Hudson River
PCBs SUPERFUND SITE

Engineering Performance Standards

Statement of the Engineering Performance Standards for Dredging

April 2004

Volume 1 of 5

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

April 14, 2004

To All Interested Parties:

The U.S. Environmental Protection Agency (EPA) is pleased to release the *Engineering Performance Standards* for the Hudson River PCBs Superfund Site (Site). EPA's February 2002 Record of Decision for the Site calls for these engineering performance standards for dredging-related resuspension, dredging residuals, and dredging productivity.

On January 27-29, 2004, EPA, through its contractor, Eastern Research Group, convened a panel of independent scientific experts to conduct a peer review of the October 2003 *Draft Engineering Performance Standards – Peer Review Copy*. EPA released an earlier version, the May 2003 *Draft Engineering Performance Standards – Public Review Copy*, for public review from May 14, 2003 through July 14, 2003.

In conjunction with this release of the *Engineering Performance Standards*, EPA is releasing its *Response to Peer Review Comments on the October 2003 Draft Engineering Performance Standards – Peer Review Copy.*

Copies of the above-mentioned documents are available online at EPA's web site for the Hudson River PCBs Site (www.epa.gov/hudson), at the site information repositories, or by calling the Hudson River Field Office at 518-747-4389 or toll-free at 866-615-6490 .

If you need additional information regarding the Engineering Performance Standards or the Hudson River PCBs Site in general, please contact Leo Rosales, Community Involvement Coordinator, at the Hudson River Field Office.

Sincerely yours,

John S. Frisco

George Pavlou, Director
Emergency and Remedial Response Division

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Prepared for:
U.S. Army Corps of Engineers, Kansas City District
USACE Contract No. DACW41-02-D-0003
On Behalf of: U.S. Environmental Protection Agency, Region 2

Prepared by:
Malcolm Pirnie, Inc.
104 Corporate Park Drive
White Plains, New York 10602

and

TAMS Consultants, Inc.
an Earth Tech Company
300 Broadacres Drive
Bloomfield, New Jersey 07003

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List Of Acronyms

AMN	Water treatment facility (*formerly known as* SRMT)
ARARs	Applicable or Relevant and Appropriate Requirements
ATL	Atlantic Testing Labs
CAB	Cellulose Acetate Butyrate
CAMU	Corrective Action Management Unit
Cat 350	Caterpillar Model 350
CDF	Confined Disposal Facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	cubic feet
cfs	cubic feet per second
CLP	Contract Laboratory Program
cm	centimeter
CPR	Canadian Pacific Railroad
CSO	Combined Sewer Overflow
CU	certification unit
CWA	Clean Water Act
cy	cubic yard(s)
DDT	Dichlorodiphenyltricholorethane
DEFT	Decision Error Feasibility Trials
DGPS	Differential Global Positioning System
DMC	Dredging Management Cells
DNAPL	Dense Non-Aqueous Phase Liquid
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DQOs	Data Quality Objectives
DSI	Downstream of the dredge area inside the silt curtain
DSO	Downstream of the dredge area outside the silt curtain
EDI	Equal Discharge Interval
EMP	Environmental Monitoring Plan
EPS	Engineering Performance Standards
EQUIL	Software model used to determine chemical equilibrium between the particle-bound solid and the water column or aqueous phase
ESG	ESG Manufacturing, LLC
EWI	Equal Width Interval
FIELDS	Field Environmental Decision Support
FISHRAND	USEPA's peer-reviewed bioaccumulation model

FJI	Fort James Water Intake
fps	feet per second
FRRAT	Fox River Remediation Advisory Team
FS	Feasibility Study
ft	foot
ft^2	square feet
GE	General Electric Company
GEHR	General Electric Hudson River
GCL	Geosynthetic Clay Liner
g/cc	grams per cubic centimeter
g/day	grams per day
GIS	Geographic Information Systems
GM	General Motors
gpm	gallons per minute
GPS	Global Positioning System
HDPE	High Density Polyethylene
HUDTOX	USEPA's peer-reviewed fate and transport model
IDEM	Indiana Department of Environmental Management
JMP	a commercial software package for statistical analysis
kg/day	kilograms per day
lbs	pounds
LWA	length-weighted average
MCL	Maximum Contaminant Level
MCT	Maximum Cumulative Transport
MDEQ	Michigan Department of Environmental Quality
MDS	ESG Manufacturing model #. For example, MDS-177-10
MFE	Mark for Further Evaluation
MGD	million gallons per day
ug/L	micrograms per liter
mg/kg	milligrams per kilogram (equivalent to ppm)
mg/L	milligrams per liter
MPA	Mass per Unit Area
MVUE	minimum unbiased estimator of the mean
ng/L	nanograms per liter
NBH	New Bedford Harbor
NJDEP	New Jersey Department of Environmental Protection
NPDES	National Pollution Discharge Elimination System
NPL	National Priorities List

NTCRA	Non-Time-Critical Removal Action
NTU(s)	Nephelometric Turbidity Units
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OBS	Optical Backscatter Sensor
O&M	Operations and Maintenance
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PCDFs	Polychlorinated Dibenzofurans
pcf	pounds per cubic foot
PL	Prediction Limit
ppm	part per million (equivalent to mg/kg)
PVC	Polyvinyl Chloride
Q-Q	Quantile-Quantile
QA/QC	Quality Assurance / Quality Control
QAPP	Quality Assurance Project Plan
QRT	Quality Review Team
RCRA	Resource Conservation and Recovery Act
RDP	Radial Dig Pattern
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RM	River Mile
RMC	Reynolds Metals Company
ROD	Record of Decision
RS	Responsiveness Summary
Site	Hudson River PCBs Superfund Site
SLRP	St. Lawrence Reduction Plant
SMU	Sediment Management Unit
SOP	Standard Operating Procedure
SPI	Sediment Profile Imaging
SQV	Sediment Quality Value
SRMT	St. Regis Mohawk Tribe Water treatment facility (*former name for* AMN)
SSAP	Sediment Sampling and Analysis Program
SSO	Side-stream of the dredge area outside of the silt curtain
SVOCs	Semi-Volatile Organic Compounds
TAT	Turn-around Time
TDBF	Total Dibenzofurans
TG	turbidity generating unit
TI	Thompson Island
TIP	Thompson Island Pool

TM	turbidity monitoring
TOC	Total Organic Carbon
Tri+	PCBs containing three or more chlorines
TSCA	Toxic Substances Control Act
TSS	Total Suspended Solids
UCL	Upper Confidence Limit
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USI	Upstream of the dredge area outside the silt curtain
USO	Upstream of dredge area outside the silt curtain
USS	US Steel
VOC	Volatile Organic Compound
WDNR	Wisconsin Department of Natural Resources
WINOPS	Dredge-positioning software system used to guide the removal of contaminated sediment
WPDES	Wisconsin Pollutant Discharge Elimination System
WSU	Wright State University

Engineering Performance Standards
Hudson River PCBs Superfund Site
Volume 1: Statement of the Engineering Performance Standards for Dredging

Executive Summary

> *USEPA ROD*
>
> - *Targeted environmental dredging*
> - *Removal of approx. 2.65 million cy of sediment*
> - *Two-phase, 6-year project*
> - *Monitored natural attenuation*

In February 2002, the United States Environmental Protection Agency (USEPA) issued a Record of Decision (ROD) (USEPA, 2002) for the Hudson River PCBs Superfund Site (Site). The ROD calls for targeted environmental dredging of approximately 2.65 million cubic yards (cy) of polychlorinated biphenyl (PCB)-contaminated sediment from the Upper Hudson River (approximately 40 river miles from the former Fort Edward Dam to the Federal Dam at Troy) in two phases over a six-year period, and monitored natural attenuation of the 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
- Minimize the long-term downstream transport of PCBs in the river

> ***Engineering Performance Standards***
>
> - *Resuspension*
> - *Residuals*
> - *Productivity*

In selecting its cleanup remedy, USEPA required establishment of performance standards for resuspension during dredging, production rates during dredging, and residuals after dredging, together called "Engineering Performance Standards."

This decision was made to address comments received from members of the public who expressed a wide spectrum of views on the project. Some were concerned that the ROD was not sufficiently comprehensive in its requirements for the environmental cleanup, while others suggested that the environmental dredging could "do more harm than good" and take much longer than stated. 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]

USEPA's consultants included a team of senior scientists and engineers who developed the 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.)

The *Draft Engineering Performance Standards* were released for public review in May 2003. General Electric Company (GE) reviewed a near-final version of the draft standards. Following the close of the public comment period, comments were incorporated as appropriate into a revised document. At the same time, USEPA responded in writing to all public comments. USEPA subsequently convened a panel of independent scientific experts to conduct a peer review of the revised document, *Draft Engineering Performance Standards – Peer Review Copy*. The peer review began in October 2003 and concluded in January 2004. As part of this peer review, the panel was provided with USEPA's responses to the public comments and other relevant information. The peer reviewers were asked to respond to USEPA's charge questions, which covered the major components of the Draft Engineering Performance Standards. The peer-reviewed standards, modified as appropriate to address the reviewers' recommendations, are published herein and will be implemented during the Phase 1 dredging.

Table ES-1
Engineering Performance Standards Development Sequence

Event	Date
Publish *Draft Engineering Performance Standards – Public Review Copy*	May 2003
Hold 60-day public comment period	May to July 2003
Revise document to address public comment, respond in writing to public commenters, and publish *Draft Engineering Performance Standards – Peer Review Copy*	July to October 2003
Conduct peer review of *Draft Engineering Performance Standards – Peer Review Copy*	October 2003 to January 2004
Incorporate peer reviewers' recommendations	February to April 2004
Publish peer-reviewed *Engineering Performance Standards*	April 2004

Consistent with the ROD, USEPA will compare the Phase 1 dredging operations with the Engineering Performance Standards to evaluate whether there are any necessary adjustments to the dredging operations in the succeeding phase (Phase 2) or to the

[1] Other performance standards 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.

standards. The report evaluating the Phase 1 dredging with respect to the standards will be peer reviewed.

Meeting Human Health and Environmental Protection Objectives

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 that:

- 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 concentrations 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 with no dredging-related PCB releases.[2]

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

- The residuals criterion identified in the ROD (approximately 1 mg/kg Tri+ PCBs remaining in dredged areas, 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.

- The three 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.

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[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.

Engineering Performance Standard Summary

A summary of each of the Engineering Performance Standards is presented below.

Performance Standard for Dredging Resuspension

Objectives

The *Performance Standard for Dredging Resuspension* is designed to limit the concentration of PCBs in river water, such that water supply intakes downstream of the dredging operations are protected, and the downstream transport of PCB-contaminated dredged material is appropriately constrained. A routine water quality monitoring program will be implemented to verify that the objectives of the Resuspension Standard are met during dredging.

The Resuspension Standard will limit PCB concentrations in river water to protect downstream water supply intakes and limit downstream transport of PCB-contaminated material.

The analytical results obtained from the water quality monitoring will be compared to the Resuspension Standard and associated action levels to monitor and control resuspension by prompting appropriate contingency actions. Such actions could include, as appropriate, modifying 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 such a 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

The Resuspension Standard is a maximum allowable Total PCB concentration in the water column of 500 nanograms per liter (ng/L) (*i.e.*, 500 parts per trillion), regardless of the source of the PCBs. Water quality monitoring conducted at a group of stations in the river (referred to as the "far-field" stations) will be used to evaluate compliance with the standard. The 500 ng/L concentration is the USEPA Safe Drinking Water Act Maximum Contaminant Level (MCL) for PCBs in drinking water supplies.[3] Potential sources of sediment resuspension during the remediation include debris removal, dredging, tender and tugboat movements, materials handling, and PCBs from upstream and non-dredging

Resuspension Standard

Maximum allowable Total PCB concentration in the water column is 500 nanograms per liter (ng/L) (i.e., 500 parts per trillion) at the far-field monitoring stations.

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

sources. Dredging is only allowed to proceed when the concentration of Total PCBs in the river water at any Upper River far-field station is 500 ng/L or less.

Near-field and Far-field Monitoring Stations

The Resuspension Standard requires water quality monitoring at both near-field stations and far-field stations. Near-field stations are located within a few hundred meters of the dredging operation and are re-established as the dredging operation proceeds, whereas far-field stations are 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, NY. 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 one mile downstream of a dredging area. The data collected at both near-field and far-field stations are compared to the action level criteria (summarized below).

The Resuspension Standard does not cover water quality impacts in the immediate dredging area, including within containment barriers that the construction manager may employ around the dredging area. Some resuspension within the dredging areas is likely to be unavoidable regardless of the type of dredging equipment used, and is considered to be of concern only to the extent that it transports PCBs downstream.

Routine Monitoring Program

Routine Water Quality Monitoring

Daily sampling and PCB analysis at the far-field stations

Real-time monitoring of turbidity as a surrogate for suspended solids data at near-field and far-field stations

The routine water quality monitoring program consists of several components. 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. Daily PCB sampling and analysis will be conducted at the far-field stations. These stations will also have continuous reading turbidity meters. At the closest far-field station, continuous reading particle size distribution meters will be deployed as well. At near-field stations, continuous reading turbidity monitors will serve as a surrogate for the collection of high frequency suspended solids data. Once-per-day suspended solids samples will be collected at both near-field and far-field stations. The routine monitoring program is specific with respect to:

- Details and frequency of the sample collection.
- Development of continuous field monitoring techniques to address suspended solids requirements.
- Development of representative discrete and composite sampling techniques.
- Number and configuration of near-field suspended solids (*i.e.,* turbidity) sampling stations.

Continuous monitoring results will be made available immediately to USEPA's designated representative in the field. Discrete 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.

Action Levels

Action levels were developed to help identify potential and impending problems and to guide appropriate responses, such as preventive actions or engineering improvements, as necessary, as a means of avoiding an exceedance of the 500 ng/L Resuspension Standard. As shown in Table ES-2, there are two action levels leading to the Resuspension Standard: the Evaluation Level and the Control Level.

The monitoring requirements become more stringent at each action level (as compared to routine monitoring) 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 Level, an engineering solution is recommended. If the monitoring shows an exceedance at the Control Level, implementation of an engineering solution is required.

The Evaluation Level is based on PCB load (net mass loss) criteria and suspended solids concentrations. The PCB load criteria are 300 grams per day (g/day) Total PCBs (and 100 g/day Tri+ PCBs), which approximate the amount of PCB release that could reasonably be distinguished from baseline (pre-dredging) conditions. These amounts are approximately three times the best engineering estimate of mass loss from a dredging operation at full production. In addition to the mass loss criteria, near-field suspended solids concentration criteria were derived for each of the three project-defined river sections of the Upper Hudson to correspond to a far-field PCB concentration of 350 ng/L Total PCBs. The averaging period for the near-field suspended solids criterion is 6 hours. A far-field suspended solids criterion was also derived to correspond to a far-field concentration of 500 ng/L Total PCBs (the Resuspension Standard). These criteria are presented in Table ES-2.

The Control Level includes both 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 percent of the 500 ng/L Resuspension Standard, which is an appropriate 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 (220 kg of Tri+ PCBs) over the duration of the dredging program, as estimated from various engineering and modeling analyses.[4] There is also an annual Phase 1 load criterion of 65 kg Total PCBs (22 kg Tri+ PCBs). The near-field suspended solids concentration criteria were derived for each of the Upper Hudson's three river sections to correspond to a far-field PCB concentration of

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

350 ng/L Total PCBs, similar to the Evaluation Level; however, the averaging period was increased to the daily dredging period or 24 hours. There is an associated far-field suspended solids criterion derived to correspond to a far-field PCB concentration of twice the Resuspension Standard (*i.e.*, 1000 ng/L). This higher level recognizes the high degree of uncertainty in the suspended solids measurement. PCB sampling required at the Control Level will be used to confirm compliance with the Resuspension Standard

Table ES-2
Summary of Resuspension Standard

Action Level	Parameter	Required Action
Routine Monitoring	• PCB loads and suspended solids concentrations remain below Evaluation Level criteria.	Continue routine monitoring.
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 over 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 over 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 over the daily dredging period if the dredging period is less than 6 hours (far-field)	Monitoring Contingencies (required) Engineering Evaluations (recommended) Engineering Solutions (recommended)
Control 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) • 65 kg/year Total PCB or 22 kg/year Tri+ PCB load during the Phase 1 dredging season (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 (all required)
Resuspension Standard	500 ng/L Total PCBs (confirmed far-field occurrence)	Temporarily Halt Dredging Monitoring Contingencies Engineering Evaluations Engineering Solutions (all required)

Required Actions

Monitoring Contingencies

If an action level is exceeded, monitoring contingencies are required at both near-field and far-field stations, increasing the level of monitoring above the routine program. 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 Evaluations and Solutions

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

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. A timetable for the initiation of the engineering solution is specified in the standard.

Engineering evaluations and solutions include, but are not limited to, 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.

Temporarily Halt Dredging

If the Resuspension Standard of 500 ng/L is exceeded, all dredging-related operations (excluding vessel movements necessary for required monitoring, for personnel changes, and for transport of previously dredged sediment) must be temporarily halted pending the results of an engineering evaluation and selection of an engineering solution in consultation with USEPA. Temporary shut-down or demobilization of dredging or other equipment in response to a temporary halt of dredging activities must be performed in an environmentally responsible manner in accordance with established and approved procedures.

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 or measured 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.[5]

Performance Standard for Dredging Residuals

> ***Residuals Standard***
>
> *Enables detection and management of contaminated sediments that may remain after achieving design cut lines for remedial dredging in the Upper Hudson River.*
>
> ***ROD Cleanup Objectives***
>
> *Removal of all PCB-contaminated sediments in targeted areas.*
>
> *Residual limited to approximately 1 mg/kg Tri+ PCBs in dredged areas (prior to backfilling).*

Objectives

The *Performance Standard for Dredging Residuals* 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 concentration in dredged areas of approximately 1 mg/kg Tri+ PCBs (prior to backfilling).

Residual sediments may consist of any or all of the following:

- contaminated sediments that were disturbed but escaped capture by the dredge
- resuspended sediments that were redeposited (settled)
- contaminated sediments remaining below the design dredging cut elevations (*e.g.*, due to uncertainties associated with interpolation between pre-design sediment sampling program coring locations 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 redredging, is then selected depending on the statistical analyses of the post-dredging data.

Statement of the Residuals Standard

> *The Residuals Standard requires confirmation that the design dredging cut lines have been achieved, followed by the collection of surface sediment samples.*

The Residuals Standard requires confirmation that the dredging cut lines have been achieved as designed and the subsequent collection of surface sediment samples.

[5] 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.

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 five-acre "certification unit" (CU) was developed 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 five-acre certification unit, sediment samples representing the 0-to-6-inch depth interval 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.[6]

Action Levels and Contingencies

The Residuals Standard requires review of the following:

- Tri+ PCB concentrations in all 40 individual sediment samples within each 5-acre certification unit
- Mean (*i.e.*, arithmetic average) Tri+ PCB concentration of the certification unit
- Median Tri+ PCB concentration of the certification unit
- Average of the mean Tri+ PCB concentrations of a 20-acre joint evaluation area (certification unit under review and the three previously-dredged units within a two-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.

Contingency Actions

- *Backfill surface concentration requirement (0.25 mg/kg Tri+ PCBs)*
- *Subaqueous capping*
- *Redredging*

Response 1: Backfill (where appropriate) and demobilize at certification units with all of the following:

- 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.

[6] The Residuals Standard does not preclude collection of samples from deeper intervals, which may be cost-effective. These deeper samples, if analyzed, would provide information on the extent of potentially undetected sediment inventory and save an additional round of sample collection effort in the event that the 0-6 inch sample results suggest such an inventory exists.

