Hudson River
PCBs SUPERFUND SITE

Engineering Performance Standards

Appendix: Case Studies of Environmental Dredging Projects

April 2004

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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

MALCOLM PIRNIE

TAMS
AN EARTH TECH COMPANY

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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

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1.0 Introduction

This section describes the sources of available data on which much of the performance standards are based. Completed dredging projects that provide information on upstream and downstream water column conditions, as well as on mass of contaminant removed, provide a basis for determining historical rates of loss and dredging-related recontamination. It is thought that dredging projects that have been completed or are currently in progress can provide practical information on resuspension issues. Information on water quality data, equipment used, monitoring techniques, etc., from these projects provide insight on how to develop the performance standards. Water column monitoring results available from other sites were used as part of the case study data analysis performed in support of the resuspension standard. The process used to gather relevant information from dredging sites and the information obtained are included herein.

It is also important to review all information that exists for the Hudson River. Available data were used to assess the existing variability in the Hudson River water quality, and can be used to estimate the water column quality during, and resulting from, the dredging operation. Descriptions of the data sets available to perform this analysis are provided herein.

2.0 Case Studies

2.1 Objective and Overview

During completion of the Hudson River Feasibility Study (FS) and the associated Responsiveness Summary (RS) (USEPA, 2002), the General Electric (GE) dredging database, the United States Environmental Agency (USEPA) web site, and other online sources were researched to identify dredging projects that were relevant and similar in size and complexity to that proposed for the Hudson River. The USEPA and state agencies were contacted to gather information for each dredging project, including, but not limited to, the following sites:

- New Bedford Harbor
- Fox River
- Saginaw River
- St. Lawrence River
- Commencement Bay
- Cumberland Bay
- Manistique River
- Sheboygan River
- Grasse River

Information gathered and tabulated included but was not limited to the following:

- Type of dredging equipment utilized.
- Contaminants of concern and associated concentrations.
- Stabilization method.
- Presence of odors.
- Noise issues.
- Problems encountered during dredging.
- Effectiveness of silt/barriers.
- Cleanup goal requirements (allowed residual).
- Reduction rate in terms of average concentration.
- Average dredge equipment productivity.
- Total volume to be removed.
- Dredge season/period.
- Average depth of cut.
- Method of monitoring for resuspension during dredging.

Final results were presented in Appendix A of the FS report and used to support statements and respond to comments on the FS report and white papers of the RS report.

It was thought that additional information was needed to support the development of the performance standards. As a result, a dredging site survey (case study search) was conducted during preparation of the Hudson River performance standards to summarize remedial work conducted at various domestic dredging sites. Information related to the following topics was collected from each of the sites surveyed when applicable and available:

- Specific removal operations
- Productivity, transport, and sediment processing and handling
- Water quality monitoring and associated work plans
- Residual cleanup goals
- Post-dredge confirmation sampling
- Water quality modeling
- Engineering contingency

2.2 Case Study Tasks

2.2.1 Initial Research

A general search was done on the Internet within each of the USEPA regional web sites to identify recent dredging projects that may have been performed since the completion of the Hudson River FS and RS reports. In addition, follow-up conversations were held with dredge site contacts established during the initial survey effort conducted during preparation of the Hudson River FS and RS. The following sources were researched to locate relevant information for dredge sites described in this document:

- USEPA Regional Offices
- Michigan Department of Environmental Quality (MDEQ)
- Wisconsin Department of Natural Resources (WDNR)
- Great Lakes National Program Office
- Fox River Group
- International Joint Commission -US and Canada Great Lakes 2000 Cleanup Fund
- Technical Journals
- GE Major Contaminated Sites Database

The GE Major Contaminated Sites database was reviewed to identify whether any new sites had been added since the completion of the Hudson River RS Report (USEPA, 2002). It was concluded that there were no major additions made to this database at the time this search was conducted, and as a result, the USEPA Regional offices, among other sources identified herein, were contacted to obtain any information on new dredging projects underway since completion of the Hudson River RS report (USEPA, 2002).

The main task performed was the development of a questionnaire that identified and targeted the information needed from each dredge site. Follow-up conversations were held with previously surveyed dredge site contacts to obtain recently released reports and information with regard to project performance. Records of Decision (RODs) recently issued by the USEPA were reviewed to identify additional dredging sites to contact for specific site information outlined in the questionnaire. Dredging reports obtained were reviewed for pertinent information, and a case study narrative was then prepared for each dredge site. This information was tabulated for quick reference for other team members and to allow for comparison between various dredge sites.

2.2.2 Research Questionnaire Development

As a first step in the search for the information needed to support the performance standards, members of the residuals, resuspension, and productivity teams compiled a list of questions and assembled an extensive questionnaire. This questionnaire served as a guide for the case study task force in soliciting information from various dredge sites. In addition, a copy of the questionnaire was available in electronic format for electronic mailing to any contact that agreed to provide specific information on a given project. This questionnaire also served as a guide for telephone conversations with project contacts to ensure all pertinent available information was obtained. Copies of the questionnaire were distributed to project personnel associated with various dredge sites and to different parties within the USEPA. The following subsections list the questions utilized in the case study survey.

2.2.2.1 General Site Details

- What type of dredge equipment was used, mechanical or hydraulic?
- How many dredges were used in the river to meet removal goals?
- How was removal of debris such as large boulders and tree limbs handled: with a separate dredge tasked only with the removal of debris ahead of “removal” dredge, or with the selected removal dredging equipment as encountered in the excavation area?
- What was the average dredge cycle time?
- What size mechanical bucket or hydraulic cutterhead was used?
- How much water was entrained in the mechanical bucket per cycle?
- What was the depth of cut achieved per dredge bite/pass of dredge?
- How long did it take to re-position the dredge? How often did the dredge require re-positioning?
- What was the dredged sediment loaded into?
- What was the dredging pattern? (channel to shore and downriver? How were multiple dredges positioned in the river?)
- Was the area backfilled? What method of backfill placement was used?
- Were wetlands dredged from the river? What type of equipment was used? What was the corresponding productivity in these areas?
- Was shoreline dredging required? How was this accomplished? How were the banks stabilized following dredging?
- Were silt curtains used to create an enclosed dredging zone? How was equipment moved into and out of the area? Did this impact productivity?
- How were the dredge and scow positioned in the river?

- What downtimes occurred and how often did these downtimes impact expected productivity?
- What were the main dredging limitations? What were the main limitations on productivity?

2.2.2.2 Dredging Productivity

- What contaminants and level of contamination were removed?
- Was more than one type of sediment commodity handled (for instance Toxic Substance and Control Act (TSCA) and Non-TSCA)?
- What was the sediment type? (Primarily cohesive, Non-cohesive, rocky)
- Where was dredging conducted? (along the shore, within the channel, or both?)
- What was the bathymetry of the river system?
- What range of removal depths was required?
- What was the average depth of removal required?
- What volume of sediment required removal?
- During what season was the dredging performed?
- Was the expected dredging schedule met?
- What volume was removed per day or week? What was the expected volume to be removed per day or week? Were removal goals met?
- What were the main problems encountered?
- Were community issues such as noise and odor a concern? If so, how were they handled?
- Were residents located along shore near the target dredging area?

2.2.2.3 Dredging Residuals

- Could you provide a report discussing the dredging operation and results?
- What type of dredging equipment was used?
- Can you provide analytical data for all pre-dredging, post-dredging and post-backfill sediment samples and measured parameters, including contaminant concentrations and sediment characteristics? Electronic data is preferred, if possible.
- Can you provide descriptive information for the samples including the coordinates, depth of the samples, sample method (core/grab), and time of collection? Electronic data is preferred, if possible.
- What were the characteristics of the area (presence of debris and boulders)?
- How were the pre-dredging, post-dredging, and post-backfilling sample collection plans developed?
- Were there limits on acceptable residual concentrations? If so, how were these boundaries determined?
- What was the spatial layout of the sampling points (e.g., a grid vs. random placement)?
- How were the sample location scheme and sampling density determined?
- What was the definition of the unit area for certification?

- What was the performance of backfilling?
- What analytical methods were used (both field and lab techniques)?
- What was the maximum number of dredging passes?
- What were the remedial options for an area with unacceptable results?

2.2.2.4 Dredging Resuspension

- How was the pre-construction variability of contaminant concentration or loads determined as the background level? Were any statistical methods used?
- What was measured as a real-time indicator of water-borne, particle-associated contaminant concentrations?
    - If it is turbidity /Total Suspended Solids (TSS), what is the correlation between these parameters and the contaminant concentrations?
    - Was Total Organic Carbon (TOC) or Dissolved Organic Carbon (DOC) measured?
    - Were dissolved phase concentrations measured?
- Can you provide the water column monitoring data for all measured parameters, monitoring locations, and time periods? Electronic data is preferred.
- How was the contaminant threshold value determined? What is it?
- What were the characteristics of the dredged material (such as, percentage of cohesive and non-cohesive sediment)?
- What equipment/devices were used for real-time monitoring? How well did each device perform?
- Where are the monitoring stations located (upstream, downstream, inside or outside of the silt curtain or barriers, by the point of dredging)? Which factors are considered in determining the location of monitoring stations?
- What was the sampling frequency for water column samples?
- How frequently did accidental releases happen? What was the major cause for accidental releases? What is the best solution to prevent accidental releases?
- What was used as the best means of enforcing limits on resuspension, the contaminant concentration, or the contaminant load per unit time?
- Was short-term bio-monitoring (e.g., with caged fish) included as a component of the resuspension monitoring?
- What was the impact, if any, of resuspension on downstream water supply intakes?
- What monitoring requirements were needed to protect downstream water intakes?
- What engineering controls were enforced for exceedances?
- What was the resuspension rate and how was it estimated?
- What dredging equipment and methods are most effective at controlling resuspension and which are least effective?

2.2.3 Review of Recently Issued Records of Decision (RODs)

Team members investigated the USEPA web site for RODs issued for sites where dredging was selected as the proposed plan within the last two years. The search was confined to the past two years because it was thought that the dredge site survey conducted during the development of the FS and RS included all dredge sites up to that time (*i.e.,* the year 2000).

Researchers reviewed the RODs meeting the search criteria, identified the relevant dredging sites, and then queried each of the USEPA regional web sites to gather available information with regard to the proposed plan, status of the project, etc. At the time of the search, approximately 897 RODs matched the search criteria. Following is a representative listing of sites from the total list that have relevance regarding time period and selected remedial action; many more sites exist than can be listed here.

- Commencement Bay – 9 dredging sub-sites
- Velsicol Chemical Corporation – Pine River
- Sheboygan Harbor and River
- New Bedford Harbor
- Saginaw River
- Kalamazoo River
- Grand Calumet River
- Black River
- Manistique River
- Wyckoff Company/ Eagle Harbor
- Waukegan Harbor/Outboard Marine
- Pacific Sound resources
- Harbor Island
- United Heckathorn – San Francisco Bay
- DuPont Superfund Site- Christina River in Newport, Delaware
- St. Lawrence River (Reynolds Metals and GM Massena)
- Grasse River: Alcoa
- New Bedford Harbor

Researchers then contacted the corresponding USEPA project managers for more detailed site-specific information. In addition, researchers also contacted Superfund or sediment management divisions of USEPA regions where little to no recent activity (year 2000 onward) was listed to inquire if any dredging projects had occurred or were being planned for the future.

Some of the dredging projects identified above were noted to have been included in the review effort completed during the development of the FS and RS reports for the Hudson River cleanup. In these cases, the information gathered previously was reviewed, and follow-up conversations were held with the respective project managers to fill in data gaps and obtain more detailed information. These sites included:

- Fox River
- Cumberland Bay
- GM Massena on the St. Lawrence River
- Alcoa on the Grasse River – Review of the Capping Report
- Reynolds Metals on the St. Lawrence River
- Manistique River
- Black River

2.2.4 Search for Additional Information on Recently Completed Projects

During preparation of the Hudson River RS in late 2001, information was gathered on a number of projects that were still underway. Some of these projects have now been completed, and additional information relating to residuals, resuspension, and productivity has become available. Recently released reports were obtained and reviewed for multiple dredge sites. The following list identifies the reports obtained and reviewed during the case study task:

- Cumberland Bay PCB Dredging Project: Final Construction Report.

- Fox River Sediment Management Unit (SMU) 56/57 Remediation- Final Report on work completed in the year 2000.

- Fox River SMU 56/57 Demonstration Project: Final Summary Report on the dredging demonstration project completed in 1999.

- Fox River Deposit N: Appendix to the Summary Report.

- Fox River Deposit N: Summary Report.

- Evaluation of the Effectiveness of Remediation Dredging for The Fox River Deposit N Demonstration Project.

- Fox River Dredging Demonstration Projects at Deposit N and SMU 56/57.

- St. Lawrence River Polychlorinated Biphenyl (PCB) dredging project at former Reynolds Metals plant: Report on dredging completed in 2001.

- Report on Pilot Study of Capping PCB-Contaminated Sediment in the Grasse River at Massena, NY.

- Grand Calumet River Section 401 Water Quality Certification Work Plan for dredging to begin in November 2002.

- Five-Year Review Report for dredging conducted as part of the remedial action at the United Heckathorn Superfund Site within San Francisco Bay.

- The Effectiveness of Environmental Dredging: A Study of Three Sites, Final Report: January 2000.

- Pre-Design Field Test Final Report: New Bedford Harbor 2002.

After completion of the review of the above-listed reports, information gathering efforts, and review of project web sites, a comprehensive case study narrative was completed for each of these sites. This information was also tabulated to allow for comparison between different projects.

3.0 Case Study Summary

The following discussion provides an overall summary for each dredge site researched as part of this case study task. A more detailed narrative for each of these sites, where information was available, follows in Section 4: Case Study Narratives. General descriptions of selected case studies are summarized in Table 3-1; resuspension data for selected case studies are summarized in Table 3-2; and residuals data for selected case studies are summarized in Table 3-3.

3.1 Reynolds Metals on the St. Lawrence River, New York

Removal of PCB-contaminated sediment at the Reynolds Metals Company was conducted from April 2001 through November 2001. Dredging was completed using mechanical equipment that consisted of a Cable Arm bucket. The major components of the selected remedy included the removal of approximately 51,500 cy of sediment with PCB concentrations above 1 ppm, polycyclic aromatic hydrocarbon (PAH) concentrations above 10 ppm, and total dibenzofuran (TDBF) concentrations above 1 ppb.

Researchers obtained and reviewed the *Final Dredging Program Design Report* (2000) and the *Draft Interim Completion Report* (2002). Information regarding the dredging operation and sediment processing, water quality monitoring, containment, post-dredge sampling, and residual levels was gathered and analyzed in this effort.

3.2 GM Massena on the St. Lawrence River, New York

This project consisted of the removal of sediments from a ten-acre, PCB-contaminated area adjacent to the General Motors (GM) aluminum casting facility in Massena, New York. Dredging was conducted between May 1995 and January 1996. Approximately 13,800 cy of sediment were removed with a hydraulic dredge consisting of a horizontal auger. Debris, rock, and boulders were removed using a barge-mounted backhoe. It was noted that the bucket of the backhoe contained openings that allowed for debris about 3 in or less in diameter to pass through. Hydraulic dredging of sediments by the horizontal auger dredge was generally conducted parallel to the shore. The work was accomplished within a sheet pile system when the designed double-silt curtain containment system was found to be ineffective due to highly variable river current speeds and variable current direction.

Resuspension monitoring data was gathered in this effort, including the collection of turbidity data, PCB water column data, and data from a water intake within the vicinity of the dredge area. In addition, post-dredge sediment data was collected and compared to the residual clean-up goal of 1 ppm, and the PCB mass removed was estimated and compared to the total PCB mass that existed prior to dredging.

3.3 Alcoa Site on the Grasse River, New York

This non-time-critical removal action (NTCRA) occurred during the summer of 1995 and involved the removal of approximately 3,000 cy of sediment and boulders that were contaminated with PCBs as a result of the operation of an ALCOA facility. The NTCRA area is located approximately 6 miles upstream of the Grasse River's confluence with the St. Lawrence River, and about ½ mile upstream of Massena, NY. The area is also slightly downstream (east) of the Massena Power Canal.

The focus of the NTCRA appears to have been a hot spot, defined as an area with the highest PCB concentration at the site, although the term "hot spot" is not included in the report (TAMS, 2002 for USEPA). The effectiveness appears to have been assessed based on the removal mass/volume, not residual concentrations; the NTCRA is described as having removed 90 percent of the targeted PCBs and 84 percent of the targeted sediment.

Performed on only part of the site, the NTCRA dredging activities were hampered by unexpectedly rocky sub-bottom concentrations and a boulder field that ran the length of the dredge area.

3.4 Cumberland Bay, New York

Cumberland Bay is located within a small section of the west bank of Lake Champlain in New York State. Removal of PCB-contaminated sediment was conducted from 1999 to 2000 using a hydraulic dredge. Sediments were conveyed to a shore-side processing facility where they were mechanically dewatered. Dredging was performed using two horizontal auger dredges within sheet piling and turbidity barriers. Researchers obtained and reviewed the *Final Construction Report*. Information regarding water quality monitoring, water intake monitoring, correlation between turbidity and TSS, and post-dredge sediment sample data was collected and evaluated.

3.5 Housatonic River, Massachusetts

The Housatonic River is located in western Massachusetts near the New York State and Massachusetts border. Cleanup on this river was divided into three segments:

- The first reach, designated the Upper ½ Mile Reach, adjacent to the GE facility (ongoing; hotspot cleanup is complete)
- The next reach downstream, designated the 1½ Mile Reach
- The third river segment, referred to as the Rest of River, which includes the downstream portions of the river in Massachusetts and Connecticut

In 1997, GE excavated and disposed of 5,000 cy of heavily PCB-contaminated sediment (average concentration of 1,534 ppm PCBs) from a 550-foot section of river and 170 feet (ft) of riverbank (the hotspot area). Sheet pile was used to divert the flow, and standard excavating equipment was used to excavate contaminated sediments in the dry. Sediments were gravity-dewatered on a pad.

In October 1999, remediation of the second phase of the Upper ½ Mile Reach clean-up began. Sheet pile was driven in the middle of the river channel, diverting half of the river flow. Removal was done in the dry using conventional equipment after dewatering. Targeted sediments extended to a depth of 2.5 ft. Contamination deeper than 2.5 ft will be capped with a silty sand sorptive layer and then covered by an armoring layer. Two more extensive removal actions are planned for the 1½ Mile Reach segment of the river. Of interest here is the dry removal strategy and the sectioning of the project into a number of individual stages.

Further information on this site is not provided in Section 4: Case Study Narratives because excavation was completed in the dry and this is not similar to the planned action for the Hudson River.

3.6 New Bedford Harbor, Massachusetts

The New Bedford Harbor Superfund Site is located in Bedford, Massachusetts, about 55 miles south of Boston. The site is contaminated with PCBs, heavy metals, and other chemicals from industrial discharges. Removal of PCB-contaminated sediments in hot spots located on the west side of the Acushnet River estuary was completed between April 1994 and September 1995. Dredging of the hot spots was performed using a hydraulic dredge, and the slurry was subsequently pumped into a confined disposal facility (CDF). Following the hot spot dredging, a predesign field test using mechanical dredging equipment was performed in August 2000. During this case study task, researchers obtained and reviewed the *Pre-Design Field Test Final Report*. The report contained detailed information regarding the dredging operation, water quality monitoring for turbidity and particulate and dissolved PCBs, threshold water column levels, and contingency plans to be put into effect in the event that the action level was detected at one of the monitoring stations.

3.7 Christina River, Delaware

This dredge site is located in Newport, Delaware, and is part of the E.I. DuPont site. Dredging to remove sediment containing elevated metals concentrations was completed in 2000. Dredging was initially planned to be conducted using hydraulic dredging equipment, however due to tidal zone influences, sheet piling was installed around the targeted area and mechanical equipment was used to meet the removal goals. During the dredging operation, turbidity was monitored upstream and downstream of the sheet piling. It was noted that turbidity measurements were not collected within the contained area. Following dredging, the area was backfilled using a clamshell bucket for placement while the sheet piling was still in place. Dredging and backfill were scheduled over a nine-month period; however, all work was completed at the end of the fourth month.

3.8 Bayou Bonofoucia, Louisiana

This site is a tidal-influenced fresh water estuary that is located seven miles upstream of Lake Ponchartrain. As a result of contamination from facility operations at the American Creosote work plant, the sediment in the bayou became contaminated with PAHs. The remedial action consisted of the removal of approximately 170,000 cy of PAH-contaminated sediment using mechanical dredging equipment equipped with a 5-cy bucket and computer controlled sensors to monitor the dredge cut depth and maintain a 3-in dredge tolerance. Removed sediments were disposed of via incineration. Turbidity barriers were deployed around the dredge area. The dredged area was backfilled with a layer of sand followed by a layer of gravel. Additional reports were not obtained for this site since the bayou tidal system is not representative of the Hudson River system.

