

Summary

To a large extent, revisions prior to Phase 1 operations will involve improvements to baseline concentration estimates and adjustments to reflect dredging schedules different than that assumed here. Revisions for Phase 2 will most likely involve adjustments to monitoring requirements, with a possible lessening in frequency and intensity of some sampling components as well as further adjustments to the baseline concentrations to better reflect the actual dredge operation schedule. The derivation of the primary PCB criteria is based on estimated loads, impacts and the Federal and State MCL for PCBs. These criteria are unlikely to change in response to information gathered during the remedial design and Phase 1.

5.0 References

Ault, J. S., K.C. Lindeman, and D.G. Clarke. 1998. "FISHFATE: Population dynamics models to assess risks of hydraulic entrainment by dredges," DOER Technical Notes Collection (TN DOER-E4), U.S. Army Engineer Research and Development Center, Vicksburg, MS. www.wes.army.mil/el/dots/doer

Burton, W. H., S.B. Weisberg, and P. Jacobson. 1982. "Entrainment effects of maintenance hydraulic dredging in the Delaware River estuary on striped bass ichthyoplankton," Report to Delaware Basin Fish and Wildlife Management Cooperative, West Trenton, NJ.

Carroll, K.M., M.R. Harkness, A.A. Bracco, and R.R. Balcarcel. 1994. "Application of a Permeant/Polymer Diffusional Model to the Desorption of Polychlorinated Biphenyls from Hudson River Sediment." *Environ. Sci. Technol.* Vol 28, pp. 253-258. 1994.

Connelly, N.A., B.A. Knuth, and C.A. Bisogni. 1992. Effects of the Health Advisory Changes on Fishing Habits and Fish Consumption in New York Sport Fisheries. Human Dimension Research Unit, Department of Natural Resources, New York State, College of Agriculture and Life Sciences, Fernow Hall, Cornell University, Ithaca, New York. Report for the New York Sea Grant Institute Project No. R/FHD-2-PD, September. (Raw survey data also received electronically from study authors.)

Farley, K.J., R.V. Thomann, T.F. Cooney, D.R. Damiani, and J.R. Wand. 1999. An Integrated Model of Organic Chemical Fate and Bioaccumulation in the Hudson River Estuary. Prepared for the Hudson River Foundation. Manhattan College, Riverdale, NY.

General Electric (GE). 2003. Habitat Delineation and Assessment Work Plan, Hudson River PCBs Superfund Site. Prepared by Blasland, Bouck, and Lee. May.

Kuo, A. Y. and D. F. Hayes. 1991. Model for Turbidity Plume Induced by Bucket Dredge, Journal of Waterway, Port, Coastal, and Ocean Engineering, Vol. 117, No. 6, Nov/Dec.

Quantitative Environmental Analysis, LLC (QEA) 1998. Supplementary Remedial Studies Data Report, Grasse River Study Area, Massena, New York, Aluminum Company of America, Massena, New York. October 1998.

Rice, C.P. and White, D.S. (1987) PCB availability assessment of river dredging using caged clams and fish, *Environmental Toxicology and Chemistry*, 6:259-274.

Sloan, R. 1999. NYSDEC. Briefing on 1997 striped bass PCB results. Sent to J. Colquhoun, NYSDEC. February 11.

Thackston, E.L., and Palermo, M. R., 2000. "Improved Methods for correlating turbidity and suspended solids monitoring," DOER Technical Note E8, U.S. Army Research and Development Center, Vicksburg, MS.

U. S. Army Corps of Engineers (USACE). 2001. Final Pre-Design Field Test Dredge Technology Evaluation Report, New Bedford Harbor Superfund Site, New Bedford, Massachusetts. Prepared by Foster Wheeler Environmental Corporation, Boston, Massachusetts. August 2001.

United States Environmental Protection Agency (USEPA). 1997. Phase 2 Report, Further Site Characterization and Analysis, Volume 2C -Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs RI/FS. Prepared for USEPA Region 2 and USACE by TAMS Consultants, Inc., the Cadmus Group, Inc., and Gradient Corporation. February 1997.

USEPA 2000a. Phase 2 Report: Further Site Characterization And Analysis. Volume 2F Revised Human Health Risk Assessment, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc. and Gradient Corporation. November 2000.

USEPA 2000b. Phase 3 Report: Feasibility Study, Hudson River PCBs Reassessment RI/FS. Prepared for EPA Region 2 and the US Army Corps of Engineers (USACE), Kansas City District by TAMS Consultants, Inc. December 2000.

USEPA 2000c. Phase 2 Report: Revised Baseline Modeling Report, Hudson River PCBs Reassessment RI/FS. Prepared for EPA Region 2 and the US Army Corps of Engineers (USACE), Kansas City District by TAMS Consultants, Inc. January 2000.

USEPA 2000d. Guidance for the Data Quality Objectives Process. EPA/600/R-96/055. August 2000.

USEPA. 2000e. Phase 2 Report Further Site Characterization and Analysis, Volume 2F – Revised Baseline Ecological Risk Assessment Hudson River PCBs Reassessment RI/FS. Prepared TAMS Consultants, Inc. and Menzie-Cura & Associates, Inc. November 2000.

USEPA. 2002a. Responsiveness Summary: Hudson River PCBs and Record of Decision, Prepared for USEPA Region 2 and United States Army Corps of Engineers by TAMS Consultants, Inc., http://www.epa.gov/hudson/rod.htm

USEPA. 2002b. Responsiveness Summary for the Hudson River PCBs Site Record of Decision. Prepared by TAMS Consultants, Inc. January 2000.

USGS. 2000. A Mass Balance Approach for Assessing PCN Movement during Remediation of a PCB-Contaminated deposit on the Fox River, Wisconsin. USGS Water-resources Investigations Report 00-4245, December.

USGS, 2002. National Field Manual for the Collection of Water-Quality Data, Techniques of Water-Resources Investigations, Book 9, Handbooks for Water-Resources Investigations, Section 4.1.1, http://water.usgs.gov/owq/FieldManual/. Visited 11/2002. Last updated 9/1999.

Additional references are provided in the attachments.

Table 1-1
Resuspension Criteria[1]

Parameter		Resuspension Standard Threshold		Action Levels: Control Level[2]		Concern Level		Evaluation Level	
		Limit	Duration	Limit	Duration	Limit	Duration	Limit	Duration
Far-Field PCB Concentration	Total PCBs	500 ng/L	Confirmed Occurrence [8]	350 ng/L	4-week running average	350 ng/L	7-day running average		
Far-Field Net PCB Load[3]	Total PCBs			65 kg/year[4]	Dredging Season				
	Tri+ PCBs			22 kg/year[4]					
	Total PCBs			600 g/day	4-week running average	600 g/day	7-day running average	300 g/day	7-day running average
	Tri+ PCBs			200 g/day		200 g/day		100 g/day	
Far-Field Net Suspended Solids Concentration[5,6]	All Sections					24 mg/L	Daily dredging period (> 6 hrs.) OR 24 hrs. on average	12 mg/L	6-hour running average net increase OR average net increase in the daily dredging period if the dredging period is less than 6 hrs.
Near-Field (300 m) Net Suspended Solids Concentration[7]	Sections 1 & 3					100 mg/L	Daily dredging period (> 6 hrs.) OR 24 hrs. on average	100 mg/L	6-hour running average net increase OR average net increase in the daily dredging period if the dredging period is less than 6 hrs.
	Sections 2					60 mg/L		60 mg/L	
Near-Field (100 m and Channel-Side) Net Suspended Solids Concentration[7]	All Sections							700 mg/L	3 continuous hrs. running average.

Notes:
1. Implemention of the criteria is described in Section 3.
2. Engineering contingencies for the Control Level will include temporary cessation of the operation.
3. Net increases in PCB load or suspended solids concentration refers to dredging related releases over baseline as defined in the text.
4. During Phase 1, half of the anticipated average production rate will be achieved. As a result, the total allowable export for Phase 1 is half of the fullscale value of 130 kg/year for a total of 650 kg for the entire program. This is equivalent to the 600 g/day Total PCB release at the target productivity schedule, during the dredging season from May to November. The Tri+ PCB values are 22 kg/year for Phase 1, 44 kg/year for full scale production and 220 kg for the entire program.
5. The increased far-field monitoring required for exceedance of suspended solids criteria must include a sample timed so as to capture the suspended solids plume's arrival at the far-field station.
6. The monitoring requirements for exceedance of the suspended solids action levels are increased frequency sampling at the nearest far field station. The increased frequency at this station will be the same as the frequency required for the PCB action levels.
7. All remedial operations will be monitored in the near-field during Phase 1, including backfilling.
8. Exceedance of the Resuspension Standard must be confirmed by the 4 samples that are collected once a concentration greater than 500 ng/L Total PCB is detected. The average of the 5 sample concentrations is compared to the Resuspension Standard. The Resuspension Standard is exceeded if the average concentration is greater than 500 ng/L Total PCB.

Table 1-2
Sampling Requirements on a Weekly Basis - Upper River Far-Field Stations

Routine Monitoring Number of Samples per Week	Lab Turn-Around Time (hr.)	Laboratory Analyses: Congener-specific PCBs: Whole Water	Sus-pended Phase	Dis-solved Phase	DOC & Susp. OC	SS	SS (1/3-hours)[3]	Probe[5]: Turbidity	DO, Temp., pH, Cond.	SS-Particle Counter	Integrating Sampler for PCBs
RM 197.0 - Bakers Falls Br.	72	1			1	1		Discrete			
RM 194.2 - Ft Edward	72	7			7.5	7.5	56	Continuous	Discrete	Discrete	0.5
RM 188.5 - TI Dam[2]	24	7			7.5	7.5	56	Continuous	Discrete	Continuous	0.5
RM 181.4 - Schuylerville[2]	24	7			7.5	7.5	56	Continuous	Discrete	Continuous	0.5
RM 163.5 - Stillwater	72	7			7.5	7.5	56	Continuous	Discrete	Continuous	0.5
RM 156.5 – Waterford	72	7			7.5	7.5	56	Continuous	Discrete	Continuous	0.5
Samples/Week		36			38.5	38.5	280				2.5
PCB analyses/week		**38.5**	**or**	**5.5 /day**							

Evaluation Level Number of Samples per Week	Lab Turn-Around Time (hr.)	Laboratory Analyses: Congener-specific PCBs: Whole Water	Sus-pended Phase	Dis-solved Phase	DOC & Susp. OC	SS	SS (1/3-hours)[3]	Probe[5]: Turbidity	DO, Temp., pH, Cond.	SS-Particle Counter	Integrating Sampler for PCBs
RM 197.0 - Bakers Falls Br.	72	1			1	1		Discrete			
RM 194.2 - Ft Edward	72	7			7.5	7.5	56	Continuous	Discrete	Discrete	0.5
RM 188.5 - TI Dam[2]	24		14	14	14.5	14.5	56	Continuous	Discrete	Continuous	0.5
RM 181.4 - Schuylerville[2]	24		14	14	14.5	14.5	56	Continuous	Discrete	Continuous	0.5
RM 163.5 - Stillwater	72	7			7.5	7.5	56	Continuous	Discrete	Continuous	0.5
RM 156.5 – Waterford	72	7			7.5	7.5	56	Continuous	Discrete	Continuous	0.5
Samples/Week		22	28	28	52.5	52.5	280				2.5
PCB analyses/week		**80.5**	**or**	**11.5 /day**							

Concern Level Number of Samples per Week	Lab Turn-Around Time (hr.)	Laboratory Analyses: Congener-specific PCBs: Whole Water	Sus-pended Phase	Dis-solved Phase	DOC & Susp. OC	SS	SS (1/3-hours)[3]	Probe[5]: Turbidity	DO, Temp., pH, Cond.	SS-Particle Counter	Integrating Sampler for PCBs
RM 197.0 - Bakers Falls Br.	72	1			1	1		Discrete			
RM 194.2 - Ft Edward	72	7			7.5	7.5	56	Continuous	Discrete	Discrete	0.5
RM 188.5 - TI Dam[2]	24		21	21	22	22	56	Continuous	Discrete	Continuous	1
RM 181.4 - Schuylerville[2]	24		21	21	22	22	56	Continuous	Discrete	Continuous	1
RM 163.5 - Stillwater[6]	72				7	7	56	Continuous	Discrete	Continuous	7
RM 156.5 – Waterford[6]	72				7	7	56	Continuous	Discrete	Continuous	7
Samples/Week		8	42	42	66.5	66.5	280				16.5
PCB analyses/week		**108.5**	**or**	**15.5 /day**							

Control Level Number of Samples per Week	Lab Turn-Around Time (hr.)	Laboratory Analyses: Congener-specific PCBs: Whole Water	Sus-pended Phase	Dis-solved Phase	DOC & Susp. OC	SS	SS (1/3-hours)[3]	Probe[5]: Turbidity	DO, Temp., pH, Cond.	SS-Particle Counter	Integrating Sampler for PCBs
RM 197.0 - Bakers Falls Br.	72	1			1	1		Discrete			
RM 194.2 - Ft Edward	72	7			7.5	7.5	56	Continuous	Discrete	Discrete	0.5
RM 188.5 - TI Dam[2]	24		28	28	29	29	56	Continuous	Discrete	Continuous	1
RM 181.4 - Schuylerville[2]	24		28	28	29	29	56	Continuous	Discrete	Continuous	1
RM 163.5 - Stillwater[6]	24				7	7	56	Continuous	Discrete	Continuous	7
RM 156.5 – Waterford[6]	24				7	7	56	Continuous	Discrete	Continuous	7
Samples/Week		8	56	56	80.5	80.5	280				16.5
PCB analyses/week		**136.5**	**or**	**19.5 /day**							

Threshold[1] Number of Samples per Day Only	Lab Turn-Around Time (hr.)	Laboratory Analyses: Congener-specific PCBs: Whole Water	Sus-pended Phase	Dis-solved Phase	DOC & Susp. OC	SS	SS (1/3-hours)[3]	Probe[5]: Turbidity	DO, Temp., pH, Cond.	SS-Particle Counter	Integrating Sampler for PCBs
RM 197.0 - Bakers Falls Br.	72	1			1	1		Discrete			
RM 194.2 - Ft Edward	72	1			1	1	8	Continuous	Discrete	Discrete	1/2-weeks
RM 188.5 - TI Dam[2,6]	24		4	4	5	5	8	Continuous	Discrete	Continuous	1
RM 181.4 - Schuylerville[2,6]	24		4	4	5	5	8	Continuous	Discrete	Continuous	1
RM 163.5 - Stillwater[6]	24	4			5	5	8	Continuous	Discrete	Continuous	1
RM 156.5 – Waterford[6]	24	4			5	5	8	Continuous	Discrete	Continuous	1
Samples/day		10	8	8	22	22	40				4
PCB analyses/day		**30**	**/day**								

Note:
1. The monitoring for the Resuspension Standard threshold is required for one day only for verification of the elevated concentration.
2. TI Dam and Schuylerville will be representative stations while the dredging is ongoing in the TI Dam and will be sampled more intensely. Samples will be composited from hourly grab samples for the Control Level and Resuspension Standard threshold at these two stations.
3. SS sampling every 3- hours will not be required at the far-field stations once a semi-quantative relationship between turbidity and SS is established.
4. The monitoring requirements vary depending on the location of the remedial activities. This scenario is for dredging in an area more than 1-mile upstream of the TI Dam.
5. Discrete measurements for dissolved oxygen at each station will be made when grab samples are collected. At Fort Edward, particle counter measurements will be made when grab samples are collected.
6. The turnaround time for PCB analyses from the integrating sampler will only be specified where the information is needed quickly for comparison to the resuspension criteria. For the Resuspension Standard the integrating sample turnaround times will be 24-hours for the two representative far-field stations (TI Dam and Schuylerville stations) and 72-hours for the stations farther downstream (Stillwater and Waterford stations). For the Concern and

Table 1-3
Sampling Requirements on a Weekly Basis - Lower River Far-Field Stations

Lower River Sampling Requirements on a Weekly Basis

Routine Monitoring	Lab Turn-Around Time (hr.)	Laboratory Analyses			Probe	
		Congener-specific PCBs Whole Water	DOC & Susp. OC	SS	Turbidity, Temp., pH, Cond.	Dissolved Oxygen
Mohawk R. at Cohoes	72	0.25	0.25	0.25	0.25	0.25
RM 140 - Albany	72	0.25	0.25	0.25	0.25	0.25
RM 77 - Highland	72	0.25	0.25	0.25	0.25	0.25
Samples/Week		0.75	0.75	0.75	0.75	0.75

Non-Routine Monitoring	Lab Turn-Around Time (hr.)	Laboratory Analyses			Probe	
		Congener-specific PCBs Whole Water	DOC & Susp. OC	SS	Turbidity, Temp., pH, Cond.	Dissolved Oxygen
Mohawk R. at Cohoes	24	1	1	1	1	1
RM 140 - Albany	24	1	1	1	1	1
RM 77 - Highland	24	1	1	1	1	1
Samples/Week		3	3	3	3	3

Note:
(1) Non-routine monitoring will be triggered only when Waterford or Troy have total PCB concentration greater than 350 ng/L.

Table 1-4
Sampling Requirements on a Weekly Basis - Upper River Near-Field Stations

Near-Field Sampling Requirements on a Weekly Basis
Routine Monitoring (with use of continuous reading probe to indicate suspended solids concentrations)

No. of Operations	No. of SS Laboratory Analyses	No. of Measurements Suspended Solids with Particle Counter	No. of Continuous Monitors
1	35	35	5
2	70	70	10
3	105	105	15
4	140	140	20
5	175	175	25
6	210	210	30
7	245	245	35
8	280	280	40
9	315	315	45
10	350	350	50

Non-Routine Monitoring

No. of Operations	Number of SS Laboratory Samples with 3-Hour Turn-Around per Week					No. of Measurements Suspended Solids with Particle Counter
	Number of Stations with Exceedences of the Standard				All Stations	
	1	2	3	4	5	
1	49	98	147	196	245	35
2	98	196	294	392	490	70
3	147	294	441	588	735	105
4	196	392	588	784	980	140
5	245	490	735	980	1,225	175
6	294	588	882	1,176	1,470	210
7	343	686	1,029	1,372	1,715	245
8	392	784	1,176	1,568	1,960	280
9	441	882	1,323	1,764	2,205	315
10	490	980	1,470	1,960	2,450	350

Notes:
1. Discrete SS samples will be collected at the five stations will be monitored per station, only if no acceptable correlation between SS and turbidity is found.
2. If a correlation between SS and turbidity is found, the upstream station will not need to have SS samples analyzed, except for the one sample per day. Only stations with control levels will required to have SS samples analyzed.
3. Turbidity, temperature, pH, conductivity and dissolved oxygen will be monitored continuously at each of the five near-field stations.
4. Hours of Operation: 14/day

5. SS samples for non-routine monitoring will be collected every three hours during the operation with one sample collected an hour prior to beginning the operation and at least two samples collected at one hour intervals after completing for the day.

Table 2-1
Case Study Resuspension Summary Table

Project/Site Name	Dates of Operation	Project Setting	Water Quality Parameters Monitored	Water Quality Standard	Water Quality Monitoring Stations	Water Quality Measurements Reported During Dredging
Fox River: Kimberly, Wisconsin Deposit N	November 1998 to December 1998 (Phase I); August 1999 to November 1999 (Phase II)	Riverine	Turbidity, TSS, and PCBs	Turbidity - Threshold limit based on hourly average value; Specific threshold not stated in materials reviewed; PCBs- water column concentrations compared to pre-dredge concentrations and upstream samples versus downstream samples compared-specific threshold not indicated	Real Time Turbidity monitoring at 6 stations: (1) upstream, (1) side gradient, (1) downstream, (1) at ILP water intake, (1) at the ILP effluent discharge, and (1) within the contained dredge area; Measured turbidity at 50% total water depth	Average PCB water column concentration during Phase I (1998) downstream of dredging was 11 ng/L compared to an average upstream measured concentration of 3.2 ng/L during dredging. Baseline concentration before Phase I was 5.0 ng/L. Average downstream PCB concentration during Phase II (1999) was 24 ng/L compared to an average upstream PCB concentration of 14 ng/L. Minor differences between upstream and downstream turbidity during dredging. No apparent difference in TSS data collected upstream and downstream of the dredge was noted from measurements collected during dredging.
Fox River: Green Bay, Wisconsin SMU 56/57 Phase I	August to December 1999 (Phase I);	Riverine	Turbidity, TSS, and PCBs	Not indicated in documents reviewed	Real time turbidity monitoring at 6 locations: (1) upstream dredge outside turbidity barrier;(1) upstream dredge inside turbidity barrier;(1) side stream dredge outside turbidity barrier;(1) downstream dredge outside turbidity barrier;(1) downstream dredge inside turbidity barrier; (1) at Fort James water intake - Each meter located in water column at 50-60% of the water depth for location	Average PCB water column concentration downstream of the dredge was 90 ng/L compared to an upstream concentration of 51 ng/L during dredging and a baseline concentration prior to dredging of 52 ng/L. Turbidity monitors downstream of the dredge, outside the silt curtain were indicative of periodic turbidity increases. TSS samples only showed minor differences between the upstream and downstream locations. Monthly averaged turbidity data indicated that a high turbidity of 41 NTU occurred during the first month of dredging (August) downstream of the dredge, outside the silt curtain.
Fox River: Green Bay, Wisconsin SMU 56/57 Phase II	August 2000 to November 2000 (Phase II)	Riverine	Turbidity, TSS, and PCBs	Turbidity - Reached threshold if downstream turbidity reading was two or more times higher than the upstream reading and cause was related to dredging; Specific PCB threshold not indicated in documents reviewed	Real Time Turbidity Monitoring at 3 locations: (1) upstream of silt curtain at the Fort James water intake; (1) 10-ft downstream of the silt curtain; and (1) 50-ft downstream of the silt curtain	Upstream and downstream turbidity values never varied by more than a factor of two during dredging. Contractor did not perform PCB water column monitoring since turbidity threshold was never exceeded however PCB water column sampling was performed by the USGS.
Manistique River, Michigan	Over Period 1995 - 1999	Riverine	Turbidity, TSS, and PCBs	TSS concentration less than 2X the background turbidity within 50-feet of the dredge head; Literature reviewed stated that this level was achieved within 10-feet of the dredge head. PCB water quality threshold not stated in literature reviewed. It was noted that PCB concentration were compared to pre-dredge water column PCB concentrations	For 1997 Dredging: seven samples from one station near dredge; one sample from upstream; six samples from a station downstream; and two samples from a station outside of the dredge area. For 1998: 9 samples from station upstream of dredge; 8 samples from locations downstream of dredge- distance and exact location not specified.	In 1997: avg. PCB water column concentrations outside dredge area was 0.37mg/L and avg. [PCB] downstream of dredge was 0.23 mg/l compared to pre-dredge concentration of 0.001 mg/L. The background sample collected during this event was 0.062 mg/L PCBs. In 1998: Avg. upstream [PCB] was 0.093 mg/L and the average [PCB] downstream was 0.066 mg/L.