Response 2: Jointly evaluate a 20-acre area for a certification unit with all of the following:

- 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.

For the 20-acre evaluation, if the area-weighted arithmetic average of the individual means from the certification unit under evaluation and the three previously dredged certification units (within a two-mile stretch of the river) is less than or equal to 1 mg/kg Tri+ PCBs, backfill may be placed. In this case, subsequent testing of the backfill is required to confirm that its surface concentration is less than or equal to 0.25 mg/kg Tri+ PCBs. If the surface concentration does not meet this criterion, the backfill must be dredged, replaced, and retested or remedied via another method with input from USEPA.

If the 20-acre evaluation does not yield a combined average of 1 mg/kg Tri+ PCBs or less, the certification unit must be redredged (see #4 below for actions required during and following redredging) or a subaqueous cap constructed. Redredging 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 Response 1 or 2, above, after two redredging attempts, capping may be implemented in lieu of further redredging attempts, as described in #5, below.

Response 3: Redredge or construct a subaqueous cap for a certification unit with all of the following:

- 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 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.

The choice of two options is provided to maintain flexibility and productivity (*e.g.*, some areas may not be conducive to redredging). If redredging is chosen, the surface sediment of the redredged area must be sampled and the certification unit reevaluated. If the certification unit does not meet the objectives of #1 or #2, above, following two redredging attempts, capping may be implemented in lieu of further redredging attempts, as described in #5, below.

Response 4: Redredging is required in any of the following cases:

- for areas of elevated Tri+ PCB concentrations within a certification unit with an arithmetic average residuals concentration greater than 6 mg/kg Tri+ PCBs,
- To address individual sampling point(s) with concentrations greater than or equal to 27 mg/kg Tri+ PCBs, or
- for instances of more than one sampling point with concentrations greater than or equal to 15 mg/kg Tri+ PCBs.

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 horizontal extent of the area requiring 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 to 12 inch, 12 to 18 inch, etc.) as necessary to recharacterize 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 required only once per certification unit.

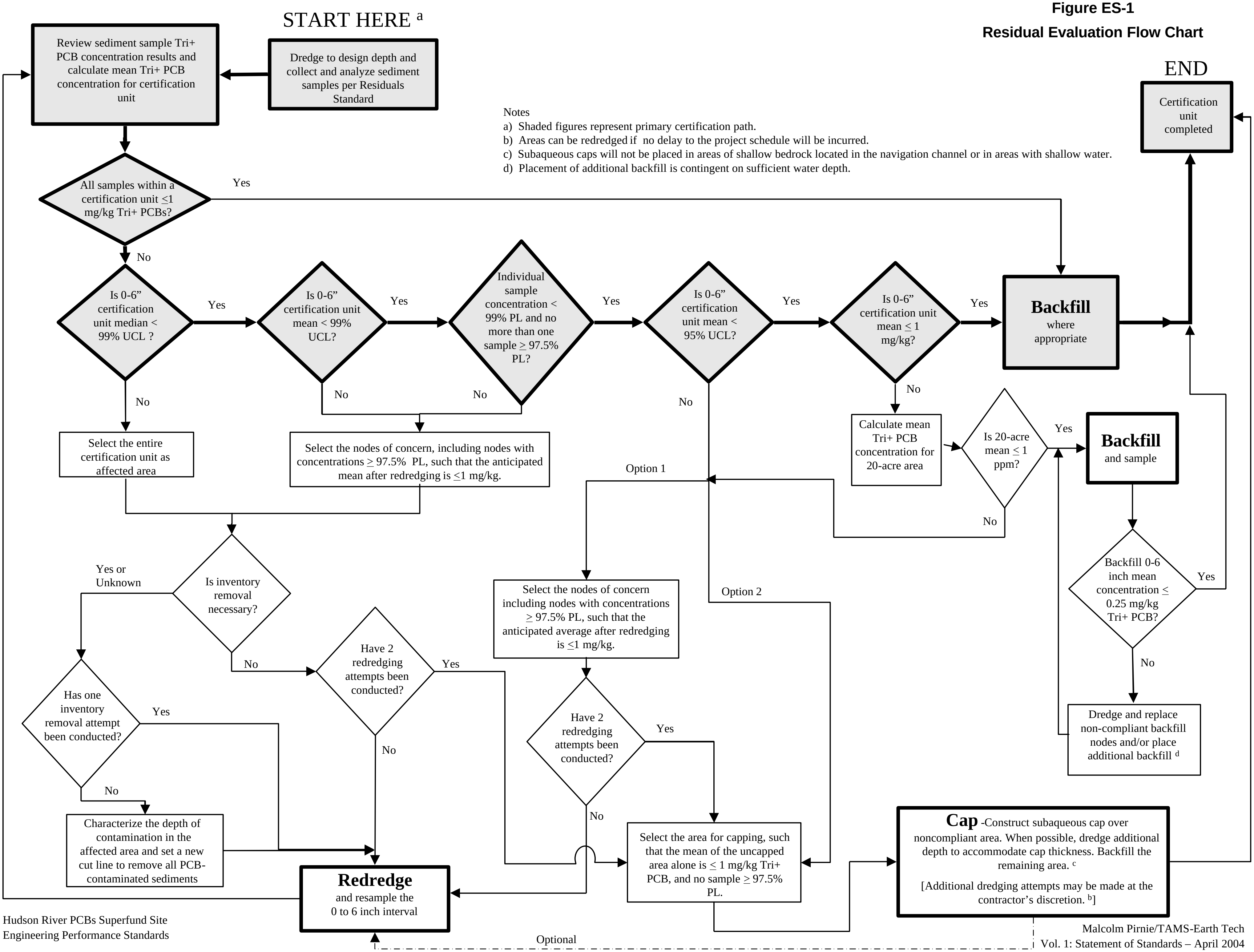
The Residuals Standard provides a mechanism for calculating the horizontal extent of redredging. All redredging attempts are to be designed to reduce the mean Tri+ PCB concentration of the certification unit to 1 mg/kg Tri+ PCBs or less and to remediate any sampling nodes with Tri+ PCB concentration equal to or greater than 15 mg/kg. If after two redredging attempts, the arithmetic average Tri+ PCB concentration in the surface sediment still is greater than 1 mg/kg, then capping is to be implemented as stated in #5, below.

Response 5: Capping. At areas where two redredging attempts do not achieve compliance with the residuals criteria, as verified by USEPA, construct an appropriately designed subaqueous 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-3.

Figure ES-1

Residual Evaluation Flow Chart



Notes
a) Shaded figures represent primary certification path.
b) Areas can be redredged if no delay to the project schedule will be incurred.
c) Subaqueous caps will not be placed in areas of shallow bedrock located in the navigation channel or in areas with shallow water.
d) Placement of additional backfill is contingent on sufficient water depth.

Table ES-3
Summary of the Residuals Standard

Case	Certification Unit Mean (mg/kg Tri+ PCBs)	No. of Sample Results where 27 > *result* $\geq$15 mg/kg Tri+ PCBs	No. of Sample Results $\geq$ 27 mg/kg Tri+ PCBs	No. of Redredging Attempts Conducted[1]	Required Action (when all conditions are met)[2]
A	$x_i \leq 1$	≤ 1	0	N/A	Backfill certification unit (where appropriate); no testing of backfill required.
B	N/A	$\geq$ 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	$1 < x_i \leq 3$	≤ 1	0	N/A	Evaluate 20-acre average concentration. If 20-acre average concentration $\leq$ 1 mg/kg Tri+ PCBs, place and sample backfill to confirm that backfill surface concentration is $\leq$ 0.25 mg/kg Tri+ PCBs.[3] If 20-acre average concentration > 1 mg/kg, follow actions for Case E below.
E	$3 < x_i \leq 6$	≤ 1	0	< 2	Construct subaqueous cap immediately OR redredge.
F	$x_i > 6$	N/A	N/A	0	Collect additional sediment samples to re-characterize vertical extent of contamination and redredge. If certification unit median > 6, entire certification unit must be sampled for vertical extent. If certification unit median $\leq$ 6, additional sampling required only in portions of certification unit contributing to elevated mean concentration.
G	$x_i > 6$	N/A	N/A	1	Redredge.
H	$x_i > 1$ (and 20-acre average > 1)	$\geq$ 2	$\geq$ 1	2	Construct subaqueous cap (if any of these mean/sample result conditions are true) and two redredging attempts have been conducted OR choose to continue to redredge.

(1)Inventory removal efforts are not included in the limit of 2 redredging attempts.
(2)Except for Case H, where any of the listed conditions will require cap construction.
(3)If the backfill testing does not meet the criterion, the backfill must be dredged, replaced, and retested or USEPA input must be obtained for a different engineering solution regarding the backfill.

Preference for Dredging

The Residuals Standard is clear in describing USEPA's preference for dredging over capping as a means of remediating PCB inventory (mass) at the site.

The selected remedy includes dredging of contaminated sediment, using PCB inventory as the primary means to target removal areas. While the Residuals Standard of approximately 1 mg/kg Tri+ PCBs prior to backfilling is achievable (based on review of case studies), it is possible that residual concentrations may exceed the standard in a limited number of areas after the initial dredging attempt. The non-compliant residuals will likely be associated with difficult-to-dredge bottom conditions such as bedrock outcrops and boulder fields. The capping contingency was added as an option to address this scenario.

Capping the existing PCB inventory was assessed as a remedial action alternative in the 2000 Feasibility Study (FS) (USEPA, 2000), 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.

The capping option in the Residuals Standard requires that dredging cut lines are met and targeted PCB inventory removed prior to its consideration.

The option for capping allowed in the Residuals Standard differs significantly from the remedial action alternative that was evaluated in the FS, in that the design dredging cut lines must be met and the targeted PCB inventory removed before capping 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.

Thus, although application of a subaqueous cap has been added as an option, the Residuals Standard is clear in describing USEPA's preference for dredging over capping as a means of remediating PCB inventory (mass) at the site. Capping is less reliable for long-term control than dredging, and there are long-term operation and maintenance requirements associated with capping.

Performance Standard for Dredging Productivity

Objective

The *Performance Standard for Dredging Productivity* is designed to monitor and maintain the progress of the dredging to meet the six-year performance period stated in the ROD. The project schedule stated in the ROD consists of the first dredging season

> *The Productivity Standard enables progress monitoring and schedule maintenance.*

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 estimate of 2.65 million cy of sediment to be removed, which is derived from the FS.

Statement of the Productivity Standard

> *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.*

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-4 below.

Required and Target Cumulative Annual Dredging Volumes

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 Table ES-4 below 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 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.

Monitoring and Record Keeping

The Productivity Standard requires the construction manager to track and report progress to the USEPA. The record keeping, in addition to and as verified by USEPA or its designated representative in the field, will become the basis for measuring compliance with the Productivity Standard. By March 1 of each year, the construction manager 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 must be developed to attain the targeted cumulative volume for that year.

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 construction manager 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 for each dredge, estimates of in-situ sediment volumes removed, the weight of dewatered sediments, and the estimated mass of PCBs shipped off-site.

Table ES-4
Summary of Productivity Standard

Dredging Season[1]	Required Cumulative Volume (cubic yards)	Target Cumulative Volume (cubic yards)
Phase 1 (Year 1)	200,000	265,000
Phase 2 (Year 2)	690,000	795,000
Phase 2 (Year 3)	1,180,000	1,325,000
Phase 2 (Year 4)	1,670,000	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]
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.

[1] The overall completion schedule, if appropriate, will 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 redredging to meet the Residuals Performance Standard.

Action Levels and Required Responses

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

In any dredging season, if the actual monthly cumulative production falls below the scheduled amount by 10% or more, the construction manager shall identify the cause of the shortfall to USEPA and take immediate steps (*e.g.*, adding equipment and crews, working extended hours, or modifying the plant and equipment or approach to the work) 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% or more for two or more consecutive months, the construction manager shall provide a written action plan to the USEPA explaining the reasons for the shortfall in production and describing the engineering and management steps taken or underway to erase the shortfall in production during that dredging season.

If a shortfall in annual production compared to the required cumulative volume occurs, USEPA will determine the appropriate action to address non-compliance with the Productivity Standard. USEPA will evaluate the circumstances that led to the annual shortfall, if encountered, when assessing compliance.

Interactions among the Standards

The development of the Engineering Performance Standards included consideration of the degree to which they are interrelated. Some of the major points of interaction among the standards, and issues identified as being significant to compliance with all the standards, are summarized in Table ES-5 below. The design of the project should be optimized in consideration of these interactions.

Possible Refinements to the Standards

Information and data collected during the design phase of the project will identify the precise areas of the river bottom that require dredging, refine the volumes that were estimated in the FS and ROD, and provide a more accurate estimate of baseline water column conditions. USEPA will use the new data from the project design to update the Engineering Performance Standards, if necessary.

The standards will also be revised, if necessary, during and/or at the end of Phase 1 for application to Phase 2, based upon knowledge gained from the first year of the remediation. The initial year of work will entail considerable monitoring of dredging operations to allow evaluation of and adjustments to the dredging program. Certain Phase 1 monitoring requirements may be reduced for Phase 2 operations. Any adjustments, modifications, or refinements to the standards as a result of Phase 1 evaluation will be the subject of a second peer review by independent experts, as required by the ROD.

Special Studies

Special studies will be conducted for limited periods of time to gather information for specific conditions that may be encountered during the remediation or to develop an alternate strategy for monitoring. Specific conditions to be investigated may include different dredge types, contaminant concentration ranges, and varying sediment textures. Each of these studies is integral to the Phase 1 evaluation, the development of Phase 2, and tied to compliance issues.

Table ES-5
Summary of Interactions Among the Engineering Performance Standards

Standard Element	Tiered Response Actions	Potential Implications to Other Standards	Further Solutions
Resuspension Action Levels	Level 1. Additional Monitoring Level 2. Project Modifications Level 3. Temporary Shut Down	1. Required project modifications must be carefully designed to control impacts on productivity (temporary shutdown will create unavoidable impact). 2. Control of increased deposition will help mitigate residuals.	> Modify equipment and operations as necessary > More effective containment
Residuals Contingency Actions	Level 1. Backfill with confirmation sampling Level 2. Capping Level 3. Redredging	1. Flexible contingencies minimize increased resuspension rates associated with low production 2. Limit on required redredging attempts minimizes lost productivity and lower solids production during redredging,	> Reevaluate design cuts > Modify dredging equipment for redredge passes > Re-evaluate number of redredging attempts before resorting to capping
Productivity Required and Target Volumes	Level 1. Analyze dredging logs to isolate causes; evaluate and adjust operations if appropriate Level 2. Increase equipment size or numbers	1. Minimize increased resuspension due to low production and longer duration 2. Control residuals if productivity loss is due to poor dredging conditions (debris, etc.).	> Increase production capacity to meet standards

There are a total of six special studies, five for the Resuspension Standard and one for the Residuals Standard. The five special studies for resuspension are:

- Near-field PCB Release Mechanism (Dissolved vs. Particulate)
- Development of a Semi-Quantitative Relationship between TSS and a Surrogate Real-Time Measurement for the Near-field and Far-field Stations (Bench Scale)
- Development of a Semi-Quantitative Relationship between TSS and a Surrogate Real-Time Measurement for the Near-field and Far-field Stations (Full Scale)
- Phase 2 Monitoring Plan
- Non-Target, Downstream Area Contamination

Of these studies, the Phase 2 Monitoring Plan study is only required if an alternate monitoring program is proposed.

The special study for the Residuals Standard is the Special Study for the Characterization of Residual Sediment Strata and Thickness.

1.0 Introduction

The Engineering Performance Standards document is published in five volumes, as listed below.

5-Volume Engineering Performance Standards
Volume 1 – Statement of the Standards
Volume 2 –Resuspension Standard
Volume 5 –Residuals Standard
Volume 4 – Productivity Standard
Volume 5 – Appendix – Case Studies

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

The first volume introduces the Engineering Performance Standards. Volumes 2 through 4 contain the technical basis and implementation details for the individual standards, and Volume 5 contains an appendix that presents case studies of environmental dredging projects.

This volume, Volume 1, contains the following information:

- An Executive Summary that provides an overview of the Engineering Performance Standards
- An introduction (Section 1.0) that describes the document's structure, summarizes the history of the Hudson River PCBs site, presents important considerations for the development of the standards, and introduces the key members of the technical team responsible for the development of the standards
- A statement of each engineering performance standard's objectives and measurement criteria (Section 2.0)
- A discussion of some of the major interactions among the performance standards (Section 3.0)
- A summary of possible refinements to the Performance Standards that may be conducted during the project design phase (Section 4.0)
- A summary of special studies required during Phase 1 of the dredging project (Section 5.0)
- A description of the evaluation to be conducted following the completion of Phase 1 (Section 6.0).

1.1 Structure and Content of the Engineering Performance Standards

The Technical Basis and Implementation of the Engineering Performance Standards are presented in Volumes 2 through 4. To provide a comprehensive and consistent presentation of each standard, each volume is subdivided into four sections. The four basic sections in Volumes 2 through 4 are as follows:

Section 1 – Technical Background and Approach

- Objectives and methodology used in the development of these standards are presented in this section.
- Brief summary of the scope for the development of the standard.
- Summaries of several case studies that are similar in nature to this project.

Section 2 – Supporting Analyses

- Analysis of available information for its applicability to this project.
- 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.

Section 3 – Rationale for Development of the Standard

- Determination of the performance standard, based on the supporting analyses performed.
- Rationale for this determination.
- Analysis of case studies, along with reasoning and explanation of decisions and judgments made to arrive at the standard.

Section 4 – Implementation of the Standard

- Full presentation of the standard, including conceptual information to be provided to assist the user to interpret application of the standard in unforeseen circumstances.
- Details of action levels, including the standard proper, along with monitoring requirements and the basis for engineering controls and contingencies to be required at each level.

1.2 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.

Hudson River PCBs Superfund Site: *Nearly 200 miles from Hudson Falls to the Battery in New York City*

Upper Hudson portion: *some 43 river miles from Hudson Falls to Federal Dam at Troy*

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 (TIP).

- *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.

- *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 approximate 30-year period ending in 1977, General Electric (GE) used PCBs in its capacitor manufacturing operations at its Hudson Falls and Fort Edward, New York 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 kilograms [kg]).

Estimated total quantity of PCBs discharged directly into the Hudson River from the 1940s to 1977: 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 in other depositional areas farther downstream. Because of its deteriorating condition, the Fort Edward Dam was removed in 1973. Five areas of PCB-contaminated sediments known as the “remnant deposits” were exposed due to the lowering of the river water level when the Fort Edward Dam was removed. 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) (USEPA, 2000) and issued a ROD for the site (the 1984 ROD) that 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

- A detailed evaluation of the Waterford Water Works treatment facilities, including sampling and analysis of treatment operations to determine whether an upgrade or alterations to the facilities were needed

Commercial use of PCBs ceases in 1977.

Releases of PCBs via bedrock fractures from GE's Hudson Falls plant continue to contaminate the river.

Although commercial uses of PCBs ceased in 1977, GE's Fort Edward and Hudson Falls plants continued 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 capping the remnant deposits.

GE's PCB removal and subsequent mitigation efforts resulted in a decline, but not a cessation, of PCB seepage into the river.

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.

In 1989, USEPA undertook a Reassessment Remedial Investigation/Feasibility Study (RI/FS) of its 1984 interim No Action decision on river sediments. The contaminated river sediments are the primary source of PCBs in the Upper Hudson.