3.9 Grand Calumet River, Indiana

This dredge site consists of a five-mile stretch of river contaminated with PCBs and volatile organic compounds (VOCs), specifically benzene. The hottest area was to be contained within sheet piling and the remainder dredged in open water. An interesting detail was use of a computer program to estimate the margin of safety on slope stability, which allowed the contractor to evaluate areas where bank stabilization might be needed prior to dredge cut. Researchers reviewed information regarding the proposed dredging methods, bank stabilization, and water quality monitoring work plan.

3.10 Outboard Marine, Illinois

This site is located on the west shore of Lake Michigan and is one of the Great Lakes Areas of Concern (AOCs). The remedial action consisted of the removal of approximately 23,000 cy of PCB-contaminated sediment. This sediment was removed with a hydraulic cutter head dredge and treated via thermal desorption. Following treatment, the sediment was placed back into an isolated slip. Researchers noted that PCB concentrations greater than 500 ppm were removed and treated. Clean sand was placed in the slip prior to placement of the treated sediment. Another interesting observation was that this sediment took a long time to settle out when it was replaced into the slip following treatment. As a result, a coagulant was added to the water column to help with settling of the sediment.

3.11 Waukegan Harbor, Illinois

This site is located on the west shore of Lake Michigan, just downstream of the Outboard Marine site, and is also one of the Great Lakes AOCs. Sampling activities determined that sediment in the harbor was contaminated as a result of both historic activities at the Outboard Marine site and transport of contaminated sediment from the Outboard Marine site to this location. Following completion of dredging activities at the Outboard Marine site in 1992, sediment and water quality at Waukegan Harbor were monitored to determine whether further action was needed. Since 1998, sand sampled from this area has proven to be suitable for beach replenishment. Thus it was concluded that dredging at the Outboard Marine site was successful in remediating the entire harbor system.

3.12 Ashtabula River, Ohio

The Ashtabula River area of concern encompasses a two-mile stretch of river and harbor area adjacent to Lake Erie. Sediments are contaminated with PCBs, heavy metals, and organic compounds. Due to the sediment contamination and degradation of fish populations, the Ohio USEPA has determined that the river should be dredged. More detailed information was not available.

3.13 Black River, Ohio

The Black River is located in north central Ohio and discharges into Lake Erie. This site is also one of the Great Lakes AOCs. Remediation consisted of the removal of PAH-contaminated sediment over a one-mile stretch of river from 1989 to 1990. Dredging was performed using a mechanical clamshell dredge. The major difficulty encountered during dredging was in-river transport of the sediment. Ultimately, dump trucks were mounted on barges, tugged to the dredging location, loaded, and returned to shore. Another interesting fact was that the landfill was designed to capture and treat water in the dredge slurry so that the dredge slurry could be placed right into the landfill.

3.14 Manistique River, Michigan

The Manistique River is located on the southern shore of Michigan's upper peninsula with an outlet into Lake Michigan. This site is also located in the Great Lakes AOC. Contamination of sediment is the result of paper mill operations along the river's banks. Initial dredging was performed in 1995 as a pilot study where capping was the preferred remedial action. The study was so successful that the ROD was revised to allow for the removal of contaminated sediment via dredging, which occurred between 1995 and 1999. Researchers analyzed data on water column PCB concentrations measured during dredging, PCB loading estimates resulting from the dredging operation, and modeling relative to actual measurements made during dredging.

3.15 Pine River, Michigan

The Pine River is located in St. Louis, Michigan, and discharges into Lake Michigan. This site, too, is part of the Great Lakes AOC. Dredging operations consisted of the removal of dichlorodiphenyltrichloroethane (DDT)-contaminated sediment using mechanical equipment. Dredging was conducted in the dry within cofferdams. Resuspension was monitored during dredging to ensure that no sediment loss occurred. In addition, post-dredge sediment samples were collected to verify that the 5 ppm DDT residual was met.

3.16 Shiawasee River, Michigan

The Shiawasee River contains PCB-contaminated sediment over an 8-mile stretch of the river. The USEPA issued a proposed plan for this site in July 2001. This plan contained details regarding existing PCB concentrations in the river and what remedial cleanup goals would most likely be implemented. To date, the USEPA has not issued a ROD.

3.17 Kalamazoo River, Michigan

The Kalamazoo River flows through the state of Michigan and ultimately discharges into Lake Michigan. This site is one of the Great Lakes AOCs. PCB contamination in river sediments is present over an 80-mile stretch of river. Currently, the USEPA is conducting a RI/FS investigation. The RI/FS and proposed plan completion date is set for spring/summer 2003, with ROD issuance set for summer/fall 2003.

3.18 Saginaw River, Michigan

The Saginaw River is one of the Great Lakes AOCs. Mechanical dredging of hot spots estimated to contain 345,000 cy of PCB-contaminated sediment began in April 2000 and was scheduled for completion in November 2000; however, the actual completion date was July 2001. Only one dredge was employed, which impacted productivity. Productivity rates were computed for this site and are evaluated herein.

3.19 Menominee River, Wisconsin

The Menominee River contains six miles of PAH-contaminated sediment. Dredging is currently being performed in the dry by diverting the river flow. Additional information was not gathered for this site because the operation is not representative of the work to be performed in the Hudson River.

3.20 Fox River Deposit N, Wisconsin

Deposit N, located in the Fox River, is one of the Great Lakes AOCs and consists of a three-acre area contaminated with PCBs. Dredging was conducted at Deposit N as a demonstration and evaluation of dredging technology. Removal of PCB-contaminated sediment occurred during November 1998 and December 1998 (Phase I), and continued from August 1999 to November 1999 (Phase II). Researchers evaluated information regarding resuspension monitoring, dredging technique and schedule, turbidity measured during dredging, and PCB loading.

3.21 Fox River SMU 56/57 1999 and 2000 Dredging Projects, Wisconsin

The Fox River SMU 56/57 is located in the Fox River adjacent to the Fort James Plant. This river system is one of the Great Lakes AOCs. Approximately 80,000 cy of PCB-contaminated sediment were targeted for removal using a hydraulic cutter head dredge. After one week of dredging, the dredge was switched to an IMS 5012 Versi dredge to increase the solids content of the dredge slurry, and subsequently upgraded twice in an attempt to meet an optimum production rate of 200 cy/hr. Dredging was performed from August 1999 to December 1999.

It was determined at the end of Phase I (December 1999) that unacceptably high residuals remained in the dredged area due to mounds of sediment left between dredge passes. As a result, the dredging equipment was switched to a horizontal auger dredge for Phase II, (late August to the end of November 2000). Phase I subunits were redredged to meet a 1 ppm PCB residual concentration. Researchers reviewed the *Final Summary Report* for Sediment Management Unit 56/57 (September 2000) and the Environmental Monitoring Report (July 2000), and evaluated information regarding water quality monitoring, PCB water column levels and loading, turbidity measurements, and post-dredge sampling data.

3.22 Sheboygan River, Wisconsin

The Sheboygan River site contains 14 miles of PCB-contaminated sediment. Pilot dredging programs to remove 4,000 cy of sediment were implemented and nearby deposits were capped. Four years after completion of this program, the USEPA concluded that the cap had deteriorated and there was little change in PCB levels in fish. As a result, the USEPA completed a FS for this site and issued ROD calling for removal of 74,000 cy of PCB-contaminated sediment. Dredging with a mechanical dredge equipped with a clamshell bucket was expected; however, no detailed information was located during the research effort.

3.23 Commencement Bay: Hylebos and Thea Foss, Wheeler, Osgood Waterway, Washington

Commencement Bay is located in a tidal zone on the coast of Washington State and consists of nine areas that require remediation. Sediment in this area is contaminated with VOCs. A hot spot within the Hylebos Waterway was to be dredged beginning in October 2002; the production goal was 600 cy/day. A Toyo pump was selected due to the nature of the contamination; the pump could be submerged into the sediment used to and directly remove sediment with minimal agitation, thus minimizing VOC releases to the water column.

Dredging, based on the plan for dredging the remaining portion of the Hylebos Waterway, was scheduled to begin in July 2003. At the time of this writing, the remedy was being planned as a two-pass approach: the first pass would be completed with a clamshell bucket, and the second pass would be performed with a horizontal profiler bucket capable of making a flat, horizontal cut. Researchers obtained and reviewed information regarding the dredging schedule, water quality monitoring, and the dredging pattern.

Dredging was scheduled to begin at a second sub-site, the Thea Foss, Wheeler and Osgood Waterway, in August 2003, to remove approximately 525,000 cyds of PAH-contaminated sediment. At this writing, dredging equipment had not been selected; however, the USEPA project manager indicated that mechanical dredging equipment would be selected. It was indicated that a turbidity standard would be set at either 20 Nephelometric Turbidity Units (NTUs) or 50 NTUs above background, but no additional operating standards have been defined. Researchers did review details regarding the anticipated water quality monitoring.

3.24 Portland Harbor, Oregon

This site, located off the coast of Oregon, was just recently placed on the National Priority List (NPL) by the USEPA due to elevated levels of metals, PCBs, and petroleum products in the harbor sediments. The USEPA is currently performing a RI/FS, which began in Fall 2002.

3.25 United Heckathorn on the San Francisco Bay, California

This site is located in the Richmond Harbor area, which is an inlet of the San Francisco Bay. Remedial investigations conducted in fall 1994 indicated that 15 acres of sediment were contaminated with DDT and dieldrin. Dredging with mechanical equipment was performed from August 1996 to March 1997. Dredging difficulties were encountered around structures along the shoreline and in areas where steep banks existed, and dredging was not completed around docks, piers and steep banks. These areas were instead backfilled with sand, as was the entire dredged area.

Data indicated that the sediment and water column were cleaner immediately following dredging; however, four months later, DDT and dieldrin concentrations had increased in the sediments to levels equal to or greater than predredge conditions, likely a result of incomplete dredging along the bank and around the piers and docks, and recontamination from the banks as the sand cover is washed away. The project is not considered a success, and the site is not considered clean. Researchers reviewed information regarding dredging methods, water quality monitoring, and post-dredge monitoring and data.

4.0 Case Study Narratives

4.1 St. Lawrence River Remediation Project at the Alcoa, Inc. Massena East Smelter Plant, New York (Reynolds Metals)

4.1.1 Site Location and Description

The St. Lawrence River segment of the Reynolds Metals Study Area was originally defined as that section of the river between the mouth of the Grasse River in the west and the International Bridge in the east, and from the southern shoreline of the river to the southern edge of the Cornwall Island navigational channel (part of the St. Lawrence Seaway). Following additional study and evaluation, the focus of remediation activities was narrowed to an approximately 3,500-foot-long segment of the river immediately north of the Reynolds Metals Company (RMC) facility, extending an average of about 450 ft from the southern shoreline into the river. The RMC St. Lawrence Reduction Plant (SLRP) is an aluminum reduction facility. Several contaminants, including PCBs, have been identified in the sediments of the St. Lawrence River north of the facility.

4.1.2 Site Characteristics

The remediation area is approximately 30 acres in size, of which approximately 22 acres underwent remediation. The remaining sections were not contaminated. The area has an average water depth of about 10 ft, with a maximum of about 27 ft. Bottom topography (bathymetry) was highly irregular due to the creation of a shallow shelf from the dumping of dredge spoil during construction of the Cornwall Island Navigation Channel. A great number of underwater obstructions were identified during surveys and sheet pile wall installation. A large navigational dredging program was performed.

Despite the fact that the main river current has flow velocities of 8 ft per second (fps) or higher, most of the shelf adjacent to the RMC plant is a slow-energy system characterized by low flow velocities and little wave action. Current speeds in the near-shore shelf area were found to be mostly less than 1 fps with an average of 0.5 fps.

Sediments in the project area overlay a till layer at depths ranging from 1.5 to 30 ft below the river bottom. The characteristics of the sediments varied widely. Sediments above the till layer ranged from low blow count mud to relatively competent sand, gravel, and clay. Dredge spoils from construction of the St. Lawrence Seaway were deposited in some areas. In other areas more competent materials were overlain by recently deposited soft sediments. In areas where soft sediments were largely absent, gravels and cobbles were the predominant materials.

4.1.3 Remedial Action

A ROD for the remediation of the St. Lawrence River was initially signed on September 27, 1993 by the USEPA and revised in 1998 based on the results of additional investigation and analysis. The major components of the selected remedy included:

- Dredging and/or excavation of approximately 51,500 cy of sediment with PCB concentrations above 1 ppm, PAH concentrations above 10 ppm, and TDBF concentrations above 1 ppb from contaminated area in the St. Lawrence River and the associated riverbank.

- Landfilling of all dredged and dewatered sediment with PCB concentrations between 50 and 500 ppm at an approved, offsite facility.

- Consolidation of all dredged and dewatered sediment with PCB concentrations less than 50 ppm in the on-site Industrial Landfill.

- Treatment of all dredged and dewatered sediments with PCB concentrations exceeding 500 ppm.

The 30-acre remediation area was subdivided into four sub-areas: A, B, C and D. The contaminated portions of each area were further divided into individual dredge cells based on the triangular sampling grids used for the *Area A Sampling and Analysis Plan* (July 1996). The configuration of the sampling grids was developed based on earlier statistical studies and input from the USEPA. A dredge cell was defined as a dredging area with one point (location) of the sampling grid located in its center. A total of 268 dredge cells were defined within the remediation area.

All remediation activities were completed between April 5 and November 25, 2001. These activities included:

- Construction of containment structures.
- Dredging.
- Sediment handling and disposal.
- Capping.
- Removal of the containment structures.

Three derrick barges equipped with cable arm environmental buckets were used to remove 86,600 cy of contaminated sediment containing an estimated 20,200 lbs of PCBs. Sediment removal was also done from the shoreline using an excavator.

With regard to the 286 dredge cells:

- 546 dredge passes were completed on the 268 cells

- 134 cells were remediated on a single pass, while 56 cells required 3 or more passes.
- 11 cells were dredged 7 or more times.
- 185 cells were remediated to < 1 ppm PCBs.
- Another 51 cells were remediated to between 1 and 2 ppm PCBs.
- 12 of the dredge cells could not be remediated to < 10 ppm PCBs, and these 12 were capped.
- An interim cap consisting of 1-2 ft of gravel was placed over 15 cells at the end of the season after determining that further dredging was not feasible.

The average PCB concentration in all three of the evaluation areas was well below the 5 ppm criterion specified in the design as the basis for determining when remediation was complete. The site-wide average PCB concentration of 0.8 ppm represents a 98.6% reduction in PCB contaminant levels across the site. Percent reduction in PCB contamination levels in the evaluation areas ranged from 93.8 to 99.4 %.

The post-dredging site-wide average PCB concentration of 0.8 ppm represents a 98.6% reduction in PCB contaminant levels across the site.

The majority of the PAH sampling results identified contamination well below the 10 ppm PAH cleanup goal. The post-dredging concentrations of PAHs in sediments were found not to be associated with any adverse risks to human health or the environment. Only two cells had polychlorinated dibenzofuran (PCDF) concentrations above the 1 ppb cleanup goal following dredging, and both were associated with PCB concentrations > 10 ppm and were covered with the interim cap. 69,000 cyds of wet sediments with < 50 ppm PCBs were brought to the on-site landfill.

Following stabilization, placement, and compaction, this material was reduced to an in-place volume of 50,300 cyds. Sediment with ≥ 50 ppm PCBs was shipped to Model City for disposal after being stabilized with Portland cement. A total of 22,356 tons was shipped off site, of which 5,909 tons measured > 500 ppm PCBs. The environmental monitoring during the project showed that there were no releases of contamination from the site, and that no other adverse impacts to human health or the environment resulted from the remediation activities.

4.1.4 Containment System

The containment system prevented the release of turbidity and/or suspended sediment generated during sediment removal activities. The containment system included:

- A steel sheet pile wall that enclosed the entire remediation area.
- Silt curtains that provided secondary containment for the more highly contaminated Area C, and isolated uncontaminated portions of Area B from the dredging area.

- Air gates that created an air-bubble curtain that acted as a circulation barrier while allowing for barge and tugboat access to areas enclosed by the silt curtain and sheet pile wall.

4.1.5 Resuspension Monitoring

Based on the sampling locations, resuspension monitoring activities can be divided into two groups: inside the sheet pile enclosure, and outside the sheet pile enclosure. Current velocity and direction studies were performed before and after the installation of the sheet pile to verify the proper placement of monitoring points.

4.1.5.1 Outside the Sheet Pile (In the St. Lawrence River*)*

Turbidity and water quality samples were collected from monitoring stations established in the St. Lawrence River outside the sheet pile during sheet pile installation, during dredging activities, and during sheet pile removal.

Turbidity Monitoring

> *GM and the USEPA identified a downstream TSS maximum limit of 25 mg/L above background as the action limit for their dredging project.*

The action level for turbidity monitoring was based on a correlation study done by GM for the dredging work at their site, downstream of the RMC remediation site. GM and the USEPA identified a downstream TSS maximum limit of 25 mg/L above background as the action limit for their dredging project. In order to use turbidity measurements as the parameter to measure compliance with the 25 mg/L action level, GM performed bench-scale testing to establish a site-specific correlation between TSS and turbidity. Based on the regression equation developed, GM identified a turbidity action level of 28 NTUs above background as their action limit for measuring compliance with the 25-mg/L TSS action limit. For this work, the turbidity action level was set at 25 NTUs, lower and more conservative than that used by GM.

A monitoring team collected turbidity measurements on the water with a direct-reading turbidimeter (Hydrolab) that was calibrated each day in accordance with the manufacture's specifications. In addition, quality control (QC) checks of the Hydrolab were conducted using a Hach turbidity measuring kit. The frequency of the QC checks varied, but averaged at least one check per station per day. Turbidity was also measured with a data-logging turbidimeter installed at a fixed location.

A fixed background station was established upstream of the remediation area. The upstream and downstream monitoring locations were selected based on the current velocity and direction studies.

Turbidity Monitoring During Sheet Pile Installation

Turbidity was monitored at three separate points relative to each derrick barge engaged in sheet pile installation. One location was situated 100 ft upstream of the active location and two locations were situated downstream, one 200 ft from the active location and one 400 ft from the active location. The turbidity measurements were taken at two-hour intervals. Most of the Hydrolab (1770 out of 1780) data were non-detect. As verified by Hach kit results, the Hydrolab was able to quantify higher levels of turbidity, but was unable to resolve low levels of turbidity (1-2 NTUs). Given that the action level was set at 25 NTUs above background, this limitation on Hydrolab measurements was not identified as a concern during the project.

Turbidity Monitoring During Dredging

> *No significant turbidity was observed during any of the river monitoring during dredging.*

Background turbidity was collected from a fixed background station located northwest of the sheet pile enclosure. Background data was also collected from stations 100 ft upstream from each active dredge. Downstream samples were collected at three locations: 10, 150, and 300 ft from the sheet pile wall closest to the dredge being monitored. The measurements were taken at two-hour intervals starting just prior to dredging operations and ending with the completion of work each day. Vertical turbidity contrasts were not observed. All measurements were taken at 50% of water depth. No significant turbidity was observed during any of the river monitoring activities during dredging. The Hydrolab measurements were mostly non-detect, while those from the Hach kit were typically in the range of 0.5 to 1.5 NTUs.

Turbidity Monitoring During Sheet Pile Removal

> *No turbidity exceedances were identified during any part of the sheet pile removal activities.*

In response to a request from the St. Regis Mohawk Tribe, RMC lowered the turbidity action level in the St. Lawrence River from 25 to 10 NTUs during sheet pile removal. A total of 1,451 turbidity measurements were collected during the 18 days of removal activities. Turbidity levels in the river were comparable to those observed during earlier phases of the work, and were predominantly in the range of 1-2 NTUs. No turbidity exceedances were identified during any part of the wall removal activities.

Water Column Sampling

Water column samples were collected at different stages of the project and analyzed in the laboratory using EPA methods 8082A (PCB), 610 (PAH) and 8290A (PCDF).

Water Column Monitoring During Sheet Pile Installation

Water samples were collected from a downstream turbidity monitoring point (typically 200 ft downstream) and from an upstream station (100 ft upstream). The samples were collected at 50% of river depth for PCB analysis and TSS measurement. A total of 111 water samples were collected, and all results were reported as non-detect for PCB at a detection limit of 0.065 µg/L.

111 water samples were collected during sheet pile installation, and all results were reported as non-detect for PCB at a detection limit of 0.065 µg/L.

Water Column Monitoring During Dredging

Water column samples were collected daily at the same monitoring stations used for turbidity monitoring. The samples were collected at 50% of river depth and analyzed for PCBs, PAHs, and PCDFs. Of the total 661 unfiltered water column samples, 40 of them were reported to have detectable levels of PCBs with concentrations ranging from 0.05 to 0.53 µg/L. All reported detections were well below the action level of 2 µg/L PCBs, which indicated that dredging did not result in the release of PCBs during the remedial action. 59 and 50 unfiltered water column samples were collected for PAH and PCDF analyses, respectively, and all results were reported as non-detect.

All reported detections were well below the action level of 2 µg/L PCBs; dredging did not result in release of PCBs during the remedial action.