Table 2-1
Case Study Resuspension Summary Table

Project/Site Name	Dates of Operation	Project Setting	Water Quality Parameters Monitored	Water Quality Standard	Water Quality Monitoring Stations	Water Quality Measurements Reported During Dredging
Reynolds Metals: St. Lawrence River, Massena. NY	April 2001 through November 2001	Riverine	Turbidity and water column samples (PCBs , PAHs, and PCDFs); TSS was not measured in this project.	Turbidity action level of 25 NTU above the background level, which was derived based on 28 NTU action level used at GM Massena. The action levels for water column samples were 2 ug/L of PCBs, 0.2 ug/L for PAHs and detectable PCDFs above the practical quantitation limit (PQL).	Monitoring was conducted at different locations for each project phase (sheetpile installation, dredging, capping, and sheet pile removal); All locations identified in Final Case Study Table (Appendix A of the Resuspension standard). For dredging: (4) stations outside the sheet piling- one upcurrent (100ft from the active dredge) and 3 down current stations (10, 150 and 300 ft from the sheet pile wall closest to the dredge being monitored). Within the sheetpiling-Water Quality was monitored at 12 to 19 different stations based on dredge location.	Outside the sheet piling : Turbidity during dredging ranged between 0.5 to 1.5 NTUs. During dredging, water column PCB concentrations ranged between 0.05 to 0.53 ug/L. and PAH and PCDF were non-detect in samples analyzed
GM Massena: St. Lawrence River, Massena, NY	May 1995 through December 1995	Riverine	Turbidity, PCBs, PAHs	Action level was selected based on a 1994 site-specific bench-scale laboratory correlation between TSS and turbidity, and experience in previous dredging projects. Downstream turbidity 28 NTUs above background corresponded to a downstream TSS of 25 mg/L above background. For PCBS: 2 ug/L (at downstream monitoring locations)	Visual observations and real-time turbidity monitoring at 3 locations: 50 feet upstream of western extent of control system, two between 200 feet and 400 feet downstream of easternmost active installations. Measurements collected from 50% water depth. Water column sampling at the same two downstream locations as the turbidity measurements.	In 18 out of 923 turbidity samples, the 28 NTU action level was exceeded (31-127 NTU) at 1-ft below the water surface for a duration of 2-8 minutes, on average, however 2 exceedances lasted for 15 minutes and 45 minutes respectively. Exceedance determined to be a result of water overflow from the dredge area over the sheet piling due to inadequate height/installation. PCBs monitored at same station as turbidity. High PCB concentrations correlated with times where high turbidity (> 28 NTU) measured. Filtered [PCB] ranged between 0.94-2.4 ug/L and unfiltered ranged between 4.51 to 9.84 ug/L. These PCB measurements collected at end of Phase I after sheet piling removed.
Cumberland Bay: New York	April 1999 to May 2000	Western side of Lake Champlain	TSS, turbidity and PCB	Turbidity was used only to alert the operators of a potential re-suspension problem-not associated with an action level. **Operational Monitoring**: TSS 25 mg/L above background. **Compliance Monitoring** (outside turbidity barrier): TSS 4 mg/L above background. When TSS action level was exceeded, dredging was suspended or modified.	**Operational Monitoring**: Real-time turbidity monitoring in 2 locations: on dredge head and using a float that trailed behind the dredge. **Compliance Monitoring:** Four OBS-3 sensor stations which changed for each active work zone: one sensor in a background location (near breakwater) and three sensors outside the perimeter of the work zone silt curtain (an additional temporary sensor was located near Georgia-Pacific's industrial water intake). **Documentation Monitoring:** Six fixed turbidity monitoring (TM) buoys (in 1999 outside perimeter turbidity curtain; 2000 locations different).	Documentation reviewed indicated that the TSS levels were not exceeded and dredging was never suspended.

Table 2-1
Case Study Resuspension Summary Table

Project/Site Name	Dates of Operation	Project Setting	Water Quality Parameters Monitored	Water Quality Standard	Water Quality Monitoring Stations	Water Quality Measurements Reported During Dredging
United Heckathorn: Parr Canal and Lauritzen Channel on the San Francisco Bay	August 1996 through March 1997	Bay area - shipping inlet/slip	TSS and Contaminants of Concern: DDT and Dieldrin	Surface water: Dieldrin 0.14ng/L and DDT 0.59ng/L both based on EPA AWQ (Ambient water Quality criteria) and also based on human health standards (risk)	Four water quality sampling stations- Locations were established both upstream and downstream of area being dredged and downstream/outside channel/ship inlet/slip in the harbor and bay at both ends	Data not available in documents reviewed for water quality data during dredging however it was noted that the area is extremely turbid naturally due to ship traffic; Post-dredge water quality data collected 4-months after dredging indicated concentrations equal to or greater than post-dredge conditions. This was a result of incomplete dredging near banks and around structures. Dredging not a success at this site and further action to be taken.
Grand Calumet River, Indiana	Dredging Began November 2002 (currently in progress)	Riverine	Level 1: Flow, total ammonia, specific conductance, DO, pH, sulfides, temp., and turbidity monitored daily by multi-parameter automatic data logger system; Level 2: microtox chemical testing for acute and chronic toxicity; Level 3: chemical monitoring for total ammonia, pH, sulfides, temp, free cyanide, hardness, oil and grease, TSS, dissolved aluminum, dissolved copper, dissolved lead, total mercury, dissolved zinc, select VOCs, and total PCBs; Each Level Monitoring is conducted concurrently at a pre-set frequency. A contingency plan exists for each Level monitoring in the event that a high measurement is recorded.	IDEM (Indiana Department of Environmental Management) chronic and acute state surface water criteria	(1) upstream background sampling location; (1) located near mid-channel 200-yd downstream from open water dredge; (1) downstream sampling site below 5-mile dredge area; (1) proposed sample location for verification analysis located 200-yd upstream of open water dredging in cell c	Data Not yet available; dredging currently underway
New Bedford Harbor (Hot Spots), New Bedford, Massachusetts	April 1994 to September 1995	Estuary/Bay	PCBs (24-hr turn-around) and metals. PCBs (Total PCBs: dissolved and particulate tested separately and summed).	PCBs: 1.3 mg/L determined by a pilot study and a Maximum cumulative transport (MCT) of PCBs during the entire operation of 240 Kg PCBs.	Down current locations: 50 ft, 300 ft, 700 ft, and 1,000 ft. from dredging area. Background measurements: ~ 1,000 ft up-current of dredging operations. Sampling depth: ~ mid-depth in the water column.	By the end of project, a total PCB transport of 57 kg was reported. Thus, the MCL was not exceeded. Toxicity tests completed during dredging were not indicative of acute toxicity and PCB accumulation in mussels was not significantly greater then pre-dredge measurements.
New Bedford Harbor (Pre-Design Field Test), New Bedford, Massachusetts	Demonstration Project in August 2000	Estuary/Bay	TSS, turbidity and PCBs (dissolved and particulate, PCB congeners)	PCBs: No set limit since background concentrations exceeded Federal criteria however did set the maximum Cumulative Transport (MCT) for PCB loss from dredging at the limit of mixing zone (300 ft from the dredge) of 400 kg PCBs throughout entire dredging project. Turbidity: 50 NTU above background at limit of mixing zone (300 ft from the dredge)	2 Monitoring stations 300 ft away from dredge; additional sampling as required 600 ft from dredge. Background measurements ~ 1,000 ft up-current of dredging operations.	Turbidity measurements exceeded the 50 NTU threshold infrequently at the 300-ft limit of the mixing zone and no further action was taken. Bioassay tests completed when turbidity exceeded 50 NTU were not indicative of an ecological impact.

Table 2-1
Case Study Resuspension Summary Table

Project/Site Name	Dates of Operation	Project Setting	Water Quality Parameters Monitored	Water Quality Standard	Water Quality Monitoring Stations	Water Quality Measurements Reported During Dredging
Commencement Bay: Hylebos Waterway	Small Hot spot dredging October 2002 (currently in progress); Full-scale dredging to commence July 2003	Tidal Waterway	Turbidity and dissolved oxygen (system currently exhibits a low dissolved oxygen level and do not want dredging to deplete any further)	It is anticipated that the turbidity standard will be set at either 20 NTU or 50 NTU over background.	2 anticipated monitoring stations; one near dredge head and one at the limit of the mixing zone (300-ft from the dredge)	Data not yet available; dredging in progress at hot spot and has not yet been conducted at full-scale
Commencement Bay: Thea, Foss, Wheeler, Osgood Waterway	Full-scale dredging to begin in August 2003	Tidal Waterway	Turbidity however water quality monitoring plan still in design	It is anticipated that the turbidity standard will be set at either 20 NTU or 50 NTU over background.	2 anticipated monitoring stations; one near dredge head and one at the limit of the mixing zone (300-ft from the dredge)	Data not yet available; dredging to begin in summer 2003

Table 2-2
Summary of Case Studies for PCB Losses Due to Dredging

Project	Period of Dredging	Total PCBs Removed (kg)	Total PCBs Resuspension Loss (kg)	Percentage Lost (%)
GE Hudson Falls Dredging	Oct.-Dec. 1997, Aug.-Nov. 1998	3,890	14	0.36%
New Bedford Harbor Hot Spots	1994-1995	43,700	57	0.13%
Fox River Deposit N	Nov. - Dec. 1998 (Phase I) Aug. -Dec.1999 (Phase II)	111	4.20	3.5% - 14% [(1)]
Fox River SMU 56/57	Aug. - Nov. 1999 (Phase I)	1,490	22	2.2% [(2)]

Notes:
(1) Average Daily Percentage Loss varied over dredge season based on dredge location and uncertainty associated with PCB removal estimation.
(2) PCB Percentage Loss based on USGS study while other values taken from the SMU 56/57 Final Summary report (September 2001).

Table 2-3
Far-Field Forecast Model Runs Completed for the Performance Standard

Scenario [5]	Description	Rate of PCB Release [1] g/day (kg/yr) [3]	Period of Dredging	Start Year	Completed Simulations [4] Upper Hudson HUDTOX	FISHRAND	Lower Hudson Farley	FISHRAND
-	MNA	NA	-	-	x	x	x	x
-	No resuspension	0 (0)	6	2004	x	x	x	x
d004	No resuspension	0 (0)	6	2006	X	X	X	X
-	2.5% Export[2]	1,700 (350)	6	2004	x	x	x	x
sr01	300 g/day	300 (70)	6	2006	X	X	X	X
sr02	600 g/day	600 (130)		2006	X	X	X	X
sr04	350 ng/L	1,600 (340)	6	2006	X	X	X	X
-	Accidental Release	600 (130)	6	2006	X			

Notes:

1. All PCB resuspension scenarios were based on a resuspension release rate (near-field release) at the specified percentage of dredging loss unless noted otherwise.
2. The model run included with the Responsiveness Summary for the ROD is effectively a 2.5 percent export scenario since all PCBs were loaded as dissolved phase. See text for further discussion.
3. The rates are based on 7 months of operation, 7 days per week at 14 hours per day.
4. x = completed for ROD
   X = completed for this report
5. The d00X and sr0x series of scenarios are new.

Table 2-4
Upper Hudson Conceptual Dredging Schedule

Sediment removal season	Dredging Location	speed
May 1 - Nov. 1, 2006	Sec. 1	half
May 1 - Nov. 30, 2007	Sec. 1	full
May 1 - Nov. 30, 2008	Sec. 1	full
May 1 - Aug. 15, 2009	Sec. 1	full
Aug. 16 - Nov. 30, 2009	Sec. 2	full
May 1 - Aug. 15, 2010	Sec. 2	full
Aug. 16 - Nov. 30, 2010	Sec. 3	full
May 1 - Aug. 15, 2011	Sec. 3	full

Table 2-5
Species-Weighted Fish Fillet Average PCB Concentration (in mg/kg)

	No Resuspension (d004)				350 ng/L (sr04)				600 g/day (sr01)				Monitored Natural Attenuation			
Year	Upper River Average	River Section 1 (RM 189)	River Section 2 (RM 184)	River Section 3 (RM 154)	Upper River Average	River Section 1 (RM 189)	River Section 2 (RM 184)	River Section 3 (RM 154)	Upper River Average	River Section 1 (RM 189)	River Section 2 (RM 184)	River Section 3 (RM 154)	Upper River Average	River Section 1 (RM 189)	River Section 2 (RM 184)	River Section 3 (RM 154)
1998	3.317	6.813	9.271	1.537	3.316	6.807	9.276	1.537	3.316	6.807	9.276	1.537	3.353	6.774	9.659	1.529
1999	3.328	6.908	9.406	1.510	3.328	6.909	9.410	1.509	3.328	6.909	9.410	1.509	3.212	6.621	8.877	1.501
2000	2.866	5.747	8.346	1.300	2.865	5.751	8.338	1.300	2.865	5.751	8.338	1.300	2.791	5.563	8.028	1.292
2001	2.582	5.098	7.588	1.177	2.583	5.104	7.585	1.177	2.583	5.104	7.585	1.177	2.504	4.924	7.210	1.171
2002	2.370	4.841	6.925	1.053	2.372	4.848	6.924	1.054	2.372	4.848	6.924	1.054	2.301	4.705	6.571	1.047
2003	2.182	4.340	6.471	0.978	2.182	4.338	6.474	0.978	2.182	4.338	6.474	0.978	2.129	4.290	6.090	0.980
2004	2.290	5.285	6.356	0.946	2.290	5.286	6.354	0.946	2.290	5.286	6.354	0.946	2.204	5.084	5.934	0.942
2005	1.905	3.912	5.712	0.816	1.911	3.910	5.740	0.821	1.908	3.909	5.726	0.819	1.852	3.739	5.523	0.812
2006	1.617	2.996	5.119	0.716	1.703	3.111	5.350	0.770	1.666	3.076	5.237	0.746	1.574	2.890	4.904	0.716
2007	1.487	2.838	4.669	0.647	1.709	3.461	5.141	0.739	1.614	3.225	4.920	0.697	1.474	2.862	4.489	0.654
2008	1.297	2.318	4.226	0.571	1.673	3.762	4.743	0.694	1.525	3.216	4.582	0.634	1.371	2.774	4.168	0.586
2009	0.964	1.573	2.949	0.489	1.323	2.317	3.769	0.687	1.106	1.907	3.140	0.583	1.262	2.616	3.877	0.519
2010	0.595	0.899	1.355	***0.398***	0.928	1.012	1.835	0.753	0.707	0.943	1.411	0.535	1.116	2.321	3.533	0.440
2011	0.447	0.661	0.847	0.332	0.817	0.736	1.122	0.781	0.568	0.697	0.901	0.483	0.971	1.921	3.164	***0.388***
2012	0.404	0.723	0.786	0.269	0.631	0.774	0.999	0.537	0.469	0.747	0.818	***0.350***	0.878	1.851	2.879	0.324
2013	***0.342***	0.568	0.717	0.229	0.515	0.600	0.883	0.433	***0.389***	0.572	0.734	0.291	0.791	1.682	2.601	0.287
2014	0.318	0.593	0.669	***0.199***	0.453	0.602	0.803	***0.361***	0.353	0.582	0.675	0.248	0.742	1.666	2.396	0.258
2015	0.289	0.520	0.638	0.178	***0.400***	0.524	0.751	0.312	0.316	0.506	0.638	0.219	0.686	1.535	2.229	0.237
2016	0.294	0.586	0.651	0.170	0.391	0.589	0.750	0.287	0.317	0.573	0.648	0.205	0.680	1.610	2.126	0.231
2017	0.296	0.671	0.612	0.161	0.379	0.672	0.704	0.260	0.315	0.660	0.610	***0.190***	0.649	1.573	1.978	0.221
2018	0.272	0.606	0.574	0.149	0.344	0.605	0.665	0.233	0.289	0.595	0.577	0.173	0.593	1.437	1.765	0.210
2019	0.281	0.710	0.567	0.140	0.341	0.702	0.656	0.210	0.295	0.694	0.572	0.161	0.577	1.497	1.619	***0.200***
2020	0.243	0.584	0.502	0.125	0.292	0.579	0.584	***0.180***	0.253	0.571	0.507	0.142	0.512	1.270	1.480	0.182
2021	0.217	0.471	0.482	0.117	0.260	0.468	0.557	0.164	0.226	0.459	0.486	0.131	0.460	1.080	1.365	0.171
2022	0.215	0.476	0.477	0.114	0.253	0.473	0.548	0.155	0.222	0.464	0.482	0.126	0.450	1.093	1.296	0.166
2023	0.216	0.529	0.454	0.108	0.247	0.524	0.514	0.142	0.222	0.517	0.461	0.118	0.435	1.088	1.225	0.158
2024	***0.195***	0.484	0.417	0.094	0.219	0.480	0.463	0.122	***0.200***	0.474	0.427	0.102	***0.385***	0.939	1.123	0.139
2025	0.176	0.415	***0.391***	0.088	***0.196***	0.413	0.426	0.110	0.181	0.406	0.402	0.094	0.350	0.842	1.019	0.129
2026	0.163	***0.357***	0.377	0.084	0.180	0.355	0.405	0.103	0.166	***0.347***	***0.388***	0.089	0.325	0.757	0.952	0.124
2027	0.183	0.490	0.380	0.083	0.197	0.488	0.403	0.100	0.186	0.483	0.387	0.088	0.339	0.888	0.920	0.121
2028	0.177	0.509	0.353	0.076	0.189	0.508	***0.371***	0.090	0.179	0.504	0.353	0.080	0.322	0.863	0.875	0.111
2029	0.158	0.414	0.337	0.072	0.168	0.412	0.351	0.084	0.159	0.407	0.332	0.076	0.287	0.720	0.801	0.105
2030	0.143	0.326	0.326	0.072	0.152	***0.325***	0.342	0.082	0.143	0.320	0.322	0.075	0.261	0.620	0.735	0.103
2031	0.151	0.422	0.303	0.067	0.159	0.421	0.320	0.075	0.152	0.418	0.302	0.069	0.257	0.679	0.675	0.095
2032	0.138	0.362	0.288	0.064	0.145	0.362	0.305	0.071	0.139	0.357	0.289	0.066	0.234	0.602	0.610	0.091
2033	0.133	0.349	0.277	0.061	0.138	0.349	0.295	0.066	0.133	0.343	0.279	0.063	0.219	0.560	0.564	0.086
2034	0.132	0.368	0.259	0.060	0.134	0.368	0.276	0.060	0.132	0.366	0.261	0.059	0.208	0.545	0.521	0.082
2035	0.123	0.279	0.249	0.068	0.116	0.279	0.266	0.056	0.114	0.275	0.251	0.055	***0.191***	0.443	0.475	0.089
2036	0.148	0.356	0.242	0.087	0.124	0.356	0.258	0.051	0.125	0.352	0.244	0.055	0.209	0.504	0.446	0.104
2037	0.137	0.297	0.234	0.086	0.115	0.298	0.250	0.053	0.125	0.295	0.237	0.070	0.190	0.427	0.410	0.101
2038	0.140	0.337	0.221	0.083	0.130	0.337	0.235	0.068	0.140	0.335	0.224	0.083	0.189	0.456	***0.386***	0.098
2039	0.128	0.270	0.214	0.083	0.132	0.271	0.227	0.087	0.131	0.268	0.218	0.087	0.173	0.382	0.363	0.096
2040	0.124	0.262	0.214	0.079	0.132	0.262	0.225	0.087	0.128	0.260	0.217	0.085	0.164	0.352	0.346	0.092
2041	0.140	0.359	0.219	0.079	0.150	0.360	0.228	0.091	0.146	0.358	0.222	0.087	0.180	0.461	0.347	0.092
2042	0.143	0.400	0.223	0.074	0.153	0.401	0.229	0.087	0.148	0.399	0.225	0.081	0.178	0.486	0.337	0.084
2043	0.123	0.318	0.202	0.068	0.132	0.318	0.206	0.080	0.129	0.320	0.205	0.075	0.155	***0.386***	0.316	0.078
2044	0.108	0.245	***0.191***	0.064	0.114	0.246	***0.193***	0.073	0.114	0.256	***0.195***	0.069	0.136	0.301	0.289	0.074
2045	0.112	0.282	0.190	0.063	0.118	0.283	0.191	0.070	0.118	0.301	0.194	0.066	0.137	0.329	0.278	0.071
2046	0.105	0.258	0.184	0.058	0.109	0.256	0.184	0.064	0.110	0.273	0.187	0.062	0.131	0.319	0.269	0.067
2047	0.109	0.284	0.187	0.058	0.112	0.271	0.187	0.065	0.112	0.285	0.190	0.062	0.153	0.474	0.261	0.066
2048	0.115	0.329	0.188	0.057	0.118	0.318	0.187	0.064	0.116	0.316	0.190	0.061	0.175	0.612	0.263	0.066
2049	0.116	0.339	0.190	0.055	0.120	0.340	0.189	0.062	0.117	0.328	0.192	0.059	0.166	0.574	0.259	0.063
2050	0.105	0.289	0.183	0.052	0.109	0.290	0.182	0.057	0.106	0.283	0.185	0.055	0.151	0.498	0.251	0.060
2051	0.101	0.286	0.180	***0.047***	0.104	0.287	0.178	0.052	0.104	0.294	0.182	***0.050***	0.140	0.457	0.242	0.055
2052	0.094	0.244	0.181	0.047	0.097	0.246	0.180	0.051	0.099	0.263	0.184	0.049	0.130	0.402	0.236	0.054
2053	0.113	0.359	0.187	0.048	0.116	0.359	0.185	0.052	0.118	0.379	0.189	0.050	0.146	0.494	0.244	0.055
2054	0.105	0.311	0.185	0.047	0.107	0.311	0.184	0.050	0.109	0.327	0.187	0.049	0.134	0.430	0.235	0.053
2055	0.098	0.274	0.182	0.045	0.100	0.274	0.180	***0.048***	0.101	0.287	0.183	0.047	0.125	0.383	0.231	0.052
2056	0.105	0.307	0.195	0.046	0.106	0.307	0.193	0.048	0.108	0.322	0.195	0.047	0.129	0.407	0.233	0.051
2057	0.105	0.323	0.185	0.045	0.107	0.324	0.183	0.047	0.108	0.337	0.186	0.046	0.126	0.397	0.231	0.050
2058	0.095	0.253	0.188	0.045	0.096	0.253	0.186	0.047	0.097	0.264	0.188	0.046	0.116	0.337	0.226	0.050
2059	0.109	0.356	0.181	0.043	0.110	0.356	0.181	0.045	0.111	0.366	0.182	0.044	0.127	0.422	0.228	***0.047***
2060	0.091	0.256	0.175	0.040	0.092	0.256	0.175	0.042	0.093	0.266	0.175	0.041	0.106	0.316	0.209	0.044
2061	0.086	0.234	0.169	0.040	0.087	0.233	0.169	0.042	0.087	0.241	0.169	0.041	0.100	0.286	***0.200***	0.043
2062	0.091	0.261	0.171	0.040	0.091	0.261	0.170	0.042	0.092	0.268	0.170	0.041	0.102	0.297	0.197	0.043
2063	0.091	0.261	0.172	0.041	0.091	0.260	0.171	0.041	0.092	0.266	0.171	0.041	0.101	0.296	0.196	0.043
2064	0.093	0.268	0.175	0.041	0.093	0.268	0.174	0.042	0.094	0.273	0.175	0.042	0.103	0.306	0.196	0.044
2065	0.092	0.255	0.178	0.043	0.093	0.255	0.177	0.043	0.093	0.260	0.177	0.043	0.100	0.283	0.195	0.045
2066	0.105	0.353	0.172	0.041	0.105	0.353	0.171	0.041	0.106	0.358	0.171	0.041	0.113	0.377	0.195	0.043
2067	0.095	0.275	0.180	0.042	0.095	0.275	0.179	0.042	0.096	0.279	0.179	0.043	0.101	0.301	0.183	0.044

BOLD-ITALICIZED - First occurrence of species-weighted fish fillet average PCB concentration below risk-based remediation goal of 0.05 mg/kg. Target concentrations of 0.2 mg/kg PCBs (protective at a fish consumption rate of 0.5 lbs/month) and 0.4 mg/kg PCBs (protective at a fish consumption rate of 0.5 lbs/ 2 months) are also italicized.
Upper Hudson River average is weighted by river section length. River Section 1: 6.3 miles = 15.4%; River Section 2: 5.1 miles = 12.5%; and River Section 3: 29.5 miles = 72.1%.