From 1993 to 1995, GE removed approximately 45 tons of PCBs from the tunnel under New York State Department of Environmental Conservation (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 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 only a minor source of PCBs to the Hudson River, although the Fort Edward outfall area currently is being remediated by the NYSDEC 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, and a request by NYSDEC for a reexamination of the 1984 decision. The February 2002 ROD is the result of the reassessment.

1.3 Engineering Performance Standards Development

This subsection presents the fundamental principles that guided the development of the Engineering Performance Standards. These principles were used to create an enforceable, yet flexible, set of standards to guide the design and protect the welfare of the public. The principles include the following:

- The standards will protect human health and the environment, while offering as much flexibility as practicable in design.

- The standards will be performance oriented rather than prescriptive in regard to means and methods.

- The standards will set goals to achieve rather than specifying management practices to be used.

- The standards will be designed to work together to achieve the overall goals of the project.

- Phase 1 and Phase 2 are parts of a single project. Phase 1 is the first year of the project, and is not a pilot study or demonstration project. Phase 2 is the remainder of the project, which will be conducted at full production.

Using the foregoing principles, each standard also incorporated standard-specific guidelines throughout development, discussed in the following subsections.

1.3.1 Fundamental Principles for Development of the Resuspension Standard

Principles for development of the Resuspension Standard are as follows:

- Concentration criteria are required to document that water column PCB levels are acceptable for downstream users under the requirements of the Safe Drinking Water Act.

- Load-based criteria are needed to minimize long-term downstream transport of PCBs, to the extent practicable.

- Short-term impacts to the water column resulting from the remediation are acceptable provided that the goals of the remediation defined in the ROD are met.

- USEPA's modeling framework developed for the Reassessment RI/FS can provide a basis to assess the impacts of dredging-related PCB release.

- Water column monitoring is needed outside the immediate vicinity of the dredging operations, to establish upstream baseline values, to address potential impacts of the full range of remedial operations, and to document water quality in the Lower River throughout the remediation.

- An increased water column sampling frequency will increase the statistical confidence in the analytical results.

- The primary means of contaminant release is believed to be in suspended matter form. As such, the standard can rely on measurements of suspended solids concentrations or a real-time surrogate as an early indication of Total PCB release.

1.3.2 Fundamental Principles for Development of the Residuals Standard

Principles for development of the Residuals Standard are as follows:

- Sediment sampling following dredging but prior to placement of backfill is necessary to verify the effectiveness of the remediation. The inclusion of an approximately 1 mg/kg Tri+ PCBs goal for sediment residuals in the ROD contains an implicit directive to conduct verification sampling.

- The post-dredging sampling should allow investigation of both dredging-related residuals (*e.g.,* sediments that escaped the dredge during removal and resettled or re-deposited) and potential "missed inventory" (*i.e.,* the original "inventory" of contaminated sediment targeted for removal by the ROD).

- Given that information specific to the Hudson River is not available, statistical evaluations of residual sediment datasets from relevant case studies will be used to develop a set of action levels for Phase 1. These action levels will facilitate the comparison of residual sediment concentrations to the ROD's objective of approximately 1 mg/kg Tri+ PCBs. Based on data obtained during Phase 1, the action levels should be reevaluated for application during Phase 2.

- The primary measure of compliance with the ROD's objective will be the arithmetic mean Tri+ PCBs concentration in a dredged area. Action criteria for individual sampling nodes (prediction limits) will be included to measure the dredged area's compliance based on the variability of individual results. A median sediment Tri+ PCB concentration in a dredging area in excess of a specified criterion can provide a trigger to investigate the dredging area for missed inventory.

- Only re-dredging is appropriate for remediation of missed inventory. The ROD specifies that all PCB inventory in the target areas is to be removed.

- Experience gained from other environmental dredging projects supports limiting the number of redredging attempts.

- For areas where compliance with the standard is difficult to achieve, contingency actions including: joint evaluations of multiple dredged areas, placement of backfill over non-compliant residuals with subsequent confirmatory testing of the backfill surface, redredging, and subaqueous capping may be needed to maintain flexibility and productivity.

- The standard will reflect the ROD's preference for dredging over capping. The ROD requires that backfill be applied where appropriate. Backfill may not be appropriate for use in the navigation channel, and there may be certain areas where habitat requirements restrict the placement of backfill. Both the backfill design and the development of design criteria for backfill placement should be intentionally left to the design phase of the project.

1.3.3 Fundamental Principles for Development of the Productivity Standard

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

- The Productivity Standard must meet the six-year time frame set in the ROD. The use of cumulative annual volume requirements will facilitate timely completion of the project. The standard should drive the design to be front-loaded, so that the final year of operations is a 'wrap up' of dredging activities, rather than 'catch up.'

- The volume and spatial extent of Phase 1 should be sufficient to test the other two standards as well as the Productivity Standard itself.

- Faster dredging does not necessarily equate to a higher resuspension rate. Based on experience gained from other environmental dredging projects, dredging slower, as well as faster than an optimal operating range, may increase resuspension.

1.3.4 Model Sequence of Work

To develop meaningful performance standards, it was necessary to envision a likely sequence of work for the major elements of the remediation project. This "model sequence" was prepared in lieu of the actual sequence of work, which is currently under development as part of the remedial design. The model sequence of work outlined below is based on information in the FS and ROD and emphasizes the points where the performance standards will interact with the work.

1. During remedial design, 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 (including contaminated sediment surface concentrations), 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 less than 1 mg/kg).

2. Also during remedial design, 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 (baseline monitoring program).

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 *Resuspension 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 *Residuals 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 *Productivity Standard*. Contingency actions are implemented if the dredging production rate deviates significantly from that required by the performance standard.

6. During and 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 monitoring required to establish compliance with the Engineering 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.

1.3.5 Human Health and Environmental Protection Objectives

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 that:

- 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.[7]

[7] 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 an annual Total PCB load (mass) transported downstream during remedial dredging that is similar to the range of annual Total PCB loads detected during recent baseline (*i.e.*, predredging) 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.

- The three 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.

1.4 Key Personnel and Roles

1.4.1 Key Project Personnel

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, USEPA's consultant Malcolm Pirnie, Inc. assembled a technical team of highly qualified professionals, many of whom had been involved with the Reassessment RI/FS for the site, or with previous work on the river on behalf of New York State. In addition, the quality review normally conducted internally was performed by 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.

The technical effort was divided among three teams, one for each standard. Following is a brief discussion of the key senior members of each technical team.

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

Mr. Fidler obtained his master's degree in civil and sanitary engineering in 1979 and has 25 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 prefeasibility 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 preparation of 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 effort.

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

Dr. Garvey is a senior environmental geochemist with TAMS Consultants, Inc., an Earth Tech Company, with more than 22 years of experience in environmental geochemistry and additional extensive 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, who is also a registered geologist/geochemist in the Commonwealth of Pennsylvania, has more than 19 years of study specific to the Hudson River to his credit, 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. Dr. Garvey brings extensive experience on the geochemical interpretation of sediment contamination data and its implications for long-term PCB transport to his role as the Resuspension Standard team leader.

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

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 industrial sites throughout the United States. Other areas of Dr. Kresic's expertise include subsurface modeling and geostatistical, probabilistic, and stochastic analyses of spatial and time data series. 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.

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

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 environmental and civil projects, including a number of hazardous waste remediation projects involving dredging and disposal of contaminated sediments. He became involved in the Hudson River PCBs project in 1974 when he served as Malcolm Pirnie's project engineer on the design of a new water main crossing the Hudson to replace existing mains damaged by the removal of the former Fort Edward Dam. The project 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, Mr. Mulligan served as Malcolm Pirnie's project manager for preparation of studies and designs for NYSDEC, aimed at remediating the PCB contamination of the river sediments. Recently, Mr. Mulligan assisted in designing the demonstration project for the remediation of PCB-contaminated sediments at Deposit N in the Fox River near Green Bay, Wisconsin, and designed a dredging project to remove and dewater PCB-contaminated sediments from the St. Lawrence River for General Motors Corporation.

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

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 sediment 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 FS for this site, as well as the to preparation of the reassessment Responsiveness Summary, which is Part 3 of the ROD. Dr. Hayes worked as a research civil engineer at the US Army Corps of Engineers (USACE) Waterways Experiment Station for more than 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).

1.4.2 Key Quality Review Personnel

A team of experts that functions independently of the technical team is performing quality reviews for the project. These reviewers are discussed in the following text.

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

Mr. Goldstein has more than 20 years experience in contaminant hydrogeology and contaminant fate and transport. A professional hydrologist/hydrogeologist at Malcolm Pirnie, he has designed work plans, field sampling plans, and quality assurance plans, and has 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.

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.

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, Washington. 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. His project experience includes design and contract oversight of navigation dredging and PCB remediation on the US Navy Puget Sound Shipyard in Bremerton, Washington; participation in Pilot Study 2000 to dredge PCBs for the New Bedford, Massachusetts, remediation; preliminary design for remediation of PCBs in the Fox River, Wisconsin; sediment remediation in Greens Bayou, Texas; and three Tacoma, Washington projects: Hylebos Waterway PCB remediation design and construction; development, design, and construction oversight for the Sitcum Waterway remediation; and remediation of the St. Paul Waterway.

Mr. Hartman has taught the USACE *Dredging Fundamentals Short Course* every year since 1982, courses on dredge cost estimating, dredge contract administration, and dredge inspection 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.

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

Dr. Palermo is an independent consultant, research civil engineer and prior director of the Center for Contaminated Sediments at the U.S. Army Engineer Research and Development Center, Waterways Experiment Station, where he managed and conducted 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.

Dr. Stasiuk is a licensed professional engineer at Malcolm Pirnie with experience in dealing with sites contaminated with PCBs. In 1975, he helped coordinate 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, New York, residential area in 1979 and the subsequent remedial action.

As director of the New York State Department of Health's (NYSDOH) Center for Environmental Health from 1985 through 1996, Dr. Stasiuk provided direction to the bureaus that conducted 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.

1.4.3 Quality Review Team Roles and Responsibilities

> ***QRT responsibility***:
> - *Evaluate the scope of work and approach for the development effort.*
> - *Evaluate draft deliverables leading up to publication of the standards for public and peer review.*

The foregoing 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. The technical team carefully considered all comments received from the QRT and implemented them 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, 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[8], 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.

1.5 Site-specific Nature of the Engineering Performance Standards

As indicated above, at this time, the Engineering Performance Standards are intended only for application to environmental dredging of the Upper Hudson River as called for in USEPA's 2002 ROD for the Hudson River PCBs Superfund Site. These standards are not intended to provide general or universal guidance for environmental dredging. While the principles employed to develop the standards may have relevance to other situations, other projects and locations may have specific features differing from those of the Hudson River, and the standards presented herein may not be applicable to those projects.

1.6 Data Quality for Performance Standard Monitoring Programs

Laboratory analytical requirements for monitoring programs required by the Engineering Performance Standards are described in Section 2.0. Data Quality Objectives for the Resuspension and Residuals Standards are provided in Volumes 2 and 3. On-site laboratory audits and performance evaluation sample analysis programs will be required to evaluate laboratory data quality and facilitate field decisions in advance of full data validation.

1.7 Required Reporting Formats

Requirements for data reporting (*e.g.*, weekly progress reports and certification unit reports) are addressed for each performance standard in Sections 2.1.5, 2.2.5, and 2.3.2. The required deliverables will be provided to USEPA in an editable electronic format using software to be agreed on during project design review.

[8] Gregory Hartman, PE was unavailable to review the standards documents 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 these documents.

2.0 The Standards

2.1 Performance Standard for Dredging Resuspension

The Resuspension Standard for water quality is the maximum allowable concentration of PCBs in river water: 500 ng/L.

The *Performance Standard for Dredging Resuspension*, hereafter referred to as the Resuspension Standard, is designed to minimize the export of PCBs from sediment during remedial dredging and to protect downstream water quality. The Resuspension Standard for water quality is the maximum allowable concentration of PCBs in the river (500 ng/L). These objectives are listed in the box below.

Resuspension Standard Objectives

- Maintain PCB concentrations in the water column at or below the federal MCL of 500 ng/L to protect downstream municipal intakes.
- Minimize the release of PCBs from sediment during remedial dredging.
- Minimize the export of PCBs to downstream areas, including the Lower Hudson.

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 for application to Phase 2, based upon knowledge gained from the first year of the remediation. 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.
- Tender and tugboat movements.
- Barge transport.
- Debris removal.
- Materials handling.
- Other remedial activities.

It is important to note that this definition specifically 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 specifies criteria for both formulations of PCBs used throughout the Reassessment RI/FS: Total PCBs and Tri+ PCBs[9]. The water quality requirements for non-PCB parameters such as metals, dissolved oxygen (DO), and pH are expected to be addressed in the 401 Water Quality Certification that is being developed by the NYSDEC.

The Resuspension Standard does not regulate resuspension within control barriers, except where such resuspension results in unacceptable downstream transport beyond the barriers.

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. 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.

2.1.1 Resuspension Standard Formulation

The Resuspension Standard was established so that remediation-related problems can be quickly identified and corrected before criteria are exceeded that would require temporarily halting the dredging operations. To this end, the Resuspension Standard is presented in terms of a standard threshold and two action levels above a routine monitoring program. Failure to be in compliance with the threshold requires that operations be temporarily halted until the exceedance can be rectified. Exceedance of an action level 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:

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

- 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 Volume 2. The Resuspension Standard addresses both long-term and short-term impacts in terms of long-term and short-term criteria. In general, short-term criteria are for the protection of public water supplies, whereas long-term criteria are intended to help secure the long-term recovery of the river and its biota.

2.1.1.1 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, which is 500 ng/L Total PCBs.[10] Remedial activities may proceed only when the ambient Total PCB concentration (PCBs from all sources) is 500 ng/L or less. For the purpose of this standard, exceedance of the Resuspension Standard threshold requires a confirmed occurrence in excess of 500 ng/L Total PCBs at a far-field station.

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.

2.1.1.2 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 the dredging-related activities (near-field) and at the fixed monitoring locations (far-field), so that changes in water quality due 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 two action levels, the Evaluation Level and the Control Level. Analyses prepared for the FS and this document suggest that the remediation reasonably can be accomplished without exceeding the Evaluation Level criteria. The criteria for the Control 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 could impact the long-term recovery if maintained indefinitely.

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

Increases in monitoring are required as an action level is exceeded. An engineering solution is recommended for the first action level (Evaluation Level), and is mandatory at the second (Control Level). The PCB criterion for the Evaluation Level is based on mass loss (units of g/day) only. The Control Level includes both PCB mass loss and PCB concentration criteria. Suspended solids criteria are specified for both the Evaluation and Control Levels. Table 2-1 below summarizes the resuspension criteria for the two action levels.

Table 2-1
Resuspension Criteria[1]

Parameter		**Resuspension Standard Threshold**		**Control Level[2]**		**Evaluation Level**	
		Limit	Duration	Limit	Duration	Limit	Duration
Far-Field PCB Concentration	Total PCBs	500 ng/L	Confirmed Occurrence [8]	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	7-day running average	300 g/day	7-day running average
	Tri+ PCBs			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 Volume 2, Section 4.
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 Volume 2.
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.

2.1.2 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 above in Table 2-1. As long as the water column conditions are in compliance with all criteria, the dredging operation is considered to be operating as designed, and no additional monitoring beyond continued routine monitoring is required.

This subsection 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 below.

2.1.2.1 Far-Field Monitoring

Far-Field Monitoring Locations

The routine monitoring program includes nine far-field monitoring stations (shown in Figure 2-1):

- Four far-field monitoring locations downstream from the main remediation areas: Thompson Island Dam (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).

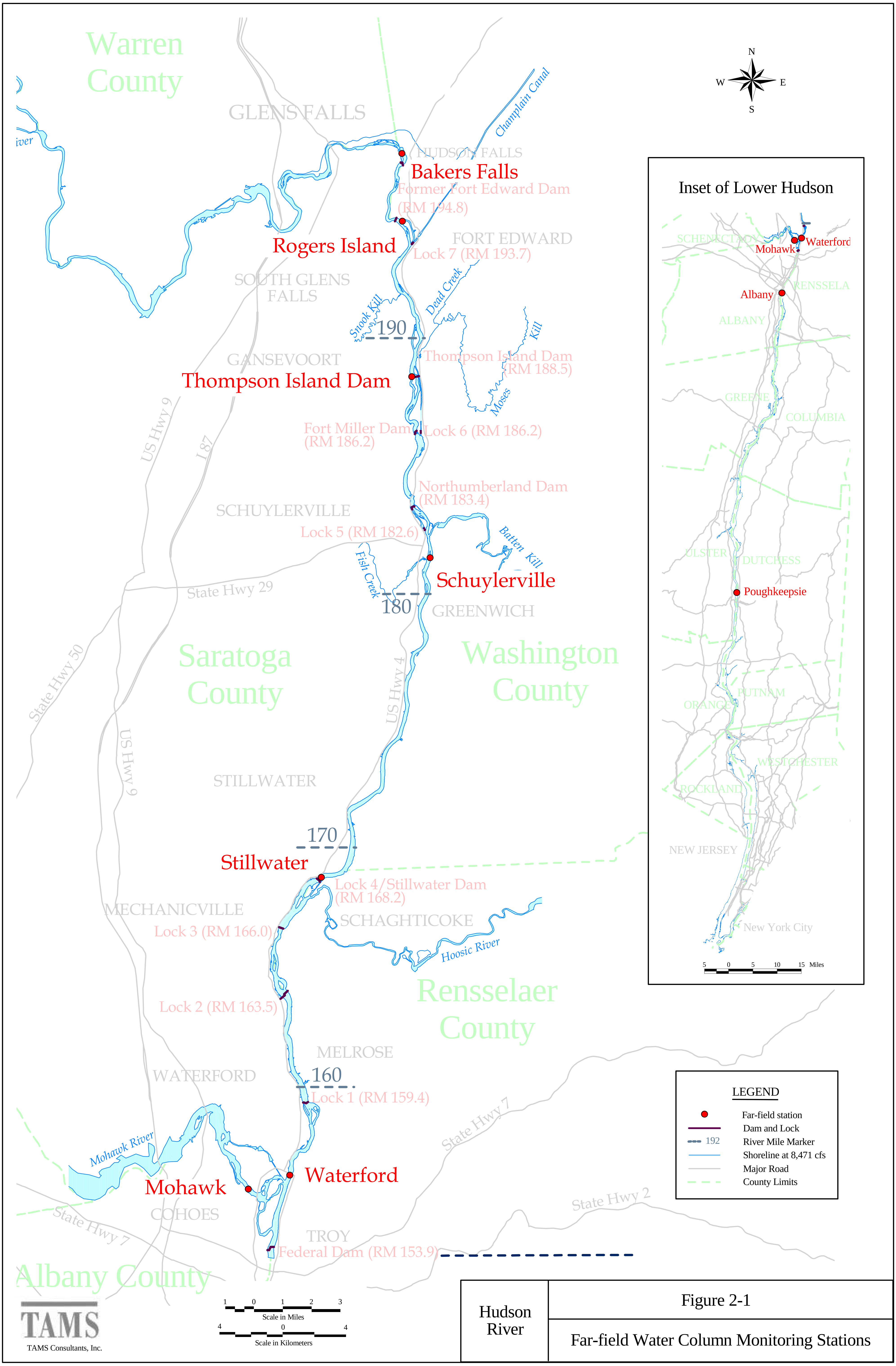
- Two Lower Hudson River stations: Albany (approximately RM 140) and Poughkeepsie (RM 77).

- One monitoring station on the Mohawk River at Cohoes, NY 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

Far-field PCB monitoring includes continuous monitoring of turbidity as a surrogate for suspended solids 24 hours per day at four Upper Hudson stations and Rogers Island.