Water Column Monitoring During Removal of Sheet Pile Wall

Staff collected and analyzed 113 PCB samples, 93 PAH samples, and 100 PCDF samples during the sheet pile wall removal activities. PCBs were detected in 18 samples, but none of the concentrations was above the 2 µg/L action level. PAHs were detected in three water samples, and all three of these detections were above the action level of 0.2 µg/L. Further evaluation suggested that these exceedances were probably due to localized turbidity rather than the sheet pile removal activities. PCDFs were detected in 10 samples, and all detected concentrations were below the action level.

During sheet pile removal, PCBs and PCDFs were below the action level. PAH detections not attributed to site activities.

4.1.5.2 Inside the Sheet Pile Enclosure

Turbidity and water column samples were collected inside the sheet pile enclosure during dredging and capping in order to provide information concerning water quality and sediment resuspension.

Turbidity Monitoring During Dredging

Daily turbidity measurements were taken at 12 to 19 different stations during a portion of the dredging operations. The number and location of the stations depended on the dredging activities occurring when the monitoring team was able to collect the measurements. As indicated by 820 turbidity measurement results, average turbidity was typically less than 25 NTUs and maximum turbidity was generally below 50 NTUs within the sheet pile enclosure. The higher turbidity values were obtained in proximity to derrick barges engaged in dredging operations. A data-logging Hydrolab turbidimeter was also used to collect continuous turbidity measurements at a fixed location. The instrument was attached to a silt curtain anchor post and monitored turbidity at 50% of the water depth. Data from the hourly measurements are available.

Water Column Sampling During Dredging

PCB concentration in the water column within the sheet pile enclosure declined rapidly once dredging was complete.

Water column samples were collected once a week during active dredging and analyzed for PCBs, PAHs, and PCDFs. Samples collected between June 20, 2001 and October 10, 2001 at one station were field filtered using a 0.45 um filter in order to limit the analysis to dissolved contaminants only. After that period, unfiltered samples were collected at several stations to investigate the contaminant level on a whole water basis. Filtered samples were reported to have total PCB concentrations of 0.2 to 0.5 µg/L, while unfiltered samples had higher levels of PCBs. PCB concentration declined rapidly once dredging was complete, and higher concentrations were observed at the stations that were associated with consistently higher turbidity. Similar phenomena were observed for PAHs and PCDFs.

Data show that if turbidity is contained, the sediment-related contamination is also contained.

PCDF contamination is absorbed to particles and is less likely to accumulate in the dissolved phase of the water column. All of the results observed in the project indicate that contaminant water column concentration increased with the higher turbidity. The absence of turbidity in a sample, resulting either from field filtering the sample or by collecting a sample from clear water, generally resulted in a sample with no contamination, or at least no contamination above the action levels. There was no evidence of any significant accumulation of dissolved-phase PCBs, PAHs, or PCDFs. The collected data show that if turbidity is contained, the sediment-related contamination is also contained.

Turbidity Monitoring During Capping

Turbidity levels during capping were comparable to levels inside the wall during dredging.

During the capping operation (October 26 – November 2, 2001), turbidity was measured at five stations, all of which were located inside the sheet pile enclosure. The stations included a background station (located 100 ft upstream), a station adjacent to the Cat 350 (the derrick used for placement of the capping materials), and downstream stations located 150 and 300 ft from the capping operation. Turbidity levels measured during capping were comparable to those observed inside the wall during dredging operations. No monitoring was done outside the sheet pile wall during capping.

Water Intake Monitoring

Potable water intakes used by AMN (formerly SRMT) and for the GM and RMC plants were sampled during dredging and sheet pile removal to monitor for any impacts from the remediation activities on the quality of water supplies obtained from the St. Lawrence River. The AMN water treatment facility is located approximately 3.9 miles downstream of the remediation area, and the GM plant intake lies approximately 0.6 miles downstream. The RMC intake lies just west of the remediation area, but is in the zone of reverse current flow, which placed the RMC intake downstream of the western part of the remediation area.

Water grab samples were collected from sample ports of raw (untreated) and filtered (treated) water within the AMN Water Treatment Building, while samples of raw (untreated) water only were obtained from sampling ports inside the GM and RMC water plants. During dredging operations involving the removal of the sediment with > 500 ppm PCBs, water samples were collected from the designated location daily. Samples were collected on a weekly basis during all other dredging activities. Daily sampling was resumed during removal of the sheet pile wall, and continued until the final week of the wall removal.

The USEPA-approved water quality action levels were non-detectable PCB and PAH concentrations, with detection limits of 0.065 µg/L and 0.2 µg/L, respectively. The water intake for the Mohawk Council of Akewsasne (located downstream of AMN) was to be sampled if any of the action levels were exceeded at the AMN water intake. There were no exceedances, and thus no samples were collected from the Mohawk Council of Akewsasne.

2001 remediation activities did not have any impact on downstream water supplies in the St. Lawrence River.

A total of 261 intake samples was collected and analyzed for PCBs. Only one sample had a reported detection of PCBs. However, this result is believed to be spurious. A total of 117 intake samples were also collected and analyzed for PAHs. PAH sampling was conducted only during dredging operations. No PAHs were detected in any of the 117 water intake samples. In summary, the remediation activities conducted in 2001 did not have any impact on downstream water supplies in the St. Lawrence River.

4.1.6 Evaluation of Dredging

Four cable arm environmental clamshell buckets (two 5.4-cy and two 2-cy) were specially designed and utilized on the project. Each bucket was equipped with sensors to allow the operator and marine technician to monitor its position with respect to the water-air and water-sediment interfaces. The buckets have a specialized closing system that allows for closure along a constant horizontal plane, a key feature in the determination of depth of cut. The cable arm buckets generally performed as expected.

The large quantity of fractured rock (long, straight edges vs. rounded cobbles) present in the dredge spoils presented a unique problem to the cable arm bucket. The cable arm bucket lacked sufficient power to shatter these rocks, and they were not easily moved through the sediment. In some cases, after removal of the overlying soft sediment, a hard bottom condition with a very thin layer of soft sediment or a mixture of rock and fine sediment remained with concentration above cleanup goals. A known limitation of the cable arm technology was its inability to remove sediment in areas with hard bottom, such as glacial till or stiff clays. This limitation led to the use of an alternative dredging method.

Three separate "evaluation areas" were defined for the remediation area, designated Evaluation Areas #1, #2, and #3. Determination that remediation requirements were complete required the following conditions:

- The requirements of the dredging procedures and flow sheet logic were accomplished in all cells within the area

- The average PCB concentration of the area was less than or equal to 5 ppm

- No individual grid node within the area had a PCB concentration above 10 ppm

As previously stated, the 30-acre remediation area was subdivided into 4 sub-areas, A, B, C and D, and the contaminated portions of each area were further divided into 268 individual dredge cells based on the triangular sampling grids used for the *Area A Sampling and Analysis Plan* (July 1996). Verification sampling locations in Areas A, B, and D reflected a triangular grid spacing of 70 ft. Verification sampling locations in Area C were based on a triangular grid spacing of 50 ft (all eight hot spots were located in Area C).

Verification samples were initially collected using a Ponar dredge sampler operated from the Atlantic Testing Laboratories, Limited (ATL) sampling barge. The sampling technique was changed to the split-spoon method when it became apparent that the Ponar dredge would not be able to generate samples representative of the 0-8 in sediment interval. The sampling locations were determined using global positioning system (GPS) instrumentation. Sample collection procedures were conducted in accordance with the methodology detailed in the Procedure for Surface and Subsurface Sediment Sampling, REP-002.

The verification samples were analyzed using a field screening immunoassay method in accordance with Method 4020 in USEPA SW-846, *Test Methods for Evaluating Solid Waste*, Rev. 0., 1996. Evaluation of the immunoassay results drove decisions regarding follow-up dredging and/or additional laboratory analyses for the samples. Expanded analyses for PAHs and PCDFs were conducted on a minimum of 10% of the dredge cells.

The cells for PAH and PCDF analysis were identified using a randomized sampling approach.

> *Site-wide, average PCB concentration was reduced from 59.1 to 0.8 ppm, corresponding to 98.6% reduction in sediment PCB concentration.*

Verification samples were collected from each of the 268 dredge cells and analyzed for PCBs. The final dataset consists of 86 immunoassay results and 182 laboratory PCB results. Post-dredging average PCB concentrations in the three evaluation areas were 0.6, 1.4, and 0.5 ppm, respectively, which are well below the 5 ppm area-wide criterion. Site-wide, the average PCB concentration was reduced from 59.1 to 0.8 ppm, corresponding to a 98.6% reduction in sediment PCB concentrations.

Nearly 70% (185) of the cells were remediated to less than 1 ppm. Another 51 cells, representing 19% of the total, were remediated to less than 2 ppm. Four percent of the cells had post-dredging concentrations greater than 10 ppm, all of which were covered with the interim cap.

No further dredging effort was warranted on cells with 1-2 ppm PCBs. One cell was capped and six cells were further evaluated. The collected data showed that there was little progress being made in the attempt to reduce the 1-2 ppm sediment PCB levels to < 1 ppm. With the USEPA's current slope factor of 0.2 for PCBs, which is nearly 75% smaller than the one used in the baseline risk assessment and original cleanup goal calculations, a PCB concentration of 1-2 ppm corresponds to a risk level that is at least as protective as that used in the derivation of the original cleanup goals.

Sixteen dredged cells were left with PCB concentrations between 2 and 5 ppm. Two of these cells were designated MFE, "Marked for Further Evaluation." Nearly one-third of the 16 cells were capped, due to proximity to cells with > 10 ppm PCBs. Four cells had final verification sample results with PCB concentrations between 5 and 10 ppm. One of these cells was capped; the other three were designated MFE.

Twelve cells could not be remediated to concentrations below 10 ppm PCB. These were covered with a 2-ft gravel layer as part of the interim capping effort. All cells with final PCB concentration > 2 ppm underwent a large number of dredge passes while attempting to reach the target concentration level of < 1 ppm.

RMC collected samples from 43 dredge cells for PAH analysis, and USEPA sampling results were generated for an additional 53 cells. There were 16 RMC samples and ten USEPA samples that had PAH concentrations exceeding the 10 ppm cleanup goal. Five of the cells with > 10 ppm PAHs were capped. Nearly 50 % of the cells with PAHs > 10 ppm had four or more dredge passes, indicating the difficulty in remediating PAH contamination at the site. Continued dredging would not necessarily have resulted in a meaningful reduction of PAH concentrations. PAHs were removed to the extent practicable given the limits of dredging technology used at the site. An evaluation of the risk associated with residual PAH contamination determined that the post-dredging concentration of PAHs is not associated with adverse human health or ecological risk.

Thirty-two final verification samples were collected for PCDF analysis. There were two cells in which the 1 ppb PCDF cleanup goal was not achieved. These cells were dredged about six to seven times, resulting in the removal of a significant quantity of sediment but not in a reduction of the contaminant concentration to below the cleanup goals for PCDF. Both cells were covered with the interim gravel cap at the conclusion of the dredging operation. The site-wide average PCDF concentration was 0.197 ppb, indicating that the remediation of the site with regard to PCDFs was highly effective.

RMC expended a considerable level of effort in the quest to achieve cleanup goals and remove as much of the contaminated sediment from the river as was technically feasible. About half of the dredge cells received two or more passes, and nearly one quarter of the cells received three or more passes. The 546 dredge passes that were completed equates to an average of just over two passes for all 268 dredge cells. Additional dredging did not necessarily mean that progress was made. It was observed that any dredging after about the fifth pass did not make any real progress toward attaining the cleanup goal. These additional dredge passes did, however, result in the removal of additional PCB mass from the river. The limit of dredging technology and the bottom stratigraphy after previous dredging passes (i.e., no longer amenable to dredging) were the two major reasons for the failure to achieve the cleanup goal in dredge cells that remained contaminated.

The conventional rock bucket and hydraulic clamshell of the Cat 350 were used as alternative dredges during the redredging of contaminated dredge cells. The decision to utilize alternative dredging methods was based on the presence of persistent contamination in these cells and the fact that previous dredging attempts had not been successful in reducing contamination levels. Such situations indicated that the limitation of the cable arm environmental bucket had been reached. The conventional rock bucket consisted of a 2.5-cy clamshell bucket that could be used with the lattice boom cranes on the derrick barge. The bucket was capable of digging into the more resistant hard bottom materials and was more effective in removing rocks and gravel.

The disadvantages of the conventional bucket were that it did not have a venting system to allow water to pass through the opened bucket during descent, which minimizes downward water pressure and sediment disturbance, and that it did not have the regulated closing system or overlapping side seals that minimize the disturbance of sediment on the bottom and reduce sediment loss on closure. The Cat 350 had a hydraulically operated clamshell bucket with a 2.5-cy capacity. The hydraulics on this bucket provided for better closure, and also allowed it to dig into stiff sediment and rocky material. Its primary disadvantage was that the operator had to be extremely careful not to overfill.

The issue of timing in the collection of verification samples is addressed in the Environmental Monitoring Plan (EMP):

> "Verification sampling will be conducted after sufficient time has passed to allow for settling of suspended solids, and thus it is expected that sampling will be conducted for groups of cells that are at least somewhat removed from the active dredging area."

It turned out that this requirement was unrealistic in the execution of the work, due primarily to the redredging effort required. The resampling effort required by USEPA identified a shift in PCB concentration in the sediment, and in general a greater number of samples with higher PCB concentrations were obtained.

Sediment samples were analyzed for PCBs using Method 8082 (Method 8270 was used for some samples but its use was curtailed as directed by the USEPA).

Variability existed in sediment sample results. This variability was mainly attributed to matrix variability, inter-lab variability, and analytical variability. Additional sampling and analyses did not eliminate the uncertainty associated with sediment PCB analyses.
As stated in the work plan, any cell with a residual concentration > 10 ppm was capped. The cap consisted of a 6-in separation layer, a 12-in containment layer, and a > 9-foot armor and bioturbation layer.

At the conclusion of the dredging work in 2001, 15 dredge cells were covered with an interim cap. The material placed for interim capping was based on the physical isolation layer as detailed in the *Remedial Action Work Plan*. The design specified that the layer consist of a 6-in (minimum) layer of gravel. For the actual application, the USEPA requested that the minimum thickness of the layer be increased to 12 in, and that the gravel be placed in two lifts. Approximately 6,717 tons of gravel were used in capping the designated area. Using a conversion factor of 1.5 tons per cy, this is equivalent to 4,478 cy of materials. The capping area, including run-out, was 47,270 ft^2. The average thickness of the gravel layer was calculated to be about 2.2 ft. Because of the absence of soft sediment in the areas that were capped, the bottom was not covered by geotextile prior to placement of the gravel. Observations through early May of 2002 indicated that the cap had withstood storms and other winter weather. Completion of the final two layers of the cap is intended to ensure that the underlying contaminated sediment remains effectively isolated from the ecosystem of the St. Lawrence River.

4.2 General Motors Corporation Powertrain Facility (a.k.a. GM Massena), St. Lawrence River Remediation Project, Massena, New York

4.2.1 Site Location and Description

The site is located seven miles to the east of Massena, New York, and approximately two miles to the south of Cornwall, Ontario, Canada. The facility is bordered to the north by the St. Lawrence River, to the south by Raquette River, to the east by St. Regis Mohawk Tribal Property, and to the west by RMC and property owned by Conrail. PCB-containing fluids were used at the site between 1959 and 1973 in die-casting machinery. In 1984 the site was placed on the NPL.

4.2.2 Site Characteristics

The portion of the St. Lawrence River that was the focus of remediation activities consists of a shallow bay area. The bottom of the bay forms a shallow shelf extending approximately 250 ft into the river before dropping sharply to approximately 40 ft in depth at the southern edge of the St. Lawrence Seaway shipping channel. The shelf was composed primarily of fine-grained sediments (clay, silt and sand) overlying dense, glacial till (weathered and soft at the surface). Coarser material (i.e., gravel, cobbles and large boulders) existed near the bottom of sediments within weathered till.
Flows from Lake Ontario range from 258,000 cubic feet per second (cfs) to 289,000 cfs. The normal high water elevation near the site is 156.0 ft, and the normal low water elevation is 153.0 ft. The water fluctuations in the channel near the site are generally less than one ft (154.0-155.0 ft). Local velocities in the main channel upstream of the mouth of the Raquette River ranged from 2.75 feet per second (fps) to 4.42 fps, and the mean velocity was 3.65 fps. Lower velocities were observed on and adjacent to the shallow bay where sediment removal activities were conducted.

4.2.3 Remedial Action

The goal of this project was the removal of sediments from a ten-acre PCB-contaminated area adjacent to the GM aluminum casting facility in Massena, New York. Between May 1995 and January 1996, approximately 13,800 cy of sediment were removed. Sediments were removed via hydraulic dredging using a horizontal auger dredge. Debris, rock, and boulders were removed using a barge-mounted backhoe. The bucket of the backhoe contained openings that allowed debris about 3 in or less in diameter to pass through. Hydraulic dredging of sediments by the horizontal auger dredge was generally done parallel to the shore.

Additional alternatives were used in Quadrant 3 where the cleanup goal was not achieved after multiple dredging passes (eight attempts were made). Alternative technologies attempted include:

- A vacuum dredge head (that did not contain an auger) with a metal shroud that collected sediment by negative pressure utilizing, the dredge's intake pump.
- Mechanical removal of sediments using a barge-mounted backhoe.

Typically two to six passes were required for remediation. In general, each pass commenced perpendicular to the shore or sheet pile wall, advanced at a rate of approximately 2 to 4 ft per minute, and made a 3- to 12-in-deep and 8-foot-wide cut. About 15 to 18 passes were required in Quadrants 1 and 3 to bring concentrations to below 500 ppm.

Dredged sediment was dewatered and the resulting filter cake was stockpiled on site for later off-site disposal. Dewatering and excavation of the cove area were not carried out as of the report date due to unsettled access issues.

4.2.4 Containment System

The work was accomplished within a sheet pile system when the designed double silt curtain containment system was found to be ineffective due to highly variable current speeds and variable current direction. Shoreline areas (less than 5 ft) were isolated with a port-a-dam and excavated in the dry.
During Phase 1 dredging, limited exchange of turbid water was observed in some areas where certain sheet piles were driven below water surface. To correct this problem, filter fabric was draped over the openings and anchored with steel cable ballast. In Phase 2, many of the low sheets were raised and short lengths of steel sheeting (8-12 in) were installed to close the openings.

It was concluded from this project that a sheet pile wall can efficiently prevent suspended solids from escaping the work areas.

4.2.5 Resuspension Monitoring

A sampling depth and location evaluation study was conducted during initial dredging operations to determine the optimum sampling locations for the measurement of turbidity and the collection of water column samples. Measurements were collected from five locations: approximately 7 ft, 15 ft, and 22 ft below the water’s surface (about 25%, 50% and 74% of measured water depths), and at two locations along the outboard side of the control system at intervals between 200 and 300 ft apart. Data were collected twice daily for three consecutive days (a total of 90 data points). Sampling locations and depths that exhibited the highest values of turbidity were used for turbidity and water column sampling during dredging operations.

Real-time turbidity monitoring was conducted at a total of 13 locations during sediment removal. All monitoring stations were located outside the sheet piling. Monitoring Station 1 (MS1) served as the upstream background monitoring station that remained in the same location throughout the project. Downstream monitoring station locations varied during different phases of the project.

4.2.5.1 Turbidity Monitoring

Turbidity measurements were collected daily from 50% water depth at approximate two-hour intervals at three stations: one station 50 ft upstream of the western extent of the control system and two stations between 200 ft and 400 ft downstream of the easternmost active installations. If the real-time turbidity value downstream exceeded the upstream value by 28 NTUs for five minutes or more, turbidity measurements downstream continued for at least one hour or until the exceedances stopped. If the exceedances continued, water-borne remediation activities were modified until the problem was rectified. The action level was selected based on a 1994 site-specific bench-scale laboratory correlation between TSS and turbidity and experience in previous dredging projects. Based on bench-scale tests, the following correlation was developed for overall conditions including elevated TSS results (i.e., > 300 mg/L):

$$\text{Turbidity (NTUs)} = 7.3745 + (0.611058 \times \text{TSS}) + (0.00094375 \times \text{TSS}^2),\ r^2=0.941$$

Based on a regression analysis for TSS < 60 mg/L and Turbidity < 60 NTUs, this equation was reduced to TSS (mg/L)=[0.63x(Turbidity in NTUs)] + 6.8, r^2=0.43. A turbidity value of 28 NTUs would correspond to a TSS of below 25 mg/L.

Turbidity measurements were collected and documented using a Horiba Water Quality Tester, Model U-10. The turbidity meter was calibrated at the beginning of the day and rechecked at the end of the day using three calibration standards (0, 10, and 50 NTUs). As mentioned above, the action level for turbidity monitoring was set at 28 NTUs higher than the background level. During sheet pile installation, turbidity measurements ranged from 0 to 13 NTUs with no measurements above the action level.