Table 2-6
Modeled Times (Years) of Compliance with Human Health Risk-Based Concentrations
Resuspension Scenarios

	No Resuspension (d004)	350 ng/L (sr04)	600 g/day (sr01)	MNA
Upper River Average				
Human Health risk-based RG 0.05 mg/kg	>2067	>2067	>2067	>2067
Fish Target Concentration 0.2 mg/kg	2024	2025	2024	2035
Fish Target Concentration 0.4 mg/kg	2013	2015	2013	2024
River Section 1- RM 189				
Human Health risk-based RG 0.05 mg/kg	>2067	>2067	>2067	>2067
Fish Target Concentration 0.2 mg/kg	>2067	>2067	>2067	>2067
Fish Target Concentration 0.4 mg/kg	2026	2030	2026	2043
River Section 2- RM 184				
Human Health risk-based RG 0.05 mg/kg	>2067	>2067	>2067	>2067
Fish Target Concentration 0.2 mg/kg	2044	2044	2044	2061
Fish Target Concentration 0.4 mg/kg	2025	2028	2026	2038
River Section 3- RM 154				
Human Health RG 0.05 mg/kg	2051	2055	2051	2059
Fish Target Concentration 0.2 mg/kg	2014	2020	2017	2019
Fish Target Concentration 0.4 mg/kg	2010	2014	2012	2011

Note: RG = risk-based remediation goal
Upper Hudson River average is weighted by river section length. River Section 1: 6.3 miles = 15.4%; River Section 2: 5.1 miles = 12.5%; and River Section 3: 29.5 miles = 72.1%.

Table 2-7
Resuspension Scenarios - Long-Term Fish Ingestion
Reasonable Maximum Exposure and Central Tendency PCB Non-Cancer Hazard Indices
Upper Hudson River Fish - Adult Angler

Remedial Alternative	PCB Conc. in Fish (mg/kg ww)	Intake (Non-Cancer) (mg/kg-day)	Reference Dose (mg/kg-day)	Hazard Index
Reasonable Maximum Exposure				
Upper Hudson Average				
No Resuspension d004	0.30	1.4E-04	2.0E-05	6.9
350 ng/L sr04	0.58	2.6E-04	2.0E-05	13
600 g/day sr01	0.50	2.3E-04	2.0E-05	11
MNA	1.4	6.4E-04	2.0E-05	32
River Section 1 (RM 189)				
No Resuspension d004	0.62	2.8E-04	2.0E-05	14
350 ng/L sr04	0.64	2.9E-04	2.0E-05	15
600 g/day sr01	0.62	2.8E-04	2.0E-05	14
MNA	1.7	7.7E-04	2.0E-05	39
River Section 2 (RM 184)				
No Resuspension d004	0.66	3.0E-04	2.0E-05	15
350 ng/L sr04	0.79	3.6E-04	2.0E-05	18
600 g/day sr01	0.67	3.1E-04	2.0E-05	15
MNA	2.3	1.0E-03	2.0E-05	52
River Section 3 (RM 154)				
No Resuspension d004	0.18	8.0E-05	2.0E-05	4.0
350 ng/L sr04	0.30	1.4E-04	2.0E-05	6.8
600 g/day sr01	0.21	9.7E-05	2.0E-05	4.8
MNA	0.23	1.1E-04	2.0E-05	5.4
Central Tendency				
Upper Hudson Average				
No Resuspension d004	0.27	1.2E-05	2.0E-05	0.6
350 ng/L sr04	0.52	2.4E-05	2.0E-05	1.2
600 g/day sr01	0.46	2.1E-05	2.0E-05	1.0
MNA	1.2	5.5E-05	2.0E-05	2.8
River Section 1 (RM 189)				
No Resuspension d004	0.60	2.7E-05	2.0E-05	1.4
350 ng/L sr04	0.61	2.8E-05	2.0E-05	1.4
600 g/day sr01	0.59	2.7E-05	2.0E-05	1.4
MNA	1.50	6.9E-05	2.0E-05	3.5
River Section 2 (RM 184)				
No Resuspension d004	0.59	2.7E-05	2.0E-05	1.4
350 ng/L sr04	0.70	3.2E-05	2.0E-05	1.6
600 g/day sr01	0.60	2.7E-05	2.0E-05	1.4
MNA	1.9	8.7E-05	2.0E-05	4.4
River Section 3 (RM 154)				
No Resuspension d004	0.15	6.8E-06	2.0E-05	0.3
350 ng/L sr04	0.24	1.1E-05	2.0E-05	0.5
600 g/day sr01	0.18	8.0E-06	2.0E-05	0.4
MNA	0.21	9.4E-06	2.0E-05	0.5

Notes: The RME non-cancer exposure time frame is seven years, while the CT time frame is 12 years.
Upper Hudson River average is weighted by river section length. River Section 1: 6.3 miles = 15.4%;
River Section 2: 5.1 miles = 12.5%; and River Section 3: 29.5 miles = 72.1%.

Table 2-8
Resuspension Standard Scenarios - Long-Term Fish Ingestion
Reasonable Maximum Exposure and Central Tendency Cancer Risks
Upper Hudson River Fish - Adult Angler

Remedial Alternative	PCB Conc. in Fish (mg/kg ww)	Intake (Cancer) (mg/kg-day)	Cancer Slope Factor (mg/kg-day)	Cancer Risk
Reasonable Maximum Exposure				
Upper Hudson Average				
No Resuspension d004	0.18	4.6E-05	2	9.3E-05
350 ng/L sr04	0.32	8.3E-05	2	1.7E-04
600 g/day sr01	0.30	7.7E-05	2	1.5E-04
MNA	0.60	1.7E-04	2	3.3E-04
River Section 1 (RM 189)				
No Resuspension d004	0.43	1.1E-04	2	2.2E-04
350 ng/L sr04	0.43	1.1E-04	2	2.2E-04
600 g/day sr01	0.42	1.1E-04	2	2.2E-04
MNA	0.86	2.2E-04	2	4.5E-04
River Section 2 (RM 184)				
No Resuspension d004	0.36	9.3E-05	2	1.9E-04
350 ng/L sr04	0.40	1.0E-04	2	2.1E-04
600 g/day sr01	0.36	9.4E-05	2	1.9E-04
MNA	0.90	2.4E-04	2	4.9E-04
River Section 3 (RM 154)				
No Resuspension d004	0.09	2.4E-05	2	4.8E-05
350 ng/L sr04	0.12	3.2E-05	2	6.4E-05
600 g/day sr01	0.10	2.7E-05	2	5.3E-05
MNA	0.12	3.2E-05	2	6.4E-05
Central Tendency				
Upper Hudson Average				
No Resuspension d004	0.27	2.1E-06	1	2.1E-06
350 ng/L sr04	0.52	4.0E-06	1	4.0E-06
600 g/day sr01	0.46	3.6E-06	1	3.6E-06
MNA	1.2	9.5E-06	1	9.5E-06
River Section 1 (RM 189)				
No Resuspension d004	0.60	4.7E-06	1	4.7E-06
350 ng/L sr04	0.61	4.8E-06	1	4.8E-06
600 g/day sr01	0.59	4.7E-06	1	4.7E-06
MNA	1.5	1.2E-05	1	1.2E-05
River Section 2 (RM 184)				
No Resuspension d004	0.59	4.7E-06	1	4.7E-06
350 ng/L sr04	0.70	5.5E-06	1	5.5E-06
600 g/day sr01	0.60	4.7E-06	1	4.7E-06
MNA	1.9	1.5E-05	1	1.5E-05
River Section 3 (RM 154)				
No Resuspension d004	0.15	1.2E-06	1	1.2E-06
350 ng/L sr04	0.24	1.9E-06	1	1.9E-06
600 g/day sr01	0.18	1.4E-06	1	1.4E-06
MNA	0.21	1.6E-06	1	1.6E-06

Notes: The RME cancer exposure time frame is 40 years, while the CT time frame is 12 years.
Upper Hudson River average is weighted by river section length. River Section 1: 6.3 miles = 15.4%;
River Section 2: 5.1 miles = 12.5%; and River Section 3: 29.5 miles = 72.1%.

Table 2-9
Upper Hudson River Average Largemouth Bass (Whole Fish) PCB Concentration (in mg/kg)

	No Resuspension (d004)				Total PCB 350 ng/L (sr04)				Total PCB 600 g/day (sr01)				Monitored Natural Attenuation			
Year	Upper River Average	Section 1 (RM 189)	Section 2 (RM 184)	Section 3 (RM 154)	Upper River Average	Section 1 (RM 189)	Section 2 (RM 184)	Section 3 (RM 154)	Upper River Average	Section 1 (RM 189)	Section 2 (RM 184)	Section 3 (RM 154)	Upper River Average	Section 1 (RM 189)	Section 2 (RM 184)	Section 3 (RM 154)
1998	7.13	16.73	17.22	3.33	7.13	16.70	17.24	3.33	7.13	16.70	17.24	3.33	7.19	16.61	18.04	3.29
1999	7.04	17.11	16.80	3.20	7.04	17.12	16.83	3.20	7.04	17.12	16.83	3.20	6.76	16.16	15.91	3.17
2000	5.84	13.71	14.51	2.66	5.84	13.74	14.47	2.66	5.84	13.74	14.47	2.66	5.74	13.09	14.57	2.64
2001	5.29	12.01	13.33	2.47	5.30	12.04	13.32	2.47	5.30	12.04	13.32	2.47	5.13	11.34	12.94	2.45
2002	4.91	11.63	12.30	2.20	4.92	11.66	12.29	2.20	4.92	11.66	12.29	2.20	4.76	11.11	11.84	2.18
2003	4.43	10.12	11.39	2.01	4.43	10.11	11.40	2.01	4.43	10.11	11.40	2.01	4.33	9.92	10.73	2.03
2004	5.12	14.37	11.49	2.04	5.12	14.38	11.48	2.04	5.12	14.38	11.48	2.04	4.88	13.63	10.57	2.02
2005	3.94	9.68	9.91	1.67	3.95	9.67	9.97	1.68	3.94	9.67	9.95	1.68	3.85	9.04	10.09	1.66
2006	3.14	6.44	8.80	1.45	3.38	6.61	9.48	1.63	3.28	6.57	9.17	1.55	3.06	5.97	8.70	1.46
2007	2.96	6.45	8.04	1.33	3.63	8.59	9.25	1.59	3.35	7.78	8.73	1.47	2.96	6.39	7.95	1.36
2008	2.59	5.37	7.38	1.17	3.88	11.02	8.77	1.51	3.40	9.02	8.30	1.36	2.78	6.45	7.30	1.21
2009	2.00	4.08	5.15	1.02	3.06	6.90	7.31	1.50	2.49	5.39	5.93	1.27	2.60	6.16	6.88	1.10
2010	1.35	2.88	2.56	0.81	2.14	3.17	3.68	1.66	1.65	3.00	2.76	1.17	2.31	5.51	6.40	0.92
2011	1.00	2.02	1.57	0.68	1.94	2.18	2.05	1.86	1.34	2.12	1.67	1.11	1.95	4.24	5.61	0.83
2012	0.94	2.35	1.48	0.55	1.38	2.45	1.85	1.07	1.07	2.41	1.54	0.70	1.78	4.21	5.16	0.68
2013	0.76	1.69	1.30	0.47	1.08	1.75	1.59	0.85	0.85	1.71	1.34	0.59	1.55	3.47	4.60	0.61
2014	0.72	1.80	1.22	0.41	0.97	1.81	1.44	0.71	0.79	1.80	1.23	0.50	1.46	3.49	4.23	0.55
2015	0.64	1.52	1.16	0.37	0.85	1.53	1.35	0.62	0.70	1.51	1.16	0.44	1.33	3.13	3.87	0.50
2016	0.68	1.72	1.26	0.36	0.87	1.72	1.43	0.59	0.73	1.71	1.26	0.43	1.36	3.53	3.65	0.50
2017	0.73	2.17	1.18	0.35	0.89	2.16	1.34	0.54	0.77	2.16	1.18	0.40	1.38	3.73	3.60	0.49
2018	0.66	1.93	1.09	0.32	0.79	1.91	1.24	0.48	0.70	1.92	1.10	0.37	1.24	3.29	3.21	0.46
2019	0.72	2.34	1.13	***0.30***	0.83	2.32	1.28	0.43	0.75	2.33	1.14	0.34	1.25	3.68	2.94	0.43
2020	0.59	1.89	0.92	0.26	0.68	1.86	1.06	0.36	0.61	1.87	0.93	***0.29***	1.08	3.02	2.71	0.38
2021	0.51	1.44	0.90	0.25	0.59	1.43	1.03	0.33	0.53	1.42	0.91	0.27	0.93	2.43	2.40	0.36
2022	0.51	1.43	0.92	0.24	0.58	1.43	1.04	0.33	0.53	1.42	0.93	0.27	0.93	2.51	2.26	0.36
2023	0.54	1.69	0.88	0.24	0.60	1.67	0.98	0.30	0.55	1.68	0.89	0.25	0.94	2.67	2.21	0.35
2024	0.49	1.58	0.79	0.20	0.53	1.57	0.87	***0.25***	0.50	1.57	0.81	0.21	0.82	2.26	2.05	***0.29***
2025	0.43	1.29	0.74	0.19	0.46	1.29	0.80	0.23	0.44	1.28	0.76	0.20	0.73	1.98	1.82	0.28
2026	0.38	1.08	0.71	0.18	0.41	1.07	0.75	0.21	0.39	1.06	0.72	0.19	0.66	1.69	1.68	0.26
2027	0.47	1.60	0.74	0.18	0.50	1.59	0.78	0.21	0.48	1.59	0.75	0.19	0.75	2.29	1.66	0.27
2028	0.46	1.69	0.65	0.16	0.48	1.69	0.68	0.18	0.46	1.69	0.66	0.17	0.73	2.33	1.61	0.23
2029	0.39	1.34	0.63	0.15	0.41	1.33	0.65	0.17	0.40	1.33	0.62	0.16	0.62	1.83	1.44	0.22
2030	0.35	0.99	0.63	0.16	0.36	0.98	0.65	0.18	0.35	0.98	0.62	0.17	0.55	1.45	1.33	0.23
2031	0.40	1.42	0.58	0.15	0.41	1.41	0.61	0.16	0.40	1.41	0.58	0.15	0.59	1.86	1.27	0.21
2032	0.35	1.18	0.55	0.14	0.36	1.18	0.58	0.15	0.35	1.18	0.55	0.14	0.53	1.59	1.13	0.20
2033	0.34	1.14	0.53	0.13	0.35	1.13	0.56	0.14	0.34	1.13	0.53	0.13	0.49	1.47	1.04	0.18
2034	0.34	1.23	0.49	0.13	0.35	1.23	0.52	0.13	0.34	1.23	0.49	0.13	0.48	1.50	0.98	0.17
2035	***0.29***	0.88	0.47	0.14	***0.28***	0.87	0.50	0.12	***0.28***	0.87	0.48	0.12	0.41	1.12	0.87	0.18
2036	0.40	1.21	0.48	0.22	0.33	1.21	0.50	0.11	0.33	1.20	0.48	0.12	0.51	1.43	0.85	0.26
2037	0.36	0.98	0.46	0.21	0.29	0.98	0.49	0.11	0.32	0.98	0.47	0.15	0.45	1.19	0.75	0.24
2038	0.36	1.13	0.43	0.19	0.33	1.13	0.45	0.14	0.37	1.13	0.43	0.20	0.45	1.32	0.72	0.22
2039	0.33	0.89	0.42	0.19	0.34	0.89	0.44	0.21	0.34	0.89	0.42	0.21	0.41	1.09	0.68	0.22
2040	0.31	0.86	0.42	0.17	0.33	0.86	0.44	0.20	0.32	0.86	0.42	0.19	0.38	0.98	0.63	0.20
2041	0.37	1.23	0.44	0.18	0.40	1.23	0.45	0.22	0.39	1.23	0.44	0.20	0.45	1.42	0.66	0.21
2042	0.39	1.40	0.46	0.16	0.42	1.40	0.47	0.20	0.41	1.40	0.46	0.18	0.46	1.56	0.65	0.19
2043	0.33	1.10	0.39	0.15	0.35	1.10	0.40	0.18	0.34	1.10	0.40	0.16	0.39	1.22	0.62	0.17
2044	0.28	0.82	0.37	0.14	0.29	0.82	0.37	0.16	0.28	0.83	0.37	0.15	0.32	0.88	0.55	0.16
2045	0.30	0.97	0.38	0.14	0.31	0.97	0.38	0.16	0.31	1.00	0.38	0.15	0.34	1.04	0.52	0.16
2046	0.27	0.86	0.36	0.13	0.28	0.86	0.36	0.14	0.28	0.88	0.36	0.14	0.32	0.95	0.51	0.15
2047	0.28	0.93	0.37	0.13	0.29	0.91	0.37	0.14	0.29	0.93	0.37	0.14	0.35	1.17	0.49	0.15
2048	0.30	1.08	0.37	0.13	0.31	1.07	0.37	0.14	0.31	1.07	0.37	0.13	0.39	1.42	0.50	0.15
2049	0.31	1.14	0.39	0.12	0.33	1.15	0.39	0.14	0.32	1.13	0.39	0.13	0.38	1.39	0.50	0.14
2050	0.28	0.96	0.36	0.12	0.29	0.96	0.36	0.13	0.28	0.95	0.37	0.12	0.34	1.21	0.49	0.13
2051	0.27	0.96	0.36	0.10	0.28	0.96	0.36	0.11	0.27	0.96	0.37	0.11	0.32	1.12	0.47	0.12
2052	0.24	0.80	0.36	0.10	0.25	0.80	0.36	0.11	0.25	0.82	0.36	0.11	***0.29***	0.98	0.44	0.12
2053	0.32	1.26	0.38	0.11	0.32	1.26	0.38	0.12	0.33	1.28	0.38	0.11	0.37	1.41	0.49	0.12
2054	0.29	1.08	0.38	0.11	0.29	1.08	0.38	0.11	0.30	1.10	0.38	0.11	0.32	1.18	0.46	0.12
2055	0.26	0.93	0.36	0.10	0.26	0.93	0.36	0.11	0.27	0.95	0.36	0.10	0.30	1.06	0.44	0.11
2056	0.28	1.03	0.41	0.10	0.29	1.02	0.40	0.11	0.29	1.04	0.41	0.10	0.32	1.16	0.45	0.11
2057	0.29	1.14	0.37	0.10	0.30	1.14	0.37	0.10	0.30	1.15	0.37	0.10	0.32	1.17	0.46	0.11
2058	0.25	0.85	0.37	0.10	0.25	0.85	0.37	0.10	0.25	0.87	0.38	0.10	0.27	0.91	0.43	0.11
2059	0.31	1.27	0.36	0.10	0.31	1.26	0.36	0.10	0.31	1.28	0.36	0.10	0.33	1.31	0.46	0.10
2060	0.24	0.88	0.35	0.09	0.25	0.87	0.35	0.09	0.25	0.89	0.35	0.09	0.26	0.93	0.40	0.10
2061	0.23	0.79	0.33	0.09	0.23	0.79	0.33	0.09	0.23	0.80	0.33	0.09	0.25	0.84	0.38	0.09
2062	0.25	0.89	0.34	0.09	0.25	0.89	0.34	0.09	0.25	0.90	0.34	0.09	0.26	0.91	0.38	0.10
2063	0.24	0.89	0.35	0.09	0.25	0.89	0.34	0.09	0.25	0.89	0.35	0.09	0.26	0.91	0.37	0.10
2064	0.25	0.92	0.36	0.09	0.25	0.92	0.36	0.09	0.25	0.92	0.36	0.09	0.27	0.97	0.38	0.10
2065	0.25	0.88	0.36	0.10	0.25	0.87	0.36	0.10	0.25	0.88	0.36	0.10	0.25	0.87	0.38	0.10
2066	0.30	1.25	0.34	0.09	0.30	1.25	0.34	0.09	0.30	1.25	0.34	0.09	0.31	1.26	0.40	0.09
2067	0.26	0.95	0.37	0.09	0.26	0.95	0.37	0.09	0.26	0.95	0.37	0.09	0.27	0.97	0.37	0.10

Notes:
Fish fillets multiplied by 2.5 to obtain whole fish concentrations.
Upper Hudson River average is weighted by river section length. River Section 1: 6.3 miles = 15.4%; River Section 2: 5.1 miles = 12.5%; and River Section 3: 29.5 miles = 72.1%.
All whole fish PCB concentrations are above target fish concentration of 0.3 mg/kg and/or 0.03 mg/kg based on the river otter lowest-observed-adverse-effects-level (LOAEL) and no-observed-adverse-effects-level (NOAEL), respectively.