The basic monitoring program for the Resuspension Standard in the Upper River consists of far-field PCB and suspended solids measurements collected daily at the four Upper Hudson far-field stations and Rogers Island ("main stem" stations). Continuous measurement of turbidity is required at the far-field stations, 24 hours a day. The continuous measurement of turbidity serves as a surrogate for suspended solids and is based on the semi-quantative relationship to be developed as part of a special study.



Hudson River	Figure 2-1
	Far-field Water Column Monitoring Stations

In addition to the turbidity measurements, monitoring of the suspended particle size distribution via laser particle analyzer is required at the first far-field station downstream of the dredging operation. Like turbidity, application of the laser particle analyzer will be based on the relationship to be developed as part of a special study.

Use of the continuous reading monitors is dependent upon the existence of a reliable relationship between suspended solids and the continuous measurement. In the event that this relationship does not remain reliable, increased suspended solids sampling must ensue until a new relationship can be developed from field data or an additional special study.

The routine monitoring program also includes the deployment of integrating samplers (*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 2-2 below outlines the parameters and frequency of monitoring at the Upper Hudson far-field stations during routine monitoring.

Far-field monitoring at Bakers Falls and in the Lower Hudson is less frequent.

Far-field stations at Bakers Falls and in the Lower Hudson will also require routine monitoring. Sampling in the Lower Hudson will include sample collection for all parameters listed below in Table 2-2, but only at a single center-channel station and at a lower frequency. The far-field station at the Mohawk River will be monitored by sampling across the river cross-section at the same frequency as the two Lower Hudson River stations. The Bakers Falls station will be comprised of a cross sectional composite, similar to the five main stem Upper Hudson stations, but at a lower frequency.

2.1.2.2 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 may 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 below in Figure 2-2:

- One upstream station
- One side-channel station
- Three downstream stations

If barriers are installed to control resuspension, a sixth station will be required inside the barrier.

Table 2-2
Sampling Requirements on a Weekly Basis – Upper River Far-field Stations

Routine Monitoring Number of Samples per Week	PCB Lab Turn-Around Time (hr.)	Laboratory Analyses					Probe		
		Congener-Specific PCBs Whole Water	DOC & Susp. OC	SS	TSS (1/3-hours)_	Integrating Sampler for PCBs	Turbidity	Do, Temp., Ph, Cond.	Laser Particle Counter
RM 197.0 - Bakers Falls Bridge	72	1	1	1			Discrete		
RM 194.2 - Fort Edward	72	7	7.5	7.5	56	0.5	Continous	Discrete	Discrete[5]
RM 188.5 - TI Dam_	24	7	7.5	7.5	56	0.5	Continous	Discrete	None
RM 181.4 - Schuylerville_	24	7	7.5	7.5	56	0.5	Continous	Discrete	None
RM 163.5 - Stillwater	72	7	7.5	7.5	56	0.5	Continous	Discrete	None
RM 156.5 – Waterford	72	7	7.5	7.5	56	0.5	Continous	Discrete	None
Samples/Week		36	38.5	38.5	280	2.5			
PCB analyses/week		**38.5 or 5.5 /day**							

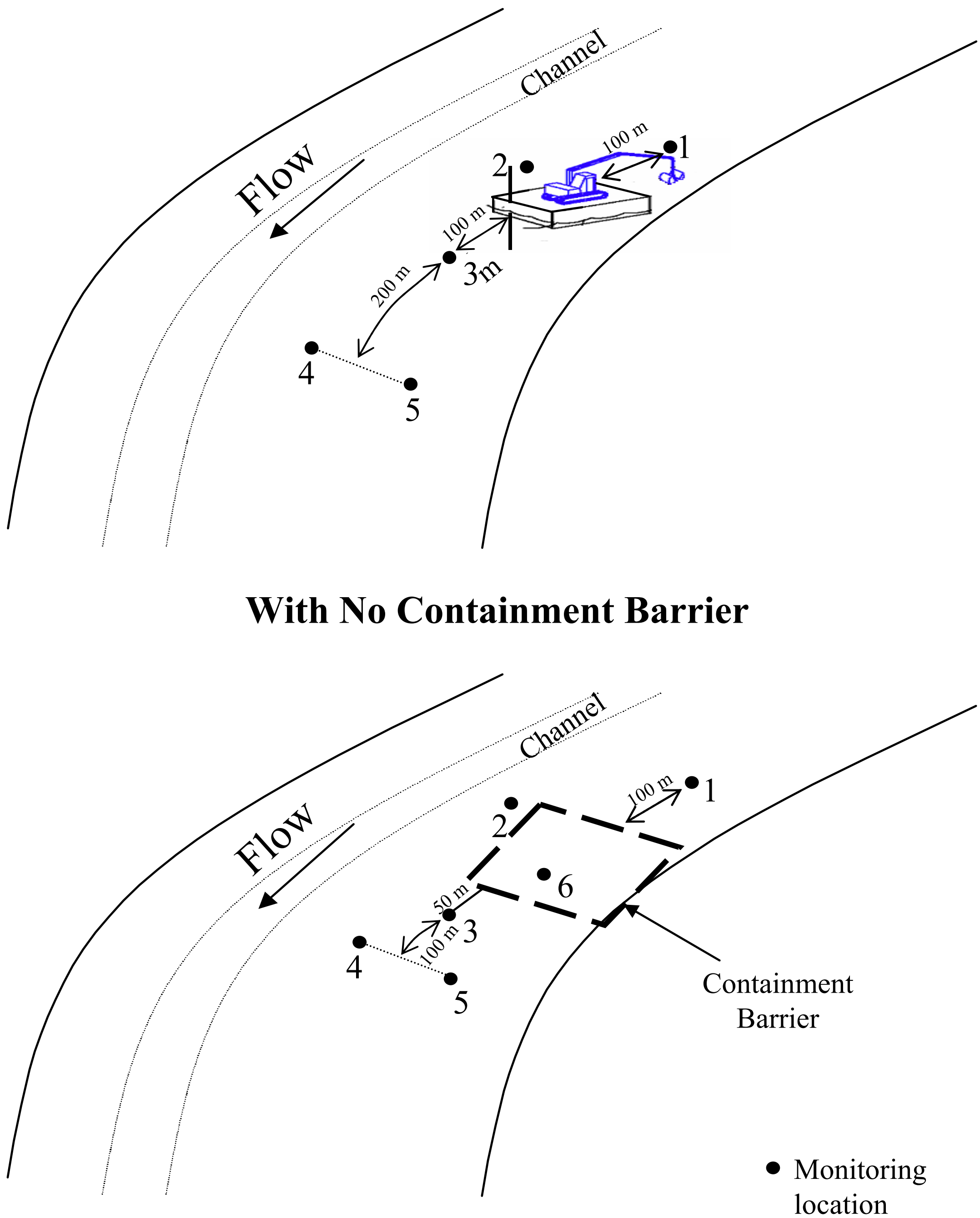
Evaluation Level Number of Samples per Week	PCB Lab Turn-Around Time (hr.)	Laboratory Analyses					Probe		
		Congener-Specific PCBs Whole Water	DOC & Susp. OC	SS	SS (1/3-hours)_	Integrating Sampler for PCBs	Turbidity	Do, Temp., Ph, Cond.	Laser Particle Counter
RM 197.0 - Bakers Falls Bridge	72	1	1	1			Discrete		
RM 194.2 - Fort Edward	72	7	7.5	7.5	56	0.5	Continous	Discrete	Discrete[5]
RM 188.5 - TI Dam_	24	14	14.5	14.5	56	0.5	Continous	Discrete	None
RM 181.4 - Schuylerville_	24	14	14.5	14.5	56	0.5	Continous	Discrete	None
RM 163.5 - Stillwater	72	7	7.5	7.5	56	0.5	Continous	Discrete	None
RM 156.5 – Waterford	72	7	7.5	7.5	56	0.5	Continous	Discrete	None
Samples/Week		50	52.5	52.5	280	2.5			
PCB analyses/week		**52.5 or 7.5 /day**							

Control Level Number of Samples per Week	PCB Lab Turn-Around Time (hr.)	Laboratory Analyses					Probe		
		Congener-Specific PCBs Whole Water	DOC & Susp. OC	SS	TSS (1/3-hours)_	Integrating Sampler for PCBs	Turbidity	Do, Temp., Ph, Cond.	Laser Particle Counter
RM 197.0 - Bakers Falls Bridge	72	1	1	1			Discrete		
RM 194.2 - Fort Edward	72	7	7.5	7.5	56	0.5	Continous	Discrete	Discrete[5]
RM 188.5 - TI Dam_	24	21	22	22	56	1	Continous	Discrete	None
RM 181.4 - Schuylerville_	24	21	22	22	56	1	Continous	Discrete	None
RM 163.5 - Stillwater_	24		7	7	56	7	Continous	Discrete	None
RM 156.5 – Waterford_	24		7	7	56	7	Continous	Discrete	None
Samples/Week		50	66.5	66.5	280	16.5			
PCB analyses/week		**66.5 or 9.5 /day**							

Threshold[4] Number of Samples per Day Only	PCB Lab Turn-Around Time (hr.)	Laboratory Analyses					Probe		
		Congener-Specific PCBs Whole Water	DOC & Susp. OC	SS	TSS (1/3-hours)_	Integrating Sampler for PCBs	Turbidity	Do, Temp., Ph, Cond.	Laser Particle Counter
RM 197.0 - Bakers Falls Bridge	72	1	1	1			Discrete		
RM 194.2 - Fort Edward	72	1	1	1	8	1/2-weeks	Continous	Discrete	Discrete[5]
RM 188.5 - TI Dam_,_	24	4	5	5	8	1	Continous	Discrete	None
RM 181.4 - Schuylerville_,_	24	4	5	5	8	1	Continous	Discrete	None
RM 163.5 - Stillwater_	24	4	5	5	8	1	Continous	Discrete	None
RM 156.5 – Waterford_	24	4	5	5	8	1	Continous	Discrete	None
Samples/day		18	22	22	40	4			
PCB analyses/day		**22 /day**							

Note:

1. TI Dam and Schuylerville will be representative stations while the dredging is ongoing in the Phase 1 areas and will be sampled more intensely. Samples will be composited from hourly grab samples for the Resuspension Standard threshold at these two stations.
2. TSS sampling every 3 hours will be required for compliance at the nearest representative far-field stations only if the semi-quantative relationship between TSS and a surrogate is not sufficiently conservative (See Volume 2, Section 4). Samples collected at the other stations will have 12 hour turn-around.
3. The turnaround time for PCB analyses from the integrating sampler will only be specified when the information is needed quickly for comparison to the resuspension criteria. For the Resuspension Standard the integrating sample turn-around 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 Control Level at Stillwater and Waterford, the turn-around times will be 72 hours and 24 hours, respectively.
4. The monitoring for the Resuspension Standard threshold is required for one day only for verification of the elevated concentration.
5. Continuous laser particle analysis is required only at the nearest far-field station to the dredge operation.



With Containment Barrier

Figure 2-2
Schematic of Near-field Monitoring Station Locations

Near-Field Monitoring Parameters and Frequency

> *Grab samples for suspended solids analysis will be collected once per day at all near-field monitoring locations.*

Near-field monitoring requirements consist of continuous reading turbidity monitors and daily grab samples for suspended solids analysis at all near-field monitoring locations. As with the far-field monitoring discussed previously, continuous monitoring sensors will serve in the place of discrete samples for comparison to the resuspension criteria, based on the relationships developed during a special study completed before the onset of dredging operations.

Under the routine monitoring program, probes mounted on buoys around the remedial operations will measure a suspended solids "surrogate" (*e.g.*, turbidity) continuously, 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.

As with the far-field monitoring, use of the continuous turbidity monitors in the near field is dependent upon the existence of a reliable relationship between suspended solids and the turbidity measurement. In the event that this relationship does not remain reliable, increased suspended solids sampling must ensue until a new relationship can be developed from field data or an additional special study.

2.1.3 Monitoring and Engineering Contingencies

The Resuspension Standard provides monitoring and engineering contingencies 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.

2.1.3.1 Monitoring Contingencies

> *If an action level is exceeded, monitoring contingencies will be required at both the far- and near-field stations.*

If an action level is 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, having only two monitoring conditions: routine or non-routine.

Far-Field Stations

For non-routine monitoring, the sampling frequency will vary depending on the location of the remediation. Table 2-2 above contains the monitoring contingencies for the Upper Hudson River. The monitoring contingencies for the Lower Hudson River are presented below in Table 2-3.

Table 2-3
Sampling Requirements on a Weekly Basis - Lower River Far-Field Stations

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 River 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 River 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 has a total PCB concentration greater than 350 ng/L.

Near-Field Stations

The monitoring requirements for the near-field stations are presented below in Table 2-4. If the suspended solids action level is exceeded at any point, suspended solids samples will be collected twice per day at each station showing an exceedance. Exceedance of any action level for suspended solids will require monitoring for PCB congeners, suspended solids, and related parameters at the nearest representative downstream far-field station, at the frequency indicated above in Table 2-2.

Volume 2 contains a discussion of criteria for reverting to lower monitoring levels.

Table 2-4
Sampling Requirements on a Weekly Basis - Upper River Near-field Stations

Routine Monitoring (Use of continuous reading probe to indicate suspended solids concentrations.)

No. of Operations	No. of SS Laboratory Analyses	No. of Probe Measurements Turbidity and Laser 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(If the surrogate analysis fails to predict TSS concentrations adequately.)[1]

No. of Operations	Number of SS Laboratory Samples with 3-Hour Turn-Around per Week					Probe Measurements Turbidity & Particle Counter
	Number of Stations (where surrogate is out of compliance)				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. A surrogate must be established to determine compliance with the TSS-based resuspension criteria. Only if this surrogate relationship fails to adequately predict TSS concentrations will sampling for TSS concentrations every 3 hours with a 3-hour turn-around be required. If compliance is based on TSS samples, 1 sample will be collected an hour prior to the beginning of the operation and at least 3 samples will be collected at 1-hour intervals after completing efforts for the day.
2. One TSS sample will be collected per day per station to confirm the surrogate semi-quantitative relationship.
3. If a TSS resuspension criterion is exceeded at a monitoring station two TSS samples will be collected per day at that station to confirm the surrogate semi-quantitative relationship.
4. Turbidity, temperature, pH, conductivity and dissolved oxygen will be monitored continuously at each of the five near-field stations.
5. 14 hours of active dredging per day assumed for the requirements above.
6. Exceedence of a suspended solids criterion will prompt monitoring at the representative far-field station nearest to the location of the exceedence at the frequency of sampling indicated for the action level.
7. If containment is used in an area, 6 stations will be required.

Relationship between Turbidity and Suspended Solids

As noted previously, the use of the continuous reading monitors is dependent upon the existence of a reliable relationship between suspended solids and the continuous measurement. This relationship must be re-evaluated on a weekly basis to confirm that the continuous reading monitor results are consistent with the daily suspended solids results and the relationship developed as part of the special study. In the event that the turbidity data do not reliably correlate with suspended solids, increased suspended solids sampling must ensue until a new relationship can be developed from field data or an additional special study.

2.1.3.2 Engineering Contingencies

> *Defining the exact nature of the engineering evaluations and the engineering solutions is part of the design process.*

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 are required and engineering improvements are recommended, but not required. When the Control Level or the Resuspension Standard threshold criteria are exceeded, engineering evaluations and implementation of engineering solutions are both required. However, the Resuspension Standard does not specify the exact nature of these engineering tasks. These are considered part of the design and are left to the dredging team. Only the monitoring contingencies and the temporary halting of operations are prescribed by the standard for exceedance of Resuspension Standard criteria

Volume 2 contains a discussion of contingencies that may be considered for each action level and the Resuspension Standard threshold.

2.1.4 Alternate Monitoring Programs

The monitoring program for this standard has been developed in accordance with USEPA quality assurance guidelines. This approach allows modifications to the program as long as the DQOs are maintained. Attachment G of Volume 2 provides a detailed assessment of the DQOs for the Resuspension Standard. The resuspension criteria have been developed based on a monitoring program that primarily relies upon grab samples. If monitoring programs that differ significantly from that specified in this document are proposed (*i.e.,* automatic samplers), adjustments to the resuspension criteria and their implementation may be needed.

In the event that alternate monitoring programs were proposed, a special study would need to be conducted to test the results from the alternate program and determine whether adjustment of the resuspension criteria or implementation were needed. This study would be conducted simultaneously with the Phase 1 monitoring program outlined in this document. Alternate monitoring programs proposed for Phase 2 cannot be assessed or approved without a special study.

2.1.5 Minimum Monitoring and Record Keeping Requirements

Weekly progress reports will be submitted to USEPA, according to a schedule to be defined by the agency, for the agency's use in determining compliance with the Resuspension Standard. The reports must summarize the results of far-field and near-field monitoring, exceedances of the Resuspension Standard criteria, and any corrective actions implemented. The description and results of engineering studies 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 a USEPA field representative immediately and submitted 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, any such exceedance of this concentration shall be reported to USEPA within three 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 six hours of the actual exceedance, as required by the action level exceeded.

2.1.6 Finalization of the Resuspension Standard

Revisions prior to Phase 1 will involve improvements to baseline concentration estimates and adjustments based on dredging schedules. Revisions for Phase 2 will likely involve adjustments to monitoring requirements and load-based concentration thresholds.

Sections 4.0 and 6.0 of this document outline approaches for the revision of the Resuspension Standard, listing possible areas of revision for Phase 1 and Phase 2. To a large extent, 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 that will be available prior to the initiation of the Phase 1 dredging) and adjustments to reflect dredging schedules other than 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.

2.1.7 Supporting Analyses and Assumptions

Many analyses were conducted to develop the Resuspension Standard. Some of the important analyses are summarized below.

Modeling indicated that the amount of dissolved-phase PCBs likely to be introduced into the Hudson River system is relatively small compared to the amount associated with the resuspended sediment.

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 pore water 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 river is relatively small compared to the amount associated with the resuspended sediment.

Peer-reviewed HUDTOX and FISHRAND models found that PCB water column concentrations and mass loads from dredging in compliance with the standard have negligible adverse impact on PCB concentrations in fish.

Modeling. USEPA's peer-reviewed fate and transport models and bioaccumulation models (HUDTOX and FISHRAND, respectively) 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 (as presented in USEPA, 2000), 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 various 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 adverse impact on PCB concentrations in Hudson River fish as compared to a scenario with no dredging-related releases. 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 five years after the completion of dredging in the Upper Hudson. Using the model results, the impacts 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 vs. PCB and suspended solids 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 occur during May and June of each year. Subsequent sensitivity analyses also indicate that the Total PCB loads specified in the Evaluation 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.

2.2 Performance Standard for Dredging Residuals

The *Performance Standard for Dredging Residuals* (referred to as the Residuals Standard) is designed to detect and manage contaminated sediments that may remain after initial dredging in the Upper Hudson River. The ROD calls for removal of all PCB-contaminated sediments in areas targeted for dredging (*i.e.,* removal of the contaminated sediment inventory), 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).
- Contaminated sediments remaining below the design dredging cut elevations (*e.g.*, due to uncertainties associated with interpolation between pre-design sampling sampling nodes or insufficient core recovery).

The objectives of the Residuals Standard are listed in the text box below.

Residuals Standard Objectives

- Affirmation of the removal of all PCB-contaminated sediment inventory in target dredging areas.
- An arithmetic average Tri+ PCBs concentration in the residual sediments of $\leq$ 1 mg/kg.