In 18 out of the 923 samples collected during dredging activities, the turbidity measurements were above the action level of 28 NTUs above background, ranging from 31 to 127 NTUs. These exceedances were observed at a depth of 1 ft below the water's surface, with the exception of one measurement that was observed at 9 ft below the water's surface. Duration of the exceedances was generally two to eight minutes, with two exceedances lasting for 15 minutes and 45 minutes. The cause of the exceedances was reported to be overflows at low steel sheets (installed as per design to assure stability of the containment system during storms and high waves). This problem was later corrected as previously described in subsection 4.2.4.

4.2.5.2 Water Column Sampling

> *By implementing a sheet pile containment system, the PCB concentrations were much lower than the action level.*

Samples were collected at the same two downstream locations as the turbidity measurements. A total of 146 samples were collected and analyzed for PCBs. PCB concentrations above the action level of 2 µg/L were detected when elevated turbidity readings were observed. In the area under the protection of sheet pile, the PCB concentrations were much lower than the action level. Thirty-eight samples were collected and analyzed for PAHs, and the concentrations were below detection limit. After the removal of the Phase 1 sheet pile wall, eight samples were collected inside the Phase 1 containment area. Both filtered and unfiltered samples were analyzed. The filtered water column concentrations ranged from 0.94 to 2.4 µg/L, and the unfiltered water column concentrations ranged from 4.51 to 9.84 µg/L.

4.2.5.3 Water Intake Monitoring

Two water treatment facilities existed within or in the vicinity of the dredging area, the GM facility and the SRMT facility. The GM treatment facility's intake was originally in the Phase 1 dredging area, but was extended an additional 85 ft beyond the dredging area due to remedial operations. The SRMT treatment facility was located 1.5 miles downstream of GM facility.

Both raw (untreated) and filtered (treated) water grab samples were collected at the SRMT water treatment building, and a treated water sample was collected from the GM facility. During dredging operations in areas where the PCB concentrations exceeded 500 ppm, sampling was done daily. During the dredging of areas where the PCB concentrations were below 500 ppm, sampling was done weekly.

The monitoring results for the SRMT facility indicated that in two out of 52 untreated water samples, the total PCB concentrations were 0.090 and 0.085 μg/L. The remaining samples were below the detection limit. Monitoring results for the GM facility treated water showed total PCB concentrations between 0.27 and 0.54 μg/L between June 19 and July 10, 1995. It was assumed that these detections were to due to a leak into the intake piping in dredging area. After the pipe was repaired, total PCBs were detected only in of two samples collected between July 10 and December 22, 1995 (0.12 and 0.14 μg/L). The PAH results collected from the same monitoring locations at the two facilities were all below method detection limits. With USEPA approval, PAH testing at these facilities was discontinued after 21 days of sampling.

4.2.6 Evaluation of Dredging

The 1 mg/kg clean-up goal was not met in some areas, attributed to the presence of a hard till layer beneath the targeted sediments, limiting the ability to over-cut into clean material.

The GM Massena project had a cleanup goal of 1 mg/kg total PCBs. Although over 99 % of the contaminated PCB sediment mass was removed from the St. Lawrence River, the 1 mg/kg goal was not met in some areas. In five of the six quadrants, the average post-dredging concentration was 3 mg/kg with no sample exceeding 10 mg/kg. In Quadrant 3, the average post-dredging concentration was 27 mg/kg (General Motors Powertrain, 1996). If the relatively high predredging concentrations within the sub-areas were considered (208 mg/kg and 2,170 mg/kg), the reduction was estimated at 98.6 % for five quadrants and 98.8 % for Quadrant 3 (Kelly, 2001). Similar to Grasse River, the inability to reach the cleanup goal in some areas was attributed to the presence of a hard till layer beneath the targeted sediments, which limited the ability to overcut into clean material.

Following sediment removal, samples were collected from the river bottom to determine the residual PCB concentration and whether or not the target cleanup goal for the river sediment had been achieved. For all areas that contained greater than 500 ppm PCBs, the grid spacing was approximately 50 ft by 50 ft. For other areas containing less than 500 PCBs, the grid spacing was approximately 70 ft by 70 ft.

Core samples were collected from the upper 6 in of sediment using Lexan™ tubes and/or stainless steel augers. Each sample was analyzed for individual Aroclors. An off-site laboratory utilizing USEPA SW-846 8082 methodology and USEPA Contract Laboratory Program (CLP) procedures performed all PCB analyses. Sample collection was performed a minimum of 24 hours after leaving an area to allow suspended solids to settle to the river bottom.

Samples were collected from 113 locations. Final PCB concentrations in individual bottom samples did not achieve the 1 ppm goal in many instances. Post-dredging PCB concentration isopleths and final sediment sampling locations are shown in Figure 4-1 and Figure 4-2, respectively.

While over 99% of the contaminated sediment mass was removed from the St. Lawrence River at the GM site, the clean up goal of 1 ppm PCBs was not met in all areas despite re-dredging efforts. A hot spot remaining in an area where the highest predredging concentrations of PCBs were found (greater than 500 ppm), was isolated with a multi-layer engineered cap. The inability to reach the clean up goal in this area was attributed to the presence of a hard till layer underneath a thin layer of residual sediments.

4.3 Alcoa Site on the Grasse River (Hot Spot Removal), New York

This NTCRA project, performed on only a portion of the site, involved the removal of approximately 3,000 cyds of sediment and boulders that were contaminated with PCBs as a result of the operation of an ALCOA facility. The cost of the project was approximately $1,670 per cubic yard. Sediments were removed by means of an auger dredge. The presence of boulders significantly interfered with and reduced the efficiency of removal operations. A backhoe was used to remove boulders, and some sediment was removed by means of a diver-assisted vacuum system. Resuspension controls included silt curtains, a sheet pile wall, and oil booms. Dewatered sediment was treated with lime and disposed in an on-site landfill.

> *The average PCB concentration in post-dredging samples was substantially reduced from predredging conditions.*

The NTCRA successfully removed 27 percent of the contaminant inventory in the river while operating in a limited area, even though the river conditions encountered at this location included the presence of boulders, rock outcrops, and a stepped river bottom. A target residuals concentration was not specified as a project goal, but the average concentration in post-dredging samples was substantially reduced from the predredging conditions. The length-weighted average concentration (LWA) of the predredging cores gives a measure of the concentration removed by dredging. The depth of the pre-dredging cores varied from 12 to 36 in. The average of the LWA values was 801 mg/kg PCBs with concentrations in individual samples ranging from 12 mg/kg to

11,000 mg/kg. Following dredging, the concentration in the residual layer was 80 mg/kg PCBs on average, with sample concentrations ranging from 11 mg/kg to 260 mg/kg. On average, the contaminant concentration in the targeted sediment was reduced by 90%.

Alternatives for more extensive remediation of the Grasse River are under consideration. The potential responsible party (PRP) has expressed a preference for a remedy that involves capping by particle broadcasting instead of dredging. Due to the fact that this project only covered a limited dredge area of one acre and because discharge from an outfall was not eliminated until after the NTCRA was complete (possibly leading to re-contamination), this project is not discussed in further detail herein.

4.4 Cumberland Bay Wilcox Dock Sludge Bed Site, Operable Unit 1 (OU1), Town of Plattsburgh, Clinton County, New York

4.4.1 Site Location and Description

The Cumberland Bay Sludge Bed – Wilcox Dock site (Cumberland Bay Site, or site) is located in the northwest corner of Cumberland Bay in Lake Champlain, east of the city of Plattsburgh, Clinton County, New York. The site is bordered to the south by the breakwater and to the west by the shoreline of Cumberland Bay.

4.4.2 Site Characteristics

Cumberland Bay is a small, somewhat rectangular part of the west side of Lake Champlain. Depths in the bay can exceed 50 ft, but average water depths in the vicinity of the site do not exceed 20 ft and are generally less than 10 ft. The Cumberland Bay Site consists of an underwater sludge bed of wood pulp, wood chip debris, macerated paper, paper pulp, and other industrial wastes deposited from a variety of local industries. The sludge bed is underlain by sandy lake bottom. Aroclor 1242 is the predominant PCB compound at the site, and the main source of PCB contamination was pulping recycled waste paper, including carbonless copy paper containing PCBs.

The sludge consisted of low-density silt, clay, and wood fiber (wood chips and paper pulp), and contained PCBs at concentrations up to 13,000 ppm (Mudflats/Breakwater areas: 33 ppm, Dock area: 431 ppm). Sludge thickness ranged from 0.25 to 16 ft, with the maximum thickness present in the Dock Sludge area.

4.4.3 Remedial Action

This 57-acre site consisted of underwater areas that contained PCB-contaminated sludge from paper mill operations. Based on pre- and post-dredging hydrographic surveys, 195,000 cyds sludge and sediments were removed.

Two dredges were used at the site for sludge bed removal. Both units were horizontal auger type dredges manufactured by ESG Manufacturing (Model Nos. MDS-177-10 and MDS-210-12). Each dredge was equipped with an 8-ft-wide, 8-in-diameter auger head attachment, with dredge-mounted pump for conveying the dredge slurry to the solids separation area. The dredge employed an ultrasonic flow meter, Differential GPS (DGPS) control, and WINOPS© computerized positioning system to allow the dredge operator to control position and progress rate.

One dredge was equipped with a 12-in-diameter high-density polyethylene (HDPE) dredge slurry delivery line, and the other with a 10-in-diameter HDPE dredge slurry delivery line. The length of the dredge slurry delivery lines varied depending on the work area being dredged. The lines were constructed using capped 10-in polyvinyl chloride (PVC) pipe "pontoons" to add buoyancy to the lines. Flexible couplings were installed incrementally along the slurry delivery line to increase flexibility and allow positioning behind the mobile dredge.

Each pass removed a 2-ft-thick layer of sludge. Upon completion of dredging operations on a line, the dredge was relocated to the subsequent line, a distance of 6 ft. Since the dredges were equipped with 8-ft-wide cutter heads, this represented a 2-ft overlap and thereby the formation of windrows was minimized. Dry sludge or sludge in shallow water was removed by excavation.

The specified target for the project was the complete removal of the sludge bed down to the underlying clean sand layer. Dredging continued based on visual observations until all fine sludge was removed. Following the removal of the sludge bed, samples were collected, and dredging continued until the cleanup goal of an average of 10 ppm of PCBs was achieved. The pre-/post-operations soil sampling locations are shown in Figure 4-3.

A "hard crust layer" originally interpreted as natural lake bottom was found to be compacted sand, silt, and paper pulp. This layer (10-16 ft below water surface) could not be penetrated by dredging equipment during the first approach, but was later re-dredged by divers and the underlying sludge (up to 4 ft thick) was removed.

4.4.3.1 Mudflats Sludge Area

Sludge was removed from a 30.6-acre area shown on Figure 4-4. The Mudflats Sludge area was characterized as having a broad, relatively thin continuous layer (bed) of sludge ranging from 0.25 to 3 ft thick, and averaging 1.5 ft thick. The estimated in-place volume of sludge in this area was approximately 55,800 cyds. The volume of material removed from this area was 49,927 cyds.

4.4.3.2 Dock Sludge Area

The Dock Sludge area occupied approximately 8.8 acres, shown in Figure 4-5, and was characterized by a relatively thick, continuous layer (bed) of sludge ranging from 0.25 ft to approximately 16 ft thick, and averaging 4.3 ft thick. Lake waves and currents were dissipated in the Dock Sludge area by the presence of the temporary sheet pile wall and Wilcox Dock located on the south and east sides. The estimated in-place volume of sludge in the Dock Sludge area was approximately 50,900 cyds. The volume of sludge removed from this area was 84,078 cyds.

4.4.3.3 Breakwater Sludge Area

The approximately 11.7-acre Breakwater Sludge area was characterized by a relatively thin sludge layer ranging from 0.25 ft to 4 ft thick, and averaging 1.5 ft thick. The estimated in-place volume of sludge in this area was approximately 23,500 cyds. The volume of sludge removed from this area was 50,995 cyds.

4.4.3.4 Shoreline Excavation Area

The Shoreline Excavation Area was composed of sludge that was either not submerged or was in water too shallow to be hydraulically dredged. Due to the low water levels present in 1999, the shoreline excavation area, originally estimated to be seven acres in size and to contain 15,000 cyds of sludge, was in actuality approximately nine acres in size, and 37,453 cyds of sludge were removed.

4.4.4 Containment System

Temporary sheet piling (1,000 linear ft, 24,000 ft^2) and perimeter silt curtains (2,200 linear ft, 4 ft deep around the sheet piling) were installed to isolate the sludge bed during dredging operations. The previously planned floating boom was replaced by a silt curtain as per the US Army Corp of Engineers (USACE) permit requirement.

4.4.5 Resuspension Monitoring

Water quality was monitored in an operational mode within each work zone, a compliance-monitoring mode around the perimeter of each work zone, and a documentation mode around the perimeter of the site. As specified below, no good correlation existed between TSS and turbidity. Turbidity was used only as an indicator and not in association with an action level. Compliance monitoring was performed by periodic sampling and on-site testing for TSS.

4.4.5.1 Operational Monitoring

Work zone monitoring was performed in the vicinity of the active dredging operation. The first aspect of this monitoring consisted of visual inspection for evidence of a suspended solids plume and use of mobile real-time OBS-3 turbidity sensors. An optical backscatter sensor (OBS) meter was mounted to each dredge head, and another OBS meter was affixed to a float that trailed behind the dredge. Sensor output was displayed real-time on the dredge's onboard computer monitor and recorded electronically. This trailing sensor was used as an operational monitor to indicate sludge resuspension immediately behind the dredge, and also to complement the turbidity sensor mounted on the dredge head. The trailing sensor was initially placed approximately 25 ft behind each active dredge. The distance between the dredge and sensor was modified to 50 ft based on the type of material being dredged and the turbidity generated. Periodically, surface water samples were collected and analyzed for PCBs by USEPA Method 8082 to assess the PCB concentrations in the water column. PCB analysis was performed at Waste Stream Technology.

Results of daily TSS and periodic PCB analyses did not indicate the presence of elevated PCB concentrations.

If the TSS results at the dredge-trailing sensor exceeded 25 mg/l above background, dredging operations were modified or suspended. Although active dredge areas sometimes exhibited high turbidity readings, the results of daily TSS and periodic PCB analyses did not indicate the continued presence of elevated PCB concentrations.

The design originally called for the real-time turbidity data to be telemetered to the contractor's trailer, with alarms to indicate exceedances of action levels. Since no reliable correlation could be made between turbidity and TSS at the Cumberland Site, no turbidity-based action level could be established. Therefore, the data was monitored and electronically recorded on the dredge but was not telemetered to the site trailers, as no one was regularly monitoring it at that location.

4.4.5.2 Compliance Monitoring

Compliance monitoring was conducted at four OBS-3 sensor stations that changed with each active work zone. One sensor was deployed in a background location (near the breakwater) at a water depth approximating that in the work zone. Three other sensors were deployed outside the perimeter of the work zone silt curtain, and one more sensor was placed temporarily near Georgia-Pacific's industrial water intake when dredging operations were underway in the Breakwater Area. Sensors were stationary and suspended at the mid-depth level of the water column. Data was telemetered to an onshore control station where it was recorded electronically. At the completion of work in a work zone, the sensors were moved and set up as appropriate for the following work zone.

As with operational monitoring, the turbidity measured by the real-time OBS monitors was only used to alert the operators of a potential resuspension problem. No action level was associated with the turbidity monitoring. Daily turbidity and TSS samples were collected using a Kemmer sampler at each of the four sensor stations at a mid-depth level and analyzed on-site (the TSS detection limit was 4 mg/l). During 24-hour operation, one sampling event was performed in the morning and one sampling event was performed in the evening. When a TSS concentration outside the turbidity barrier exceeded the background concentration by more than 4 mg/l, dredge operations were modified. Occasionally a surface water sample was collected for PCB analysis (USEPA Method 8082). Air temperature, wind velocity, and wind direction were measured and recorded during each monitoring event.

> *The generally low levels of TSS outside the work zone can be attributed to stringent management of dredging operations and effectiveness of the silt curtains.*

Sludge resuspension was observed in association with dredging activities, and occasionally an elevated TSS result was detected outside the work zones. TSS results greater than 4 mg/l above background, sometimes resulting from high winds and associated waves, were not sustained for more than a few days. The generally low levels of TSS outside the work zone can be attributed to the stringent management of dredging operations and the effectiveness of the silt curtains. In cases where dredging was being performed near an opening in the silt curtain (for exiting or entering, or weather/current related breaches), the contractor was required to immediately cease dredging operations, secure the silt curtain, and close off the work zone prior to resumption of dredging operations.

4.4.5.3 Documentation Monitoring

Documentation monitoring was performed at six fixed turbidity monitoring (TM) buoys. Initially, one sample per day was collected using a Kemmer sampler from each location at a mid-depth level, and analyzed on-site for turbidity and TSS (with a TSS detection limit of 4 mg/l). An additional sample was collected for PCB analysis by USEPA Method 8082 (with a detection limit of 0.065 ppb), on a weekly basis. During 24-hour dredging operations, one sample was collected at the beginning of each 12-hour shift using the same sampling and analysis protocol.

In the event that a TSS concentration exceeded the background concentration by more than 4 mg/l, dredging operations were evaluated and modified as necessary, depending on the extent to which weather conditions were a factor.

4.4.5.4 Water Intake Monitoring

A Georgia-Pacific, large-volume water intake was located at the western most point of the Breakwater area. The Georgia-Pacific water intake was monitored prior to and during dredging to document the intake water quality prior to construction and to assure that Georgia-Pacific intake water was not contaminated during dredging.

Two rows of permeable silt curtains were installed in front of the Georgia-Pacific water intake to protect the intake from suspended material. During the course of dredging in the Breakwater area, Georgia-Pacific was placed on city water to eliminate the potential for PCB-contaminated suspended material to be introduced into their process. It was more cost-effective to provide the city water than to construct a temporary water intake in an alternate location.

4.4.6 Correlation between TSS and Turbidity

The specifications set forth a specific numeric limit for TSS in the nearby lake water during dredging. It was anticipated that sludge resuspension would be measured real-time by monitors installed both physically trailing behind the dredge and outside the active work area silt curtains. The specifications required that the contractor develop a site-specific correlation between TSS and turbidity so that action levels could be defined for the more easily measured parameter, turbidity, which in turn could be correlated to TSS action levels. Preconstruction bench-top testing, reported in the 1998 predesign investigation report, indicated that development of such a correlation would be plausible for monitoring and control purposes.

Earth Tech and the contractor collaborated to perform a number of tests using lake water in an effort to develop a correlation prior to start up of sediment removal activities. During the construction phase of the work, however, Earth Tech found that a reliable TSS-turbidity correlation could not be made due to unforeseen factors, possibly including algal bloom and light refraction that appeared to affect turbidity readings in addition to TSS. It is believed that these extraneous factors caused turbidity to vary in a way that could not be directly correlated to TSS. As a practical matter, the decision was made to collect daily lake water samples during dredging and analyze them directly in an on-site laboratory for TSS. This process took about 2 hours to complete, and was therefore, not real-time. As a result, the “real-time” benefits of monitoring and control using this correlation method could not be realized. A lesson learned is that the feasibility of developing a correlation between TSS and turbidity must be evaluated in the field under conditions that simulate the dredging operations.

4.4.7 Evaluation of Dredging

Using a predredge analytical dataset that contained a limited number of data points, it was determined that the average PCB concentration in the Mudflats and Breakwater areas before dredging was 33 ppm, while the average concentration in the Dock area was 431 ppm.

Four phases of post-excavation sampling were performed in 1999 and 2000, after dredging in each of the active work zones. The sampling was performed in four phases in 1999 and 2000. After dredging, 115 confirmation cores were collected. Analysis was not performed for 73 of the 115 cores either because the collection point was located onshore (5 cores) or because the core materials were visually verified to contain only sand (68 cores). The remaining 42 cores yielded 51 samples that were analyzed for PCBs. The results ranged from 0.04 mg/kg to 18.0 mg/kg, and averaged 5.87 mg/kg. If sand cores had been included, the average residual concentration could be as low as 2.5 mg/kg (assuming the PCB concentration in the sand cores is 0 mg/kg). In all it is estimated that 20,118 pounds of PCBs were removed from the sludge bed.

Phase I sampling began after dredging activities were completed in November 1999 to determine the presence of remaining consolidated sludge. The results of the Phase I sampling proved not to be representative of the remaining sludge, as it was discovered that the sampling tool used did not retain all of the sludge present during retrieval. The sampling tool penetrated the sludge and retrieved only bottom sand having low or no PCB concentrations.

A second phase of sampling was conducted at the end of November 1999 to determine residual PCB concentrations in the bottom of the bay. Phase II sampling consisted of sampling the entire bottom of the work area on a 50-ft grid. At the same time, core samples were collected to obtain information about the bottom sediment. Divers assisted in retrieving samples in locations where conventional sampling equipment was not effective. Compared to Phase I sampling, more areas were identified that still contained sludge. Also, it was determined that certain areas were missed during the 1999 dredging operation.