Table 2-10
Modeled Times of Compliance with River Otter Risk-Based Fish Concentrations Upper Hudson River

	River Otter - RI/FS TRVs (whole fish tissue)	
	LOAEL 0.3 PCBs mg/kg	NOAEL 0.03 PCBs mg/kg
Upper Hudson River Average		
No Resuspension (d004)	2035	> 2067
Total PCB 350 ng/L (sr04)	2035	> 2067
Total PCB 600 g/day (sr01)	2035	> 2067
Monitored Natural Attenuation	2052	> 2067
Upper Hudson River Section 1		
No Resuspension (d004)	> 2067	> 2067
Total PCB 350 ng/L (sr04)	> 2067	> 2067
Total PCB 600 g/day (sr01)	> 2067	> 2067
Monitored Natural Attenuation	> 2067	> 2067
Upper Hudson River Section 2		
No Resuspension (d004)	> 2067	> 2067
Total PCB 350 ng/L (sr04)	> 2067	> 2067
Total PCB 600 g/day (sr01)	> 2067	> 2067
Monitored Natural Attenuation	> 2067	> 2067
Upper Hudson River Section 3		
No Resuspension (d004)	2019	> 2067
Total PCB 350 ng/L (sr04)	2024	> 2067
Total PCB 600 g/day (sr01)	2020	> 2067
Monitored Natural Attenuation	2024	> 2067

Notes:
First year in which fish target concentrations are achieved are provided.
Upper Hudson River average is weighted by river section length. River Section 1: 6.3 miles = 15.4
River Section 2: 5.1 miles = 12.5%; and River Section 3: 29.5 miles = 72.1%.

Table 2-11
Lower Hudson River Average Largemouth Bass (Whole Fish) PCB Concentration (in mg/kg)

	No Resuspension (d004)				Total PCB 350 ng/L (sr04)				Total PCB 600 g/day (sr01)				Monitored Natural Attenuation			
Year	River Mile 152	River Mile 113	River Mile 90	River Mile 50	River Mile 152	River Mile 113	River Mile 90	River Mile 50	River Mile 152	River Mile 113	River Mile 90	River Mile 50	River Mile 152	River Mile 113	River Mile 90	River Mile 50
1998	7.15	5.21	3.55	3.26	7.15	5.21	3.55	3.26	7.15	5.21	3.55	3.26	7.54	5.30	3.55	3.24
1999	4.53	4.12	3.30	3.01	4.53	4.12	3.30	3.01	4.53	4.12	3.30	3.01	4.37	4.06	3.28	2.99
2000	3.81	3.56	2.93	2.73	3.81	3.56	2.93	2.73	3.81	3.56	2.93	2.73	4.01	3.56	2.91	2.71
2001	4.50	3.54	2.66	2.49	4.50	3.54	2.66	2.49	4.50	3.54	2.66	2.49	4.51	3.54	2.65	2.47
2002	3.97	3.19	2.49	2.31	3.97	3.19	2.49	2.31	3.97	3.19	2.49	2.31	3.91	3.17	2.47	2.28
2003	3.42	2.82	2.26	2.10	3.42	2.82	2.26	2.10	3.42	2.82	2.26	2.10	3.39	2.82	2.25	2.08
2004	2.42	2.26	1.97	1.89	2.42	2.26	1.97	1.89	2.42	2.26	1.97	1.89	2.39	2.23	1.96	1.88
2005	2.27	1.95	1.69	1.67	2.27	1.95	1.69	1.67	2.27	1.95	1.69	1.67	2.25	1.94	1.68	1.66
2006	2.37	1.85	1.49	1.48	2.53	1.89	1.49	1.49	2.49	1.86	1.49	1.49	2.34	1.86	1.49	1.47
2007	1.93	1.71	1.35	1.34	2.37	1.86	1.40	1.36	2.20	1.79	1.38	1.34	1.89	1.70	1.35	1.32
2008	1.54	1.41	1.22	1.20	2.33	1.77	1.33	1.25	1.97	1.60	1.27	1.23	1.57	1.42	1.21	1.20
2009	1.21	1.15	1.06	1.05	2.03	1.53	1.18	1.12	1.62	1.34	1.12	1.08	1.27	1.16	1.06	1.05
2010	1.10	1.02	0.92	0.94	2.55	1.71	1.16	1.06	1.73	1.30	1.02	1.00	1.36	1.13	0.94	0.95
2011	1.25	1.01	0.84	0.86	5.16	2.57	1.35	1.10	2.43	1.49	1.01	0.96	1.63	1.22	0.91	0.89
2012	0.92	0.86	0.75	0.77	2.17	2.06	1.38	1.13	1.32	1.20	0.96	0.90	1.30	1.11	0.86	0.83
2013	1.02	0.82	0.68	0.71	1.78	1.63	1.28	1.11	1.27	1.08	0.88	0.84	1.48	1.13	0.83	0.79
2014	0.86	0.74	0.62	0.64	1.33	1.29	1.12	1.04	1.01	0.92	0.78	0.77	1.27	1.03	0.79	0.74
2015	0.72	0.65	0.56	0.59	1.04	1.04	0.96	0.94	0.82	0.78	0.69	0.70	1.00	0.90	0.73	0.70
2016	0.55	0.53	0.50	0.53	0.76	0.78	0.79	0.83	0.61	0.61	0.60	0.63	0.76	0.72	0.65	0.64
2017	0.46	0.45	0.44	0.48	0.54	0.60	0.65	0.73	0.51	0.51	0.51	0.56	0.68	0.62	0.57	0.59
2018	0.43	0.41	0.39	0.44	0.45	0.50	0.54	0.63	0.47	0.45	0.45	0.50	0.65	0.58	0.51	0.53
2019	0.34	0.35	0.35	0.40	0.35	0.39	0.44	0.54	0.37	0.38	0.39	0.45	0.52	0.50	0.46	0.49
2020	0.42	0.35	0.32	0.36	0.42	0.37	0.38	0.46	0.45	0.37	0.35	0.40	0.68	0.51	0.42	0.44
2021	0.41	0.34	***0.30***	0.34	0.41	0.36	0.34	0.41	0.44	0.36	0.32	0.36	0.63	0.49	0.40	0.41
2022	0.35	0.32	0.29	0.32	0.35	0.33	0.31	0.37	0.37	0.34	0.30	0.34	0.51	0.45	0.38	0.39
2023	0.30	***0.29***	0.27	***0.30***	0.30	***0.29***	***0.28***	0.33	0.32	0.30	***0.28***	0.32	0.46	0.41	0.35	0.37
2024	0.32	0.28	0.25	0.28	0.32	0.28	0.26	0.31	0.33	***0.29***	0.26	***0.30***	0.48	0.40	0.34	0.35
2025	0.35	0.30	0.25	0.27	0.35	0.30	0.26	***0.29***	0.37	0.31	0.26	0.29	0.53	0.43	0.34	0.34
2026	0.33	0.29	0.25	0.27	0.33	0.29	0.25	0.28	0.34	0.29	0.25	0.28	0.48	0.40	0.33	0.33
2027	***0.26***	0.26	0.24	0.26	***0.26***	0.26	0.24	0.27	***0.26***	0.27	0.24	0.27	0.37	0.36	0.32	0.32
2028	0.24	0.24	0.23	0.25	0.24	0.25	0.23	0.26	0.25	0.25	0.23	0.26	0.35	0.34	***0.30***	0.31
2029	0.29	0.25	0.22	0.24	0.29	0.25	0.22	0.25	0.30	0.25	0.22	0.25	0.42	0.34	0.28	***0.30***
2030	0.29	0.25	0.22	0.24	0.29	0.25	0.22	0.24	0.30	0.25	0.22	0.24	0.40	0.34	0.28	0.29
2031	0.25	0.24	0.21	0.23	0.25	0.24	0.21	0.23	0.25	0.24	0.22	0.24	0.34	0.32	0.27	0.28
2032	0.25	0.24	0.21	0.23	0.25	0.24	0.21	0.23	0.26	0.24	0.22	0.24	0.35	0.32	0.27	0.28
2033	0.23	0.23	0.21	0.23	0.23	0.23	0.21	0.23	0.23	0.23	0.21	0.23	0.31	0.30	0.26	0.28
2034	0.22	0.22	0.20	0.22	0.22	0.22	0.20	0.22	0.22	0.22	0.20	0.23	***0.29***	***0.29***	0.25	0.27
2035	0.35	0.25	0.21	0.22	0.35	0.25	0.21	0.22	0.27	0.23	0.20	0.22	0.42	0.33	0.25	0.26
2036	0.48	0.32	0.23	0.23	0.48	0.32	0.23	0.23	0.23	0.22	0.20	0.22	0.54	0.38	0.27	0.26
2037	0.57	0.39	0.26	0.24	0.57	0.39	0.26	0.24	0.40	0.28	0.21	0.22	0.69	0.46	0.30	0.28
2038	0.58	0.40	0.28	0.26	0.58	0.40	0.28	0.26	0.65	0.38	0.24	0.23	0.65	0.47	0.32	0.29
2039	0.48	0.39	0.29	0.27	0.48	0.39	0.29	0.27	0.56	0.41	0.27	0.25	0.55	0.44	0.33	0.30
2040	0.43	0.37	0.29	0.27	0.43	0.37	0.29	0.27	0.51	0.40	0.29	0.26	0.48	0.42	0.33	0.31
2041	0.30	0.32	0.28	0.27	0.30	0.32	0.28	0.27	0.35	0.35	0.28	0.27	0.35	0.36	0.31	0.30
2042	0.25	0.27	0.26	0.26	0.25	0.27	0.26	0.26	0.29	0.30	0.27	0.27	0.28	0.30	0.28	0.29
2043	0.29	0.26	0.24	0.25	0.29	0.26	0.24	0.25	0.33	0.29	0.25	0.26	0.35	0.30	0.26	0.28
2044	0.35	0.28	0.23	0.24	0.35	0.28	0.23	0.25	0.38	0.31	0.25	0.25	0.42	0.32	0.26	0.27
2045	0.33	0.28	0.23	0.24	0.33	0.28	0.23	0.24	0.34	0.30	0.24	0.25	0.38	0.32	0.26	0.26
2046	0.29	0.26	0.22	0.24	0.29	0.26	0.22	0.24	0.30	0.27	0.23	0.24	0.33	0.30	0.25	0.26

Notes:
Fish fillets multiplied by 2.5 to obtain whole fish concentrations.
All whole fish PCB concentrations are above target fish concentration of 0.3 mg/kg and/or 0.03 mg/kg based on the river otter lowest-observed-adverse-effects-level (LOAEL) and no-observed-adverse-effects-level (NOAEL), respectively.

Table 2-12
Modeled Times of Compliance with River Otter
Risk-Based Fish Concentrations Lower Hudson River

	River Otter - RI/FS TRVs (whole fish tissue)	
	LOAEL 0.3 PCBs mg/kg	**NOAEL 0.03 PCBs mg/kg**
Lower Hudson River RM 152		
No Resuspension (d004)	2027	> 2067
Total PCB 350 ng/L (sr04)	2027	> 2067
Total PCB 600 g/day (sr01)	2027	> 2067
Monitored Natural Attenuation	2034	> 2067
Lower Hudson River RM 113		
No Resuspension (d004)	2023	> 2067
Total PCB 350 ng/L (sr04)	2023	> 2067
Total PCB 600 g/day (sr01)	2024	> 2067
Monitored Natural Attenuation	2034	> 2067
Lower Hudson River RM 90		
No Resuspension (d004)	2021	> 2067
Total PCB 350 ng/L (sr04)	2023	> 2067
Total PCB 600 g/day (sr01)	2023	> 2067
Monitored Natural Attenuation	2028	> 2067
Lower Hudson River RM 50		
No Resuspension (d004)	2023	> 2067
Total PCB 350 ng/L (sr04)	2025	> 2067
Total PCB 600 g/day (sr01)	2024	> 2067
Monitored Natural Attenuation	2029	> 2067

Notes:
First year in which fish target concentrations are achieved are provided.

Table 2-13
Results for Average Source Strength Estimated Fluxes

	INPUT				TSS-Chem RESULTS				PERCENT LOSS	
	PCB Production rate kg PCB/day	Sediment production rate kg solids/day	Silt Fraction unitless	TSS Silt Source Strength (1,2) (kg/s)	Net TSS Flux at 1 mile (2) (kg/day)	Net Total PCB Flux at 1 mile (2) (g/day)	Net Fraction Dissolved PCBs at 1 mile unitless	Concentration increase at 1 mile (ng/l)	TSS Loss at 1 mile %	PCB Loss at 1 mile %
River Section										
Section 1	57	2,099,921	0.37	0.077	2,303	78	0.35	14	0.11	0.14
Section 2	116	1,857,493	0.48	0.088	2,642	209	0.39	37	0.14	0.18
Section 3	45	1,563,927	0.48	0.074	2,225	81	0.40	14	0.14	0.18

Notes:

1. Source strengths apply to silt and finer particles only
2. Production rates are based on 7 days/week, 14 hours per day, 630 days in Section 1 and 210 days each in River Sections 2 & 3.
3. Values are based on river-wide volumetric flow of 4000 cfs.

Table 2-14
Resuspension Production, Release, and Export Rates from TSS-Chem and HUDTOX Models

TSS-Chem and HUDTOX Simulations

Scenario	Sediment Removal Period	Dredging Location and Monitoring Station	Resuspension Production Rate of Sediment[1] (kg/s)	Resuspension Production Rate of Total PCB[2] (g/day)	Silt Fraction in Dredged Material	Net SS Flux at 1 mile from SS-Chem (kg/s)	Total PCB flux at 1 mile3 from TSS-Chem (Resuspension Release Rate) (g/day)	Fraction Dissolved total PCB from TSS-Chem	Total PCB Flux at Far-field Monitoring Stations from HUDTOX[4] (Resuspension Export Rate) (g/day)	Removal Rate of total PCB via Dredging[6] (g/day)	Removal Rate of Solids via Dredging[7] (kg/s)	Source Strength as Percentage of total PCB Removed[8] (%)	Resuspension Export Rate as Percentage of total PCB Removed[9] (%)	Total PCB Export Fraction - (Resuspension Export Rate/Resuspension Production Rate)
				A			B		C	D		(A/D)	(C/D)	(C/A)
Evaluation Level - 300 g/day total PCB Flux at the Far-Field Monitoring Stations	May 1 - November 30, 2006	Section 1, TID	1.3	1,700	0.37	0.28	410	0.22	320	5.7.E+04	42	3%	0.56%	0.19
	May 1 - November 30, 2007	Section 1, TID	1.3	1,700	0.37	0.27	410	0.22	320	5.7.E+04	42	3%	0.56%	0.19
	May 1 - November 30, 2008	Section 1, TID	1.1	1,500	0.37	0.24	360	0.23	300	5.7.E+04	42	3%	0.53%	0.20
	May 1 - August 15, 2009	Section 1, TID	0.9	1,300	0.37	0.20	310	0.25	310	5.7.E+04	42	2%	0.54%	0.24
	ugust 16 - November 30, 200	Section 2, Schuylerville	0.3	1,100	0.48	0.10	360	0.35	330	1.2.E+05	37	1%	0.29%	0.30
	May 1 - August 15, 2010	Section 2, Schuylerville	0.3	900	0.48	0.08	310	0.37	300	1.2.E+05	37	1%	0.26%	0.33
	ugust 16 - November 30, 201	Section 3, Waterford	0.9	1,300	0.48	0.25	400	0.25	340	4.5.E+04	31	3%	0.75%	0.26
	May 1 - August 15, 2011	Section 3, Waterford	0.7	1,000	0.48	0.19	310	0.28	340	4.5.E+04	31	2%	0.75%	0.34
Concern Level - 600 g/day total PCB Flux at the Far-Field Monitoring Stations	May 1 - November 30, 2006	Section 1, TID	2.6	3,600	0.37	0.57	820	0.15	620	5.7.E+04	42	6%	1.1%	0.17
	May 1 - November 30, 2007	Section 1, TID	2.6	3,600	0.37	0.57	820	0.15	630	5.7.E+04	42	6%	1.1%	0.18
	May 1 - November 30, 2008	Section 1, TID	2.3	3,100	0.37	0.50	720	0.16	620	5.7.E+04	42	6%	1.1%	0.20
	May 1 - August 15, 2009	Section 1, TID	2.0	2,700	0.37	0.43	620	0.18	590	5.7.E+04	42	5%	1.0%	0.22
	ugust 16 - November 30, 200	Section 2, Schuylerville	0.7	2,300	0.48	0.21	730	0.29	620	1.2.E+05	37	2%	0.5%	0.27
	May 1 - August 15, 2010	Section 2, Schuylerville	0.6	1,900	0.48	0.17	630	0.30	590	1.2.E+05	37	2%	0.5%	0.31
	ugust 16 - November 30, 201	Section 3, Waterford	1.9	2,700	0.48	0.52	810	0.17	660	4.5.E+04	31	6%	1.5%	0.24
	May 1 - August 15, 2011	Section 3, Waterford	1.4	2,100	0.48	0.40	630	0.20	650	4.5.E+04	31	5%	1.4%	0.31
Control Level - 350 ng/L total PCB Concentrations at the Far-Field Monitoring Stations	May 1 - November 30, 2006	Section 1, TID	5.6	7,600	0.37	1.2	1,700	0.09	1,200	5.7.E+04	42	13%	2.1%	0.16
	May 1 - November 30, 2007	Section 1, TID	5.6	7,600	0.37	1.2	1,700	0.09	1,200	5.7.E+04	42	13%	2.1%	0.16
	May 1 - November 30, 2008	Section 1, TID	4.9	6,700	0.37	1.1	1,500	0.10	1,300	5.7.E+04	42	12%	2.3%	0.19
	May 1 - August 15, 2009	Section 1, TID	4.2	5,700	0.37	0.91	1,300	0.11	1,200	5.7.E+04	42	10%	2.1%	0.21
	ugust 16 - November 30, 200	Section 2, Schuylerville	2.7	8,300	0.48	0.75	2,500	0.14	2,000	1.2.E+05	37	7%	1.7%	0.24
	May 1 - August 15, 2010	Section 2, Schuylerville	2.3	7,100	0.48	0.64	2,100	0.16	2,000	1.2.E+05	37	6%	1.7%	0.28
	ugust 16 - November 30, 201	Section 3, Waterford	7.5	10,900	0.48	2.1	3,100	0.06	2,200	4.5.E+04	31	24%	4.9%	0.20
	May 1 - August 15, 2011	Section 3, Waterford	5.8	8,400	0.48	1.6	2,400	0.07	2,300	4.5.E+04	31	19%	5.1%	0.27

TSS-Chem Simulations Only

Scenario	Sediment Removal Period	Dredging Location and Monitoring Station	Resuspension Production Rate of Sediment[1] (kg/s)	Resuspension Production Rate of Total PCB[2] (g/day)	Silt Fraction in Dredged Material	Net SS Flux at 1 mile from SS-Chem (kg/s)	Total PCB flux at 1 mile3 from TSS-Chem (Resuspension Release Rate) (g/day)	Fraction Dissolved total PCB from TSS-Chem	Total PCB Flux at Monitoring Stations[10] (Resuspension Export Rate) (g/day)	Removal Rate of total PCB via Dredging[6] (g/day)	Removal Rate of Solids via Dredging[7] (kg/s)	Source Strength as Percentage of total PCB Removed[8] (%)	Resuspension Export Rate as Percentage of total PCB Removed[9] (%)	Total PCB Export Fraction - (Resuspension Export Rate/Resuspension Production Rate)
				A			B		C	D		(A/D)	(C/D)	(C/A)
Resuspension Standard - 500 ng/L total PCB Concentrations at the Far-Field Monitoring Stations	May 1 - November 30, 2006	Section 1, TID	9.4	12,800	0.37	2.0	2,800	0.06	2,100	5.7.E+04	42	23%	3.7%	0.16
	May 1 - November 30, 2007	Section 1, TID	9.3	12,700	0.37	2.0	2,800	0.06	2,100	5.7.E+04	42	22%	3.7%	0.17
	May 1 - November 30, 2008	Section 1, TID	8.2	11,200	0.37	1.8	2,500	0.06	2,100	5.7.E+04	42	20%	3.7%	0.19
	May 1 - August 15, 2009	Section 1, TID	7.1	9,600	0.37	1.53	2,100	0.07	2,100	5.7.E+04	42	17%	3.7%	0.22
	ugust 16 - November 30, 200	Section 2, Schuylerville	3.5	10,900	0.48	0.99	3,200	0.12	2,700	1.2.E+05	37	9%	2.3%	0.25
	May 1 - August 15, 2010	Section 2, Schuylerville	3.0	9,300	0.48	0.84	2,800	0.13	2,700	1.2.E+05	37	8%	2.3%	0.29
	ugust 16 - November 30, 201	Section 3, Waterford	11	16,600	0.48	3.2	4,800	0.04	3,500	4.5.E+04	31	37%	7.7%	0.21
	May 1 - August 15, 2011	Section 3, Waterford	8.8	12,800	0.48	2.5	3,700	0.05	3,500	4.5.E+04	31	28%	7.7%	0.27

Notes:
Numbers are rounded to 2 significant digits.
1 Source strength represents the amount of solids being suspended to the water column at the dredge-head in kg/s. The value is obtained from the CSTR-Chem model.
2 Total PCB flux for source strength is obtained by multiplying the solids source strength with the total PCB concentration in the sediment. The total PCB concentration for River Sections 1, 2, and 3 is 27, 62, and 29 mg/kg, respectively.
3 Net SS flux is the TSS-Chem model result at a distance 1 mile downstream of the dredge-head. This number is also the SS flux input to the HUDTOX model.
4 Values represent the amount of total PCB flux at the monitoring stations as predicted by HUDTOX.
5 Total PCB flux is obtained from TSS-Chem model. It is the total PCB flux at 1 mile downstream of the dredge-head. This is also the input total PCB flux to the HUDTOX model.
6 Removal rate of total PCBs via dredging is based on the total total PCB being removed in each river section (36,000 kg, 24,300 kg, and 9,500 kg of total PCB for River Sections 1, 2, and 3, respectively); assuming 7days/week, 14 hours/day, 630 days in River Section 1 and 210 days each in River Sections 2 and 3.
7 Removal rate of solids via dredging is calculated based on the total sediment being removed including overcut (1.5x10^6 cy, 5.8x10^5 cy, and 5.1x10^5 cy of solids in River Sections 1, 2, and 3, respectively); assuming 7days/week and 14 hours/day, 630 days in River Section 1 and 210 days each in River Sections 2 and 3.
8 Percentage is calculated as total PCB source strength divide by the total PCB production rate.
9 Percentage is calculated as total PCB flux at the monitoring station divide by the total PCB production rate.
10 Total PCB flux values are extrapolated from the previous HUDTOX runs above.