The Residuals Standard requires implementation of a post-dredging sampling and analysis program to detect and characterize PCB concentrations in the sediments to determine whether these objectives are being met. The post-dredging sediment data will be compared to the anticipated residual of approximately 1 mg/kg Tri+ PCBs (as 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 redredging, is then selected depending on the statistical analyses of the post-dredging data.

To maintain flexibility and facilitate adherence to the productivity schedule, it is appropriate to allow residuals to be addressed *in situ* at concentrations greater than the

ROD's requirement of 1 ppm. There are several mechanisms appropriate for control of dredging residuals that should be implemented in a tiered approach, based on the concentration of Tri+ PCBs in the residuals. In order of increasingly rigorous response, the following contingency actions are required if the objectives of the Residuals Standard cannot be achieved:

- backfilling with confirmatory testing of the surface of the backfill.
- capping with an subaqueous cap.
- additional sampling at depths greater than 6 inches followed by redredging.

Residuals Standard Contingency Actions

- Placement of backfill over residual sediment with Tri+ PCB concentrations greater than 1 mg/kg but less than or equal to 3 mg/kg, with subsequent testing of the backfill surface to confirm an arithmetic average Tri+ PCBs surface concentration of $\leq$ 0.25 mg/kg .
- Subaqueous cap construction.
- Redredging.

In addition to the discussion of the Residuals Standard in this subsection, Volume 3, *Technical Basis and Implementation of the Residuals Standard*, provides the technical background and approach (Section 1.0), supporting analyses (Section 2.0), rationale for the development of the standard (Section 3.0), and a full version of the Residuals Standard (Section 4.0). The following subsections briefly describe the action levels, sampling requirements, and decision points included in the Residuals Standard.

2.2.1 Residuals Standard Criteria

The Residuals Standard refers to each dredged area to be evaluated as a certification unit (CU), and uses a group of action levels to evaluate the sediment quality in each CU after dredging. Certification units are defined as five acres in size, based on the average size of existing targeted areas. Once it is confirmed that the dredging construction manager has reached the design cut lines in a particular certification unit, 40 sediment cores (each a minimum length of the 0 to 6 inch interval) are to be collected. Each core sample will then be analyzed for its Tri+ PCB concentration and the results compared to the Residuals Standard's action levels, which are associated with the required actions summarized below.

In addition, core samples from deeper intervals may need to be collected and analyzed until a compliant horizon is encountered (see below). This is necessary in specific instances to ensure that the vertical extent of contaminated residual sediment is adequately characterized prior to implementing the required actions of the Residuals Standard (*e.g.,* redredging).

The Residuals Standard includes review of the following:

- Tri+ PCB concentrations in all 40 individual sediment samples within each 5-acre certification unit
- Mean (*i.e.*, arithmetic average) Tri+ PCB concentration of the certification unit
- Median Tri+ PCB concentration of the certification unit
- Average of the mean Tri+ PCB concentrations of a 20-acre joint evaluation area (certification unit under review and the three previously-dredged units within a two-mile stretch of river)

Adjustments to the standard 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. The following responses are required for Phase 1 of the dredging project:

Response 1: Backfill (where appropriate) and demobilize at certification units with all of the following:

- an arithmetic average residuals 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.

Response 2: Jointly evaluate a 20-acre area at a certification unit with all of the following:

- 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.

For the 20-acre evaluation, if the area-weighted arithmetic average of the individual means from the certification unit under evaluation and the three previously dredged certification units (within two miles of the current unit) is less than or equal to 1 mg/kg Tri+ PCBs, then backfill may be placed. In this case, subsequent testing of the backfill is required to confirm that its surface concentration is less than or equal to 0.25 mg/kg Tri+ PCBs. If the surface concentration does not meet this criterion, then the backfill must be dredged, replaced, and retested or otherwise remedied with input from USEPA.

If the 20-acre evaluation does not yield a combined average of 1 mg/kg Tri+ PCBs or less, then the certification unit must be redredged (see #4 below for actions required during and following redredging) or a subaqueous cap constructed. Redredging 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 redredging attempts, then capping may be implemented in lieu of further redredging attempts, as described in #5, below.

Response 3: Redredge or construct subaqueous cap at a certification unit with all of the following:

- 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.

The choice of two options is provided to maintain flexibility and productivity (*e.g.*, some areas may not be conducive to dredging). If redredging is chosen, then the surface sediment of the redredged area must be sampled and the certification unit reevaluated. If the certification unit does not meet the objectives of #1 or #2, above, following two redredging attempts, then capping may be implemented in lieu of further redredging attempts, as described in #5, below.

Response 4: Redredging is required for any of the following:

- For areas of elevated Tri+ PCB concentrations within a certification unit with an arithmetic average residuals concentration greater than 6 mg/kg Tri+ PCBs.
- To address individual sampling point(s) with concentrations greater than or equal to 27 mg/kg Tri+ PCBs.
- For instances of more than one sampling point with concentrations greater than or equal to 15 mg/kg Tri+ PCBs (in which case all such locations must be addressed).

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, then collection and analysis of additional sediment samples is required from deeper intervals over the entire certification unit (*e.g.*, 6 to 12 inch, 12 to 18 inch, etc.) as necessary to recharacterize the vertical extent of PCB contamination. If the median concentration is 6 mg/kg Tri+ PCBs or less, then 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 required only once. Dredging efforts subsequently conducted to remove missed inventory, if necessary, do not count toward the limit of 2 redredging passes.

The Residuals Standard provides a mechanism for calculating the horizontal extent of redredging. All redredging 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 redredging attempts, the arithmetic average Tri+ PCB concentration in the surface sediment still is greater than 1 mg/kg, then capping is to be implemented as stated in #5, below.

Response 5: Capping: At areas where two redredging attempts do not achieve compliance with the residuals criteria, as verified by USEPA, construct an appropriately designed subaqueous cap, where conditions allow.

In cases where redredging is required but fails to reduce the concentration below the action levels (after two additional attempts), there are two options available.

- An appropriately designed subaqueous cap may be placed to isolate the PCB residuals (refer to Volume 3, Section 3.6).

- The construction manager (defined, for the purposes of the Residuals Standard, as a resident engineer responsible for execution of all construction activities, including implementation of the Residuals Standard requirements) may choose to continue dredging, based on cost considerations, consideration of impacts to the schedule, and knowledge of the dredging area and equipment.

The rationale for the action levels is provided in Volume 3. Based on the evaluation of currently available case study data, the action levels below represent the associated statistical limits on the certification unit arithmetic averages and individual sample concentrations:

- 27 mg/kg Tri+ PCBs – 99% Prediction Limit (PL)
- 15 mg/kg Tri+ PCBs – 97.5% PL
- 6 mg/kg Tri+ PCBs – 99% Upper Confidence Limit (UCL)
- 3 mg/kg Tri+ PCBs – 95% UCL

The 99% PL and 95% PL are prediction limits considering individual samples, and the 99% UCL and 95% UCL are upper confidence limits on the mean (*i.e.*, arithmetic average; see Volume 3, Section 2.0 for further information).

All PCB concentrations are to be rounded conventionally to whole numbers in mg/kg Tri+ PCBs. The PL and UCL values may be revised pending new data that may be available prior to the Phase 1 effort, or during or subsequent to the Phase 1 dredging effort (refer to Sections 4.0 and 6.0 of this volume).

2.2.2 Residuals Standard Implementation

Post-dredging sediment sampling must be completed within 7 days after dredging is completed in a given CU.

Post-dredging sediment sampling must be completed within seven days after dredging is completed within the certification unit. Dredging completion is defined as the entire certification unit meeting the design cut elevations. Post-dredging sediment sampling and analyses generally consist of the following tasks:

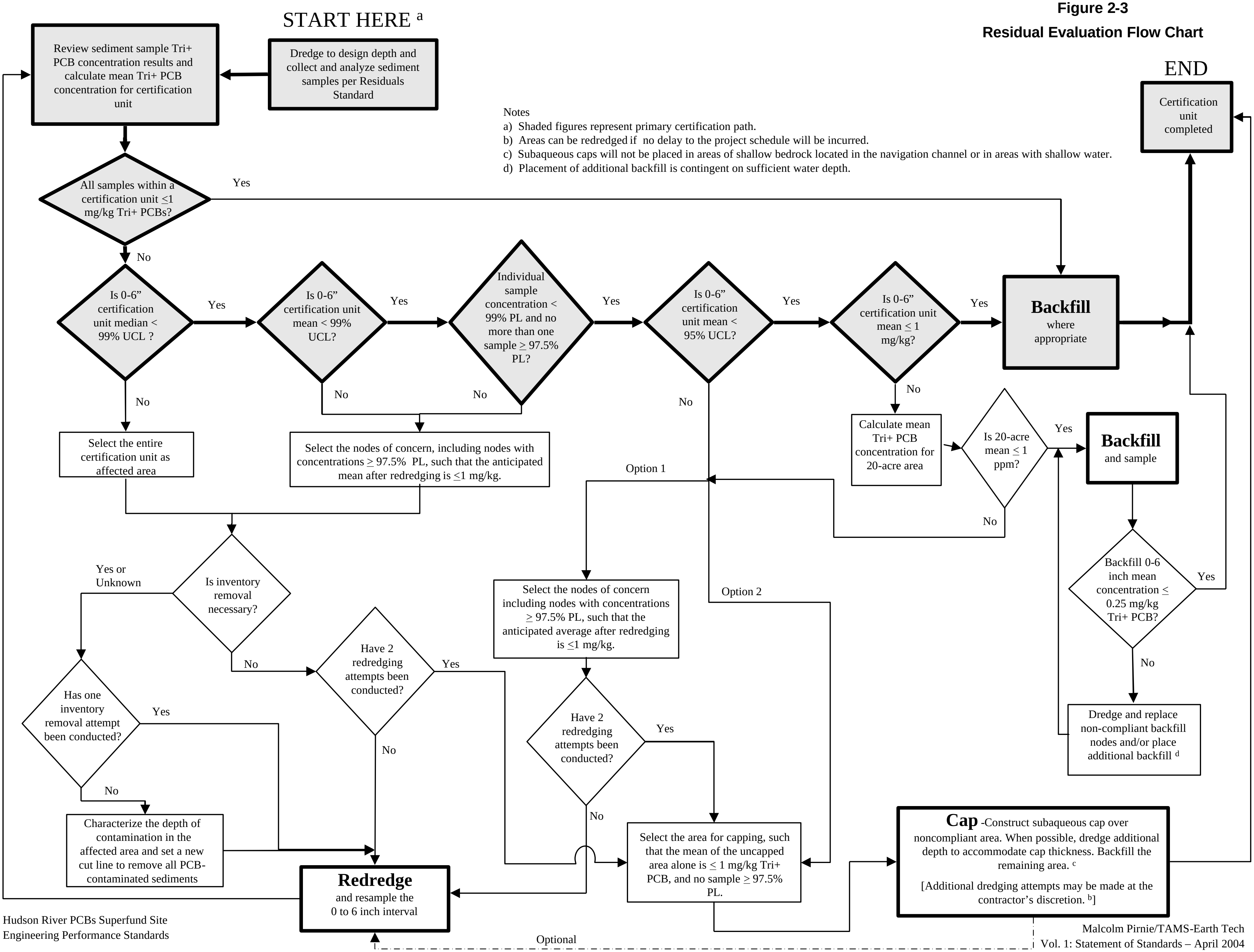
- Collection of 40 uniformly spaced sediment cores from each CU less than or equal to five acres in size
- Processing of each sediment core to obtain a 0 to 6 inch sample
- Laboratory extraction of the samples and analysis of the extracts for PCBs. Analysis of deeper samples (6 to 12 inch, 12 to 18 inch, etc.) may be required, if the arithmetic average concentration encountered in the 0-to-6-inch layer is greater than 6 mg/kg Tri+ PCBs.
- Calculations of the CU arithmetic average, CU median, and area-weighted average for the 20-acre area
- Comparison of individual results, CU arithmetic average, CU median, and 20-acre joint evaluation area-weighted averages to Residuals Standard's action levels.

Required actions following the tasks described above are shown in Figure 2-3 as a flowchart and summarized in Table 2-5.

2.2.3 Preference for Dredging

The selected remedy includes dredging of contaminated sediment, using the mass of PCB contamination as the primary means to target removal areas. The Residuals Standard specified in the ROD (anticipated concentration 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 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 Hudson River, it may be difficult to achieve the Residuals Standard. Capping of areas where the residual concentrations exceed the action levels following two redredging attempts has been added as an option to address this scenario.

Figure 2-3
Residual Evaluation Flow Chart



Notes
a) Shaded figures represent primary certification path.
b) Areas can be redredged if no delay to the project schedule will be incurred.
c) Subaqueous caps will not be placed in areas of shallow bedrock located in the navigation channel or in areas with shallow water.
d) Placement of additional backfill is contingent on sufficient water depth.

Table 2-5
Summary of the 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 Redredging Attempts Conducted[1]	Required Action (when all conditions are met)[2]
A	$x_i \leq 1$	≤ 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	$1 < x_i \leq 3$	≤ 1	0	N/A	Evaluate 20-acre average concentration. If 20-acre average concentration ≤ 1 mg/kg Tri+ PCBs, place and sample backfill to confirm that backfill surface concentration is ≤ 0.25 mg/kg Tri+ PCBs.[3] If 20-acre average concentration > 1 mg/kg, follow actions for Case E below.
E	$3 < x_i \leq 6$	≤ 1	0	< 2	Construct subaqueous cap immediately OR redredge.
F	$x_i > 6$	N/A	N/A	0	Collect additional sediment samples to re-characterize vertical extent of contamination and redredge. 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	Redredge.
H	$x_i > 1$ (and 20-acre average > 1)	≥ 2	≥ 1	2	Construct subaqueous cap (if any of these mean/sample result conditions are true) and two redredging attempts have been conducted OR choose to continue to redredge.

(1)Inventory removal dredging is not included in the limit of 2 redredging attempts.
(2)Except for Case H, where any of the listed conditions will require cap construction.
(3)If the backfill testing does not meet the criterion, the backfill must be dredged, replaced, and retested or USEPA input must be obtained for a different engineering solution regarding the backfill.

Capping was assessed as a remedial action alternative during the FS, but the use of a cap to contain the existing contaminant inventory was not found to provide the same degree of reliability as the dredging alternative. 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 the removal alternatives.

The option for capping allowed in the Residuals Standard differs significantly from the remedial action alternative in that the design dredging cut lines must be met and the targeted PCB inventory removed before this option can be considered: the capping contingency in the Residuals Standard is an element of the dredging remediation, not a stand-alone remedial action alternative. Because the mass of PCBs to be isolated is greatly reduced, the reliability of the cap in isolating the 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 greater volume of surrounding capping material.

The capping option in the Residuals Standard is an element of the dredging remediation, and is only considered after dredging cut lines have been met and targeted inventory removed.

Although the application of an engineered cap for elevated residual concentrations has been added as an option in the 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 this option. Factors for deciding whether an area should be capped and whether preparation of the site-specific cap design should commence 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. USEPA will be fully involved in the decision-making for areas to be capped. Through the required submittal of certification unit-specific closure reports, USEPA will:

There is a preference for dredging because capping is less reliable for long-term control and requires long-term O&M.

- Review the residual sampling data collected for the areas.
- Confirm that the dredging cut lines have been met.
- Review field notes.
- 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.

2.2.4 Minimum Reporting Requirements

Weekly progress reports will be prepared by the construction manager and submitted to the USEPA site manager, according to a schedule to be defined by the USEPA, for the USEPA's use in determining compliance with the Residuals Standard. The reports will need to summarize, at a minimum, the results of residual sediment sampling, exceedances of the Residuals Standard criteria by CU and joint evaluation area, the course of actions taken, and rationale. Laboratory data will need to be made available to USEPA upon receipt from the laboratory.

Following the completion of remedial activities in each CU, the construction manager will prepare individual certification unit reports and submit them to the USEPA site manager, according to a schedule to be defined by the USEPA, for the USEPA's use in determining compliance with the Residuals Standard. Each certification unit report will need to include, at a minimum, the following information:

- Certification unit identification
- Description of type(s) of dredging equipment used
- Description of sediment type(s) encountered
- Residual sediment sampling results
- An attestation that the sampling data was validated, including a discussion of any data qualifiers applied
- The results of the required comparisons to action levels for each dredging pass
- Discussion of any contingency actions taken
- Number of dredging passes for residual concentration reduction
- For each attempt, a map of the CU showing the concentration at each node and the non-compliant area to be redredged or capped
- A signed attestation that the certification unit was closed in accordance with the requirements of the Residuals Standard and the approved remedial design.

2.2.5 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 dataset available pending completion of the pre-design sampling), case study residuals data from other environmental dredging projects, and USEPA statistical guidance supported the use of 40 samples to characterize each five-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 50%, plus or minus 10% 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 five-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).

The highest estimate of the necessary sampling frequency to characterize the residual sediments, 310 samples, was obtained from a calculation using USEPA's DEFT software. A data population of 320 samples will be available from eight 5-acre certification units, or 40 acres of dredging, and will be statistically evaluated at the conclusion of Phase 1 to allow an examination of residual concentrations with greater statistical certainty than can be conducted in a single certification unit.

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. A common, scientifically-accepted practice for interpreting environmental data is to develop statistical thresholds to evaluate residuals sampling data and trigger responses, which was done in this case. The subject thresholds consist of action levels for the area-weighted mean concentration (UCLs) and action levels for individual sample results (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.

Review of residuals sampling data from environmental dredging case studies indicates that individual sample concentrations may be much higher than the average concentration for an area. If there are several sampling locations with elevated values, the variability of the residual concentrations may be large and the arithmetic average (based on 40 samples) may be an underestimate of the certification unit's "true" mean. Therefore, PL criteria limiting concentrations at individual sampling nodes were included in the Residuals Standard.

Because 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 Residuals Standard requires collection of additional sediment samples where the initial mean Tri+ PCB concentration (0-to-6-inch interval) for the certification unit is > 6 mg/kg.

Requirement for Collection of Additional Core Samples. The collection and laboratory analysis of 0-to-6-inch sediment core segments will be used to investigate and characterize both residuals and potential missed inventory (via evaluation of the detected PCB concentration in the samples); attempts to collect more discrete samples of potential residual layers cannot be conducted initially due to data gaps regarding the likely thickness/characterization of the residuals. The presence of missed inventory will be inferred if the arithmetic average Tri+ PCB concentration of the 0-to-6-inch sediment sample data set is greater than 6 mg/kg, and deeper sampling will be required, where necessary, prior to redredging. A Tri+ PCB concentration above the 99% UCL in residual sediments implies that 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 to 12 inch, 12 to 18 inch, or deeper 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 Residuals Standard. A median sediment Tri+ PCB concentration in a certification unit in excess of 6 mg/kg provides a trigger to recharacterize the sediment concentrations at depths greater than 0 to 6 inches over the entire CU, because more than half of the points will have a concentration greater than the 97.5 percent UCL. Following the collection and evaluation of the deeper sediment samples, new dredge cut lines must be established and redredging conducted to reduce the residual concentrations. If missed inventory is present, dredging to remove the inventory does not count towards the required number of redredging attempts discussed below.

The Residuals Standard limits the number of required redredging attempts to two, but that could be modified based on Phase 1 results and the second peer review.

Required Number of Redredging Attempts. To maintain dredging productivity, and noting that case studies of other environmental dredging projects report diminishing returns for successive redredging in an attempt to obtain the remedial objectives, the number of required redredging attempts was limited to two attempts. Redredging attempts are dredging efforts conducted to reduce residual concentrations, and by definition occur subsequent to the USEPA's confirmation of attainment of the design cut elevations to remove inventory. The construction manager may also choose to conduct additional redredging 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.[11]

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).