The project team conducted the Phase III sampling program in spring 2000, using a penetrating rod and a disc to determine the depth of any remaining soft material and a coring device to determine the amount of sludge remaining. The sampling crews found 1 to 3 ft of unconsolidated material and up to 7 in of consolidated sludge in parts of Areas 1A, 2A, 5, 6, and 7. The consolidated sludge was also found in depressions scattered along the bottom of the lake in Areas 2A and 2B. In May 2000, divers were used to more extensively identify and locate remaining sludge. The divers reported the presence of additional windrows of sludge remaining after the 1999 dredging operations in Areas 2A and 7. A limited portion of Area 5 was found to contain material with PCB concentrations up to 132 ppm.

The final sampling event, Phase IV, took place during the summer and fall of 2000. The purpose of the Phase IV sampling was to compare the final sediment total PCB concentrations with the data generated during the Remedial Investigation and design. The results of the Phase IV core sampling and inspection by divers indicated that several areas still needed to be dredged. Divers dredged these areas using hand-held hydraulic dredge lines. The hand-held dredging proved effective in these areas that had been identified as difficult to dredge using the hydraulic auger.

The results of the Phase IV sampling showed an average PCB concentration across the sampling grid of 6-7 ppm, with only a few areas exceeding 10 ppm and none exceeding 18 ppm, as shown on Figure 4-6. In addition, a number of confirmation samples were collected from the bottom sands and evaluated in the field. Based on data from this and previous sampling events, the native sands beneath the sludge bed contained little or no PCB-contaminated material. Consequently, these sands were not dredged. Taking into account the concentration of PCBs in the sand, the average PCB concentration across the grid was 3 ppm.

> *The native sands beneath the sludge bed were found to contain little or no PCB-contaminated material.*

Although the contractor was required to select and operate a dredge that would minimize resuspension or underwater "spillage" at the dredge head, not all of the disturbed bottom material was captured and removed, even after multiple passes. A thin layer of the disturbed material up to approximately 1 ft in thickness was left behind, virtually floating near the bottom as a relatively homogeneous, fine-grained, low solids residuum, particularly during the early stages of the project. This material, which the field crews called "fluff," was typically undetectable by samplers operated from the water surface. The fluid-like material was readily displaced when disturbed by sampling devices and the dredge head. Its nature and presence was discerned only by the divers, who stated that it resembled naturally occurring, mobile, low solids content organic lake bottom silts. Although analysis of diver-collected samples indicated that the fluff did not contain significant concentrations of PCBs, its presence was initially a concern.

The following were noted as lessons learned during the dredging operations at this site:

- The feasibility of developing a correlation between TSS and turbidity must be evaluated in the field under conditions that simulate the dredging operations.
- It is important to quickly evaluate the effectiveness of the contractor's dredging method and dredge speed soon after a dredging pass is completed in a given area, even if real-time turbidity (or TSS) monitoring is implemented.
- Due to the thickness of deposits and high organic content in the Dock Sludge area, gases of decomposition caused chunks of sludge to break away and float to the surface. This material was captured using seine nets.
- Dredging with horizontal auger causes resuspension of fine sediments. The problem is exacerbated if the auger is rotated too rapidly, or if the equipment is advanced too quickly. The capture efficiency at the controls may have been better if provisions on the rate of auger rotation and advance were included in the specifications.
- Occasional high turbidities were observed due to backflushing of dredge slurry when dredging operations were interrupted. This could be minimized as follows: "Instead of flushing the screen with dredge slurry residing in the dredge line, lift the cutter head off the bottom, and suck in enough clear water to displace the slurry in the piping and use it for screen backwash."

4.5 New Bedford Harbor (Predesign Field Test), New Bedford, Massachusetts

4.5.1 Site Location and Description

The New Bedford Harbor Superfund Site is located in Bedford, Massachusetts, about 55 miles south of Boston. The site is contaminated with PCBs, heavy metals, and other chemicals originating from industrial discharges.

USEPA originally divided the site into three units, with the first unit comprised of those locations on the west side of the Acushnet River estuary, where PCB levels in sediments exceeded 4,000 ppm (hot spots). With assistance from the USACE, a pilot project was conducted in 1989 to establish the preferred dredging technology for sediment removal. Technologies examined were cutterhead, horizontal auger, and matchbox dredges. To accommodate site-specific operating procedures to limit sediment resuspension, the cutterhead dredge was selected as the preferred technology.

Dredging of the hot spot sediments began in April 1994 and continued through September 1995. On October 1, 1998, the USEPA announced its decision for the rest of the New Bedford site. The decision called for the dredging of approximately 500,000 cyds of sediment. In New Bedford's upper harbor, sediments with a PCB concentration above 10 ppm were to be removed, and in its lower harbor, sediments with a PCB concentration above 50 ppm were to be removed. In addition, certain popular though contaminated shoreline areas were to also undergo soil/sediment removal.

In August 2000 a predesign field test (PDFT) was performed at the site to determine site-specific dredge performance values for use in developing a full-scale remediation plan. Dredge performance values were previously estimated based on results obtained from the use of conventional and alternative hydraulic dredging systems at the site in a pilot study in 1989, and for the dredging of hot spots in 1995. Due to changes in dredging technology after these activities were completed, the PDFT was done to evaluate the effectiveness of the newer technologies.

The site location and the dredge test area are shown in Figure 4-7 and Figure 4-8, respectively.

4.5.2 Site Characteristics

The sediments at the site consisted of a black organic silt surface layer underlain by a native clean gray clay layer. A core sample from a location within 100 ft of the dredge area contained 19 % sand, 53 % silt, and 28 % clay. In some sub-tidal areas near the test area, some organic (root matter) was encountered. Based on information obtained from the USACE site representative, pre-dredging depth-averaged sediment PCB concentrations were 857 mg/kg for 0-1 foot, 147 mg/kg for 1-2 ft, and 26 mg/kg for 2-3 ft (Simeone, 2001).

4.5.3 Remedial Action

Dredging during the PDFT was performed in the summer of 2000 over a 100 x 550-ft area in the New Bedford upper harbor. Based on predredge surveys and daily progress survey results, the total volume of *in situ* material removed from the PDFT area was approximately 2,308 cyds. Since this was a pilot study to evaluate dredge performance and to set dredging parameters, a cleanup goal was not specified for this project. The cleanup criteria for the full-scale remediation of upper and lower harbors were set at 10 ppm 50 ppm, respectively.

A Bean TEC Bonacavor hydraulic excavator, which is a hybrid of mechanical and hydraulic dredges, was used for the project. On this dredge, the horizontal profiling bucket was fitted to a hydraulic excavator equipped with an onboard digital geographic positioning control and monitoring system. The excavated sediments were reslurried and pumped to shore side ponds or cells.

Based on post-demonstration samples, the average PCB concentration was reduced to 29 mg/kg in the top 1-ft layer. The reduction was calculated to be 96.5 % using the 0-to-1-ft predredging concentration and 91.5% using the average concentration of 0 to3 ft. The project goal for residual contamination was substantially higher than 1 mg/kg.

4.5.4 Containment System

No information was found in the available document on the containment system used during the PDFT.

4.5.5 Resuspension Monitoring

The water quality monitoring program conducted for the PDFT included the following components:

- Predictive modeling to aid in the design of the water quality monitoring field program and to assess the utility of modeling for the full-scale remediation effort
- Field monitoring and sample collection
- Laboratory analysis of water samples
- Correlation assessment between field and lab data

A numerical hydrodynamic and sediment transport model was included in the predictive model, and was used to predict the expected suspended sediment concentration resulting from dredging activities under a variety of transport assumptions. The monitoring program was structured to document water column conditions during dredging operations. Water samples were analyzed for TSS and dissolved and particulate PCBs. Assessments of the correlation of the turbidity and TSS and TSS and PCB data were performed. A plot of lab TSS (mg/L) vs. field turbidity (NTUs) based on data collected during PDFT showed the following general correlation:

$$TSS = 1.378 \times Turbidity - 4.35 \; (r^2=0.556).$$

A general positive correlation was observed between TSS and particulate PCBs.

The water column turbidity measurement was performed using an OBS. Turbidity was monitored prior to dredging to characterize the baseline turbidity, and the targeted distance predicted by the model was used to set up the sampling location for TSS and PCB. For monitoring performed on August 16, stations were set at 50 ft, 100 ft, and 500 ft downstream of the dredging, as well as a reference station 1,000 ft upstream. For the monitoring performed on August 17, an additional downstream station was added, and stations were set at 50 ft, 300 ft, 700 ft, and 1,000 ft, downstream of the dredging based on a review of the previous day's data.

The following action levels were set for monitoring:

- Since the harbor background and ambient concentrations in water column exceeded the federal surface water quality criteria, no limit was set for monitoring for PCBs. The maximum cumulative transport (MCT) at Monitoring Station 2 (MS2) (at the limit of mixing zone 300 ft from the dredge) was set as 400 kg PCBs for the entire dredging project.

- The action level for turbidity was defined as 50 NTUs above background at MS2 (300 ft from the dredge). When this limit was exceeded, a MS2 bioassay test was conducted to determine if acute or chronic toxicity was occurring (i.e., sea urchin fertilization, mysid 48-hr mortality, red alga 48-hr viability), and turbidity was measured at 600 ft from dredge. If the turbidity exceeded 50 NTUs, dredging would stop, but this was infrequent during the PDFT, and since bioassay tests did not show any ecological impact, dredging was not halted.

Upon examination of the data, the following conclusions were drawn:

- The actual dredging process (removal of sediment with the hydraulic excavator) appeared to have a limited impact on the water column.

- Activities performed in support of the dredging (operation of support vessels) appeared to have a much greater impact on water quality than the dredging.

- Normal fluctuation in water quality occurs in the upper harbor (related to changing environmental conditions) that appears similar or greater in scale than the overall impacts related to the dredging operation.

4.5.6 Evaluation of Dredging

Predredging sediment core samples were collected at each of 40 stations, 30 stations of which were located within the original 100 x 400-ft dredge footprint of the test area and 10 stations of which were located in the provisional test area. Post-dredging cores were collected at stations where dredging was completed, and sampling methodology was similar to that of the predredge effort. Post-dredge grab samples were collected at adjacent core locations and at other locations in the test area to assess surficial sediment conditions. Post-dredging sampling locations are shown in Figure 4-9. For the grab samples, the PCB concentrations represented a composite of the 0-2 cm sediment depth. PCB concentrations were significantly higher in the grab samples than in the upper 1-ft core composites at 16 of the 18 locations where both grabs and cores were analyzed.

The results indicated that approximately 97% of the PCB mass was removed within the dredging boundaries. The average sediment PCB concentration (upper 1 ft) was reduced from 857 ppm to 29 ppm over the dredged area. This met the full-scale clean up criteria of 50 ppm for the lower harbor, and approached the criteria of 10 ppm for the upper harbor. It appears that the observed average post-dredging PCB concentration (29 ppm upper 1 ft composite) can be attributed to deposition of mobilized sediments (either from the original dredged area or from adjacent areas by sloughing, tidal action, etc.), rather than inefficient or inaccurate dredging. A thin surface veneer contained all the PCB mass after dredging.

Sediment removal data and PCB data indicated efficient technology and high probability of achieving sediment cleanup goals.

The tested dredging equipment demonstrated dredge performance values exceeding those achieved at the New Bedford Harbor site during hot spot dredging and the 1989 pilot study (i.e., dredge production, accuracy, and slurry solids concentration). Both the sediment removal data and PCB data indicated that the dredging technology used was very efficient and had a high probability of achieving sediment cleanup goals established for upper New Bedford Harbor.

Sloughing or migration of sediments can be addressed by modifying dredging procedures, dredging from upslope to downslope, and understanding the tidal regime.

The study also concluded that the question of residual contamination due to sloughing or migration could be addressed by modifying certain dredging procedures during the full-scale remediation (i.e., design values were recommended such as rate of dredging for various water depths, dredging accuracies, average solids concentration of dredge slurry). It was also concluded that recontamination due to sloughing during full-scale operation can be reduced by dredging from upslope to down-slope, and gaining a better understanding of the tidal regime. Additional conclusions on dredging operation were that return sweeps, tighter overlap of bucket grabs, and slower retrieval of final bucket grab would provide a cleaner bottom surface and reduce sloughing of adjacent areas.

4.6 New Bedford Harbor (Hot Spots), New Bedford, Massachusetts

4.6.1 Site Location and Description

The New Bedford Harbor Superfund Site is located in Bedford, Massachusetts, about 55 miles south of Boston. The site is contaminated with PCBs, heavy metals, and other chemicals originating from industrial discharges.

The USEPA originally divided the site into three units, with the first unit comprised of those locations on the west side of the Acushnet River estuary where PCB levels in sediments exceeded 4,000 ppm (hot spots). With assistance from the USACE, a pilot project was performed in 1989 to establish the preferred dredging technology for sediment removal (technologies were cutter head, horizontal auger, and match box dredges). The cutter head dredge, constrained by site-specific operating procedures to limit sediment resuspension, was selected as the preferred technology.

4.6.2 Site Characteristics

The hot spot sediments were situated in a shallow tidal estuarine area where the Acushnet River merges with upper New Bedford Harbor. These sediments are generally a fine-sandy silt with some clay, and by definition contained greater than 4,000 ppm total PCBs. Cadmium, chromium, copper, and lead were also present at high levels. Removal of the hot spot sediment was estimated to result in removal of approximately 45% of the total mass of PCBs in the harbor.

4.6.3 Remedial Action

Dredging of the hot spot sediments began in April 1994 and continued through September 1995. From an area about five acres in size, approximately 14,000 cy of sediment were hydraulically dredged and pumped via floating pipeline to an interim shoreline CDF. One of the principal goals of the hot spot dredging program was the removal of a significant percentage of the PCB mass in the upper harbor without causing significant additional risks to human health or the environment. A second objective was to avoid additional remediation in the lower harbor as a result of the dredging program (i.e., contaminant transport to less contaminated areas).

4.6.4 Containment System

Initially the selected containment system consisted of silt curtains, but they were later abandoned due to their continuous disturbance of the harbor bottom.

4.6.5 Resuspension Monitoring

Two strategic stations were selected to limit the contaminant transport from the upper harbor to the lower harbor and Buzzards Bay, the Coggeshall Street Bridge (NBH-2) and the Hurricane Barrier (NBH-4). Monitoring station locations are shown in Figure 4-10. Station NBH-2 was positioned at the transition between the upper and lower harbor. Criteria were established there to limit the net transport of PCBs to the lower harbor, and to monitor for significant PCB bioaccumulation and sub-lethal biological effects in mussels. No chemical criteria for water column samples were established at HBH-4 because an earlier pilot study indicated that when concentrations were controlled at NBH-2, no corresponding signal was observed at NBH-4. Chemical concentrations in the water column were measured only at NBH-2. Mussel bioaccumulation was quantified at NBH-

4, which provided an integrated assessment of water column PCB concentration over time.

Other stations for water column monitoring included NBH-1, immediately to the south of the dredging operation, and NBH-7, in the vicinity of the CDF. Sampling frequency at the monitoring stations was one sample (composite of 13 grabs) at each flood tide and one sample (composite of 13 grabs) at each ebb tide (6-in rise and fall). Total PCB concentrations were obtained by analyzing the dissolved and particulate concentrations separately, since the analysis of Total PCBs gave relatively lower concentrations. PCBs were analyzed as 18 individual congeners.

Criteria for net transport between the upper and lower harbors were not violated during the remediation.

A water column concentration of 1.3 mg/L PCBs was determined to be the action level during the 1989 pilot study. The MCT of PCBs during the entire operation at station NBH-2 (transition between upper-lower harbor) was also used for monitoring. MCT was based on the mass of PCBs transported out of the upper harbor, above background concentrations, that would increase the mean lower harbor sediment concentration by more than 1 ppm. The estimated mass of lower harbor sediments within the biologically active upper 4 cm was estimated as 240×10^6 Kg (dry weight); thus the MCT throughout the entire dredging operation was not to exceed 240 Kg PCBs. This mass of PCBs became the MCT decision value criteria value for NBH-2. For the entire operation, the total mass of PCBs transported under the bridge was approximately 57 kg, representing only 24 % of the MCT. Therefore, criteria for net transport were not violated during the remediation.

Toxicity tests included the sea urchin sperm cell test, 7-day mysid growth survival test, red alga survival test, and 28-day bioaccumulation test (using ribbed mussels that have a greater temperature tolerance than blue mussels) at two stations (NBH-2 and NBH-4). The results showed that during remediation, there were no acute toxicity effects that could be attributed to the dredging operation. PCB accumulation in mussels was not significantly greater than pre- or post-operation deployments.

4.6.6 Evaluation of Dredging

The monitoring results showed that the hot spot dredging operation had a minimal environmental effect on New Bedford Harbor and Buzzards Bay.

4.7 Christina River Newport, Delaware

4.7.1 Site Location and Description

The Christina River is part of the E.I. DuPont Superfund Site in Newport, Delaware. This river was dredged during the year 2000 due to elevated levels of metals in the sediment.

Approximately 10,000 cyds of sediment within a 1.5-mile stretch of the river was removed.

The ROD initially stated that hydraulic dredging was to be used because it was believed that lower levels of resuspension would result with hydraulic equipment when compared to mechanical dredging equipment. In addition, the ROD indicated that silt barriers must be used. However, because the river is located in the tidal zone, it was determined during the design phase that silt barriers would not be effective. Instead, sheet piling was designed for and used in the dredge area. The selection of sheet piling was as the containment system resulted in a switch to mechanical dredging equipment so that a large wastewater treatment plant (WWTP) would not be needed at the landside facility.

4.7.2 Site Characteristics

Sediment consisted primarily of fine clay. Water depth was 6 ft on average. The removal depths were 2 ft on average, with the deepest cuts extending to 4 and 6 ft in select areas.

4.7.3 Remedial Action

The target areas were divided into three main areas, and each was confined within sheet piling. It was indicated that the Christina River is 300 ft wide, and in some places the sheet piling blocked more than half the river, extending about 200 ft from shore. Thus, other river traffic was impacted during implementation of the remedy. An open bucket clamshell was used to perform the removal. It was stated that no additional precautions regarding resuspension were needed because of the sheet pile containment. Sediment was loaded onto a scow and allowed to drain in the scow. The scow was then tugged to the edge of the sheet piling, where sediment was loaded into another scow located on the outside of the sheet piling. Sediment was then tugged downstream to a CDF or an on-site landfill. The dredging was slated for completion in nine months, but the work was completed ahead of schedule.

4.7.4 Restoration

The area was backfilled following dredging. A clamshell bucket was used, and the material was dropped from the bucket above the water. Backfilling was performed while the sheet piling was still in place. Lastly, no specific bank stabilization was conducted. Backfill was placed at all locations to return the river to its pre-dredge grades, and wetlands were restored along the banks in two areas. Planting was done from the water since shore access was difficult. It was indicated that no specialty equipment was used to dredge or restore the two wetland areas.

4.7.5 Resuspension Monitoring

Turbidity monitoring was performed upstream and downstream of the sheet piling for each of the three areas during dredging, but no monitoring was done within the area. In addition, no post-dredge sampling was done to verify that metals contamination was reduced to acceptable state standards. It was indicated that extensive sampling was done to classify the area prior to dredging so the exact vertical and horizontal limits were known. It was felt that as long as the depth of the cut was accurate, all contaminated material had been removed.

4.8 Bayou Bonofoucia, Louisiana

Bayou Bonofoucia was the site of a creosote works that operated from 1892 to 1970. The principal contaminants of concern were PAHs, and the contaminated media were soils, sediments, and groundwater. Included within the final remedial strategy was the dredging of approximately 170,000 cyds of contaminated sediment and treatment of that material by incineration. Information provided by USEPA suggests that dredging represented less than 20 percent of the total cost of remediation.

Of particular importance is the fact that the sediment removal work was accomplished using a specially configured bucket excavator mounted on a barge. Computer controlled dredging sensors allowed a 3-in dredge tolerance. In addition, since the contaminated sediments were relatively fine grained, multiple containment barriers (turbidity curtains) were employed to reduce migration of the sediments.

4.9 Grand Calumet River, Indiana

4.9.1 Site Location and Description

The Grand Calumet River system originates in eastern Gary, Indiana, and flows approximately 13 miles through Gary, Indiana, East Chicago, and Hammond. Ultimately, the river drains into Lake Michigan via the Indiana Harbor and Ship Canal. Contamination of this river system begins just south of Chicago and continues through the eastern branch of the Grand Calumet River, a small segment of the western branch of the river, and within the Indiana Harbor and Ship Canal. Multiple industries are located on the banks along the entire stretch of the Grand Calumet River. Literature reviewed stated that currently, approximately 90% of the river’s flow originates as municipal and industrial effluent, cooling and process water, and storm water overflows. Approximately five to ten million cyds of contaminated sediment exists in the AOC within the Grand Calumet River. Contaminants consist of PAHs, PCBs, heavy metals, and VOCs. Contaminated sediment exists to depths as great as 20 ft. In addition, shipping capacity within the Grand Calumet River has decreased by 15% as a result of accumulated sediment with the harbor and restrictions on sediment removal.