Table 2-15
Increase in PCB Mass from Settled Material 2-Acres Below the Target Area
Estimated Using the TSS-Chem Model Results

Management Level	Condition at Far Field Station	River Section	Total PCBs Length Weighted Average Concentration (mg/kg)
Evaluation	300 g/day PCB Mass Loss	1	2.6
Concern	600 g/day PCB Mass Loss	1	4.2
Control	350 ng/L	1	6.6
Evaluation	300 g/day PCB Mass Loss	2	2.0
Concern	600 g/day PCB Mass Loss	2	3.3
Control	350 ng/L	2	9.1
Evaluation	300 g/day PCB Mass Loss	3	2.2
Concern	600 g/day PCB Mass Loss	3	3.5
Control	350 ng/L	3	8.6

1. Mass/Area used to define the lateral extent of dredging in River Sections 1 and 2 is approximately 6.6 g/sq. m and 34 g/sq. m, respectively. In River Section 3, a mass/area was not used to select the areas in this way.

2. The length weighted average concentration was calculated assuming the concentration below the deposited PCBs is 1 mg/kg Total PCBs.

Table 3-1
Estimated 7-Day Total PCB Concentrations[1] Corresponding to the Evaluation Level (300 g/day) at the Schuylerville Monitoring Station

			Total PCB (ng/L)- Schuylerville Station[2,3]					
Flow (cfs)	Flow (m^3/s)	TPCB increase (ng/L)	May & June	July	August	Sept.	Oct.	Nov.
95% UCL Baseline Total PCB Concentration			**121**	**103**	**81**	**60**	**84**	**75**
2,000	57	105	226	208	186	165	189	180
2,500	71	84	205	187	165	144	168	159
3,000	85	70	191	173	151	130	154	145
3,500	99	60	181	163	141	120	144	135
4,000	113	53	174	155	133	113	136	128
4,500	127	47	168	149	127	107	131	122
5,000	142	42	163[4]	145	123	102	126	117
5,500	156	38	160	141	119	98	122	113
6,000	170	35	156	138	116	95	119	110
6,500	184	32	154	135	113	92	116	108
7,000	198	30	151	133	111	90	114	105
7,500	212	28	149	131	109	88	112	103
8,000	227	26	148	129	107	86	110	101
8,500	241	25	146	127	105	85	109	100
9,000	255	23	145[5]	126	104	83	107	99
9,500	269	22	143	125	103	82	106	97
10,000	283	21	142	124	102	81	105	96

Notes:

1. PCB concentrations are estimated based on the assumption of a 7-day per week operation, 14 hours per day for May to November (210 days). This is conservative since operating less than 7 days per week would increase the daily allowable PCB load. These values will be adjusted to reflect the planned period of operation once it is defined as part of the remedial design.
2. Italicized numbers reflect the actual estimates for Total PCB at the action level. However, in these instances the absolute concentration of 350 ng/L specified by the Level 3 criterion will govern. Exceedances of 350 ng/L will require Level 3 contingencies in all cases.
3. Shaded areas represent the concentration at the mean flow for the month, based on flow estimates derived from the USGS flow data (1977-present).
4. Condition for June.
5. Condition for May.
6. The values provided in this table are based on historic data. Final numbers will be derived at the end of the remedial design period when baseline monitoring data are available and more is known about the operating schedule and production rate.

Table 3-2
Estimated 7-DayTotal PCB Concentrations[1] Corresponding to the Concern Level (600 g/day) at the Schuylerville Monitoring Station

			Total PCB (ng/L) - Schuylerville Station[2,3]					
Flow (cfs)	Flow (m^3/s)	TPCB increase (ng/L)	May & June	July	August	Sept.	Oct.	Nov.
95% UCL Baseline Total PCB Concentration			**121**	**103**	**81**	**60**	**84**	**75**
2,000	57	210	331	313	291	270	294	285
2,500	71	168	289	271	249	228	252	243
3,000	85	140	261	243	221	200	224	215
3,500	99	120	241	223	201	180	204	195
4,000	113	105	226	208	186	165	189	180
4,500	127	93	215	196	174	154	177	169
5,000	142	84	205[4]	187	165	144	168	159
5,500	156	76	198	179	157	137	160	152
6,000	170	70	191	173	151	130	154	145
6,500	184	65	186	167	145	125	149	140
7,000	198	60	181	163	141	120	144	135
7,500	212	56	177	159	137	116	140	131
8,000	227	53	174	155	133	113	136	128
8,500	241	49	171	152	130	110	133	125
9,000	255	47	168[5]	149	127	107	131	122
9,500	269	44	166	147	125	104	128	119
10,000	283	42	163	145	123	102	126	117

Notes:

1. PCB concentrations are estimated based on the assumption of a 7-day per week operation, 14 hours per day for May to November (210 days). This is conservative since operating less than 7 days per week would increase the daily allowable PCB load. These values will be adjusted to reflect the planned period of operation once it is defined as part of the remedial design.
2. Italicized numbers reflect the actual estimates for Total PCB at the action level. However, in these instances the absolute concentration of 350 ng/L specified by the Level 3 criterion will govern. Exceedances of 350 ng/L will require Level 3 contingencies in all cases.
3. Shaded areas represent the concentration at the mean flow for the month, based on flow estimates derived from the USGS flow data (1977-present).
4. Condition for June.
5. Condition for May.
6. The values provided in this table are based on historic data. Final numbers will be derived at the end of the remedial design period when baseline monitoring data are available and more is known about the operating schedule and production rate.

Table 3-3
Estimated 4-Week Average Total PCB Concentrations[1] Corresponding to the Control Level (600 g/day) at the Schuylerville Monitoring Station

			Total PCB (ng/L) - Schuylerville Station[2]					
Flow (cfs)	Flow (m^3/s)	TPCB increase (ng/L)	May & June	July	August	Sept.	Oct.	Nov.
95% UCL Baseline Total PCB Concentration			121	103	81	60	84	75
2,000	57	210	317	292	284	262	285	277
2,500	71	168	275	250	242	220	243	235
3,000	85	140	247	222	214	192	215	207
3,500	99	120	227	202	194	172	195	187
4,000	113	105	212	187	179	157	180	172
4,500	127	93	200	176	167	146	169	160
5,000	142	84	191[3]	166	158	136	159	151
5,500	156	76	183	159	150	129	152	143
6,000	170	70	177	152	144	122	145	137
6,500	184	65	171	147	138	117	140	132
7,000	198	60	167	142	134	112	135	127
7,500	212	56	163	138	130	108	131	123
8,000	227	53	159	135	126	105	128	119
8,500	241	49	156	132	123	102	125	116
9,000	255	47	153[4]	129	120	99	122	114
9,500	269	44	151	126	118	96	119	111
10,000	283	42	149	124	116	94	117	109

Notes:

1. PCB concentrations are estimated based on the assumption of a 7-day per week operation, 14 hours per day for May to November (210 days). This is conservative since operating less than 7 days per week would increase the daily allowable PCB load. These values will be adjusted to reflect the planned period of operation once it is defined as part of the remedial design.
2. Shaded areas represent the concentration at the mean flow for the month, based on flow estimates derived from the USGS flow data (1977-present).
3. Conditions for June.
4. Conditions for May.
5. The values provided in this table are based on historic data. Final numbers will be derived at the end of the remedial design period when baseline monitoring data are available and more is known about the operating schedule and production rate.

Table 3-4
Estimates for Baseline Concentration Factors at Thompson Island Dam (TID), Schuylerville, and Waterford[1]

TID West Total PCB Estimates[2]

Parameters	Monthly Upper Bound						
7 Day Running Average (ng/L)	May 181	June 205	July 151	August 106	September 83	October 241	November 241
Daily Value - Prediction Limit (ng/L)	May 368	June 368	July 212	August 149	September 119	October 297	November 297

TID PRW2 Total PCB Estimates[2]

Parameters	Monthly Upper Bound						
7 Day Running Average (ng/L)	May 111 [3] 47 [4]	June 111 [3] 47 [4]	July 71	August 71	September 50	October 64	November 45
Daily Value - Prediction Limit (ng/L)	May 161 [3] 68 [4]	June 161 [3] 68 [4]	July 106	August 106	September 72	October 92	November 65

Schuylerville Total PCB Estimates

Parameters	Monthly Upper Bound						
7 Day Running Average (ng/L)	May 121	June 121	July 103	August 81	September 60	October 84	November 75
Daily Value - Prediction Limit (ng/L)	May 195	June 195	July 99	August 107	September 85	October 118	November 107

Waterford Total PCB Estimates[5]

Parameters	Monthly Upper Bound						
7 Day Running Average (ng/L)	May 90	June 90	July 76	August 60	September 44	October 62	November 56
Daily Value - Prediction Limit (ng/L)	May 144	June 144	July 73	August 79	September 63	October 87	November 79

Notes:

[1] These tables are initial estimates for C_{bl} and $\overline{C_{bl}}$ for the TID and Schuylerville stations. These values will be revised using the data collected during the baseline monitoring program. Similar values will be determined for Stillwater and Waterford from the baseline monitoring as well.
[2] The actual TID values were expected to fall between those obtain for TID West and TID PRW2.
[3] For flow < 5000 cfs.
[4] For flow > 5000 cfs.
[5] The values were obtained by multiplying a dilution factor of 0.74 to the Schuylerville concentrations.

Table 3-5

Far-Field Monitoring - Analytical Details

Parameter	Analytical Method / Instrument	Detection Limit Goal	Method Range	Accuracy	Precision	Sample Size	Holding Time	Sample Container	Preservation
Congener-specific PCBs (Total)	Green Bay or equivalent	0.05 ng/L/congener	Lab-specific and congener-specific	60-150%	40% RPD[1]	1 Liters	5/40[2] days	1 Liter amber glass	Maintain at 4° C (± 2° C)
Congener-specific PCBs (Water)	Green Bay or equivalent	0.05 ng/L/congener	Lab-specific and congener-specific	60-150%	40% RPD	20 Liters	5/40[2] days	4 Liter amber glass	Maintain at 4° C (± 2° C)
Congener-specific PCBs (Particle)	Green Bay or equivalent	1 µg/kg	Lab-specific and congener-specific	60-150%	40% RPD	200-800 mg	5/40[2] days	Amber glass	Maintain at 4° C (± 2° C)
DOC (TOC on filtered water)	Persulfate Digestion (415.2)	0.025 mg/L	50 µg/L to 10 mg/L	90-110%	20% RPD	2 x 40 mL (25 mL minimum)	28 days	VOA vial	Maintain at 4°C H_2SO_4 pH ≤2
TSS	ASTM D 3977-97	0.5 mg/L (on 1 L sample)	0.5 to 2000 mg/L on 1 L sample	90 - 110%	20% RPD	1 Liter	7 days	4 Liter plastic	Maintain at 4° C (± 2° C)
TSS (using particle counter)	LISST Series	TBD	1.2 to 250 µm	TBD	TBD	25-50 mL	Field	Per instrument requirement	NA
Turbidity	YSI 6-Series	2 NTU	0 to 1000 NTU	± 5% or 3 NTU[3]	5%	25-50 mL	Field	Per instrument requirement	NA
Temperature	YSI 6-Series	0.15° C	-5 to +45 °C	± 0.15° C	± 0.15° C	25-50 mL	Field	Per instrument requirement	NA
pH	YSI 6-Series	0.2 pH unit	0 to 14 pH units	± 0.2 pH unit	± 0.2 pH unit	25-50 mL	Field	Per instrument requirement	NA
Dissolved Oxygen	YSI 6-Series	0.2 mg/L	0 to 50 mg/L	0-20 mg/L: ± 2% or 0.2 mg/L[3]	15%	25-50 mL	Field	Per instrument requirement	NA
Conductivity	YSI 6-Series	0.001 mS/cm	0 to 100 mS/cm	± 0.5% or 0.001 mS/cm[3]	10%	25-50 mL	Field	Per instrument requirement	NA
TOC on SS – routine EPA 160.4	Volatile solids on SS as surrogate for TOC.	0.5% dry wt based on SS	± 0.3 mg assuming 0.1 mg sensitivity	± 10% or ± 0. 2 mg	± 0.4mg or 10%	100 mg solids based on 0.1 mg sensitivity	Lab	Glass only	NA
TOC for SS – periodic confirm	L Kahn – EPA Region II	0.5 % dry wt basis on SS	100 mg/kg	80 – 120%	RSD < 10 percent on quadruplicate	20 g filtered matter at 0.5%	Lab	Glass only	NA

Notes:
1 RPD = Relative Percent Difference; RPD criteria applicable only where sample concentrations ≥ 5 x the sample reporting limit.
2 Holding times for extraction/analysis from time/date of sample collection.
3 Whichever is greater

NA Not applicable
TBD To Be determined
TOC Total Organic Carbon
ICP Inductively Coupled Plasma – atomic emission spectrometry
CV Cold Vapor atomic absorption
SS Suspended solids (i.e., particulate matter on filter)
mS milli-siemen

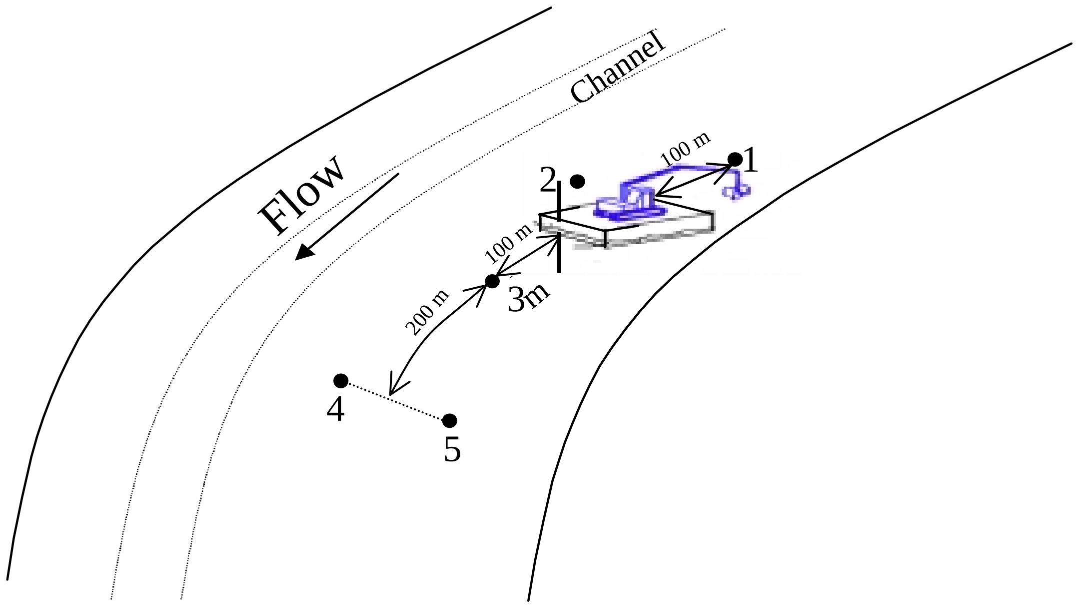
Table 3-6
Near-Field Monitoring - Analytical Details

Parameter	Analytical Method/direct Reading Instrument	Detection Limit	Range	Accuracy	Precision	Sample Size	Holding Time	Sample Container	Preser-vative
Turbidity	YSI 6-Series	2 NTU	0-1000 NTU	+/- 5% or 3 NTU	5%	NA	Field	NA	NA
TSS using particle counter	LISST Series	TBD	1.2-250 um	TBD	TBD	25-50 mL	Field	NA	NA
TSS Laboratory	ASTM D3977-97	0.01 mg/L	20%	LCS 90-110%	NA	TBD	7 days	plastic bottle	4 liter
DO	YSI 6-Series	TBD	0 to 500% air saturation	0-200 % : ±2% air sat. or ±2% of reading, whichever is greater; 200-500%	0.1% air saturation or 1% selectable	NA	Field	NA	NA
Conductivity	YSI 6-Series	0.001 mS/cm	0 to 100 mS/cm	± 0.5% or 0.001 mS/cm3	0.1	25-50 mL	Field	NA	NA
Temperature	YSI 6-Series	0.15o C	-5 to +45 oC	± 0.15o C	± 0.15o C	25-50 mL	Field	NA	NA

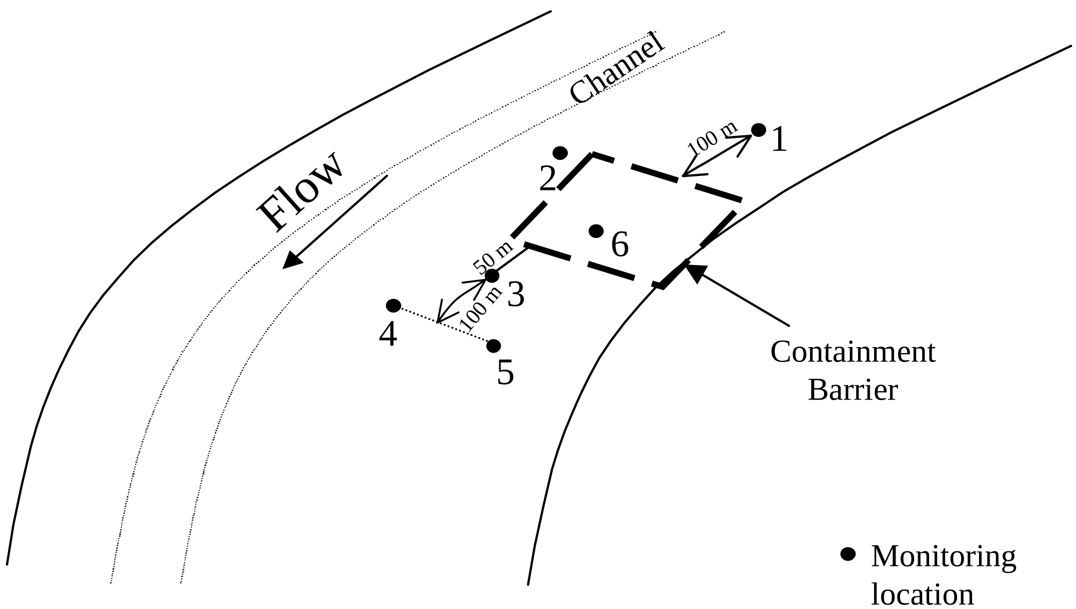
Notes:
1. SSC Analytical Method ASTM D3977-97 Standard test method for determining sediment concentration in water samples.
2. TBD - to be determined

Table 4-1
Pre- and Post-Phase 1 Anticipated Refinements to the Resuspension Standard

Element	Pre-Phase 1	Post-Phase 1
Far-Field Monitoring		
Stations	--	--
Parameters	--	--
Analytical Methods	--	--
Sampling Frequency	--	Frequency may be reduced if there is little impact found at the far-field stations during Phase 1, and the suspended solids measurements serve as a real-time indicator of dredging-related PCB concentrations.
Sampling Methods	--	--
PCB Load-Based Action Levels	These limits will be adjusted using the baseline water column concentrations for stations historical data and developed for stations with little historical data. These limits may be adjusted if the PCB mass estimated for removal is significantly larger than estimated during the RI/FS or if the remediation schedule differs from the assumed schedule.	Load limits may be adjusted if the remediation schedule differs from the assumed 14 hr/day, 7 d/wk schedule.
PCB Concentration-Based Action Levels	--	The 350 ng/L PCB action level may be adjusted downward if a lower concentration is needed to provide a larger margin of safety for the public water supply.
Suspended Solids Concentration-Based Action Levels	--	The suspended solids concentration levels may be adjusted using the Phase 1 paired suspended solids and PCB results.
Turn-Around Times	--	Turn-around times may be reduced if there is little impact found at the far-field stations during Phase 1, and the suspended solids measurements can serve as a real-time indicator of elevated dredging-related PCB concentrations.
Near-Field Monitoring		
Stations	--	Station locations may be adjusted to better capture the plume based on Phase 1 results.
Parameters	--	--
Analytical Methods	--	--
Sampling Frequency	--	--
Sampling Methods	--	--
Suspended Solids Concentration-Based Action Levels	--	Suspended solids concentration limits may be adjusted using the Phase 1 near-field suspended solids concentrations and far-field suspended solids and PCB concentrations. Near-field action levels may be adjusted to account for silt barriers.
Turn-around Times	--	--
Engineering Contingencies		
Remediation	The contingencies needed will be determined as part of the remedial design.	Additional engineering contingencies may be required as a part of the standard.