A subaqueous cap may be placed over residual PCB contamination in areas where dredging cannot achieve the Residuals Standard.

Capping. In the event that the dredging operations, after two or more redredging attempts, cannot achieve a mean residual concentration of 1 mg/kg Tri+ PCBs or less, the construction of a subaqueous cap must be implemented to address the residual PCB contamination, where conditions permit, over the recalcitrant area.

Where further dredging is not practicable, the subaqueous 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.

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

The installation of a subaqueous cap is likely to further reduce residual concentrations of PCBs and may require additional dredging to accommodate the cap thickness. While not expected, if conditions encountered in the navigation channel require the installation of a subaqueous cap, then 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, USEPA has required that prototype capping specifications for typical river conditions and ecological settings be developed during the remedial design phase. These prototypes can then be readily customized during the remedial action phase for the situations encountered in the field. General cap design criteria and relevant USEPA and USACE guidance documents for cap design are identified in the Residuals Standard. 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 redredging 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 any 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 area was developed to maintain flexibility where the mean residual concentrations in selected five-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 and transport and bioaccumulation models for the Upper Hudson River (HUDTOX and FISHRAND, respectively), 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 predicted by the USEPA models are attained 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 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, then backfill may be placed without a redredging attempt. In this case, testing of the backfill after placement is required. This is acceptable considering the error in estimating the average concentration on the 5-acre basis is large relative to the error in the average concentration on the 20-acre basis.

The backfill testing is to be accomplished by collecting surface sediment samples (0 to 6 inches) of the backfill after it is placed, using the same grid spacing used for the residual sediment sampling. Each 0-to-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, then the non-compliant areas of the backfill layer must be removed via dredging, replaced, and retested until the criterion is achieved. Alternatively, in some areas it may be possible to place additional backfill material; however, USEPA approval is required for this option.

Backfill may be contaminated via mixing with residual sediments during placement, and upstream sources may recontaminate the backfill surface. The HUDTOX model used to estimate recovery of the Hudson River following remediation indicates that if the backfill surface is contaminated above 0.25 ppm Tri+ PCBs, the desired recovery will not be achieved. Reasonable estimates of the mixing of a clean backfill layer with a contaminated residuals layer indicate that if the backfill completely mixes with the residuals instead of covering them, the backfill could be contaminated to 0.25 mg/kg Tri+ PCBs during placement. Although it is expected that backfill will be placed much more efficiently, where backfill is placed to treat residual sediments with Tri+ PCB concentrations greater than the ROD's objective of 1 mg/kg Tri+ PCBs, the application of the backfill must be managed so that backfill surface concentrations remain below 0.25 mg/kg Tri+ PCBs.

The ROD requires backfilling where appropriate, but not in the navigation channel and not where habitat constraints exist.

Placement of Backfill. The ROD requires that backfill be applied where appropriate. Backfill is not to be placed in the navigation channel, and there may be certain areas where habitat requirements restrict the placement of backfill. Both the backfill design and the development of design criteria for backfill placement are intentionally left to the design phase of the project. It is acknowledged that one function of backfill is to dilute and isolate residual sediments. However, it is not envisioned that backfill will require any type of long-term monitoring. Further information on the application of backfill is provided in Section 1.0 of Volume 3.

2.3 Performance Standard for Dredging Productivity

The Productivity Standard enables progress monitoring and schedule maintenance.

The *Performance Standard for Dredging Productivity* is designed to monitor and maintain the progress of the dredging project to meet the schedule stated in the ROD. The project schedule stated in the ROD has a six-year duration and consists of one dredging season designated Phase 1 and five dredging seasons collectively designated as Phase 2. Phase 1 consists of initial dredging at a reduced scale with extensive monitoring to evaluate compliance with the performance standards. Phase 2 consists of dredging at full production to remove the remainder of the contaminated sediments that are targeted for removal.

2.3.1 Productivity Standard Criteria

The Productivity Standard establishes the contaminated sediment volumes that are to be dredged during each dredging season. Maintaining an appropriate dredging production rate will result in implementation of the project within the timeframe specified in the ROD, and simultaneously limit the duration of construction-related impacts. USEPA will compare the Phase 1 operations to the performance standards to determine if there are any necessary adjustments to the dredging operations or to the standards .

The volume of contaminated sediment referred to in this Productivity Standard is the volume as measured *in situ* in the riverbed. It is estimated to be approximately 2.65 million cy based on sediment sampling data available through the end of 2001.[12] New data from the ongoing sediment sampling program and other analyses begun by GE in 2002 may result in a revision of this volume estimate. A change of 10% or less in the overall volume will be addressed by revising the required volume for the final year of Phase 2. However, if the volume of sediment to be dredged changes by more than 10% as a result of the current sampling program and final design considerations, the Phase 2 required and target volumes will be adjusted based on the guiding principles and approach that were used to develop the Productivity Standard (refer to Section 4.3).

The following subsections contain a discussion of the Productivity Standard that has been developed.

2.3.1.1 Dredging Productivity - Phase 1 (First Year Dredging)

1. The minimum volume of sediment to be removed, processed, and shipped off-site during Phase 1 shall be 200,000 cubic yards. Phase 1 must be designed and scheduled to meet the targeted removal volume of 265,000 cubic yards.

2. For a time period of at least one month during Phase 1, the minimum production rate shall be the rate required to meet the Phase 2 Performance Standard (currently estimated at 70,000 cy/month based on a seven-month dredging season), in order to verify the capabilities of the dredging operations, including the equipment and the sediment processing and transportation systems.

3. Stabilization of shorelines and backfilling of areas dredged during Phase 1, where appropriate, shall be completed by the end of the calendar year. All dredged

[12] The volume of sediment to be dredged, processed, and disposed of has been estimated in the FS and ROD at 2.65 million cubic yards (USEPA, 2001, 2002). This estimate includes material to be dredged for remediation and material to be dredged for navigational purposes in order to implement the USEPA remedy.

material shall be processed and shipped off-site for disposal by the end of the calendar year.

2.3.1.2 Dredging Productivity – Phase 2

1. The minimum cumulative volume of sediment to be removed, processed, and shipped off-site during each of the five years of Phase 2 (full scale dredging) shall be as shown below in the middle column of Table 2-6. Phase 2 must be designed and scheduled to meet the targeted cumulative removal volumes shown below in the right-hand column of Table 2-6. The project must be designed to be completed with a reduced required volume for the project's final season (Phase 2, Year 6).

2. Stabilization of shorelines and backfilling, where appropriate, of areas dredged during Phase 2 shall be completed by the end of the work season (*i.e.,* prior to the following spring high flow period in the river).

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

Table 2-6
Productivity Standard Requirements and Targets (3)

Dredging Season (1)	Required Cumulative Volume (cubic yards)	Target Cumulative Volume (cubic yards)
Phase 1 (Year 1)	200,000	265,000
Phase 2 (Year 2)	690,000	795,000
Phase 2 (Year 3)	1,180,000	1,325,000
Phase 2 (Year 4)	1,670,000	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, will be adjusted in accordance with the USEPA-approved remedial design schedule.
(2) Represents total estimated, in-situ volume projected for remediation as per the ROD. Requirements and targets shall be adjusted based on new information as described in Volume 4.
(3) The construction manager will be responsible for providing estimates of the volume removed for verification by USEPA. Volume that will count toward meeting the productivity standard will be that volume that is dredged and disposed that was called for in the design. The volume will be calculated on an *in-situ* basis by comparison of before and after dredging bathymetric survey data that demonstrate that the sediment has been removed to the designed dredge cut lines. Dredged sediments removed that will count toward meeting the Productivity Standard include, but are not limited to, the following: sediment targeted for dredging including any overcut, side slopes, and overdredging allowance; material dredged for navigational purpose; and material dredged for restoration purposes, all as included in the dredge prisms shown in the final design. Sediment that may be dredged that will not count toward meeting the Productivity Standard includes the following: sediment dredged to remove inventory outside the dredge cut lines shown or specified in the final design, sediment removed during redredging to capture dredging residuals, additional material removed to facilitate cap/backfill

placement, sediment dredged from non-target areas, and/or contaminated backfill required to be removed.

2.3.2 Implementation

2.3.2.1 Minimum Monitoring and Record Keeping Requirements

By March 1 of each year, the construction manager shall provide USEPA with a production schedule showing anticipated monthly sediment production for the upcoming dredging season. The schedule must meet or exceed the target cumulative volume defined by the Productivity Standard.

Monthly and annual productivity progress reports shall be submitted to the USEPA according to a schedule to be defined by the agency, for use in determining compliance with the Productivity Standard. Monthly productivity progress reports will include daily reports of operations that will address the same information required by a USACE Daily Report of Operations for the appropriate dredge type. Monthly progress reports will be compared to the production schedule submitted by the Construction manager and will be the primary tool for demonstrating whether the project is on schedule. USEPA will use the annual production progress reports to determine compliance with the Productivity Standard.

2.3.2.2 Action Levels and Required Responses

The action levels and required responses are summarized below in Table 2-7. In any given dredging season, whenever the monthly dredging productivity falls below the scheduled productivity for that particular month by 10% or more, the construction manager shall identify the cause of the shortfall to USEPA and shall take immediate steps to correct the situation. Steps the construction manager can take to correct the shortfall may include, but are not limited to, adding equipment and crews, working extended hours, and modifying his plant and equipment or approach to the work. The steps taken must be intended to achieve the necessary production rate and erase the cumulative shortfall in productivity over the following two months or by the end of the dredging season, whichever occurs sooner. Any such 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 shipments, will require USEPA approval.

If the monthly productivity falls below the scheduled productivity by 10% or more for two or more consecutive months, the construction manager shall provide a written action plan to the USEPA explaining the reasons for the shortfall in production and describing the engineering and management steps taken or underway to erase the shortfall in production during that dredging season. Failure to erase the shortfall by the end of the dredging season will result in USEPA taking action. USEPA will review the specific circumstances that led to the annual production shortfall prior to determining what

USEPA action would be appropriate to address noncompliance with the Productivity Standard.

Table 2-7
Productivity Standard Action Levels and Required Responses

Action Level	Situation	Response
Concern Level	Monthly production rate falls 10% or more 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 to EPA explaining the reasons for the lower production and describing the engineering and management actions taken or underway to increases production and erase shortfall by end of the dredging season.
Standard	Annual cumulative volume fails to meet production requirements.	USEPA action to be determined based on Agency review of specific circumstances.

2.3.3 Supporting Analyses and Assumptions

Conceptual Project Schedule. To evaluate the required and target cumulative volumes specified in the Productivity Standard (refer to Table 2-6), 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. The Productivity Standard, however, does not require that the remedial design adhere to the assumptions and work sequence used to develop the 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 cy 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. A change of 10% or less in the overall volume will be addressed by revising the required volume for the final year of Phase 2. However, if the volume of sediment to be dredged changes by more than 10% as a result of the current sampling program and final design considerations, the Phase 2 required and target volumes will be adjusted based on the guiding principles and approach that were used to develop the Productivity Standard (refer to Section 4.3).

Construction Schedule and Dredging Season. The Productivity Standard is based on a six-year construction period for the project, as stated in the ROD (including Phases 1 and 2), and assumes that there will be a minimum of 30 weeks available each year to conduct dredging operations, unconstrained by any work hour limitations. To implement this schedule, coordination would be required with the New York State Canal Corporation to extend its 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 assumptions inherent in the conceptual project schedule 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 silt barriers were assumed to 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 conceptual 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, have been completed.

- Backfilling and shoreline stabilization at each area dredged in a particular season are 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 analyses 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 appropriately 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, whereas a more conservative assumption would be one facility at or below the southern extreme of the project area.

3.0 Interactions Among the Standards

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

3.1 Resuspension and Productivity Standards

The Resuspension Standard controls PCB mass loss during dredging, which is intrinsically related to all aspects of productivity.

The Resuspension Standard and Productivity Standards are linked due to the need to limit the overall PCB mass loss. The Productivity Standard sets the cumulative volume of sediment that will be removed from the river each year, and different project activities conducted to achieve those volumes (debris removal, dredging, vessel traffic, and installation and removal of barriers, if used) will contribute to the PCB mass loss to varying degrees. At the same time, the Resuspension Standard's Control Level is triggered if the average daily Total PCB mass loss exceeds 600 g/day for more than a one-week period in Phase 1.[13] Design and implementation of the project must reflect both the need to remove sediment volume and the need to limit PCB mass loss. Aspects of the project where the objectives of these two standards are to be balanced include adherence to the dredging schedule, the appropriate selection and use of resuspension control equipment, and data gathering/reporting efforts.

3.1.1 PCB Mass Loss and Dredging Schedule

Compliance with the Productivity Standard, i.e., maintaining the 6-year project schedule, will control the total PCB mass loss.

Adherence to the Productivity Standard, so that the six-year project duration is maintained, will control 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 Resuspension Standard's overall project action level for PCB mass loss of 650 kg. Achievement of the target cumulative volumes in the Productivity Standard minimizes the total project-related downstream transport of PCBs.

Faster dredging does not necessarily equate to a higher resuspension rate. Based on experience gained from other environmental dredging projects, dredging slower, as well as faster than an optimal operating range, may increase resuspension.

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

3.1.2 PCB Mass Loss and Resuspension Control Equipment

Resuspension control equipment must be carefully selected and deployed in recognition of the numerous interrelations between dredging activities and PCB mass loss.

The Control Level and threshold of the Resuspension Standard require the implementation of engineering solutions, such as silt barriers. The installation (and removal) of silt barriers and the increased number of vessels in the river (work boats to deploy the barriers) may contribute to an increase in sediment resuspension. Balancing the limits on PCB concentrations in the water column in the Resuspension Standard and the cumulative annual dredging volumes required 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 Engineering Performance Standards.

The conceptual project schedule assumes that barriers (if used) will be left in place until shoreline stabilization and backfilling are complete, so that residual sediments loosened by the dredging would not be transported downstream en masse when the barriers are removed and normal river currents again pass over the dredged area. The use of barriers could actually delay the completion of dredging and lead to a greater loss of PCBs to the Lower River than if the project were completed without them.

3.1.3 Data Gathering for Engineering Evaluations

The data gathering requirements of the Productivity Standard (*i.e.*, completion of daily dredging reports) are expected to prove useful during engineering evaluations and in selecting engineering solutions required by the Resuspension Standard.

3.2 Resuspension and Residuals Standards

The Resuspension Standard's control of PCB export is expected to contribute to achievement of the Residuals Standard.

The Residuals Standard requires characterization and management of residual sediments, which may include redeposited/settled sediments. Modeling conducted during development of the Resuspension Standard indicated that dredging may create a deposit of resuspended sediments slightly downstream of each dredging area (to be investigated via a special study described in Section 5.0). Dredging above the Resuspension Control Level could create depositional areas that would exacerbate contaminant concentrations in nearby targeted areas/certification units. The Resuspension Standard's objectives to constrain mass loss/PCB export are expected to ease compliance with the Residuals Standard, especially if dredging is conducted in multiple river sections/reaches simultaneously. Consideration of these issues should guide the design sequencing of the dredging project.

3.3 Residuals and Productivity Standards

Flexibility was designed into 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 Residuals Standard limits required redredging to 2 attempts per CU to maintain productivity.

The Residuals Standard requires that a maximum of two redredging attempts be made at a certification unit to achieve the Residuals Standard, following initial removal of the PCB contaminated sediment to the design cut lines and removal of all PCB-contaminated sediment inventory. Failure to meet the standard after two re-dredging attempts is likely to require construction of a subaqueous cap. The limit is intended to avoid extensive, non-productive redredging that could adversely impact compliance with the Productivity Standard.

The Productivity Standard included the requirements of the Residuals Standard in its example schedule.

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 Productivity Standard includes a conceptual sequence of work and schedule for the dredging work to demonstrate the reasonableness and achievability of the required and target cumulative dredging volumes. The conceptual sequence of work and schedule accounted for, among other elements:

- the time needed to comply with the requirements of the Residuals Standard for sampling and analysis of each certification unit.
- installation and removal of barriers (although the use of barriers is not a requirement of the standards and will be addressed in the remedial design).
- possibly two redredging attempts and/or subaqueous cap construction.
- placement of backfill (where appropriate) prior to demobilization.

In the development of the conceptual schedule, USEPA assumed that redredging could require half of the total time spent on the initial dredging, to conservatively accommodate the requirements of the Residuals Standard.

Table 3-1 below summarizes the interactions among the Engineering Performance Standards.

Table 3-1
Summary of Interactions Among the Engineering Performance Standards

Standard Element	Tiered Response Actions	Potential Implications to Other Standards	Further Solutions
Resuspension Action Levels	Level 1. Additional Monitoring Level 2. Project Modifications Level 3. Temporary Shut Down	1. Required project modifications must be carefully designed to control impacts on productivity (temporary shutdown will create unavoidable impact). 2. Control of increased deposition will help mitigate residuals.	> Modify equipment and operations as necessary > More effective containment
Residuals Contingency Actions	Level 1. Backfill with confirmation sampling Level 2. Capping Level 3. Redredging	1. Flexible contingencies minimize increased resuspension rates associated with low production 2. Limit on required redredging attempts minimizes lost productivity and lower solids production during redredging,	> Reevaluate design cuts > Modify dredging equipment for redredge passes > Re-evaluate number of redredging attempts before resorting to capping
Productivity Required and Target Volumes	Level 1. Analyze dredging logs to isolate causes; evaluate and adjust operations if appropriate Level 2. Increase equipment size or numbers	1. Minimize increased resuspension due to low production and longer duration 2. Control residuals if productivity loss is due to poor dredging conditions (debris, etc.).	> Increase production capacity to meet standards

4.0 Possible Refinements to the Standards during Design

Information collected during the design phase of the project will be used to identify the precise areas of the river bottom that require dredging, refine the volumes that were estimated in the FS and ROD, and provide a more accurate estimate of baseline water column conditions. USEPA will use the new data from the project design to update the standards, as necessary, using the approach and methods outlined below.

Additional data from pre-Phase 1 water column monitoring and sediment sampling will improve the ability to measure exceedances but will not change Resuspension Standard criteria.

Prior to Phase 1, the baseline monitoring program water column sampling will be conducted and remedial design sediment sampling will be completed. The additional data from these efforts, collected after the issuance of these standards, will improve the ability to measure exceedances of the Resuspension Standard, but are not expected to change the main criteria of the standard. The acceptable rate of PCB loss and the acceptable water column concentrations are not expected to change as the result of additional data, because these criteria are based on modeling of future impacts and associated risks.

The baseline monitoring program is an enhancement of the ongoing water column monitoring program. Some modifications to the sampling program may include:

- 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.
- Additional monitoring stations.

The baseline monitoring program is expected to provide an important set of additional data prior to the start of construction. The resultant water column monitoring data will be considered in the refinement of the Resuspension Standard criteria, because the data will improve the knowledge of baseline conditions. Baseline monitoring samples will be collected at far-field stations that will be monitored as part of the Resuspension Standard, but currently have only limited historical data available. These data will be utilized to better populate the monthly data distributions used to estimate the 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.

Load-based criteria in the Resuspension Standard will be reviewed if the mass of PCBs to be removed is significantly different from previous estimates.

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. These data will be used to revise the estimate of mass to be removed during the remediation. Load-based criteria in the Resuspension Standard will be reviewed if the mass of PCBs to be removed is significantly different from previous estimates. Adjustments may also be made if the schedule differs greatly from what is anticipated. The following sections discuss potential changes to each standard prior to Phase 1.