Remedial dredging within river is being performed by US Steel (USS), since it has been determined that sediment contamination resulted from operations at the Gary Works facility, which occupies a 4,000-acre site along the Grand Calumet River and southern shore of Lake Michigan. Specifically, wastewater discharge containing the contaminants of concern entered the river system from outfalls located at the Gary Works facility. Dredging within the five-mile river section aimed to remove 750,000 cyds of sediments contaminated with PCB, VOCs, PAHs, and metals. Dredged sediment was to be placed into a corrective action management unit (CAMU) for dewatering and disposal that is located on the USS property and constructed in accordance with RCRA Subtitle C requirements (hazardous waste landfill). Earth Tech was the contractor hired to construct the CAMU and coordinate project implementation. All water generated from dredging was to be treated in a waste treatment plant and ultimately discharged back to the river.

4.9.2 Site Characteristics

The five-mile stretch of contaminated sediment has been divided into 36 transects. Transects 1 through 11 are located in front of the USS facility, where the highest concentrations of PCBs and benzene have been detected. Approximately 164,000 cy of sediments will be removed from those 11 transects, which contain the greatest mass of RCRA- and TSCA-regulated material. In addition, Transect 17, Horizon 1, contains an additional 11,000 cyds of TSCA-regulated sediment. Approximately 95 percent of the organic contamination exists within this stretch of the river.

4.9.3 Remedial Action

As a result of a 1993 sediment characterization study performed within the Grand Calumet River by USS, followed by submission of a scope of work that described work items to be performed to clean up the contamination, the USEPA issued a consent decree in 1998 in conjunction with a RCRA Corrective Action Order stating that contaminated sediment must be removed from the river. The RCRA order also requires that USS conduct a facility-wide corrective action program to investigate soil, sediments, surface water, and groundwater at Gary Works and take appropriate action for releases, which may pose a risk to people and other ecological receptors.

Dredging began in December 2002. Dredging cut lines were established to a maximum depth of 16 ft. J.F. Brennan is the dredging contractor hired to perform this work. It was expected that dredging would be performed using 8-in and 12-in hydraulic swinging ladder dredges. The 8-in dredge has a draft of approximately 2 to 2.5 ft and a working reach of 45 ft at an angle of 30 degrees. An amphibious excavator would also be used to assist in the removal of sediment in shallow river sections, in and around structures, and within areas not accessible by the large swinging ladder dredge.

Dredged sediment/slurry was to be transported via double lined HDPE 12-in pipelines and accompanying booster pumps to the CAMU. Booster pumps enclosed with engineered mufflers would be used to reduce noise levels and impacts on the surrounding community. It was noted that expected noise levels from the dredging operation were in the range of 45-55 dBA. Dredging pipelines were to be positioned in the water along the banks of the river. The dredging operation was to be performed 24 hours per day, six to seven days per week, with an expected completion date of December 2003.

The on-site CAMU, covering 36 acres, is capable of accepting approximately 12,000 cyds of sediment per day. The PCB-contaminated sediment (approximately 125,000 cy) was to be dewatered within a discrete disposal cell, and the resulting wastewater was to be pumped to the water treatment plant and subsequently treated. Dredge slurry that does not contain PCB-contaminated sediment would be directed into a separate cell within the CAMU and subsequently dewatered.

Two separate water treatment plants were designed for the treatment of site-generated wastewater from the dredging operation. The first system, a 160-gpm plant, was designed to treat PCB-contaminated wastewater through the use of a clarifier followed by activated carbon. Following confirmation of PCB removal from the wastewater, the water would be conveyed to terminal lagoons and ultimately discharged into the river in accordance with a project NPDES permit.

The second treatment plant, a 5,000-gallon-per-minute (gpm) plant, was designed to handle wastewater with metals contamination. This system was designed with a chemically assisted clarifier. It was noted that treatability studies were performed for both waste streams to determine proper treatment and contaminant removal. It should be noted that sampling was conducted within 36 transects to determine the extent and type of contamination (PCBs, VOCs, semi-volatile organic compounds (SVOCs), and metals) so that the dredge slurry could be directed into the correct CAMU unit/cell and treatment plant.

Dredging of the most contaminated area, within transects 1 through 11, was divided into three isolation cells (A, B, and C). Dredging in these three cells constitutes approximately 1.5 miles and was to be contained within cofferdams. Within each cell, oil booms and an oil control fence were to be employed to protect water quality. The river was to be bypassed around the isolation cell being dredged. The remainder of the river to be dredged, approximately 3.5 miles contained within transects 12 through 36, was to be dredged in open water without isolation cells. For open water dredging, two three-element water quality control systems would be used. Each system consists of a floating trash boom, a floating oil fence, and a silt curtain. Dredging would be completed to depths consistent with non-native material plus a 6-in overcut to ensure complete removal of contaminants.

Dredging was to be performed up to and including the banks of the river. To minimize impacts associated with dredging along the shoreline, USS modified the dredge plan so that dredging of river banks would be conducted just below the water level to 6 in above the water level, following which native seed will be hydro-seeded onto these steeper slope areas to aid in re-vegetation. A few select areas would require the dredging severely steep slopes. For these areas, studies concluded that bank stabilization must be completed prior to dredging. A bank stabilization cost analysis indicated that the cost of bank stabilization in such areas would be more than the actual dredging operation.

An interesting facet of this issue is that a model was developed to determine a safety factor for the slope along the river. The output of this model helps to identify areas where the bank slopes are too steep and would require predredging stabilization. Stabilization measures in the form of sheet pile installation and partial bank grading were to be completed prior to dredging.

4.9.4 Residual Verification Activities

The performance standards for this project include removal of all non-native sediment (plus about 6 in of over-dredging) and removal of "hot spot" areas containing PCBs at concentrations greater than 50 ppm. Achievement of project objectives would be demonstrated by comparing pre- and post-dredging surveys and analytical sampling for PCBs at specific locations in the river. Pre-dredge surveys were conducted at 100-ft intervals along the river length. Elevation measurements of the top and bottom of the non-native sediments were obtained at each cross section at 10-ft intervals across the river. Post-dredge surveys were to be performed in a similar manner.

PCB confirmation sampling was to be completed in transects 1 through11 and transects 20, 32, and 34. In isolation cell A, four linear transects were established at 400-ft intervals with three equally spaced sampling points along each linear transect. In isolation cell B, transects are spaced every 500 ft and in cell C, every 600 ft. If it was found that sediment containing greater than 50 ppm PCBs was still present, exceedance locations would be redredged and the area resampled until concentrations reached levels less than 50 ppm. It was stated that post-dredge monitoring would be conducted to document the increase in the health of river as a result of dredging. Specific details were not provided.

4.9.5 Restoration

Approximately 14 acres of wetlands would be impacted by the dredging work, and USS was to mitigate approximately 32 acres of dune and swale to compensate for this impact. In addition, the compensatory areas would be transferred in ownership to the National Park Service. In the long run, USS expected vegetation to return to the impacted wetland areas following completion of dredging activities. It was not expected that backfill would be placed over the dredged area upon completion of the dredging work.

4.9.6 Air Monitoring

An air quality monitoring plan for air emissions and odors was prepared and approved to support and respond to public concern regarding air quality during dredging. USS expected minimal potential for generation of air emissions and odors as a result of dredging because the dredged sediment would be contained in within pipes and not exposed to air during dredging and conveyance to the CAMU. Risk-based notification and action levels were developed for 22 chemicals (benzene, toluene, xylene, ethylbenzene, PAHs, and PCBs) with guidance from the USEPA. It was further stated that the *Air Monitoring and Operation Plan* was based on a study of air emissions calculations, sediment characterizations, and a field test that simulated dredging conditions and in-river sediment transport.

This plan was developed for two emission sources, one within the river at the dredge site and a second at the CAMU. It was concluded that emissions would not be present during sediment transport since transport was to occur via closed pipelines. USS utilized conservative inputs into the analyses to provide the highest level of protection to human health and the environment. More specifically, USS assumed that the highest projected exposure would occur over 24 hours. It was also noted that exposure levels are typically greatest during the summer months, when the heat causes emissions to be located closer to the surface.

Analytical results indicated there would be no unacceptable risk from project-generated emissions.

The analysis was performed for three types of receptors: residents, off-site industrial workers, and on-site project workers. For each of these situations, the model was applied assuming maximum exposure limits for a child with conservative estimates of frequency and exposure (24 hours per day, 365 days/year for two years). Results of this analysis indicated that there would be no unacceptable risk from project-generated emissions.

According to the monitoring plan, three stations would be situated around the CAMU, and one mobile station that would be repositioned in the river as dredging progressed. Air samples would be collected continuously over a 24-hour period at each of these stations, along with meteorological data to determine daily dispersion patterns of emissions. Grab samples would also be collected at the residential area near the CAMU. Sampling was planned for all five stages of the project:

- Baseline sampling prior to dredging
- At the initial stage of the project
- During dredging within each containment cell (A, B, C) within transects 1 through 11
- During dredging in transects 12 through 36
- At the close of the project

Sampling frequency would vary with each stage, with a greater frequency of monitoring events at initial stages of the project.

Air constituent standards were set based on notification levels (most conservative risk levels), and action levels were set based on the upper bound of risk-based concentrations of (five times the notification levels). In the event of a notification level exceedance, USS is required to contact USEPA. In the event of an action level exceedance, USS was required to notify USEPA, investigate the cause of the exceedance, and propose a remedy/contingency action to be put into effect.

In addition to emissions from dredging, the public questioned potential emissions from the diesel-driven booster pumps. It was stated by USS that emissions from six to eight booster pumps would be minimal since numerous diesel trucks already operate at the USS Gary Work facility. No air quality issue existed with the diesel truck operation, and the pumps, by comparison, are much smaller than the trucks, and.

Another component of the air monitoring plan included assessment and monitoring of project-generated odors that may result from dredging and/or landside activities at the CAMU. This assessment was based on the dispersion model developed for site emissions and was conducted by collecting samples of odor emissions from field tests. The assessment concluded that odors would not be a problem for residents near the CAMU nor at the location of active dredging. Odors have not appeared to be a problem at the dredge; however odors have been sporadically noted from the CAMU. It was further stated that contact numbers would be provided to residents for use in the event that a nuisance odor is detected.

Air monitoring showed that average concentrations of all constituents at the CAMU were below established action levels.

Air monitoring results have been closely tracked since dredging began in December 2002 and showed that average concentrations of all constituents at the CAMU are below the established action levels. Average concentrations of benzene and naphthalene at the CAMU do exceed the notification level. From mid-May to mid-July, 2003, monitoring results showed several exceedances of the action level for benzene and naphthalene. In response, the monitoring frequency was increased and USS completed several measures to address the exceedances. These measures included constructing a covered device around the sediment discharge at the CAMU to contain any floating oils and adding powdered activated carbon to the CAMU. It is anticipated that maintenance doses of activated carbon will continue to be added to the CAMU during dredging of transects 1 through 11.

4.9.7 Resuspension Monitoring

The Section 401 *Water Quality Certification Work Plan* was reviewed for details regarding water quality background studies conducted prior to dredging, water quality action levels, and the water quality contingency plan in the event that monitoring indicated an adverse impact to the Grand Calumet River during dredging operations.

It was indicated that the Indiana Department of Environmental Management (IDEM) stated that water quality samples (a minimum of 20) for chemical and biological analyses could be collected prior to the initiation of dredging to provide background water quality data to be used as benchmarks for comparing analytical results collected during dredging operations. However, USS proposed that an additional water quality station situated upstream of dredging be utilized as a verification/confirmation sampling station during dredging. In the event that water quality sampling indicates an exceedance of the water quality criteria, this station would be used to collect an additional sample to determine if the exceedance is a result of the dredging operation. Locations of the water quality sampling sites are shown on Figure 4-11.

Three water quality monitoring locations are defined as the primary monitoring sites. The first location, Site A, was located mid-channel in the river at Transect 4 and was re-located to Transect 2 as dredging progressed from cell A to cell B (so that it would continue to monitor water quality upstream of the dredging operation). The second station, Site B, is also located mid-channel approximately 200 yards downstream of the open water dredge. Site B will be relocated with the dredge as dredging progresses through transects 12 through 36. The third station, Site C, is the downstream sample site and is located mid-channel and downstream of Transect 36 (downstream of the limit of dredging).

A fourth sample location, Site D, proposed in lieu of background sampling prior to dredging and also known as the verification sample site, was planned for 200 yards upstream of the open water dredge in Transects 12 to 36 and would be used to verify/confirm water quality exceedances and determine whether the exceedance was a result of dredging or originated from a different point source. All water samples are equal volume composites created from a total of three samples per location. These three samples per location are taken from the water surface, at 50 % of the water depth, and at 80 % of the water depth.

Three types of water quality programs were established, Level 1 Monitoring, Level 2 Monitoring, and Level 3 Monitoring, discussed in the following subsections.

4.9.7.1 Level 1 Monitoring

Level 1 Monitoring consisted of daily measurement of flow rates, dissolved oxygen (DO), TOC, total ammonia, specific conductance, pH, sulfides, temperature, and turbidity. A multi-parameter monitoring system equipped with an automatic data logger is used to measure DO, pH, temperature, turbidity, and specific conductance. Data for these parameters will be collected four times per day and reported to the IDEM and USEPA for each 24-hour period.

4.9.7.2 Level 2 Monitoring

Level 2 Monitoring consisted of integrated biological and chemical monitoring using Microtox to determine both chronic and acute toxicity to biological organisms. Microtox is a toxicity measurement technique that involves the measurement of the amount of light given off by a luminescent test organism. Toxicity is defined as the statistical difference between Site A and Site C sampling results for the mean EC50 (DEFINE), based on a 95% confidence interval of the respective mean. Level 2 Monitoring was initiated two weeks prior to dredging activities to allow for calibration and to establish a statistical variability.

Composite samples were to be collected once every other dredging day from Sites A, B, and C and analyzed for acute toxicity using standard test D5660-95 (test method for assessing the microbial detoxification of chemically contaminated water and soil using a toxicity test with a luminescent marine bacterium) immediately following sample collection. If acute toxicity were determined in these samples, then confirmatory biological sampling for acute toxicity would be done.

The confirmatory biological sampling consists of collection of additional samples from Sites A, B, C, and D. Confirmatory samples from these locations must be collected within 12 hours of the time that toxicity results were determined from the first round of samples. If toxicity were determined from the confirmation samples (second round of samples collected), then water samples from Sites A, B, and C, collected at the same time the confirmation biological sample was collected, must be analyzed for total ammonia, pH, sulfides, temperature, free cyanide, hardness, oil and grease, TSS, dissolved copper, and dissolved zinc.

If results from the chemical monitoring exceeded set criteria at all sites or did not exceed at all three sites, it would be concluded that dredging is not causing the elevated concentrations and biological sampling from Level 2 will resume its normal frequency (once every other day). If, however, chemical analytical results from the water samples indicated an exceedance at Sites B and C but not at Site A (exceedances downstream of dredge but not upstream), the water sample collected at Site D, the verification location, was to be analyzed for the aforementioned chemical parameters. If the chemical parameters were also exceeded at Site D, it would be concluded that dredging was not the source and normal frequency sampling (once every other day) will resume. However, if the chemical parameters were not exceeded at Site D, it would be assumed that the exceedances at Sites B and C were resulting from dredging, and enhanced monitoring would be implemented.

Enhanced monitoring was to consist of additional sample collection at a frequency of once per week at Sites A, B, and C for the parameters of concern. When the measured concentration of the parameter of concern could be demonstrated to be less than the criteria/standard for two consecutive samples, the enhanced monitoring would be discontinued and normal frequency sampling (once every dredging day) resumed.

A second aspect of the Level 2 Monitoring Program consisted of chronic toxicity monitoring. Samples for chronic toxicity were to be collected twice per month at Sites A, B, and C and immediately analyzed according to the Microtox Chronic toxicity testing protocol. If toxicity was not determined, sampling and analyses was to continue at a frequency of twice per month. In the event that chronic toxicity was determined, confirmatory biological sampling was to be conducted at Sites A, B, and C. If these samples indicated acute toxicity, then chemical analyses would be conducted on water samples collected at the time the acute toxicity sample was collected and analyzed.

Parameters were the same as those listed above for chronic toxicity chemical monitoring. If results of the chemical monitoring indicated no exceedances at Sites A, B, and C or if exceedances occur at all three of these sites, then it was be concluded that dredging was not the source and normal monitoring consisting of sampling twice per month will resume. If exceedances were detected at Sites B and C but not Site A, then the water sample collected from Site D was to be analyzed. If exceedances were found with this sample, it would be concluded that dredging was not the source and normal monitoring would resume (sample collection twice per month). However, if no exceedances were found at Site D, dredging would be assumed to be the source and enhanced monitoring (previously described) would be carried out at a frequency of one sample per week for chronic toxicity analysis. When results were below the criterion for two consecutive samples, enhanced monitoring would be discontinued.

4.9.7.3 Level 3 Monitoring

Level 3 Monitoring consisted of collecting composite water samples once per month using automatic samplers at Sites A and C and manually at Sites B and D for analysis of the following parameters:

Total ammonia	TSS	Total 2,4-dimethylphenol
pH	Dissolved ammonia	Total fluoranthene
Sulfides	Dissolved copper	Total fluorine
Temperature	Dissolved lead	Total naphthalene
Free cyanide	Total mercury	Total PCBs
Hardness	Dissolved zinc	
Oils and grease	Total acenaphthene	

If results indicated no exceedances at Sites A, B, and C, or exceedances at all three sites (A, B, and C), then it would be concluded that dredging was not the source and normal sampling will resume (once per month). If, however, results indicated exceedances at Sites B and C but not Site A, then the water sample collected at site D would be analyzed. If the sample from Site D indicated the parameters exceeded at Sites B and C was also exceeded at Site D, it would be assumed that the downstream exceedances at these sites were not a result of dredging and normal frequency sampling would resume.

However, if no exceedances were found at Site D, it would be concluded that dredging was the source and enhanced monitoring, consisting of additional sample collection at Sites A, B, and C, would be implemented at a rate of three times per week. When results indicated that the parameters of concern were less than the criteria for two months of consecutive samples, enhanced monitoring would be discontinued and normal frequency monitoring would be initiated, once per month.

In addition to increasing the sampling frequencies in response to exceedances determined to be due to dredging, IDEM and the USACOE would implement a response action. If it was thought that an immediate threat to human health or aquatic life existed, the required response action would be issued within 72 hours and the USS would be expected to place this action into effect as quickly as possible (with a maximum time to implementation of one week). If the USS did not meet this schedule, enhanced monitoring would be automatically implemented as previously described, based on the parameters exceeded and the level of monitoring under which the exceedance occurred. Possible response actions could consist of the following engineering contingencies:

- Decrease dredging operation.
- Install additional turbidity barriers or control mechanisms.
- Temporary suspension of dredging activities.
- Conduct additional monitoring.

4.9.8 Results and Conclusions

Dredging began in December 2002 and was expected to end by December 2003. All project data and dredging progress was to have been posted on the USS web site under the Gary Works facility web page and the subdirectory "RCRA Correction Action." Project information was supplied to the community through bi-monthly public meetings and fact sheets that were mailed to about 2,000 people.

4.10 Outboard Marine, Waukegan, Illinois

4.10.1 Site Location and Description

This site is located on the west shore of Lake Michigan. Historically, a marine products manufacturer discharged PCB-laden hydraulic fluids into the harbor area. An estimated 700,000 pounds of PCBs were released on site, and an additional 300,000 pounds into Waukegan Harbor. Navigational dredging within the harbor had been severely hampered by the presence of highly contaminated sediments. The most contaminated sediment existed within ship slip No. 3 at the Outboard Marine facility.

USEPA's 1989 ROD called for the isolation of Slip No. 3 from the harbor area and subsequent removal and treatment of sediments with PCB concentrations in excess of 500 ppm. The slip was then to be converted into an isolated containment structure where the treated sediment and less-contaminated harbor sediments located outside of this slip would be placed following removal. Ultimately, the slip would be capped.

4.10.2 Remedial Action

Approximately 23,000 cyds of sediments were removed from the isolated slip and processed by thermal desorption. In addition, approximately 27,000 cyds of contaminated sediment were removed from other areas in the harbor by means of a hydraulic cutter head dredge and were placed into Slip No. 3, which was designed to act as a containment cell. Dredging was conducted during 1991 and 1992. A cut-off wall (i.e., a physical structure) was placed at Slip No. 3 to isolate it from the harbor area.

Within the harbor area, bottom-anchored silt curtains were installed to control resuspension; however, the silt curtains required repair on multiple occasions due to high winds and currents. Literature reviewed also noted that following dredging activities within the harbor, a coagulant was added to aid in the settling of any resuspended sediment. It was indicated that this polymer was added via the dredge discharge line to the harbor area.

Sediments containing PCB concentrations in excess of 500 ppm were removed from Slip No. 3 and the area was then capped with clean sand. Sediments removed from the slip were thermally desorbed and placed back into the slip above the sand cap. In addition, sediment removed from the harbor was also placed into this isolated slip. It was noted that harbor sediments were not thermally desorbed prior to placement in the slip. It was stated that all sediment placed into Slip No. 3 required three years to settle.