With No Containment Barrier



With Containment Barrier

Figure 1-1
Schematic of Near-field Monitoring Station Locations

Figure 2-1
Comparison Between Upper Hudson River Remediation Scenario Forecast for Thompson Island Dam

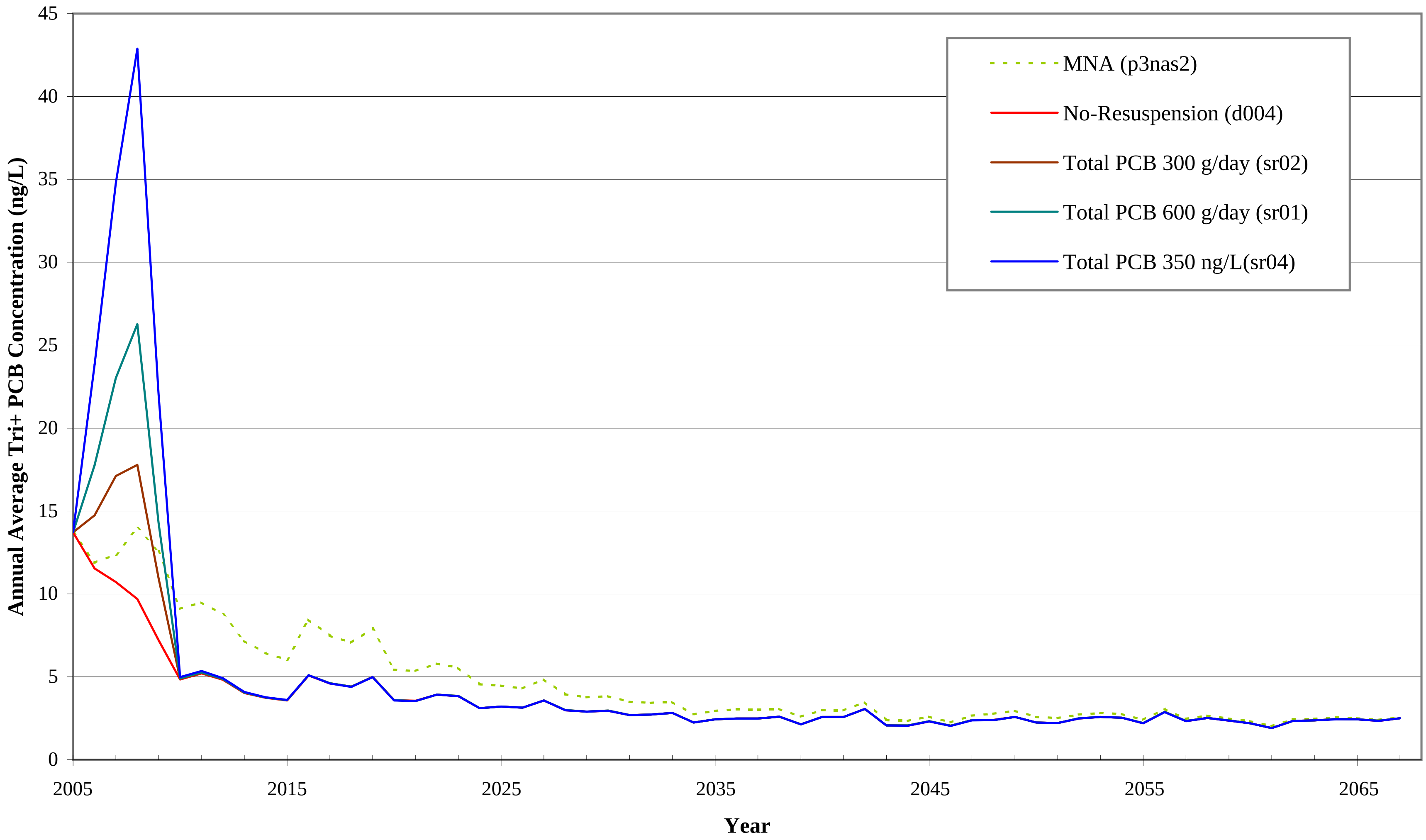


Figure 2-2
Comparison Between Upper Hudson River Remediation Scenario Forecast for Schuylerville

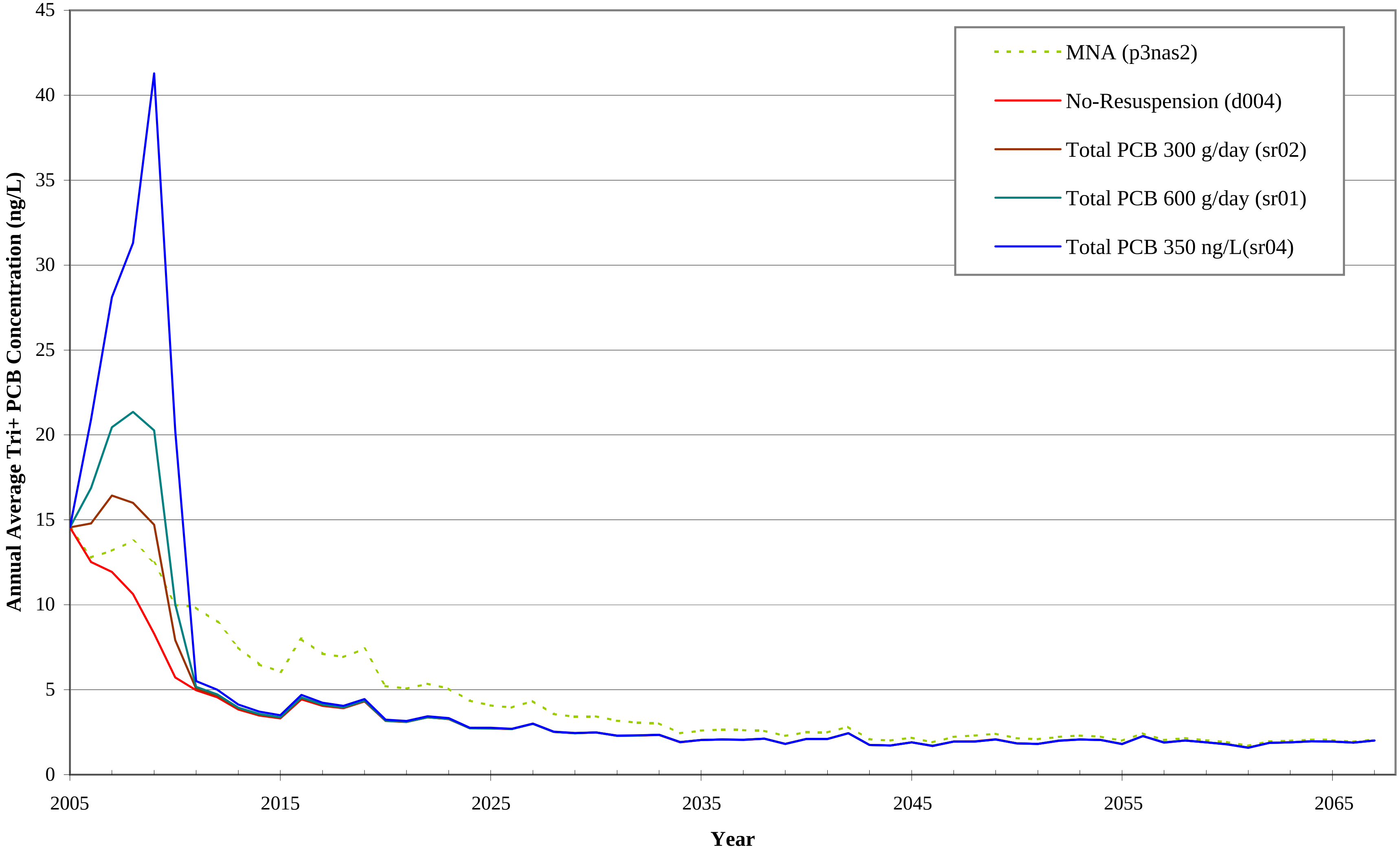


Figure 2-3
Comparison Between Upper Hudson River Remediation Scenario Forecast for Waterford

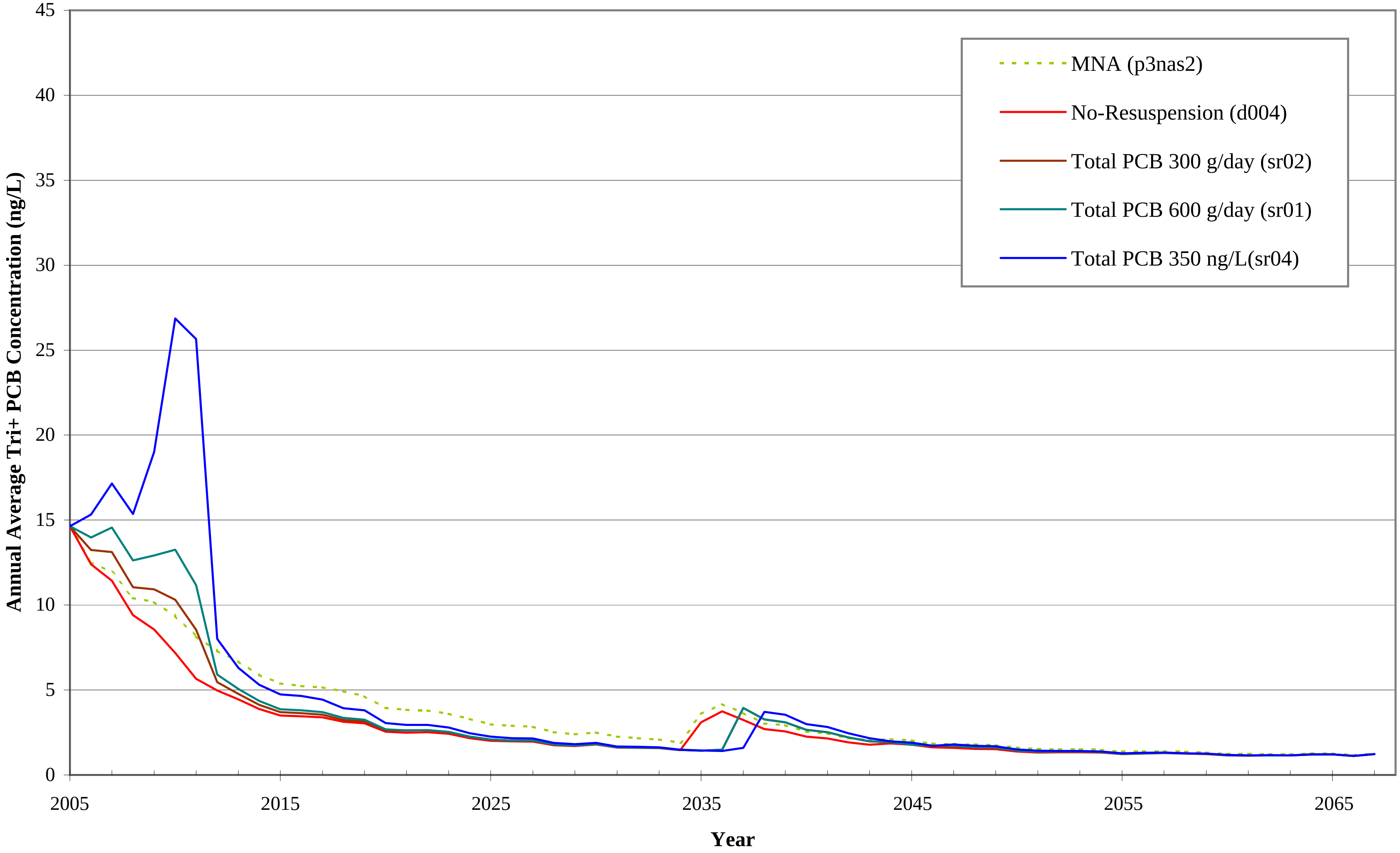
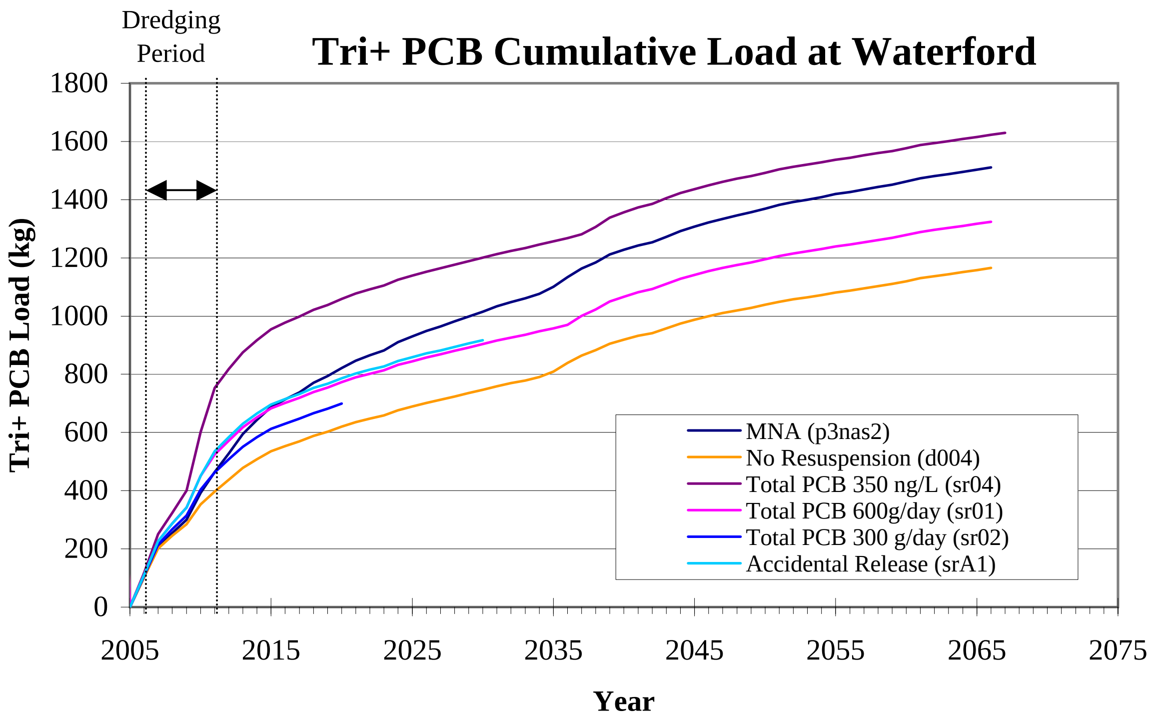


Figure 2-4
Cumulative PCB Loads at Waterford



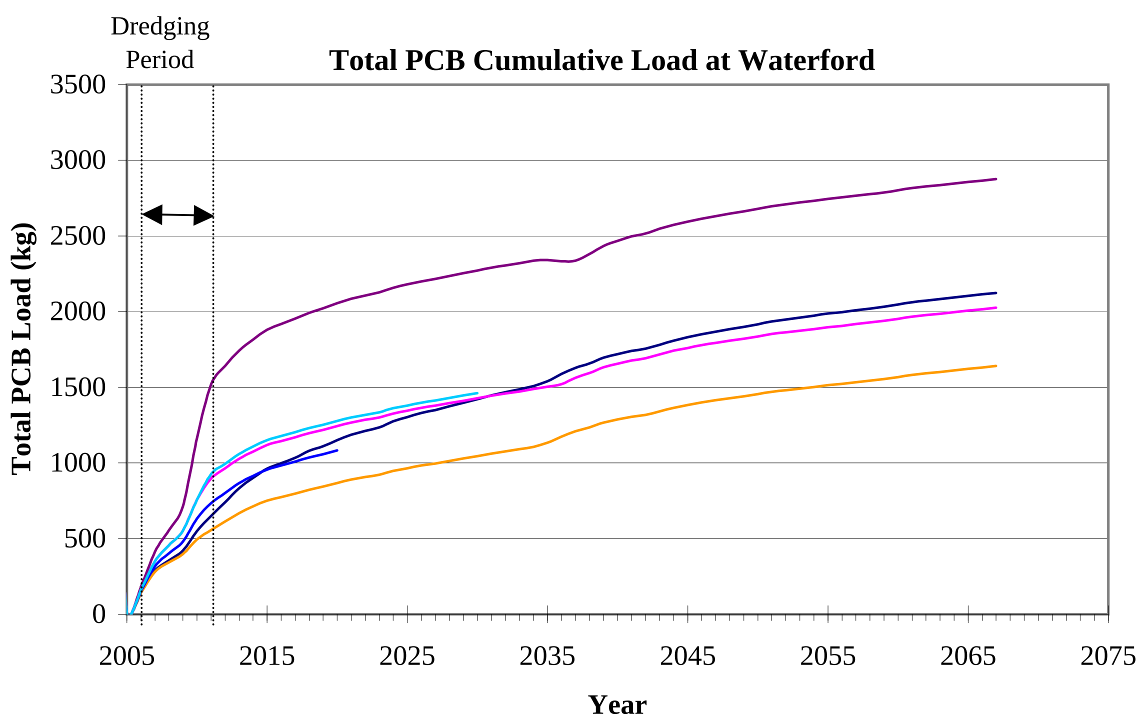


Figure 2-5

HUDTOX Forecast of Whole Water, Particulate, and Dissolved Total PCB Concentrations for Evaluation Level - 300 g/day Scenario

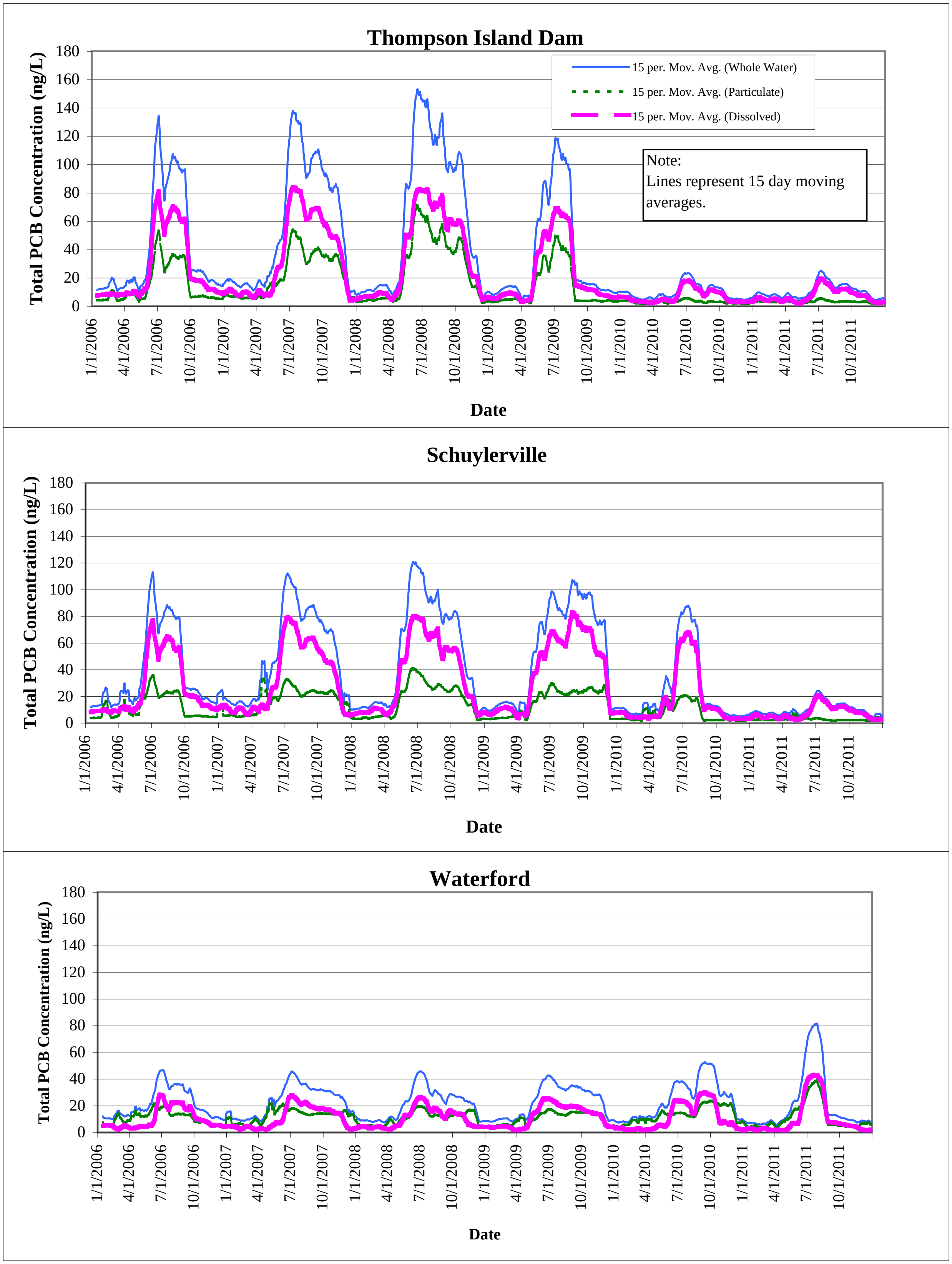


Figure 2-6

Whole Water, Particulate and Dissolved Total PCB Concentration for Concern Level - 600 g/day Total PCB Flux Dredging Scenario (sr01)

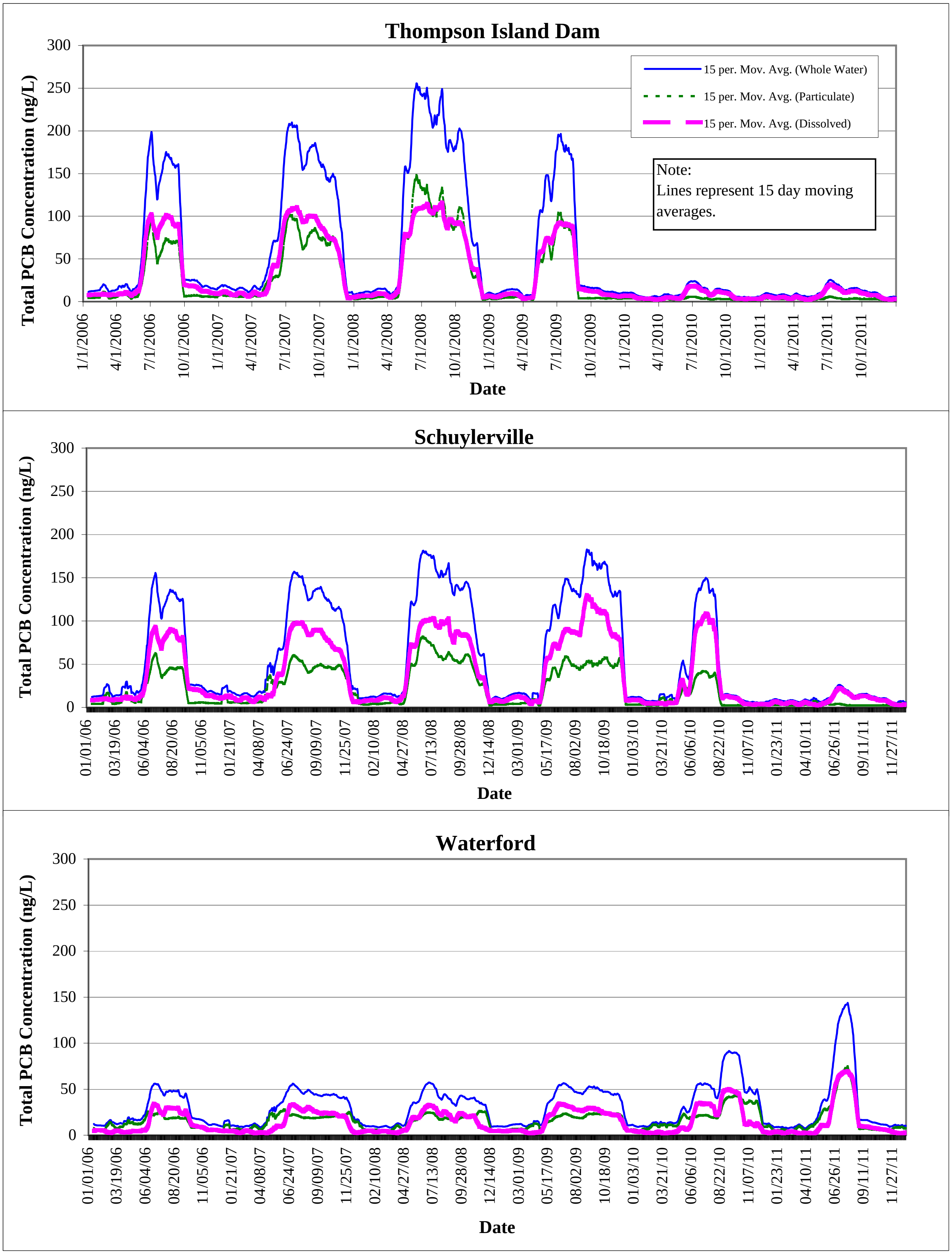


Figure 2-7

Whole Water, Particulate, and Dissolved Total PCB Concentrations for 350 ng/L Dredging Scenario (sr04)