4.1 Resuspension Standard

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 [Control Level], see Table 2-1), will be adjusted according to the final production schedule 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. These data will be used to assess the results of the Near-Field Total PCBs special study.

The baseline monitoring data will be used, along with the historical data, to refine the action levels. In addition to providing years of new 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 UCL values calculated to date. The analysis of baseline data available at this time is presented in Attachment A of Volume 2.

The acceptable mass of PCBs exported as a result of dredging was added to the baseline concentrations and will be adjusted according to the method defined in Attachment B of Volume 2 if the hours and days of operation differ from the assumed values during Phase 1 or Phase 2. The concentration thresholds for the load-based criteria will change further if the productions schedule deviates from the target level.

A special study will be conducted prior to Phase 1 to develop a semi-quantitative relationship between suspended solids concentrations and turbidity (or another surrogate measure of suspended solids concentrations). This correlation will be used initially in the near-field, and potentially the far-field, in place of the more labor intensive and time consuming solids measurements. It is expected that this relationship will be refined throughout the remediation to accurately predict suspended solids concentrations as the remediation moves to areas of different sediment properties.

A list 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 TI Dam-West and TI Dam PRW2 results with the TI Dam cross sectional results. Determine whether there is a correlation between the historical data and the baseline monitoring program data and whether or not the historical data can be combined with data from the Baseline Monitoring Program.

2. Compare the Schuylerville vertical composite results with the Schuylerville cross sectional results. Determine whether there is a correlation between the historical data and the baseline monitoring program data and whether or not the historical data can be combined with data from the Baseline Monitoring Program.

3. Calculate the UCL values according to the method outlined in Attachment A of Volume 2 for all far-field stations. Potentially include the historical data in the analysis.

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, specifically the measurements taken during the Near-Field Total PCB special study.

6. Revise the PCB load-based standard if the amount of PCBs to be removed increases significantly (*i.e.*, by a factor of two or more) than previously estimated in the RI/FS. This information should be available in the design reports. 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. Revise the PCB load limits to adjust for differences in the schedule and incorporate the information from the Baseline Monitoring Program.

8. Assess the results of the bench scale study conducted to develop an initial relationship between TSS and a real time surrogate measurement for the far-field and near-field stations.

9. Identify the portions of the Phase 1 areas that will be investigated during each of the special studies.

10. Review and approve work plans for alternate monitoring programs, if submitted, that would be the subject of the Phase 2 monitoring program special study.

11. Review and approve work plans and QAPPs developed as part of the design for the implementation of the Phase 1 monitoring program.

4.2 Residuals Standard

No modifications to the Residuals Standard are anticipated prior to Phase 1. Given the current state of dredging projects at other sites, USEPA does not expect additional case study data will become available prior to the start of Phase 1 activities that could be used to refine the standard. The following tasks may be conducted prior to Phase 1:

1. Review and approve work plans and QAPPs developed as part of the design for the implementation of the Phase 1 residuals sampling program.

2. Review and approve work plans and QAPPs developed as part of the design for the special study to characterize the residual sediment strata and thickness.

3. Identify the Phase 1 target areas that will investigated during the special study.

4.3 Productivity Standard

Revised production volumes for Phase 2 will be defined if design sampling and analysis indicate that the volume of material to be dredged differs by 10% or more from the 2.65 million cy estimated in the FS and ROD.

As discussed previously, the design sediment sampling expected to be completed at the end of 2004 will be used during the design phase to finalize the delineation of target dredging areas and facilitate the calculation of an overall project dredging estimate in terms of cy of contaminated sediment to be removed. If the total estimated removal volume for the dredging design differs by more than 10% from the 2.65 million cy considered in the development of the Productivity Standard, the Phase 2 annual required and target volumes will be evaluated to determine whether modifications are required. The revised Phase 2 volumes would be calculated during the design phase, using the formulae presented below:

The Phase 1 Productivity Standard is based on the fact that, as identified in the ROD, Phase 1 will span one construction season and Phase 2 activities will span five construction seasons. Utilizing 2.65 million cy as the total estimated project volume, the total production rates for Phase 1 and Phase 2 activities were calculated as follows:

Phase 1 Required Production Volume = 200,000 cy
Phase 2 Required Production Volume = 2,650,000 – 200,000 = 2,450,000 cy or 490,000 cy annually

A target dredging rate has been developed and included in the standard to constrain the design such that the dredging is completed early in the final season of Phase 2 (approximately one half of a season's worth of work in the final season.) The target productivity rate was calculated as follows:

Phase 1 Target Production Volume = 265,000 cy
Phase 2 Target Annual Production Volume (Seasons 1 through 4 of Phase 2):
(2,650,000-265,000)/4.5 = 530,000

5.0 Summary of Special Studies during Phase 1

The monitoring programs for the Resuspension and Residuals Standards are organized to separate sampling necessary to measure compliance with the standard from sampling necessary to evaluate and refine the implementation of the standard. This has been accomplished by designating the second category of sampling efforts as "special studies." The special studies will be conducted for limited periods of time to gather information for specific conditions that may be encountered during the remediation or to develop an alternate strategy for monitoring. Specific conditions to be investigated may include different dredge types, various contaminant concentration ranges, and different sediment textures. Each of these studies is integral to the Phase 1 evaluation and the development of Phase 2, and also tied to compliance issues.

There are a total of six special studies, five for the Resuspension Standard and one for the Residuals Standard. The five special studies for the Resuspension Standard are:

- Near-field PCB Release Mechanism (Dissolved vs. Particulate)
- Development of a Semi-Quantitative Relationship between TSS and a Surrogate Real-Time Measurement for the Near-field and Far-field Stations (Bench Scale)
- Development and Maintenance of a Semi-Quantitative Relationship between TSS and a Surrogate Real-Time Measurement for the Near-field and Far-field Stations (Full Scale)
- Alternate Phase 2 Monitoring Plan
- Non-Target, Downstream Area Contamination

Of these studies, the Phase 2 Monitoring Plan study is only required if an alternate monitoring program is proposed.

The special study for the Residuals Standard is the Study for Characterization of the Residual Sediment Strata and Thickness.

A discussion is provided below for each study, describing the goals, reasoning, extent, possible outcomes, timing, reporting requirements, and evaluation period. Specific requirements for each study are provided in the implementation sections for the standards in Chapter 4 of Volumes 2 and 3.

5.1 Near-Field PCB Release Mechanism

5.1.1 Goal of the Study

The goal is to determine the nature of PCB release during dredging (sediment resuspension/particle-associated or dissolved phase mechanism).

5.1.2 Need for the Study

The Resuspension Standard utilizes PCB measurements to trigger responses such as engineering evaluations or engineering solutions. However, USEPA recognizes that PCB analyses are relatively time-consuming and expensive and, in periods of higher flow, the PCB results may not be available in time to provide an adequate warning to the downstream public water intakes.

If resuspension of sediment is the primary mechanism of release, it may be possible to use indicators of suspended solids concentrations to monitor resuspension. Reliance on turbidity measurements as an indication of compliance has been a common practice at other sites. Measurements of turbidity or laser particle counters could potentially provide a real-time measure of suspended solids, and an indication of potential exceedances of the PCB resuspension criteria.

A quantitative PCB-to-suspended solids relationship cannot be developed due to the heterogeneity of the sediments. However, it may be possible to define near-field or far-field suspended solids thresholds that indicate that water column concentrations are likely to be out of compliance, the remediation is being conducted at elevated levels of release, and action should be taken.

5.1.3 Extent and Scheduling of the Study

This study will be conducted in a variety of near-field settings chosen to define the nature of release from the range of sediment types, concentrations, and remedial equipment to be encountered or employed (during both phases of the project). These locations will be selected for Phase 1 once the *Phase 1 Intermediate Design Report* is approved. If the conditions for Phase 1 are limited in some manner (*e.g.,* Phase 2 will utilize different dredge types), this study may need to extend into Phase 2.

The study will be conducted during Phase 1, when the remedial operations are in effect at the predetermined locations. Each specific condition identified for study will be tested for one full work week (approximately six consecutive days). The study may also be conducted during Phase 2, if different equipment or conditions are encountered that were not addressed during Phase 1.

5.1.4 Possible Outcomes

If the release mechanism is primarily from resuspension of contaminated sediment, then the suspended solids criteria could be used to trigger actions such as requiring engineering solutions to reduce contaminant levels. Conversely, if the release mechanism is primarily dissolved phase, then suspended solids may not provide a useful indicator of exceedances and the standard would not be modified to use the real-time indicators of suspended solids.

5.1.5 Reporting Requirements and Evaluation

A work plan for this study will be prepared during the design phase. Separate field summary reports will be prepared for each study area, summarizing the results at each sampled location and identifying any deviations from the work plan. The data will be provided in electronic form consistent with the format of the SSAP database. Each field summary report will be provided to USEPA within three weeks of the completion of an individual study area.

USEPA will review the field summary reports during Phase 1 as the reports become available.

5.2 Development of a Semi-Quantitative Relationship between TSS and a Surrogate Real-Time Measurement for the Near-Field and Far-Field Stations (Bench Scale)

5.2.1 Goal of the Study

The goal is to develop a real-time measure of suspended solids. It is likely that turbidity can be used in the near field, but at the far-field locations, a laser particle distribution sensor may be needed to identify exceedances of the suspended solids criteria that are near or within the range of baseline concentrations.

5.2.2 Need for the Study

Suspended solids measurements will not provide a real-time indication of the water quality in the near field, because the analyses may require a laboratory TAT of several hours and there may be significant travel time to the laboratory. Also, the suspended solids sampling cannot be conducted at a rate that is sufficient to know the suspended solids levels with confidence (see Attachment G of Volume 2).

Real-time measurements that provide an estimate of suspended solids concentrations are lower in cost and less labor-intensive than the frequent collection and analysis of TSS samples. These studies will generate initial relationships between the suspended solids concentrations and the surrogate measurement that can be used during Phase 1. These relationships are site-specific and cannot be estimated from a theoretical basis.

Suspended solids sampling is required as a part of the Phase 1 monitoring program at the far-field stations. The far-field measurements integrate all of the resuspension impacts from the remediation, including barge traffic or spillage that is measured by the near-field sampling only when the barges are within range of the monitors. Assuming that the primary mechanism for contaminant release is through resuspension of sediment, suspended solids concentrations could provide a real-time indication of elevated PCB concentrations and early warning to downstream public water supplies. Turbidity is less likely to serve as a surrogate measure of suspended solids concentrations for the far field due to lack of sensitivity to low suspended solids concentrations. The resuspension criteria are low relative to the baseline suspended solids concentrations and may fall within the range of baseline values. Laser particle counters are expected to provide adequate sensitivity for the far-field suspended solids concentrations.

5.2.3 Extent and Scheduling of the Study

The Phase 1 effort may be conducted in a region of the river that does not capture all of the major sediment types that will be encountered during Phase 2; however, this study must address all sediment types that are likely to be encountered during the remediation, otherwise, a second study will be needed for Phase 2. It is likely that additional bench scale studies will be needed throughout the remediation, because small changes in the sediment properties may alter the semi-quantitative relationship.

The initial study will be conducted prior to the start of Phase 1 and is likely to be a part of the supplementary treatability studies. Additional studies may be conducted throughout the remediation, if necessary, to refine the relationship for differing sediment conditions.

5.2.4 Possible Outcomes

If a usable relationship with turbidity is developed, turbidity will become the primary measure for the suspended solids criteria. It is anticipated that a usable relationship can be developed for the near field, but potentially not for the far field due to the low suspended solids criteria relative to baseline. If the laser particle analysis demonstrates a markedly different mass fraction distribution from baseline, then these real-time measurements will be the primary compliance measurement for the far-field suspended solids criteria.

If a usable relationship cannot be developed for the near field, then the near-field standard may default to the best management practices approach frequently used at other sites. There would be a turbidity level triggering an exceedance, but the associated suspended solids levels would not be well defined. This level might be altered depending on the results of the far-field PCB monitoring over time.

If a usable relationship cannot be developed for the far field, frequent (every three hours) samples will be collected at the first downstream far-field station. These samples will be analyzed for suspended solids with a modified method that will allow a quick turn-around, and periodically a co-located sample will be collected and analyzed with the standard ASTM 3977-97 method (or equivalent). The modified method will be used for near-field and far-field suspended solids analysis whenever the surrogate measurements are not acceptable or there are exceedances of the criteria.

5.2.5 Reporting Requirements and Evaluation

A work plan for the study, including the specifics of the sample collection, will be prepared during the remedial design phase. A report summarizing the results and conclusions of the initial study will be prepared and submitted to USEPA at least six months prior to the start of Phase 1 to allow time for review and revision. This report will include all of the associated laboratory analyses and study results (grain-size characterization, TSS concentrations, turbidity measurements, etc.). For subsequent studies, summary reports will be prepared and submitted to USEPA within one week of completion of the study for review and approval.

USEPA will review the results of the initial study prior to the start of Phase 1 to determine whether a semi-quantitative relationship of sufficient quality has been developed and can be used in place of suspended solids measurements (with only minimal suspended solids sampling as a check on the regression). USEPA will review the results of subsequent studies as the reports become available. A means of expediting the reviews may be instituted so that the relationships developed can be used in place of the suspended solids sample analyses.

5.3 Development and Maintenance of a Semi-Quantitative Relationship between TSS and a Surrogate Real-Time Measurement for the Near-Field and Far-Field Stations (Full Scale)

5.3.1 Goals of the Study

The goals are to establish the baseline levels for the laser particle analysis at the far field, to determine whether laser particle analysis will serve as a surrogate measure of suspended solids in the far field, and to determine whether the surrogate measures are adequately predicting suspended solids concentrations.

5.3.2 Need for the Study

Baseline levels for the laser particle analyzer must be established to form a basis of comparison to the measurements acquired during the remediation and to determine whether there is likely to be an appreciable difference in the sediment distribution during the remediation. If there is no appreciable difference in the sediment distribution patterns, then laser particle analysis may not be an acceptable surrogate.

For both the near field and far field, the relationships developed in the bench scale tests may not hold in the field. The suspended solids sample results collected during the remediation will be compared to the predicted values to determine if the relationships are adequate or additional studies are needed for the sediment currently being remediated.

This full-scale study will also address how factors such as backfilling affect the predictive ability of the surrogate measurements.

5.3.3 Extent and Scheduling of the Study

The study will encompass all near-field monitoring locations and the nearest downstream far-field station.

This study will be conducted throughout Phase 1 and is likely to be continued to some degree throughout the remediation, to account for changes in sediment properties that affect the relationship between suspended solids concentrations and the surrogate measurements.

5.3.4 Possible Outcomes

If adequate surrogate measures of suspended solids concentrations are found, these measurements may provide an early indication of unacceptable water quality conditions. If the surrogate is not adequate for the near-field or the far-field, additional bench scale studies may be conducted. Until an adequate surrogate is available, samples will be collected every three hours at each station and analyzed using a modified suspended solids analysis that would provide a short turnaround time.

5.3.5 Reporting Requirements and Evaluation

The reporting requirements are the same as those specified for continuous reading devices for the surrogates (*i.e.*, submittal to USEPA within 12 hours of measurement). Each week, the TSS concentrations that are measured daily at each station must be assessed against the predicted values to determine the adequacy of the relationship. The results of this analysis and the decisions made based on the results must be documented in weekly reports.

The baseline laser particle analysis results will be assessed along with the initial bench scale study results to determine whether laser particle analysis is likely to be an adequate surrogate for the far field prior to the commencement of Phase 1. During Phase 1, USEPA will evaluate the results of the study as the data and reports become available.

5.4 Phase 2 Monitoring Plan

5.4.1 Goal of the Study

The goal of the Phase 2 Monitoring Plan study is to determine whether a proposed alternate monitoring program would adequately meet the data quality objectives (DQOs) of the Resuspension Standard.

5.4.2 Need for the Study

The Resuspension Standard has been developed with specific sampling methods that meet the objectives of the standard. The monitoring program specified in the standard fully meets the DQOs of the standard. Any proposed alternate monitoring program must be evaluated to ensure that it adequately addresses the DQOs. In addition, changes to the monitoring could alter the statistical confidence of the data, prompting changes to the averaging periods for the resuspension criteria. This study provides an opportunity to test alternate monitoring programs that are proposed to reduce costs or provide other benefits.

5.4.3 Extent and Scheduling of the Study

The study would need to fully represent the proposed changes to the monitoring program. For instance, if automatic samplers were proposed to replace grab samples for PCBs, then the alternate program would be fully implemented at each station where this change is proposed, in tandem with the required Phase 1 program as written in the standard.

The study would be conducted at some time during Phase 1 and will include the month of full-scale production.

5.4.4 Possible Outcomes

The results of the study could generate changes to the monitoring program and resuspension criteria for the Phase 2 program. These changes could be made during Phase 1, if the study and review of the results were completed in time.

5.4.5 Reporting Requirements and Evaluation

A work plan detailing the implementation of the alternate program will be prepared during the remedial design phase, if proposed. All sample results would need to be reported in the same manner as the required Phase 1 monitoring results. The same deadlines for submittal to USEPA would apply. A summary report comparing the results of the Phase 1 program to the proposed alternate program will be provided to USEPA within three weeks of completion of the study. This report will describe any deviations from the proposed work plan for the study, problems encountered during the study and solutions implemented.

USEPA will review the field summary reports once the reports become available.

5.5 Non-Target Area Contamination

5.5.1 Goal of the Study

The goal of this study is to determine the extent of potential increases in contamination in areas downstream of the dredging operations.

5.5.2 Need for the Study

The study is needed to determine the spatial extent and degree of potentially increased contamination in the areas downstream from the target areas. Resuspension from the dredging operation is the potential mechanism of concern for this type of contamination.

5.5.3 Extent and Scheduling of the Study

This study will be conducted in a limited number of areas during Phase 1 and/or Phase 2, if the areas dredged during Phase 1 are not appropriate (all areas immediately downstream from the Phase 1 dredge areas may be selected for dredging in Phase 2).

The study will be completed once the dredging is complete in the adjacent upstream area. Samples will be collected during the dredging operations, if necessary, to address conditions or situations that have not been tested.

5.5.4 Possible Outcomes

If high levels of contamination have been deposited over a large area (*i.e.*, five acres), this might prompt evaluation and modification of the resuspension controls specified for the design.

5.5.5 Reporting Requirements and Evaluation

A work plan for the study, including specifics of the sample collection, will be prepared during the remedial design phase. Separate field summary reports will be prepared for each study area that will summarize the study results and identify any deviations from the work plan. Data will be provided in electronic form consistent with the format of the

SSAP database. Each field summary report will be provided to USEPA within three weeks of the completion of an individual study area.

USEPA will review the field summary reports as the reports become available.

5.6 Characterization of Residual Sediment Strata and Thickness

5.6.1 Goal of the Study

The goal of the study is to characterize the sediment type, stratigraphy, and thickness of disturbed and/or resettled layer(s) in a target area, subsequent to removal of PCB-contaminated sediments by dredging. The sampling required by the residuals standard is intended to characterize this sediment layer. The study may be conducted by the collection of core samples or the use of an innovative technology such as sediment profile imagery (SPI), based on the thickness and nature of the disturbed layer encountered following dredging.

5.6.2 Need for the Study

As a component of the Phase 1 evaluation, the stratigraphy and thickness of the disturbed sediment layer and/or the resettled residuals must be characterized. Depending on the type of dredge used and other site-specific considerations, the layer of interest may be more than 1-foot thick or may consist of a veneer or "fluff" layer consisting of resettled material that escaped capture by the dredge. The information to be obtained from the special study is relevant to the requirements for sample collection and management under the Residuals Standard.