The USEPA's remedial action and target cleanup goal for the harbor area was removal of contaminated sediment, treatment via thermal desorption of all contaminated sediments to a concentration of 50 ppm PCBs, and containment/final disposal of all excavated sediment in Slip No. 3. The target clean up goal of 50 ppm PCB was derived from a site-specific modeling analysis which showed that below a 50 ppm residual sediment level, little additional PCB contamination would be discharged to Lake Michigan.

The USEPA estimated that approximately 900 kg of PCBs remained in the harbor sediments following the cleanup. Since it is now thought that these residual sediments are potentially being resuspended by navigational activity, an effort is underway to investigate and resolve this problem, if necessary.

4.10.3 Residual Verification Activities

> *Post-dredge confirmation samples revealed PCB concentrations between 3 ppm to 9 ppm PCBs, well under the target of 50 ppm.*

The contract documents for the harbor dredging specified that removal would be completed to a stated post-dredge elevation or to a designated soil type. This approach was expected to achieve the less than 50 ppm target PCB concentration. Post-dredge confirmation samples collected by USEPA revealed PCB concentrations ranging between 3 ppm to 9 ppm PCBs.

It was also reported that harbor bottom sediment samples collected in 1996 showed PCB levels less than the targeted level of 50 ppm. The samples also indicated the presence of heavy metals, which were not considered in the ROD.

4.10.4 Resuspension Monitoring

Turbidity was measured daily during dredging activities. Measurements were collected at depths of 10 and 20 ft from the water surface. All measurements were below the turbidity action limits. The turbidity action limit was not indicated in the documents reviewed.

4.10.5 Results and Conclusions

Additional dredging funded by the City of Waukegan and the USACE is planned for 2002. The goal is to remove PCB contamination and restore adequate navigation depths for commercial shipping within Waukegan Harbor.

4.11 Waukegan Harbor, Illinois

4.11.1 Site Location and Description

This AOC is located on the west shore of Lake Michigan. The harbor area is contaminated as a result of historic activities at the Outboard Marine site, which was discussed in the previous case study narrative. Remedial activities included the removal of 453,600 kg (1 million pounds or greater than 494 tons) of PCBs from the site. Three other point sources of contamination at Waukegan Harbor consisted of land-side industries/facilities that underwent remediation at the same time as the Outboard Marine facility, but the cleanups are not yet complete. The ongoing remedial activities consist of removal of storage tanks containing paint solvents and flammable solids and excavation of asbestos-contaminated soils over an area of 24 hectares.

4.11.2 Remedial Action

Monitoring has shown a decline in PCB concentrations in fish tissue.

Since 1992 when dredging was completed, environmental sampling has been conducted in Waukegan harbor to monitor the decline in contaminants. This monitoring has shown a decline in PCB concentrations in fish tissue, specifically in carp, where results indicate a decline from 5.2 ppm in 1993 (57 samples) to 3.2 ppm in October 2000 (19 samples).

4.11.3 Results/Conclusions

Samples from USACE navigational dredging indicate that dredged sand is suitable for beach replenishment.

The USACE resumed navigational dredging in the harbor area in 1998, which includes the removal of 40-50,000 cyds of sand annually from the shipping channel. Samples collected from this material indicated that the dredged sand is suitable for beach replenishment projects. Thus, it has been concluded that dredging of the Outboard Marine site was successful in cleaning up the Waukegan Harbor area.

4.12 Ashtabula River, Ohio

This area of concern consists of a two-mile stretch of river extending to the Ashtabula harbor area and adjacent Lake Erie near shore. This area is contaminated with PCBs, heavy metals, and organic compounds. Studies have determined that there has been degradation in the fish population, fish and bird deformities and tumors have been detected, navigational dredging has been restricted, and fish consumption advisories have been issued. As a result, the Ashtabula River Foundation, in conjunction with the Ohio EPA, has been promoting plans to dredge the river. The web site is current for this site up to the year 2000. Additional information is being obtained from the USEPA project manager.

4.13 Black River, Ohio

4.13.1 Site Location and Description

The Black River is located in north central Ohio. The east and west branches of the river join to form the main channel, which extends for 16 miles northward and ultimately discharges into Lake Erie. This river is one of the Great Lakes AOCs, and is the only area of concern that encompasses an entire watershed. Along the banks of the main channel, USS/KOBE Steel operated a coking facility that accounted for the largest industrial discharge of wastewater (greater than 1 million gallons per day or 1 MGD) into the Black River until 1982. The USEPA determined USS/KOBE Steel to be the main source of PAH and metal contamination within the Black River.

4.13.2 Site Characteristics

Sediments within the area of concern consisted of a fine material comprised of clays and silt with sand over an underlying layer of "hard bottom" or shale bedrock. It was determined that all sediment contamination existed within the top layer and that the hard shale material was uncontaminated.

4.13.3 Remedial Action

The final remedy selected for the site consisted of the removal of PAH- and metal-contaminated sediment from the Black River within the vicinity of the USS/KOBE steel facility. Mechanical dredging was conducted in 1989, and ultimately 45,000 cyds of contaminated sediment were removed and placed in a CDF on the USS/KOBE Steel property. An average dredge cut of 6 ft was completed over the 1-mile stretch of

contaminated area. It was noted that the river was approximately 500 ft wide, and that no other river traffic was present during dredging. Removal was conducted using a clamshell bucket. The clamshell bucket was customized with a lid constructed of a thick rubber mat to prevent leakage while the bucket was brought up through the water column.
An oil boom was deployed in the vicinity of dredging to prevent the spread of oil in the event of an oil spill. No turbidity barriers were used to control resuspension during dredging. Dredging was conducted in open water at all locations. Literature reviewed for this site also stated that a contingency plan, in the event of a spill, was defined, and that environmental monitoring was conducted prior to, during, and following dredging; however, no specific details with regard to the contingency plan and environmental monitoring conducted have been obtained to date (October, 2003).

The major difficulty encountered during implementation of the remedial action was the transportation of contaminated sediments to the shore-side processing facility. Alternative materials handling methods were attempted, including rolling containers off barges using a ramp leading to the shore, as well as the unloading of barges using a shore-based bucket unloader. Ultimately, seven barges were welded together and large dump trucks were driven onto the barges and secured in place. The barges were towed to the dredge site, where the dump trucks were direct loaded. Once all of the dump trucks were loaded, the barge was towed back to the land-side access area. Each truck was then driven off the barge, onto land, and unloaded into the on-site landfill.

Dewatering of sediments prior to dumping was not conducted. The dredge spoils were directly placed into the on-site landfill, which was constructed with geomembrane liners and French drains to direct collected water to a pump station, where the water was then conveyed to the onsite water treatment process. It was reported that treated water was clearer than potable drinking water.

4.13.4 Residual Verification Activities

Target clean up goals stated that sediment was to be removed at all locations to the “hard bottom” (shale bedrock). There was no specific quantitative residual goal set for this project; however, post-dredging sediment sampling was conducted to verify that elevated PAH concentrations were remediated during dredging activities.

Data provided in the literature reviewed indicated that predredge PAH concentrations ranged from 8.8 to 52.0 mg/kg and two years after dredging (1992), sediment PAH concentrations ranged from 1.6 to 3.7 mg/kg.

Since removal of the contaminated sediment in 1989, the Black River has become part of the RAP/RAC group under the Great Lakes AOC Projects. The Black River RAP has been assessing the health of the river since dredging was completed. In addition, the RAP identifies other pathways of river contamination such as combined sewer overflows and sanitary sewer line leakages. The Black River RAP performs benthic and fish surveys, sediment sampling, watershed analyses, water quality monitoring, and overall beneficial use river assessments.

Beginning in the fall of 1997, a team composed of Wright State University (WSU), Dr. Paul Bauman of the USGS, Ohio EPA, USEPA Great Lakes National Program Office, and the RAP group undertook a one-year study of sediment, benthic organisms, and overlying water. Approximately 12 sampling locations were selected within the lower reach of the Black River, at the confluence of the east and west branches of the Black River, and at its mouth at Lake Erie. The goal was to evaluate whether dredging improved the quality of the Black River and to assess whether improvements to the river system merit beneficial use de-listing.

Analytical results of the sampling conducted over a five-mile stretch of the lower Black River were compared to upstream reference stations. It was noted that the USACE routinely performs maintenance dredging within the channel, from the mouth of the Black River up to River Mile 2.5 at the turning basin. All sediment sampling locations were situated near the riverbanks, where depositional sediments are located, and outside of the USACE dredging areas. Surficial and deeper sediments were analyzed to assess contamination gradients in the River. Benthic sampling included both laboratory and field exposures for four aquatic species (fathead minnow, water flea, amphipod, and midge).

Sediment samples were collected from a minimum of 12 locations within a five-mile AOC. A Ponar dredge was used to collect samples from depths of 0-2 centimeters (cm) and 8-10 cm. The samples were collected in October 1997. At the same time, a sediment core sample was collected from each location. The upper 2 cm of the core were analyzed for PAHs, while the remainder of the core was frozen for potential future analysis.

Sediment sampling results indicated a greater toxicity in the historic/deeper sediments. It is also thought that these deeper sediments may be exposed during resuspension events resulting from storms and associated high flow conditions, boat traffic, and channel maintenance dredging. It was concluded, however, that the sediments do not contain elevated levels of PAHs and that the remedial dredging from 1989 to 1990 was effective.

4.13.5 Results/Conclusions

Bio-monitoring within the Black River following dredging indicated that fishery impacts increased immediately after dredging but then dramatically diminished as the full benefit of remediation took effect. USEPA Region 5 indicated that the sediment removal project has been considered a success because the incidence of liver tumors in brown bullhead continues to be low. Additionally, as stated above, sampling conducted in 1997 indicated that the river and its biota are healthier and do not contain elevated levels of PAHs as they did prior to dredging in 1989.

4.14 Manistique River, Michigan

4.14.1 Site Location and Description

The Manistique River and Harbor are located in Manistique, Michigan on the southern shore of Michigan's upper peninsula and its outlet into Lake Michigan. Historically, the Manistique River and Harbor were used to export lumber from numerous sawmills located along the river's banks and a dam was installed approximately 1.4 miles upstream of Lake Michigan to support a hydroelectric facility. These industries have been determined to be the source of the contamination in the river and harbor. Investigations of both the sediment and biota detected PCBs at harmful levels. Studies determined that Aroclor 1248 and Aroclor 1254 represent more than 90% of the PCB contamination. The AOC includes a 1.7 mile stretch of waterway extending from the power station dam to Lake Michigan. This area has been divided into two hot spots in the river and one large hot spot in the harbor area before it enters Lake Michigan. The harbor area contains the largest amount of PCB contamination, with the majority of sediment in this area containing PCB-concentrations greater than 50 ppm.

4.14.2 Site Characteristics

Predredging sediment sampling and characterization activities indicated that PCB concentration increased with sediment depth. Sediment cores collected were divided into the following segments: 0-3 in, 3-24 in, and greater than 24 in. Analytical studies indicated that the average PCB concentration in the top 3 in was 16.5 ppm, 77.5 ppm in the 3-to-24-in interval, and almost 200 ppm at depths greater than 24 in, with an overall average PCB concentration of 85.5 ppm. The average thickness of sediment was measured to be 3 ft. In addition, predesign sampling revealed large amounts of wood chips and sawdust embedded in the sediment from past lumber and paper mill operations.

4.14.3 Remedial Action

The pilot program demonstrated that resuspension into the river was highly unlikely.

The USEPA, after initially planning to cap all PCB-contaminated areas with the exception of a single hot spot in the Manistique River and Harbor area and as a result of a pilot dredging study conducted in 1995 when the remedial action was first implemented, decided to dredge the entire AOC. The pilot dredging study was conducted over a three-month period and resulted in the removal of 10,000 cyds of contaminated sediment. This study concluded that dredging costs are comparable to capping costs and that dredging would minimize the long-term environmental risks and financial liability to the PRPs and the community. In addition, the pilot program demonstrated that resuspension into the river was highly unlikely. However, it was concluded that silt barriers would be sufficient to contain resuspended sediment, if necessary.

Dredging activities occurred August through November 1995. A cofferdam and silt barriers with floating booms were placed around the perimeter of the dredge area to aid in the control of resuspension. Debris present in the area being dredged was removed prior to dredging. A hydraulic cutter head dredge was used with twin suction pumps and a modified head. It was concluded that no resuspension of sediment occurred while the hydraulic dredge operated. Project personnel confirmed this by visual observation and surface water monitoring and analysis.

Following the 1995 work, dredging was conducted from 1996 through 1999, during the period of May through October. Approximately 15,000 cyds of sediment were removed in 1996, 62,000 cyds in 1997, 31,000 cyds in 1998, and 25,050 cyds in 1999. Similar to the pilot dredging project in 1995, a hydraulic cutter head dredge equipped with a dual pump system and a 10-in vortex pump was used. The dredge was 13.5 ft wide and was moved via cables anchored to two spud barges. The dual pump system was utilized to minimize dredge downtime and to prevent backwash of the pump lines in the event of a clog in the pump line or pump shutdown.

The dredge operated at 8,000 gallons per minute and generated a solids content of 5.5%. Diver-assisted dredging was also utilized, employing a suction pump to aid in the removal of residual sediment areas and furrows that remained after removal operations to the required dredge depth. It was indicated that a single diver would guide the suction hose over the mounded material to ensure accurate removal of residuals.

The sediment slurry was conveyed from the dredge into two hopper barges that were double hulled, positioned in tandem so that the first barge received the dredge slurry and the second received the overflow water pumped out of the first barge. Once full, each barge was tugged to the sediment-slurry processing area located on the upstream shore. Water and sediment was pumped into a water treatment system designed to capture solids via settling and hydrocyclones, while the water retained during dredging was treated, sampled, and then discharged back into the Manistique River.

Containment utilized from 1996 to 1999 consisted of a silt curtain positioned on the downstream edge of the downstream barge. Buoys were used to keep the top of the curtain afloat with a two-foot gap between the top of the curtain and the buoys. Weights were placed on the bottom edge of the silt curtain to keep it positioned near the river bottom. The curtain was not anchored to the river bottom so that it could rise and fall with the current. It was noted that the curtain was not placed along the mouth of the harbor so as to not restrict river traffic. In addition, project literature stated that a more extensive containment system was not employed due to the design of the dredge and pump system. The dredge was built with high torque blades capable of cutting through debris (such as wood) and equipped with a short pumping head to maintain maximum vacuum during dredging. In addition, sealing of the pumps and the dual pump design prevented complications and spills in the event of pump failure.

4.14.4 Residual Verification Activities

Project specifications indicated that all PCB-contaminated sediment must be removed to a level of 10 ppm or less. Post-dredge confirmation sampling was conducted to verify that this goal was achieved. In cases where sediment contained greater than 10 ppm of PCBs, diver-assisted dredging, as previously described, was implemented to remove residuals and furrows in the hot area. A summary of post-dredge sediment data collected after the 1997 dredging activities stated that ten sediment samples were collected. The mean and median PCB concentrations from these ten samples were 18.1 ppm and 7.2 ppm, respectively.

Since 1995, the Field Environmental Decision Support (FIELDS) team has been assisting with fieldwork and technical analyses of the dredging project on the Manistique River. The FIELDS team consists of USEPA Region 5 employees and research associates centered in the USEPA Region 5 Superfund division. This team assists with sediment characterization, including sampling plan designs, bathymetric surveys, and PCB contamination analyses. With regard to the Manistique River, the FIELDS team developed sampling plans to determine the extent and degree of PCB contamination.

The most recent residuals sampling plan designed by the FIELDS team for the Manistique River included 400 sample locations in the river and harbor area. The samples were collected along an unaligned grid designed to verify that the site-wide average concentration of PCBs was less than or equal to 10 ppm throughout the sediment column. Sampling at these 400 locations indicated that the site cleanup goal was achieved by dredging. The average site-wide PCB concentration was determined to be 7.06 ppm. Further, the 95% confidence interval for this value ranged from 4.40 to 9.72 ppm. Thus, there is 95% confidence that the mean PCB value in the Manistique River and harbor is between 4.40 ppm and 9.72 ppm PCBs. It should be noted that this data is representative of the top 12 in of sediment.

4.14.5 Resuspension Monitoring

Water quality was sampled prior to dredging to establish a baseline for comparison both during and after implementation of the remedial action. Prior to dredging, four water sampling studies were conducted during the period from 1980 to 1994. In 1980, the average PCB water concentration was determined to be 23.9 ng/L; however, between 1990 and 1992, PCB concentrations in the water column were determined to be non-detect. Finally, during the period 1993 to 1994, the average PCB water column concentration was recorded as 1 ng/L.

Monitoring during dredging included the measurement of both turbidity and PCB concentrations. Project specifications required a suspended solids concentration of less than two times the background turbidity measurement within 50 ft of the dredge head. Literature reviewed indicated that less than two times the background turbidity was achieved within 10 ft of the dredge head; no data were presented to support this statement.

Water quality data was provided for dredging activities completed in 1997 and 1998. Data was compared to a predredge average water column PCB concentration of 0.001 mg/L. During dredging activities in 1997, seven water quality samples were obtained near the dredge within the harbor area, one water quality sample from an upstream/background location, six water quality samples from downstream of the dredging operations, and two river samples outside of the dredge area.
Results indicated that the average PCB concentration of the two river samples collected outside the dredging area was 0.37 mg/L, while the average PCB concentration of the samples collected from locations downstream of the dredge was 0.23 mg/L, including samples that were non-detect. It should be noted that the detection limit was 0.05 mg/L and that the two non-detect samples were assumed to have a concentration of 0.05 mg/L when computing the average concentration. The one background sample collected had a PCB concentration of 0.062 mg/L.

In 1998, 17 water quality samples were collected, 9 upstream of the dredge, and the remainder from locations downstream of the dredge. Analytical results indicated that the average upstream PCB concentration was 0.093 mg/L and the average downstream PCB concentration was 0.066 mg/L. Only one non-detect sample was collected, and was taken at a downstream location.

4.14.6 PCB Loading as a Result of Dredging

The PCB transport from the Manistique Harbor area (during dredging operations in 1997 and 1998) was determined from measured river flow rates and water column PCB concentrations detected during dredging activities. As previously stated, dredging occurred May through October each year or for six months per year. Thus, the transport time was assumed to be 24 hours per day for six months. The dredging-related PCB loss downstream was estimated to be approximately 75.8 kg PCBs in 1997 and approximately 21 kg in 1998.

4.14.7 Post-Dredge Monitoring

The Manistique River is part of the Great Lakes AOC and, as a result, is part of the area-wide remedial action plan that is focused on improving water quality within the entire watershed. The Manistique River system is regularly monitored as part of the efforts to improve its overall quality. This includes monitoring of all benthic organisms, monitoring water quality in beachfront areas, maintaining fish advisories based on fish fillet PCB concentrations, and closure or control of all combined sewer overflows (CSOs) into the river system under the National Pollution Discharge Elimination System (NPDES). The dredging project has helped to increase the quality of the entire system, and the improvements have been demonstrated via the monitoring program findings.

4.14.8 Modeling

The USACE RECOVERY model was employed to predict the temporal responses of surface water to contaminated sediment and to simulate natural recovery of the river system. Input data to the RECOVERY model consists of sediment contaminant concentration data from the sediment mixed-layer and corresponding surface water concentrations. Output data consist of contaminant and water column concentrations over a projected period of time.
For the Manistique River system, a second USACE model employed was the turbidity generating unit (TGU) model. This model projects the amount of suspended mass per unit volume that will result from dredging operations (i.e. resuspension). Typically, values of TGU range from 2 to 50 kg/m3 for various dredges and a variety of sediment bed types. This model assumes that the dredge operates within a specific volume of water and uses a mass balance to estimate the solids concentration in the water column surrounding the dredge, assuming the use of permeable vertical barriers both upstream and downstream of the dredge. This model bases its analysis on the theory that the turbidity barriers will retain all solids while allowing water to pass through the area. The model assumes that the solids must eventually settle out onto the stream body when the system reaches a steady state.

Once output is generated from the TGU model, the Equilibrium Model (EQUIL) is utilized. EQUIL is a chemical release model that determines chemical equilibrium between the particle-bound solid and the water column or aqueous phase. An end result of this model is an estimate of the soluble fraction partitioning from the resuspended solid and the constituent concentration in the dredged suspended sediment that settles to the river bottom.

A combination of these three models was used to simulate the dredging operation at Manistique Harbor. The TGU/EQUIL models were used to predict the dredging-related water column concentration increase and the dredging-related suspended sediment deposit increase (i.e., residual from dredging). The results from the TGU/EQUIL models were set as the starting or boundary condition into the RECOVERY model to simulate the post-dredge sediment and water quality recovery.

Results of the TGU/EQUIL model predicted a PCB water column concentration during dredging of 460 ng/L. In comparison, actual water quality samples collected during dredging detected an average PCB concentration in the water column of 230 ng/L in 1997 and 81 ng/L in 1998, or an overall average for these two dredge seasons of 170 ng/L. With regard to sediment concentrations within the sediment mixed-layer following dredging, the model predicted that sediment PCB concentrations would increase to 30 ppm immediately following dredging. Assuming a natural depositional rate of 1 in per year, the model further predicted a reduction in PCB concentration in the sediment to 10 ppm in the year 2000 (two years after dredging), and to 0.012 ppm by the year 2020 (22 years after dredging).