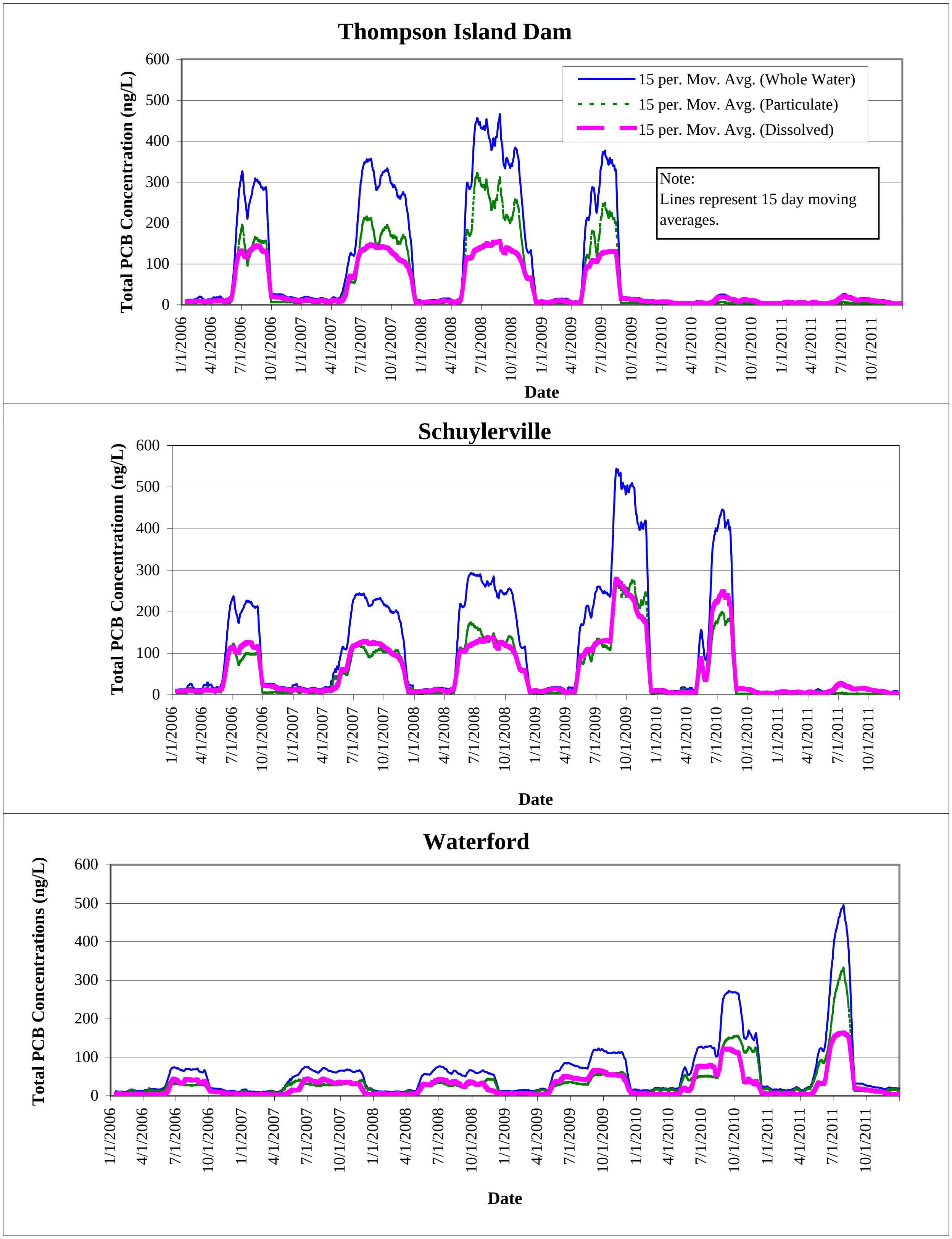
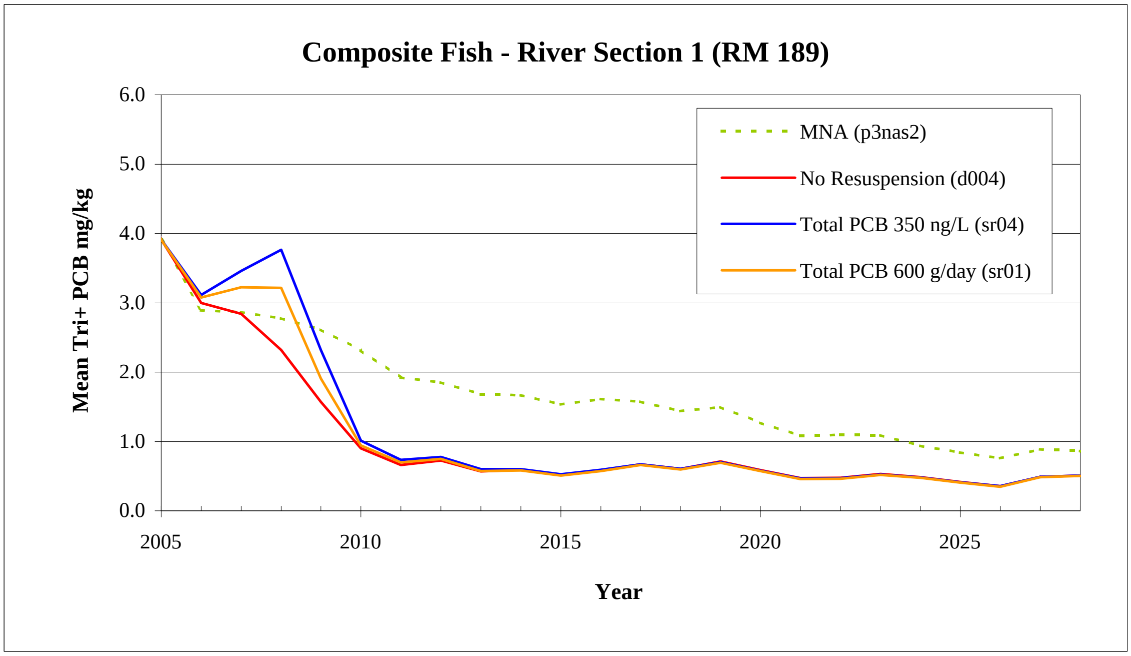
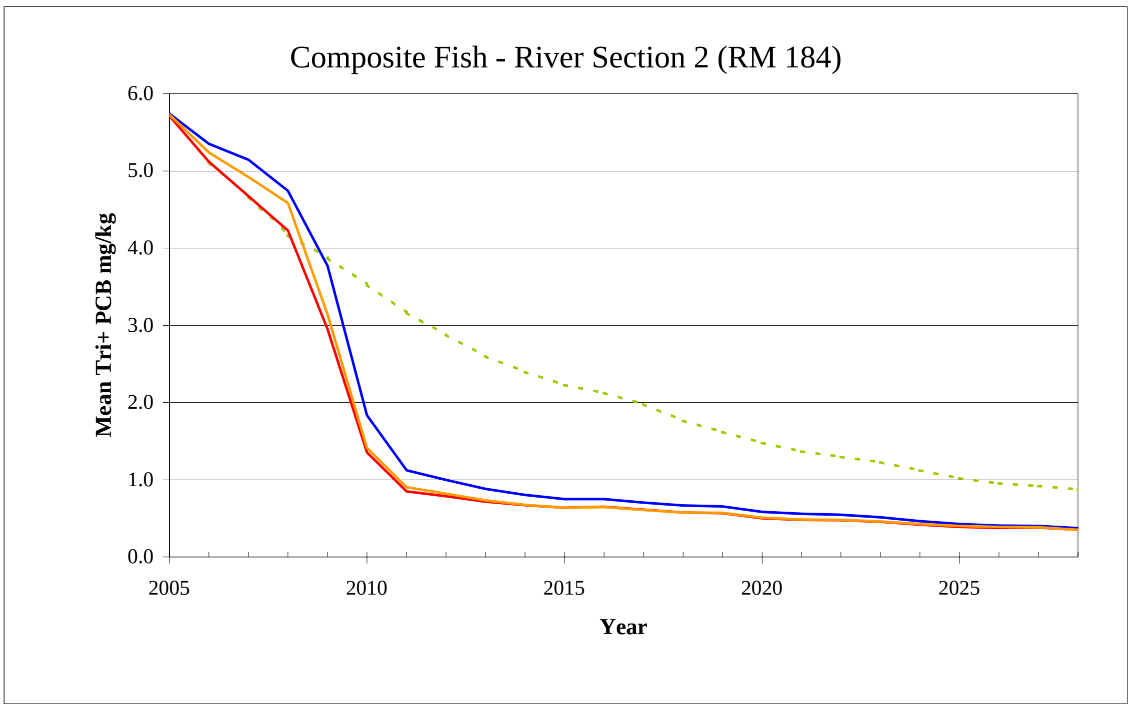


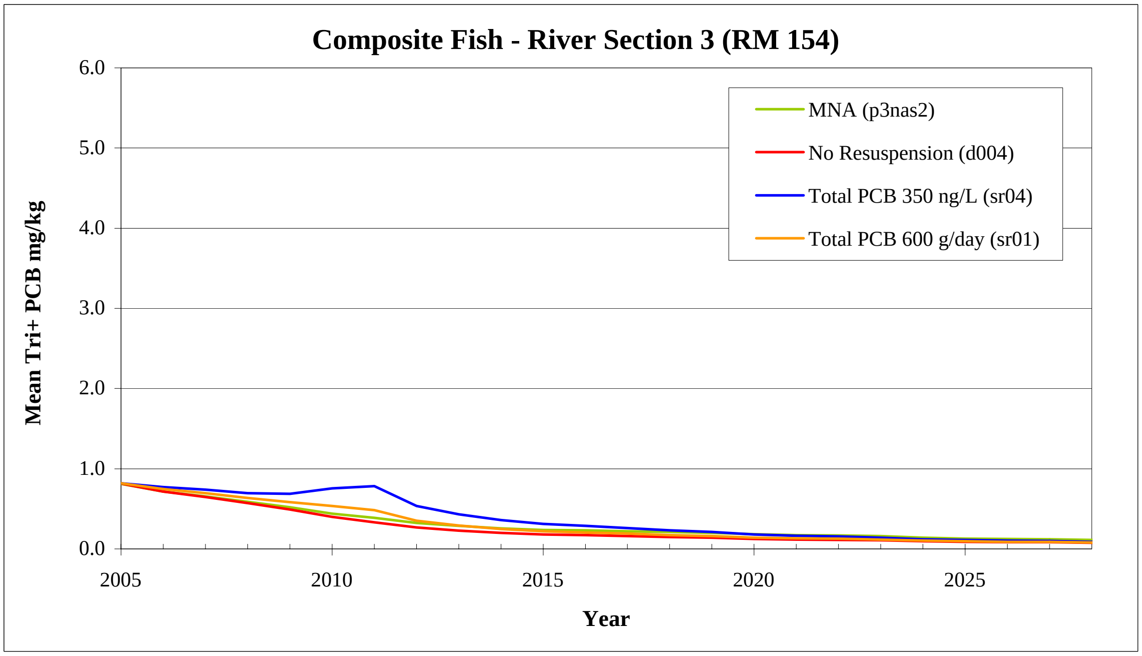
Figure 2-8
Composite Fish Tissue Concentrations for the Upper River

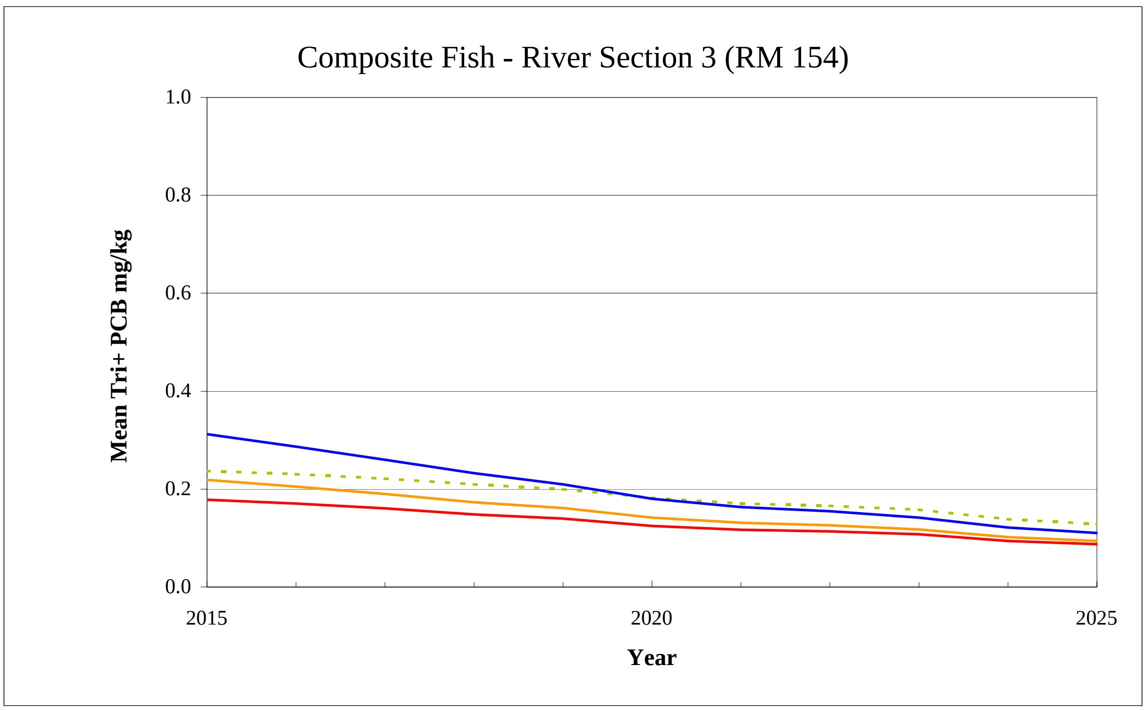




Note:
Fish composite is 47% largemouthbass + 44% brown bullhead + 9% yellow perch

Figure 2-8 (Cont.)
Composite Fish Tissue Concentrations for the Upper River

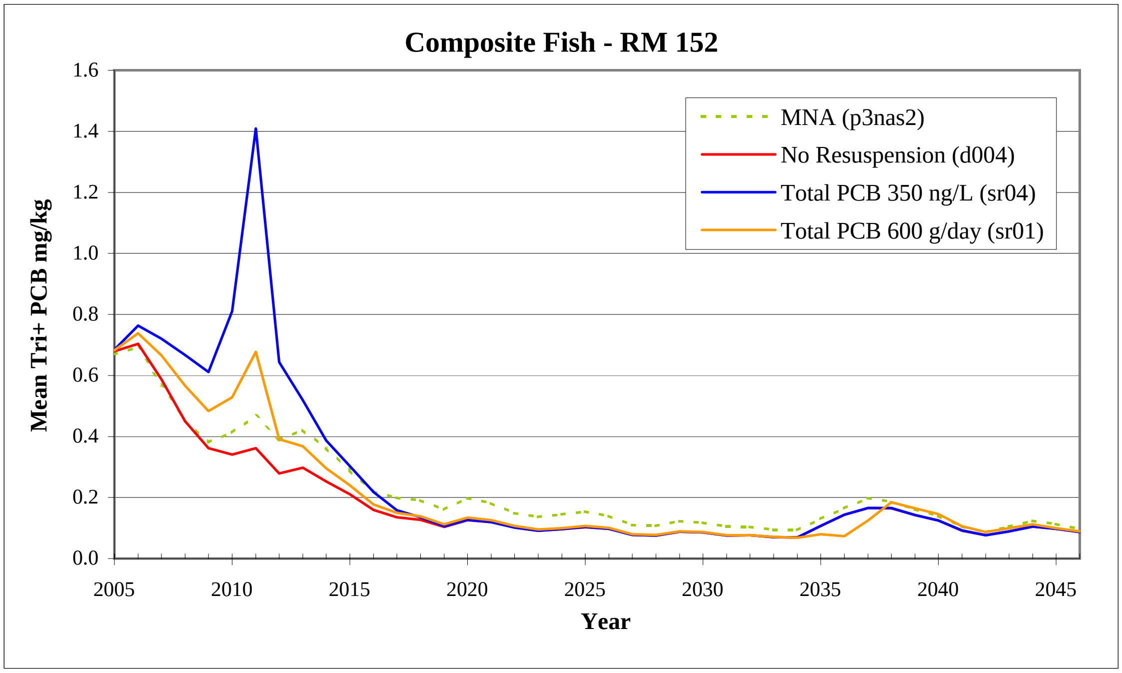


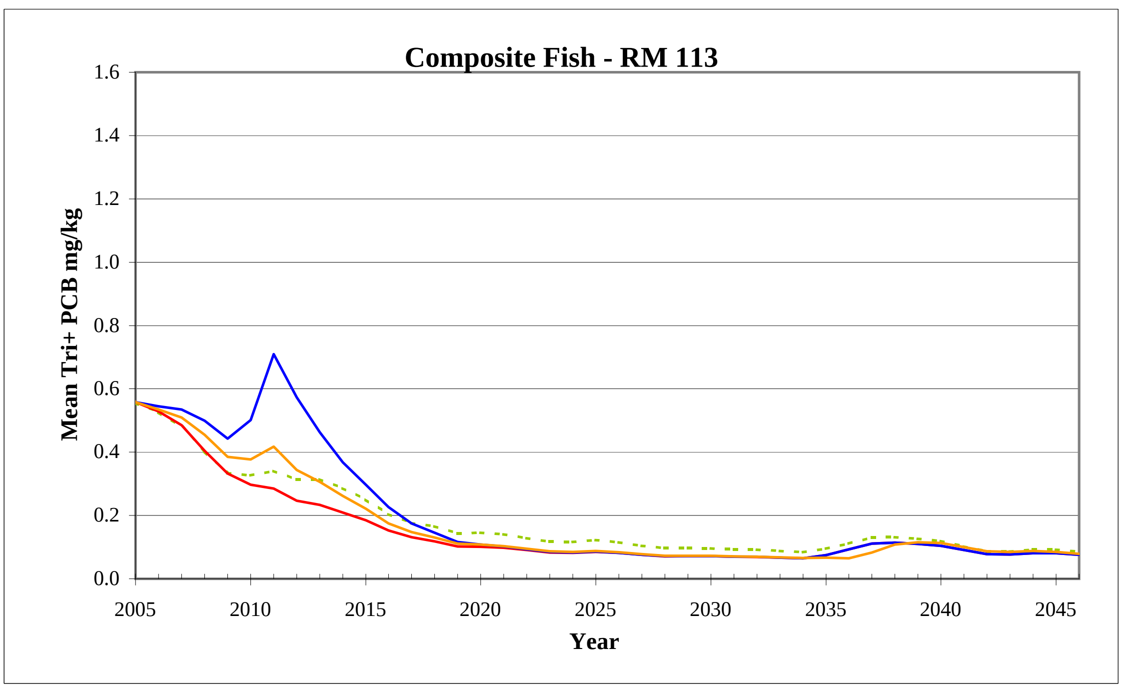


Notes:
Fish composite is 47% largemouthbass + 44% brown bullhead + 9% yellow perch
The bottom figure is portion of the top figure.