5.6.3 Extent and Scheduling of the Study

This study will be conducted in a variety of settings chosen to encompass the range of sediment types, PCB concentrations, and remedial equipment to be encountered or employed during Phase 1 and Phase 2. These locations will be selected for Phase 1 once the *Phase 1 Intermediate Design Report* is approved. If the conditions for Phase 1 are limited in some manner, this study may need to extend into Phase 2.

The study will be conducted during Phase 1, after dredging is completed, at predetermined locations. The study may also be conducted during Phase 2 to evaluate different equipment or conditions not encountered in Phase 1.

5.6.4 Possible Outcomes

The residual sediment sample collection and management procedures will be adjusted, if necessary, based on the findings of the study.

5.6.5 Reporting Requirements and Evaluation

A work plan for this study will be prepared during the remedial design phase. A separate field summary report will be prepared for each study area, summarizing the study results at each sampling node and identifying any deviations from the plan that may have occurred. If SPI is used, images will be included in electronic form (.jpeg file format or as agreed during design review). A field summary report will be provided to USEPA within three weeks of the completion of that individual study area.

USEPA will review the field summary reports during Phase 1, as the reports become available.

6.0 Phase 1 Evaluation

The Engineering Performance Standards will be revised as necessary at the end of Phase 1 for application to Phase 2, based upon knowledge gained from the first year of the remediation. The initial year of work will entail considerable monitoring to allow evaluation of, and adjustments to, the dredging operations. A number of the monitoring requirements of Phase 1 may be reduced for Phase 2 operations. Any adjustments, modifications, or refinements to the standards as a result of the Phase 1 evaluation will be the subject of a second peer review by independent experts, as required by the ROD.

It is expected that Phase 1 dredging will be performed in areas exhibiting a range of dredging conditions that might be expected during the remainder of the project, including dredging in both deep and shallow areas of the river and in areas with differing bottom characteristics. It is further expected that the monitoring program conducted during this phase will provide sufficient data to refine the project operations, as necessary, for the full-production dredging work to be done in Phase 2.

6.1 Elements of the Evaluation

During Phase 1, specific aspects and outcomes of the dredging process will be reviewed for each standard, as a result of which revisions and adjustments may be made in Phase 2. The following subsections contain a discussion of the elements that will be evaluated for each standard.

6.1.1 Resuspension

Elements of the Resuspension Standard that will be evaluated during Phase 1 include, but are not limited to:

- Location and Number of Monitoring Stations
- Analytical Methods
- Sampling Frequency
- Sampling Methods
- PCB Load-Based Action Levels
- PCB Concentration-Based Action Levels
- Suspended Solids Concentration-Based Action Levels
- Laboratory Analytical Turn-around Time (TAT)
- Resuspension Control Devices

6.1.2 Residuals

Elements of the Residuals Standard that will be evaluated during and subsequent to Phase 1 include, but are not limited to:

- Analytical Methods
- Sampling Frequency and Depth
- Sampling Methods
- Analytical TAT
- Joint Evaluation Area Size
- Required Horizontal Extent of Redredging and Capping
- Engineering Contingency Plans (*e.g.*, number of redredging attempts)

6.1.3 Productivity

Elements of the Productivity Standard and related issues that will be evaluated during Phase 1 include, but are not limited to:

- Required and Target Volumes
- Dredging Production
- Use of Resuspension Controls
- Backfill Placement Rate
- Processing Facility Throughput
- Transportation and Disposal Logistics
- Hours of Operation
- Navigational Issues
- Seasonal Mobilization and Close-out Duration

6.1.4 Potential Modifications During Phase 1

Data gathered during Phase 1 will characterize the implementation and efficiency of the remedial design by quantifying residual Tri+ PCB concentrations after various dredging and redredging attempts, tracking actual dredging productivity, and quantifying water column Tri+ PCB concentrations during dredging and other activities. It is possible that "lessons learned" during Phase 1 will generate requests for modifications to the remedial design (*i.e.*, corrective actions) and selected aspects of the performance standards to capitalize on the information gathered as Phase 1 is being accomplished. It is envisioned that requested corrective actions would be reviewed and acted upon via the following process:

1. The construction manager will prepare and submit correspondence to USEPA describing the requested modification and including supporting data to facilitate agency decision-making.

2. USEPA will review the request and supporting data in regard to the requirements of the Engineering Performance Standards and respond as appropriate with an approval, request for further information, or rejection of the requested modification.

3. During the USEPA review period, the construction manager will continue work under the then-existing remedial design and Engineering Performance Standards. The requested modification may not be implemented in the field until approval is received from USEPA.

6.2 Guidelines for Possible Revision of the Standards for Phase 2

Certain criteria for each of the standards may be reduced, revised, or modified following completion of Phase 1. The standards have been reviewed to predetermine guidelines for possible revision due to the rapid turn-around time required for Phase 2 operations to commence.

6.2.1 Resuspension

An outline for the approach for refinement of the Resuspension Standard is presented below, describing how new information obtained during the remedial design phase, Phase 1, and if appropriate, Phase 2, can be reflected in the performance standard criteria. The Resuspension Standard is likely to remain at 500 ng/L for protection of the downstream water intakes.

The Phase 1 data will be reviewed on a continuing basis. If the collected monitoring data in the near-field and far-field are meeting or exceeding necessary levels for protection of human health and the environment, USEPA may, at its discretion, reduce the level of monitoring in the program.

USEPA will consider developing and implementing a potential Phase 2 monitoring program before the end of Phase 1, if the data support such a decision. Table 6-1 provides prototype Phase 2 resuspension criteria. Monitoring results acquired during Phase 2 may also indicate the necessity of further refinements. 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.

Changes to the criteria and other potential modifications to the standard are summarized below:

1. Total PCB mass loss criteria for the Evaluation Level and Control Level, 300 g/day and 600 g/day, respectively, will be adjusted according to the operating schedule if there are changes from the assumptions used to develop the standard.

Evaluation of the Phase 1 results will determine whether the lower load loss level is achievable and should be continued in Phase 2.

2. The seasonal load loss criteria will be adjusted according to the production schedule if there are changes from the target level.

3. Near-field suspended solids action levels may be adjusted, taking into consideration the far-field suspended solids and PCB concentrations observed during dredging.

4. The sampling frequency may be revised. The Phase 1 data will be used to reassess the statistical confidence provided by the sampling program, based on the observed variance in the PCB and suspended solids concentrations.

5. The 350 ng/L PCB concentration for the action levels may be modified if needed to provide an appropriate notification to public water suppliers.

6. The suspended solids far-field and near-field concentration limits may be adjusted, if warranted, based on the relationship between Phase 1 suspended solids and PCB results.

7. Suspended solids criteria may be set that trigger engineering evaluations or engineering solutions.

8. Analytical TAT for PCBs and suspended solids may be adjusted.

9. Near-field station locations may be adjusted based on the data gathered during Phase 1. Fewer stations may be required once the behavior of the system has been tested. The number of monitoring locations in the near field is likely to be reduced to the stations that best characterize local water quality conditions.

10. The averaging periods for the Control Level will be assessed to determine if a longer period is more appropriate for Phase 2.

11. The far-field PCB load limit for the Evaluation Level will be assessed to determine if the 300 g/day should be continued for Phase 2.

12. The far-field and near-field suspended solids criteria are both likely to be simplified and the number of criteria reduced. These suspended solids criteria may trigger engineering evaluations or engineering solutions in Phase 2, not only additional sampling for PCBs.

Table 6-1
Prototype Resuspension Criteria for Phase 2

Parameter		Resuspension Standard Threshold		Action Levels			
				Control Level		Evaluation Level	
		Limit	Duration	Limit	Duration	Limit	Duration
Far-Field PCB Concentration	Total PCBs	500 ng/L	Confirmed Occurrence	TBD ng/L	TBD-average	TBD ng/L	7-day running average
Far-Field Net PCB Load	Total PCBs			130 kg/year	Dredging Season		
	Tri+ PCBs			44 kg/year			
	Total PCBs			600 g/day	TBD-average	TBD g/day	7-day running average
	Tri+ PCBs			200 g/day		TBD g/day	
Far-Field Net Suspended Solids Concentration	All Sections					TBD mg/L	6-hour running average net increase OR average net increase in daily dredging period if dredging period is less than 6 hrs
Near-Field (TBD m)	All Sections					TBD mg/L	3 continuous hrs running average

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6.2.2 Residuals

Following Phase 1, the residual sample data will be analyzed in the same manner as the case study data to determine whether the size of the certification unit, the number of sample locations per certification unit, and sampling depths are appropriate for the Upper Hudson River sediments. It is expected that at least 310 residual sample results will be available for statistical evaluation at the completion of Phase 1, so that the evaluation can be conducted on a population of the magnitude required by USEPA's DEFT software (refer to Volume 3, Section 2.7). The sampling density and action levels (UCLs and PLs) may be adjusted according to the site-specific variance of the residual concentrations, but it is unlikely that the action levels will be changed without substantial modifications to the framework of the standard. Potential modifications to the Residuals Standard are summarized below:

1. The sampling parameters (*e.g.*, sampling density for each CU) required for Phase 1 were developed using case study data from sites that may have different sediment textures, spatial distributions, and contaminants than those in the Hudson River. These elements of the standard will be evaluated via statistical analyses of the site-specific residuals dataset obtained during Phase 1. For example, the distribution of the residual sediment data in each target area will be determined using goodness of fit tests.

2. The findings of the special study to characterize the residual sediment strata and thickness and observations of the collected sediment samples will be used to evaluate the core sample collection and management procedures.

3. The required extent of redredging will be evaluated for different patterns of concentration exceedances. The evaluation will include generation of semi-variograms to determine whether the Phase 1 data are spatially correlated, and if so, calculate the distance at which the spatial correlation is statistically significant. This information will be used to adjust, as necessary, the required extent of redredging/capping around individual samples that exceed the criteria.

4. Procedures for redredging will be further evaluated by examining the spatial distribution of Phase 1 residual results using polygonal declustering. For each Theissen polygon, an average Total PCB concentration will be calculated. The results will be used to evaluate the degree to which samples containing Total PCB concentrations greater than the action levels are clustered.

5. The size of the 20-acre joint evaluation areas included in the Residuals Standard may be modified to include the use of 40-acre joint evaluation areas during Phase 2.

6. The areas capped (if any) during Phase 1 will be evaluated to review the decisions that were made given river conditions in the capped area and impact on productivity. Using the information gathered during Phase 1 and 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.

7. The number of redredging attempts required for Phase 1 may be revised for Phase 2. The number of dredging attempts required in Phase 1 will be assessed along with other information from the associated certification unit(s), such as the subbottom conditions encountered, using engineering judgment. For instance, in areas where bedrock is encountered, it may be reasonable to allow contingencies other than redredging to be implemented to reduce the residual concentrations, if redredging attempts consistently failed to reduce the inventory or residual concentrations.

6.2.3 Productivity

Information on dredging productivity will be collected by the construction manager on a daily basis using the appropriate USACE Daily Report of Operations (*e.g.*, USACE Form ENG 4267) and made available for inspection. These data, coupled with observations obtained during field oversight, may be used to adjust the Productivity Standard for Phase 2. Any adjustments, modifications or refinements to the Productivity Standard as a result of Phase 1 work will be the subject of a second peer review by independent experts, as required by the ROD. It is not expected that the required and target volumes currently set for Phase 2 will be modified.

Key information collected during Phase 1 will aid in determining the effectiveness and implementability of the design and remedial operations. There are many components of the dredging project that are contributors to the overall productivity obtained and therefore must be evaluated. If the required and/or target volumes established in the Phase 1 Productivity Standard are not met, the following project elements will be scrutinized:

1. Dredging production details will be reviewed, as reported on the required daily reports. The number of redredging passes necessary to meet the Residuals Standard and the duration of the redredging effort will be evaluated. The effectiveness and applicability of both the standard and the assumed time for redredging will need to be examined and modified as necessary. The Phase 2 requirements and targets, including: the distribution of the work over the 5-year Phase 2 period; the Phase 2 productivity reporting requirements; and the 10% value for the Concern and Control Action Levels will be evaluated.

2. The rate of backfilling will need to be evaluated following Phase 1 to determine the effect it has on productivity. It is not possible to know, in advance, how much of the area targeted for dredging will have to be backfilled, so a very conservative assumption has been made for the extent of this work, which can be modified for a more accurate estimate in Phase 2.

3. Use of resuspension controls during Phase 1 will be reviewed. Although the use of silt barriers should enable compliance with the Resuspension Standard, their installation and use could delay the start of dredging each spring, slow production due to the need to enter the enclosed area through gates in the barrier, and require the construction manager to cease dredging and place backfill over a dredged area early enough in each dredging season to be able to remove the silt barriers before ice forms on the river. The selected containment method, if any, will be evaluated with regard to the assumptions made in the example schedule.

4. The rate of sediment dewatering and water treatment achieved at the land-based processing facility will be reviewed to identify any processes that may be impeding productivity. Modifications to equipment, processes or operations will be required where necessary to meet Phase 2 production targets.

5. Transportation and disposal logistics will be examined. Processes and operations that have a negative impact on production or efficiency will be identified and addressed.

6. The effect of hours of operation (days per week and hours per day), use of multiple crews, and downtime on productivity will be reviewed. Downtime was incorporated into the example production schedule to address routine weekly maintenance tasks on dredges and ancillary equipment. Downtime will be evaluated in regard to equipment malfunction (unavoidable, but can be overcome through proper planning and design), weather and river flow issues.

7. Navigation issues, if any, will be evaluated and addressed. Of particular concern are the potential for interference with normal canal traffic and locking time. The use of larger scows to reduce the number of trips through each lock, decanting supernatant from scows and treating it in a water-borne treatment plant to increase the volume of sediment transported in each scow, and docking support vessels near the dredge sites when not in use will all be considered if movement of equipment through the canal becomes a bottleneck in production.

8. Setup time, which includes tasks such as mobilization and containment, will be closely observed to determine whether any steps are hindering the project's schedule and thus require refinement. Closure time will also be reviewed and may include shoreline stabilization, completion of backfilling, winterizing equipment to be left on site and demobilization. It is assumed that conducting post-dredging soundings to confirm that the sediment has been removed to the design depth and sampling to determine the level of residual contamination remaining, if any, will be carried out as soon as a sufficient area has been dredged to the design grade, and are not included in closure time.

9. The impact of the performance standards for resuspension, residuals, and quality of life on productivity will be evaluated during and after Phase 1. These standards are intertwined and each must be effective in order for the others to be met.

6.3 Transition Plan

This Transition Plan outlines an approach to refine the engineering performance standards so that Phase 2 will commence at the beginning of the following construction season, hence maintaining the integrity of the project, consistent with the ROD. The two main objectives of the Transition Plan are:

- To evaluate the information gathered during Phase 1 in a timely fashion.

- To establish a mechanism that will allow the peer review panel to periodically review the data as it is gathered during Phase 1 and thereby facilitate the peer review process.

The following subsections discuss the actions anticipated to accomplish the objectives of the Transition Plan and to maintain the flow of information from the construction manager (who is responsible for the data collection, summary, initial analysis, and implementation of the actions required by the engineering performance standards) to USEPA, which is responsible for the data review, the Phase 1 evaluation, and the Final Phase 2 performance standards. In this way, USEPA can subsequently transmit data to the peer review panel to address their information requests.

6.3.1 USEPA Review of Phase 1 Data

The construction manager is required to submit regular reports to the USEPA, which transmit the results of Phase 1 monitoring, to ensure that collected data is readily available for decisions on Phase 1 progress, as well as decisions pertinent to Phase 2 operations. The specific elements that each report must contain are addressed in the requirements of the individual performance standards (refer to Sections 2.1.5, 2.2.5, and 2.3.2). During Phase 1, the data reported by the construction manager will be evaluated in an ongoing process by USEPA. Collected field data will be used, along with the construction manager's reports, to assess Phase 1 operations in terms of the remedial objectives and the Engineering Performance Standards.

6.3.2 USEPA Phase 1 Evaluation Report

The ongoing evaluations described in Section 6.3.1 above will culminate in the development of the *Phase 1 Evaluation Report*. The working outline for the *Phase 1 Evaluation Report* is presented in Attachment A. By evaluating data on an ongoing basis throughout Phase 1, it is intended that the *Phase 1 Evaluation Report* can be published around the same time that Phase 1 dredging is completed, or shortly thereafter.

As part of the development of this report, USEPA will hold regular meetings with the construction manager to track project implementation and operational changes during Phase 1, and discuss additional modifications that are likely to be necessary.

6.3.3 Peer Review

USEPA will provide the collected data to the peer review panel every two months during Phase 1, along with preliminary evaluations, as technical memoranda. These memoranda and data compilations may be configured so that the peer review panel can access them remotely. In addition, USEPA will organize a site visit for the peer review panel during Phase 1. The plan to arrange a field visit and provide data for review throughout Phase 1 is intended to facilitate review and allow Phase 2 to start at the beginning of the construction season immediately following Phase 1, consistent with the structure of the project as stated in the ROD.

6.3.4 Early Transition

If Phase 1 dredging operations are proceeding well and exceptional compliance with the Phase 1 Engineering Performance Standards is achieved, USEPA may consider, at its discretion or via a request from the construction manager, transitioning to Phase 2 EPS at the end of the Phase 1 season prior to formal documentation and formal review. This would depend on meeting the data quality objectives set forth in the standards during Phase 1 (*e.g.*, obtaining data to represent the full range of conditions likely to be encountered during the dredging project).

The working timeline for the Transition Plan is contained in Table 6-2. The goal of the timeline is to illustrate how Phase 2 dredge operations can commence without delay in May of the second year of the remediation project, when the locks on the Champlain Canal open for navigation.

Table 6-2

Working Timeline for Phase 2 Transition

Month	Tasks to Accomplish
May - November	Phase 1 Dredging. Construction manager submits Phase 1 progress and monitoring reports as required by performance standards. USEPA conducts ongoing evaluation of required reports; maintains ongoing development of the Phase 1 Evaluation Report. USEPA meets monthly with construction manager to review ongoing adjustments to the operation, and discuss/evaluate petitioned interim refinements of the standards.
June, August, & October	USEPA provides bi-monthly data memoranda, including preliminary evaluations, to peer review panel with remote access. Peer review panel participate in field visit.
November	USEPA issues “Phase 1 Evaluation Report and Proposed Phase 2 Engineering Performance Standards.”
December	Peer review of “Phase 1 Evaluation Report and Proposed Phase 2 Engineering Performance Standards.” Consensus meeting at the end of peer review.
January	Final peer review report is submitted to USEPA (15 days after consensus meeting). USEPA meets with construction manager to review Phase 2 standards and any refinements necessary to dredging operations or monitoring programs.
March	USEPA issues “Final Phase 2 Engineering Performance Standards,” considering peer and public review comments.
May	Phase 2 dredging begins

7.0 References

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Attachment A: Working Outline of Phase 1 Evaluation Report

Executive Summary

1.0 Introduction

2.0 Resuspension Standard Special Study Findings

- 2.1 Near-field PCB Release Mechanism
- 2.2 Semi-Quantitative Relationship between TSS and a Surrogate Real-time Measurement for the Near-field and Far-field Stations (Bench Scale)
- 2.3 Semi-Quantitative Relationship between TSS and a Surrogate Real-time Measurement for the Near-field and Far-field Stations (Full Scale)
- 2.4 Alternative Phase 2 Monitoring Program
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5.0 Phase 1 Residuals Monitoring Data

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6.0 Phase 1 Productivity Data

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- 6.2 Impact of Other Standards on Key Elements of the Productivity Standard