Figure 2-9

Composite Fish Tissue Concentrations for the Lower River

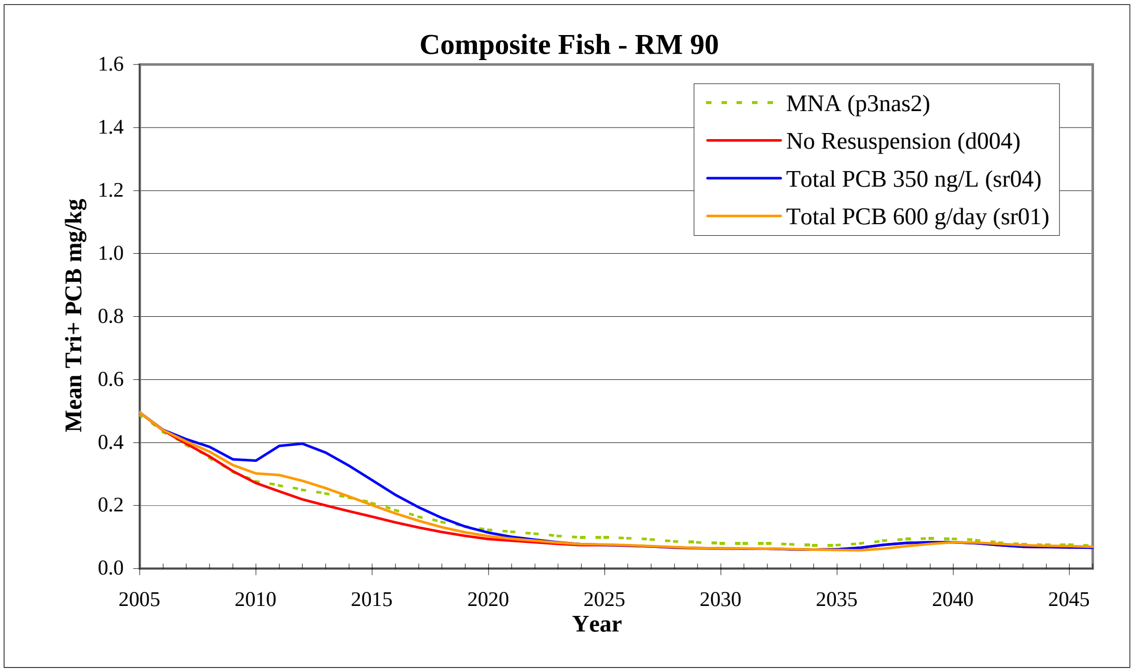


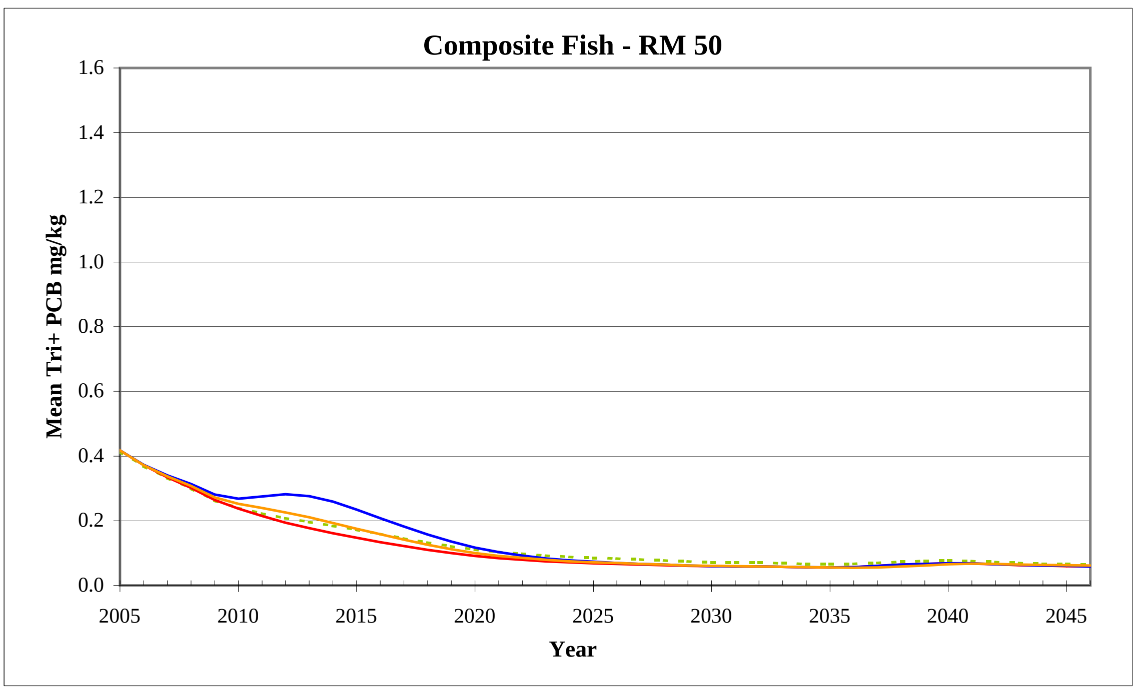


Note:
Fish composite is 47% largemouthbass + 44% brown bullhead + 9% yellow perch

Figure 2-9 (Cont.)

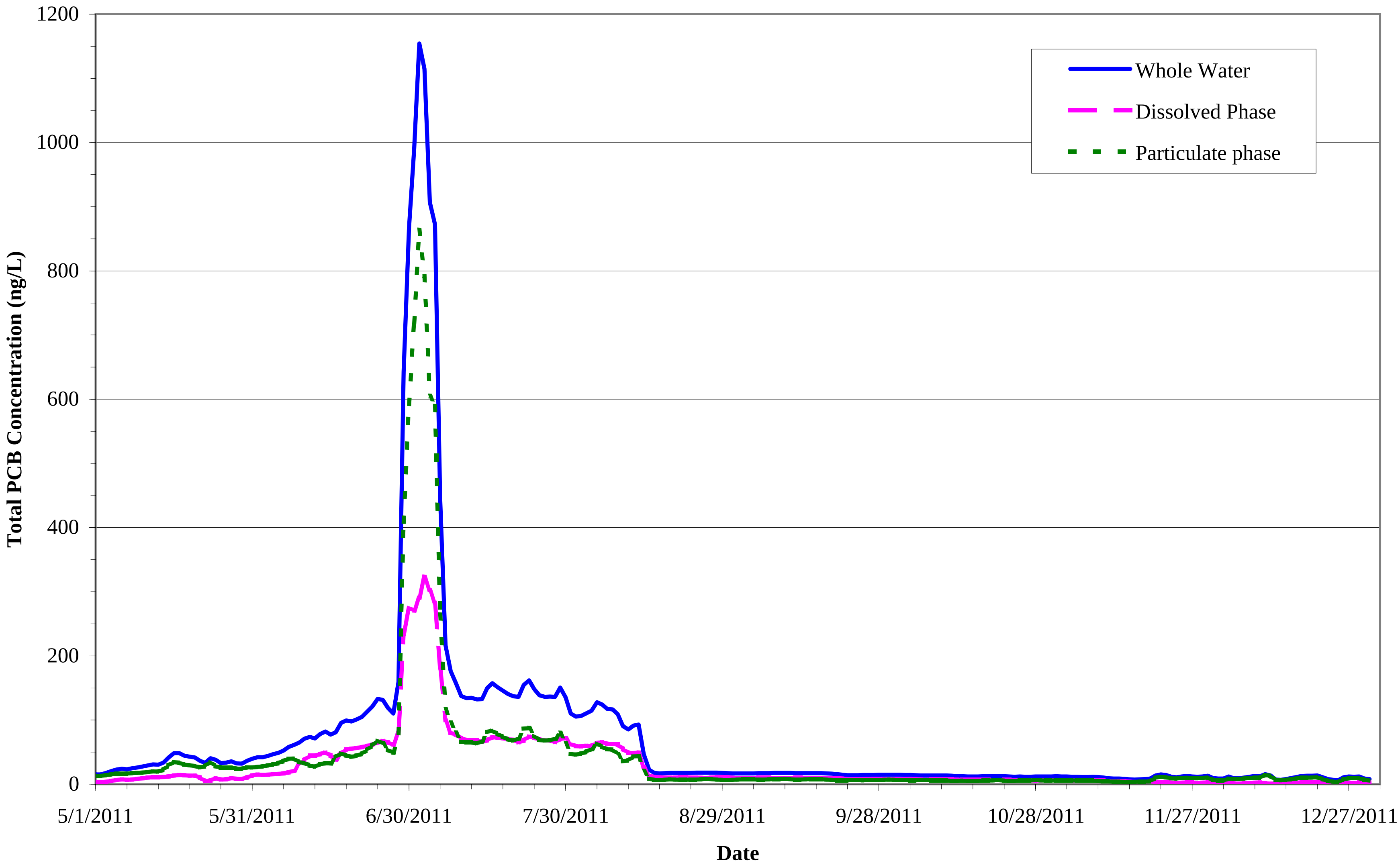
Composite Fish Tissue Concentrations for the Lower River





Note:
Fish composite is 47% largemouthbass + 44% brown bullhead + 9% yellow perch

Figure 2-10
Total PCB Concentrations at Waterford for the Accidental Release Scenario



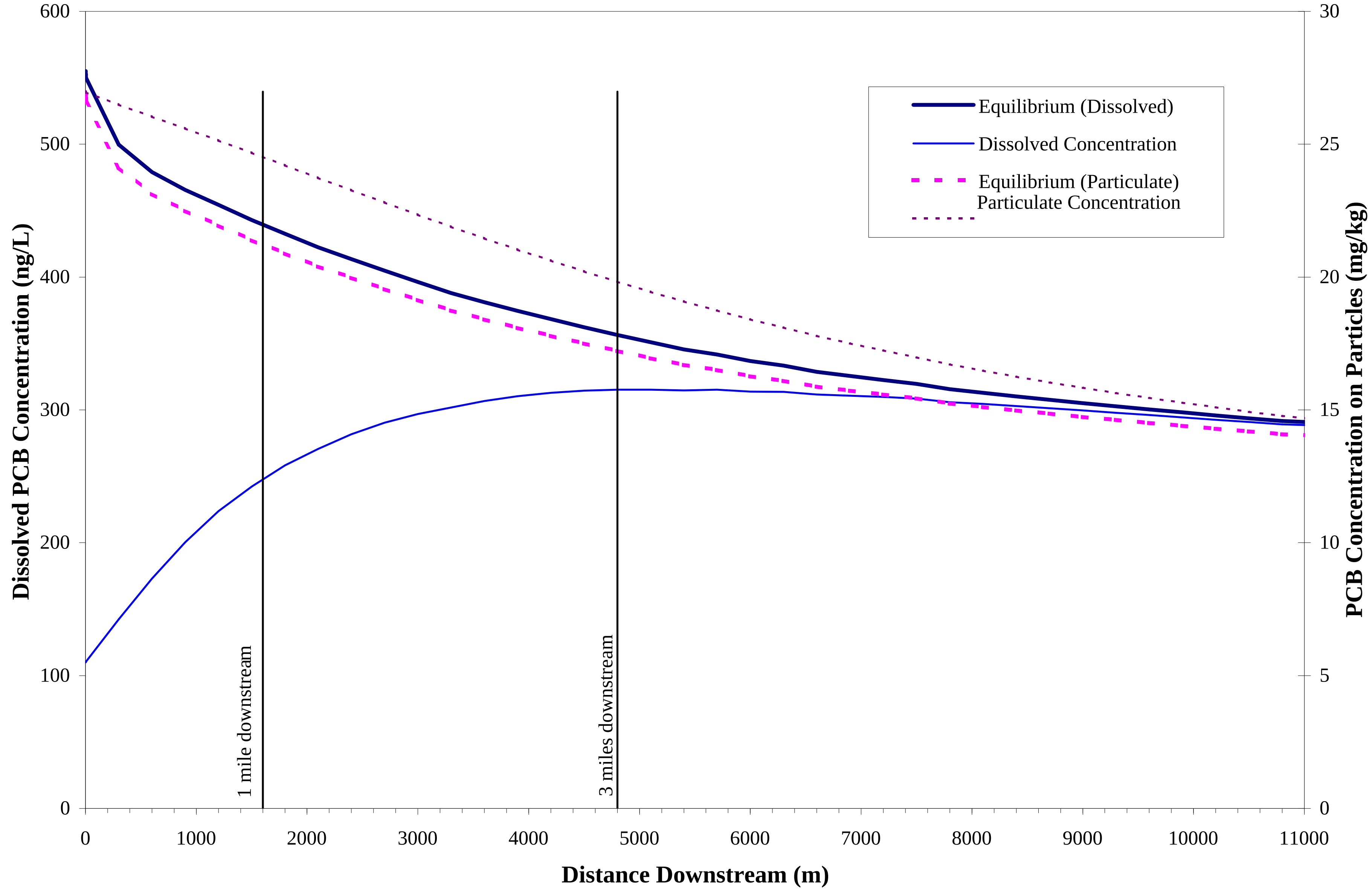


Figure 2-11
PCB Concentrations Downstream of Dredge for 350 ng/L Scenario
Section 1 at 1 mile and 3 miles

Figure 3-1

Flow Chart for Near-field SS

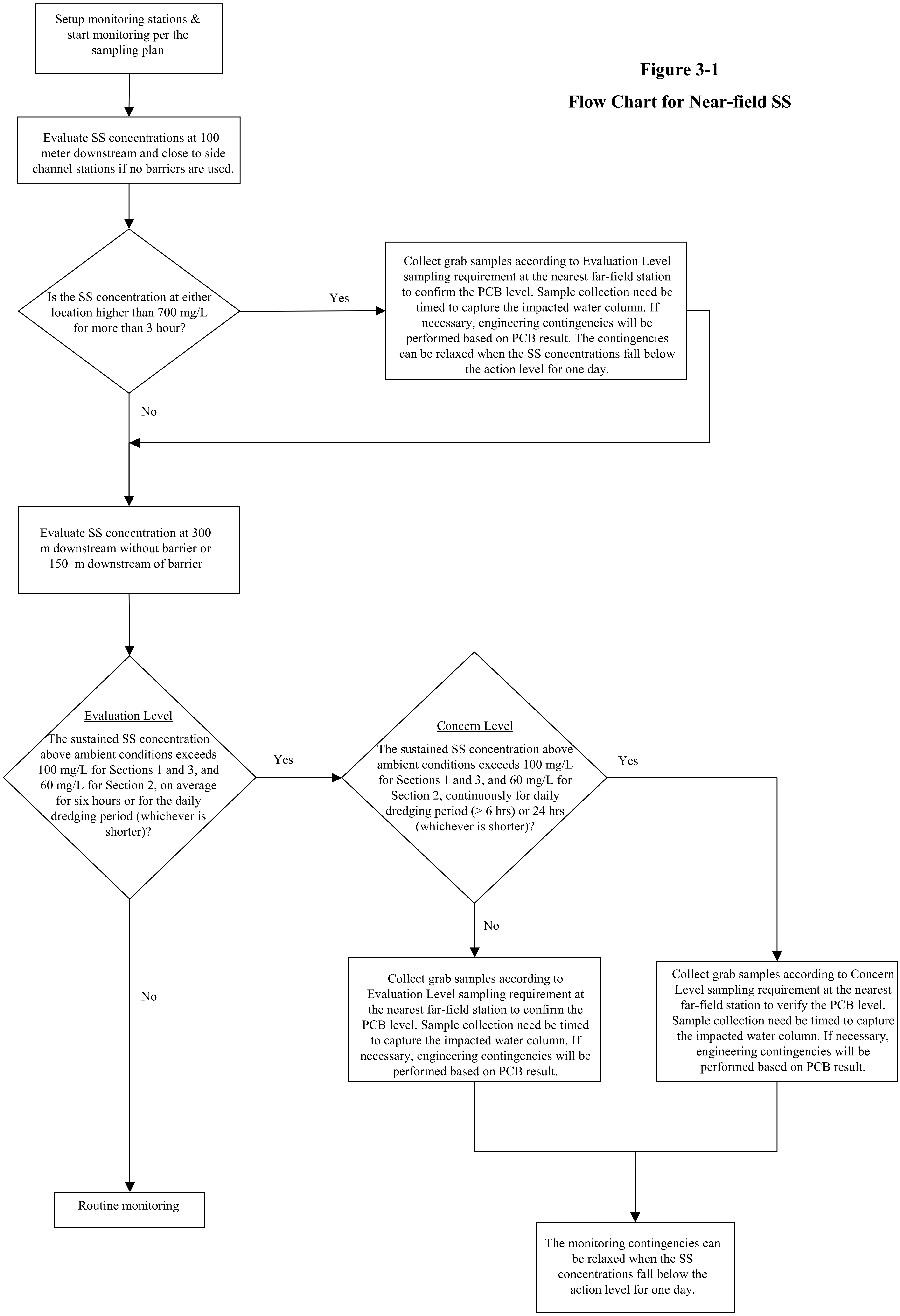
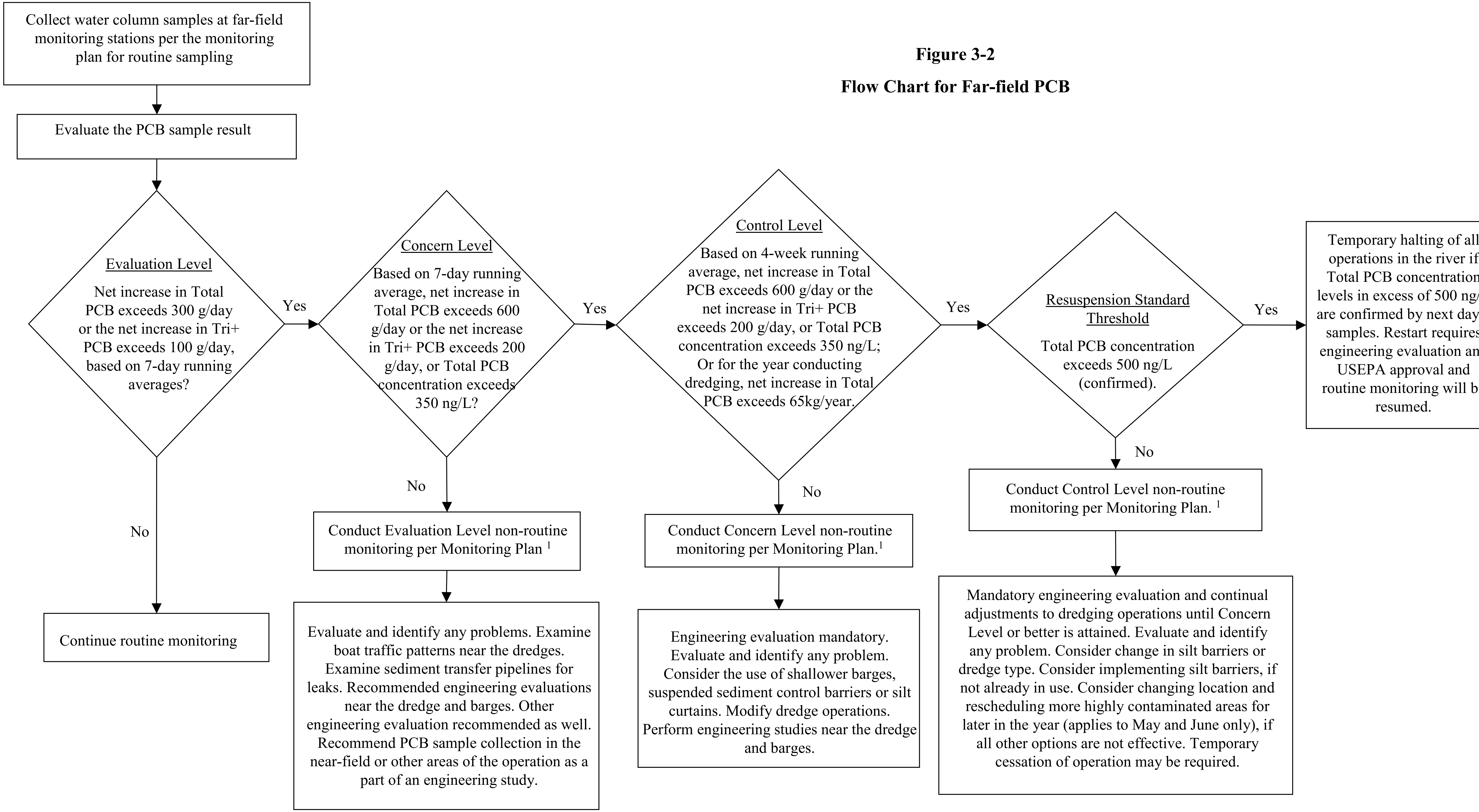


Figure 3-2

Flow Chart for Far-field PCB



Note:

1. Non-routine monitoring will be required continuously for the period of time as specified in Section 3.3.5.

Figure 3-3

Flow Chart for Far-field SS

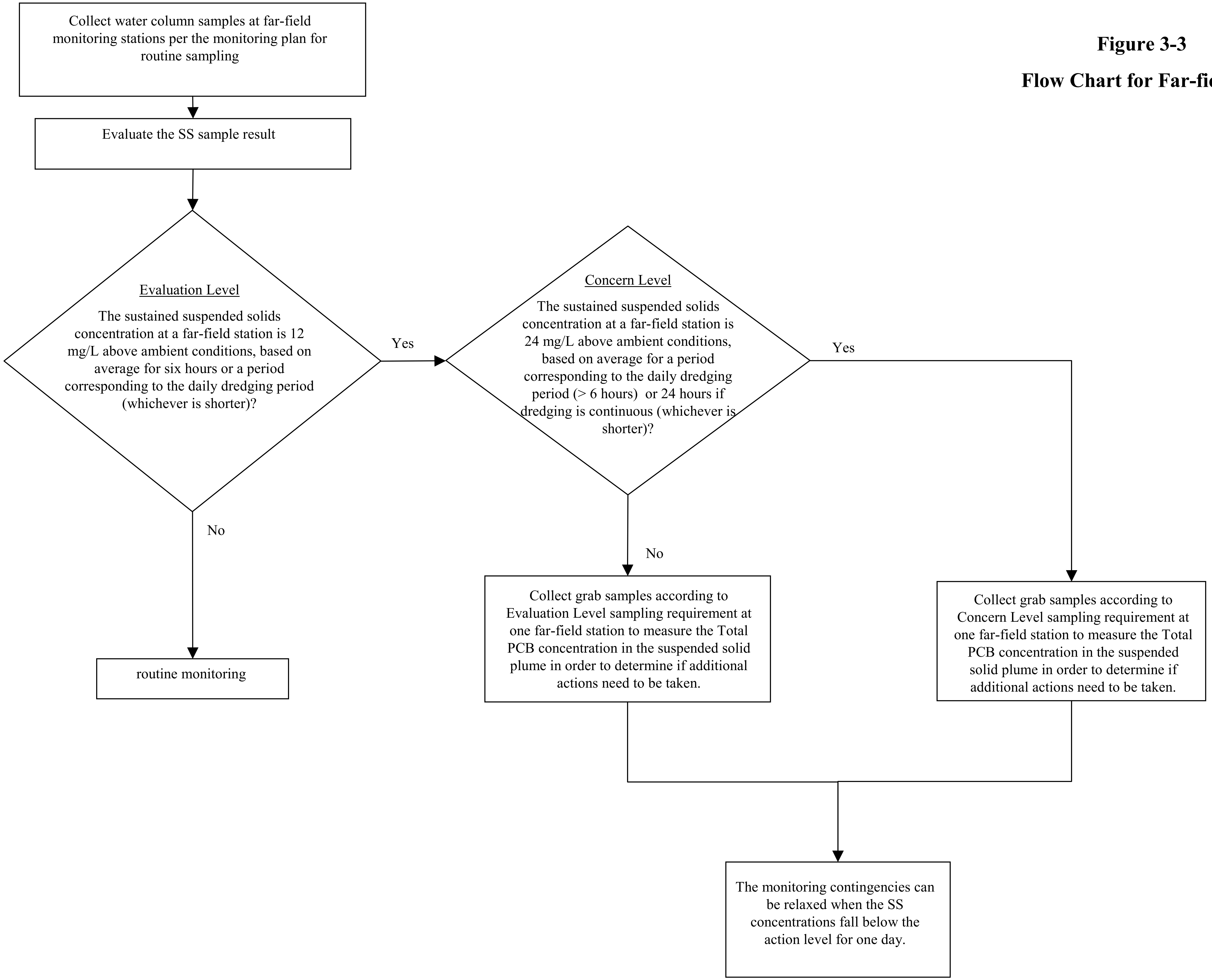


Figure 3-4

PCB Profile in the Cores Samples Collected Post- Non-Time Critical Removal Action in the Grasse River