As indicated previously, the average PCB concentration measured in the sediment following dredging in 1997 was 18.1 ppm, while the average sediment PCB concentration measured in the year 2000 by the FIELDS team, following the completion of all dredging activities, was 7.06 ppm. Thus, it can be concluded that the TGU/EQUIL model overestimated dredging-related resuspension and sediment residual concentrations following dredging activities.

4.14.9 Results/Conclusions

Dredging was completed at the end of 1999. As indicated above, sediment sampling results from the FIELDS team indicated that 10 ppm or less of PCBs is present throughout the entire dredged area. This project is considered a success. Success of the project is believed to be a result of a dredge with site-specific design, operated at low speeds to produce low resuspension. Removal of residuals was successful due to diver-assisted hand operation of a suction dredge to removal furrows and sediment in residual areas. The final report on dredging is currently in the review phase at USEPA Region 5 and is to be finalized and released in the near future.

4.15 Pine River, Michigan

4.15.1 Site Location and Description

The Pine River flows through St. Louis, Michigan and discharges into Lake Michigan. Approximately 260,000 cyds of sediments are contaminated with DDT in this stretch of river. The ROD issued by USEPA on February 15, 1999 supported dredging as a remedy, and indicated that the sediment must be remediated to 5 ppm DDT. This project is under direction of USEPA Region 5 and the MDEQ.

4.15.2 Site Characteristics

Water depth in the section of the river to be dredged ranges from 7 to 10 ft. Historical sediment data are available for the years 1980, 1981, 1996, and 1997.

4.15.3 Remedial Action

The selected remedy for this site was dredging with the use of cofferdams. The cofferdams are required so that the section of the area to be dredged will be dewatered and excavated in the dry. Dredged sediment will be transported to a processing facility, where it will be stabilized with a drying agent prior to off-site transport to a RCRA Class C or Class D landfill. All water captured at the processing site will be treated in an on-site water treatment plant and subsequently discharged back into the Pine River.

USEPA/MDEQ plans to monitor for resuspension during removal and perform post-removal confirmatory sediment sampling. More detailed information was not gathered since removal will be completed in the dry, which is substantially different from the dredging planned for the Upper Hudson River. Removal has not yet commenced on the river system. The work plans are currently being completed.

4.16 Shiawasee River, Michigan

USEPA issues a proposed plan for the Shiawasee River Superfund Site in July 2001. The site includes the former Cast Forge Company property and an eight-mile stretch of the South Branch of the Shiawasee River. The MDEQ completed RI/FS activities for this site. Proposed remediation for the river includes the removal via dredging of PCB-contaminated sediments. PCB concentrations range from 1 ppm to 700 ppm in the hot spot area (covering 1.5 miles of river) and approximately 1 ppm to 22 ppm PCBs over the remaining six miles of contaminated river. In addition, the remedial action will consist of the removal of PCB-contaminated soil in the flood plains, wetlands, and forested areas along the subject eight-mile stretch of river. Proposed residual clean-up levels are 1 ppm PCBs for river sediment. The river width in the section to be remediated ranges from 20 to 45 ft. To date, USEPA has not yet issued a ROD USEPA for this site.

4.17 Kalamazoo River Superfund Site, Michigan

This AOC includes 80 miles of river beginning at the Kalamazoo River's confluence with Portage Creek and extending to Lake Michigan. In addition, the AOC includes three miles of Portage Creek. As of August 2002, USEPA has assumed responsibility for the clean up of this site. Sediment contamination consists of PCBs, which are still entering the river from ongoing point sources (exposed paper wastes along the riverbank). It is expected that the project will be handled on a dam-by-dam basis, and remediation has been divided into two phases. Phase I consists of the Kalamazoo River from Morrow Pond Dam to Lake Allegan, and Phase II consists of the Kalamazoo River from the Lake Allegan Dam to Lake Michigan. USEPA expected to complete the RI/FS and issue a proposed remediation plan by spring/summer 2003, with the ROD to follow by summer/fall 2003.

4.18 Saginaw River, Michigan

4.18.1 Site Location and Description

The Saginaw River/Bay is located in Michigan. Dredging of 345,000 cyds of PCB-contaminated sediment from five hot spots in the lower Saginaw River commenced the week of April 2000. The remedial action goal was to remove approximately 90 percent of the PCBs in the river and bay, with dredging activities to be completed by November 2000. The actual completion date for this project was July 2001, at which time it was reported that approximately 342,433 cyds of PCB contaminated sediment had been removed from the river system.

4.18.2 Remedial Action

Mechanical dredging with a cable arm bucket was used for removal of contaminated sediment. This equipment was selected since it was thought that the cable arm bucket would help to minimize turbidity. A conventional clamshell bucket was also utilized to remove wood debris when encountered. Turbidity and air monitoring were conducted, and no particular problems (exceedances) were reported. Following removal, sediment was transported by hopper barge to a CDF just outside the mouth of the Saginaw River, constructed and managed by the USACE. The dredged material was off-loaded from the barges into dump trucks and subsequently placed within a sub-cell in the northeast quadrant of the CDF. Ultimately, the CDF was capped with cleaner material from the USACE's maintenance dredging activities.

The cable arm bucket was equipped with a modified WINOPS dredge positioning software system to guide the removal of contaminated sediment on the project. The WINOPS system provided the following capabilities:

- Ability to position the crane derrick barge in an X-Y graphic display in real time to any scale with heading in state plane coordinates.
- Provision of an accurate, geodetically oriented image of the bucket footprint and crane boom to the operator during digging operations at a maximum of one-second intervals. This image was located using state plane X-Y coordinates;
- Ability to superimpose bucket targets with individual designations over the derrick image at any scale to assist the operator in placing the bucket over each target for complete coverage.
- Provision of a cross section display depicting the area template and showing the bucket depth with history in real time.
- Logging of pertinent data to allow chronological and graphical replay of the entire job, showing the X-Y-Z position of the bucket at any point.

The WINOPS PC-based dredge software provided the crane operator with a geodetic image of the crane barge, spuds, derrick circle, boom, and bucket and was used with three DGPS receivers to complete derrick positioning and orientation. WINOPS also was used to provide the operator with a precise image and orientation of the bucket during real time dredging operations. In addition, a radial dig pattern (RDP), created by entering the bucket footprint, boom angle, and angular separation between bucket targets, was used. RDPs were developed by superimposing individually numbered bucket targets over the derrick image to give the operator a concise picture of each bucket position. A two-ft side-to-side and set overlap was the required input into the RDP to provide complete coverage of the removal area.

The Saginaw River remediation project did not achieve the production rates required to meet the dredge schedule. Dredging took half a season (4 months) longer then expected, as a result of a combination of factors: the equipment utilized, the overall dredge pattern, metrological conditions, and river vessel traffic. Only one mechanical dredge was deployed in the river and this dredge was used for both debris removal and production dredging.

Productivity attained at the Saginaw River Superfund Site can be computed from project available data and compared/contrasted with productivity estimates for the Hudson River to evaluate if productivity estimates for the Hudson River are reasonable and achievable. By one estimate, the mechanical system employed at the Saginaw River (a conventional crane-mounted clamshell) was able to remove, on average, 981 cy of sediment daily or about 41 cy/hr. Assuming this estimate is accurate, it should be noted that only one dredging unit was employed for all work at this site, both dredging and debris removal. It[EKZ2] is expected that debris removal on the Upper Hudson River will be accomplished by another piece of equipment, so that work by the main dredges will proceed, as much as possible, unimpeded. It is clear from documents reviewed that productivity on the Saginaw River would have been considerably greater if a separate piece of equipment had been dedicated to pulling piles, an operation that did not contribute to sediment removal but did consume time that could have otherwise been used for dredging work (personal communication, William Rito, USACE, Project Manager).

Another inefficiency related to using only a single dredge on the Saginaw River site involved the six different size buckets that were employed (4, 5, 8, and 10 cubic yard conventional buckets and 6 and 16 cubic yard cable arm buckets). Every bucket changeover that occurred (some changes were due to space limitations) required a complete shut down of in-river production. It is assumed that multiple pieces of equipment would be used on the Upper Hudson River, so that loss of a single unit would not result in complete shutdown.

Finally, as mentioned above, the average production rate of the dredge equipment at the Saginaw River was approximately 41 cy/hr. The average removal rate for the Upper Hudson River, based on equipment estimates in the FS report, could be approximately 54.5 cy/hr, which does not vary greatly from the 41 cy/hr rate calculated for the Saginaw River. Considering that only one dredge was employed on the Saginaw River and that this machine was used for both debris removal and production dredging, the production estimates for the Upper Hudson River mechanical dredging equipment are most likely underestimated, and a higher productivity than estimated in the FS could be achieved during implementation of the Upper Hudson remedy.

Information gained from the Saginaw River remediation indicates a higher productivity than estimated in the FS could be achieved during implementation of the Upper Hudson remedy.

4.18.3 Resuspension Monitoring

Turbidity and water quality were closely monitored during dredging. Each of the five targeted areas was fully enclosed with silt curtains extending from the water surface to the river bed where they were anchored, prior to the start of dredging. Three monitoring stations were established for each targeted area. These stations were located halfway between the shoreline and the federal channel limit. One station was located 300 ft upstream from the boundary of the silt curtain in the area being dredged to allow for collection of background turbidity measurements and water samples. The other two stations were located 300 and 600 ft downstream from the downstream boundary of the silt curtain (downstream of the dredging operation).

Turbidity measurements were collected at both downstream stations while water samples for PCBs were collected daily only at the first downstream station (300-ft station). After the first week of dredging, water samples for PCB analysis were collected only when/if the turbidity action level was reached (or at the lead agency's discretion). It was stated in the construction specifications for dredging that if the downstream turbidity measurement exceeded the upstream background turbidity measurement by 50% or more, the contractor was required to cease dredging and introduce corrective procedures.

4.19 Menominee River, Wisconsin

This area of concern consists of a six-mile stretch of river that contains PAH-contaminated sediments. Remediation is currently underway and is being conducted by diverting the river flow to allow excavation of the contaminated sediment in the dry. More detailed information was not obtained since this project is not relevant to the remedial action proposed for the Upper Hudson River, which will not be conducted in the dry.

4.20 Fox River, Wisconsin, Deposit N and O (1998 and 1999), Wisconsin

4.20.1 Site Background and Description

Deposit N is one of 34 PCB hot spots identified along the Fox River. It is a three-acre deposit and is situated in waters that are approximately 8 ft deep, on average. The average PCB concentration of Deposit N is 45 ppm. The objective of the demonstration project was, among other matters, to validate dredging using hydraulic dredging equipment. During the late 1998 work period (work was halted by severe weather conditions), about 4,200 cyds of sediment were removed, containing approximately 100 pounds of PCBs. Work resumed in August of 1999 on Deposit N, and dredging of a second area, Deposit O, was initiated. The total sediment volume removed was 8,190 cyds; 7,160 cyds from Deposit N and 1,030 cyds from Deposit O.

4.20.2 Site Characteristics

Sediments within Deposit N consist of 1% gravel, 54% sand, 27% silt, and 18% clay. Generally, this sediment is classified as a silty clay and sandy loam with 37% solids, on average. The highest PCB concentrations were present in the silty clay; the sandy loam contains a lesser degree of PCB contamination. The sediment depth is 3 ft in most locations, and the sediment overlies fractured bedrock. The average river velocity through Deposit N ranged from 0.09 ft/sec to 0.87 ft/sec, with an average velocity of 0.47 ft/sec at 20% depth and an average velocity of 0.59 ft/sec at 80% depth.

4.20.3 Remedial Action

The sediment was dredged with a hydraulic swinging ladder dredge (Moray Ultra Dredge) and conveyed through an 8-in HDPE double-walled pipeline for a distance of approximately 0.25 mile to the shore-side processing facility. It should be noted that double-casing of the dredge line was not utilized during the 1999 dredge season. Approximately 11,000 cyds of contaminated sediment were present in Deposit N; however, only 65%, or 7,1500 cyds, of sediment was targeted for removal due to the presence of bedrock. As previously stated, a total of 7,149 cyds was removed from Deposit N.

In instances where redredging of contaminated sediment was required, the same dredging equipment was utilized; however, the suction pipe was extended inside the dredge head to decrease the area of the mouth by 15 percent and to increase the dredge head vacuum pressure, which would in turn create a greater suction pressure for removing residual sediment.

Bench scale tests were performed to establish the dewatering system design. The target sediment water content corresponded to a minimum compressive strength of 0.4 tons/ft^2. The dewatering processing train produced a filter cake of 45% solids. Bench scale tests were also conducted to determine sediment resuspension and settling rates. This test was conducted by placing a 1-ft thick aliquot of Deposit N sediment under 5 ft of river water and agitating the system by introducing forced air. Water samples were collected for turbidity and TSS, and sediment settling rates were observed within this system. The results of this study produced the following relationship between turbidity and TSS:

$$y = TSS = (-1.27) + 1.313x$$

where x = turbidity.

This relationship is based on an r^2 value of 0.98. As a result of this relationship, TSS was predicted in the field during dredging based on real-time turbidity measurements.

There were no accidental releases documented from dredging.

During dredging, turbidity from the dredge was controlled with an 80 mil HDPE turbidity barrier. This barrier was installed and fastened to the river bottom with railroad ties and enclosed the perimeter of Deposit N. A silt curtain was then deployed within Deposit N in the vicinity of dredging. For Phase II dredging in Deposit N during 1999, the perimeter turbidity barrier was not used. Instead, a silt curtain was deployed at a distance of 150 ft or less downstream of the dredge. There were no accidental releases documented from dredging.

Phase IV dredging of Deposit O during the period October 15, 1999 through November 3, 1999, located on the opposite bank of the Fox River, occurred 12 hours per day and ultimately removed approximately 1,026 cy of PCB contaminated sediment or 0.4 pounds of PCBs. Two turbidity monitoring stations were used during dredging activities. One station, M-7, was situated upstream of dredging and the second station, M-8, was located downstream of the dredge. This adjunct project indicated that in-river mobilization of dredge equipment to a different target area did not result in a large impact to project productivity and schedule.

4.20.4 Residual Verification Activities

Sediment samples were collected from the Fox River by a certified diving contractor prior to and following dredging. Sampling locations were based on the location of predredge samples and were field-located by surveyors and subsequently marked with a buoy. Divers manually collected sediment core samples to refusal. The samples were segmented and analyzed from 0-4 in, 4-12 in, and 12 in to refusal. Ponar grab samples were used for thinner sediment layers. Sediment samples were analyzed for PCB Aroclors, mercury, TOC, particle size, density, and water content. In addition, 13 randomly selected samples were analyzed for PCB congeners. Results of the Phase I post-dredge sampling is shown in Figure 4-12.

Project specifications did not require either total removal of the sediment or removal to a specific PCB sediment concentration, as these sediments rested on a fractured bedrock surface, preventing a dredge cut into a clean underlying layer. Removal was completed to 3 in over bedrock during Phase I within the west lobe (during 1998 dredging activities) and to 6 in above bedrock during Phase II and Phase III dredging activities within the east lobe (1999 dredging of Deposit N). It should be noted that the west lobe contained the highest PCB concentrations. As a result, it was anticipated that PCB concentrations of the sediment after dredging would be similar to pre-dredge sediment concentrations.

According to the 1998 post-dredge sediment data, collected just prior to dredging in Phase II, the average PCB sediment concentration in Deposit N was 16 ppm PCBs, with a maximum concentration of 160 ppm PCBs. The post-dredge average PCB sediment concentration in Deposit N following completion of Phase II dredging activities was 14 ppm PCBs, with a maximum of 130 ppm PCBs.

4.20.5 Resuspension Monitoring

4.20.5.1 Turbidity

To measure possible sediment resuspension during dredging, turbidity meters were placed in the river and within the water intake stream of Inter Lake Papers. The meters recorded turbidity and produced a digital signal that was transmitted to the onshore treatment site. Throughout the project, turbidity results were generated at 15-minute intervals from the monitoring stations. The average hourly turbidity value was then computed and reported for each station and compared to the hourly allowable turbidity threshold value. It should be noted that the threshold was not stated in the literature reviewed. Turbidity was measured at 50% depth at each monitoring station.

During 1998 dredging operations, turbidity monitoring occurred at six stations, M-1 through M-6. Station M-1 was located upstream of dredging, M-2 on one side of the dredging location, and M-3 downstream of dredging. Station M-4 was located in the intake stream of Inter Lake Papers, and M-5 was located at a post-water treatment location within Inter Lake Papers. Station M-6 was located inside the turbidity containment barrier.

In 1999, slight changes were made to the turbidity monitoring plan. Because the containment curtain was not used, station M-6 was deleted. Similar to the 1998 disposition, stations M-1, M-2, and M-3 were located upstream, side-stream, and downstream, respectively, of the dredge. Station M-4 was located in the intake stream of Inter Lake Papers, and M-5 was located at the post-water treatment location at Inter Lake Papers. Overall in 1998, the river downstream of the dredging site was very similar to the upstream background. In 1999, the river downstream of the dredge had a slightly higher average turbidity reading than values recorded at the upstream stations.

The differences in both years were slight, on the order of 2 to 4 NTUs, and within the range of the turbidity meter accuracy. It was also observed that the range of values, or vertical spread, for data points representing times of dredging and non-dredging were similar, which indicates a natural variability of turbidity in the river. The range of positive and negative values was as wide (spread) when no dredging was occurring as it was when dredging was occurring.

Overall, based on these turbidity data and construction observations, it appears that the contractor was successful in minimizing construction-induced resuspension and off-site loss of sediment. Monitoring performed by the paper mill adjacent to the site, further validates this conclusion, as the mill reported no degradation of water quality in their river water intake at any time during the dredging operation.

4.20.5.2 Water Column Sampling

Water column samples were also collected and analyzed for PCB concentrations during Phase I dredging (1998) and Phase II and III dredging (1999) of Deposit N by Wisconsin Department of Natural Resources (WDNR). Measured values were compared to average predredge PCB water column concentrations. Samples collected during dredging were also compared on a basis of upstream versus downstream of the dredge.

Generally, the average predredge PCB water column concentrations were similar upstream and downstream of Deposit N; both were reported at 15 ng/L. The average predredge PCB concentration for two water samples collected closest to commencement of dredging in 1998 was 4.2 ng/L upstream and 5.0 ng/L downstream of Deposit N.

During dredging in 1998 (Phase I), the upstream average reported PCB water column concentration was 3.2 ng/l compared to the average downstream PCB water column concentration of 11 ng/L. The variation between the upstream PCB water column concentration and the downstream PCB water column concentration measured during dredging reflects an average increase downstream of 3.5 times the upstream value.

Differences between upstream and downstream PCB water column concentrations during dredging indicate that dredging did cause an increase in PCB concentrations.

Similar water column PCB results were obtained during Phase II and III in the 1999 dredge season. For the 1999 dredge period, the average upstream PCB water column concentration was 14 ng/L compared to the average downstream PCB water column concentration of 24 ng/L. This variation represents an increase of 1.7 times the upstream reported value. It can be concluded from this data that dredging caused an increase in PCB concentrations downstream of the dredge site.

4.20.6 PCB Loading as a Result of Dredging

The PCB load resulting from Deposit N dredging operations was computed as a function of the flow rate and the measured PCB water column concentrations discussed previously. The average daily river flow was measured at the USGS Appleton gauging station (#04084445). Daily PCB loads were computed only for days in which PCB water column data was measured/available. The average daily upstream PCB load was computed to be 31 grams/day and the average daily downstream PCB load was computed to be 106 grams/day, representing a net loss of 75 grams/day from the dredge site.

The total PCB load to the river during dredging was computed by multiplying the average daily load by the 30 day Phase I dredging duration (1998 season). This results in an estimate of 2.3 kg of PCBs added to the river as a result of dredging.

A similar computation was performed to determine the PCB load during the 1999 dredge season at Deposit N. The average upstream PCB load was computed to be 59 grams/day and the average downstream PCB load was computed to be 100 grams/day, representing a PCB loss rate from dredging of 41 grams/day. This load was the multiplied by the 45-day dredging duration to estimate that 1.9 kg of PCBs was lost to the river as a result of dredging in 1999.

Dredging of Deposit N resulted in a total PCB load of 4.2 kg of PCBs to the Fox River system.

In summary, dredging of Deposit N resulted in the addition of a total PCB load of 4.2 kg of PCBs (sum of loads from 1998 and 1999) to the Fox River system.

4.20.7 Results/Conclusions

The goal of dredging within Deposit N was to demonstrate that sediments could be removed from the Fox River in accordance with set project specifications and designed work plans. These specifications included dredging, dewatering, water treatment, and community relations.

> *Sediment was effectively removed with hydraulic dredging equipment. Dredging above bedrock requires removal techniques suited to that environment.*

At the completion of Deposit N dredging in 1999, it was concluded that sediment was effectively removed with hydraulic dredging equipment to meet project contract specifications (with regard to the average remaining thickness of sediment above bedrock). It was also noted that removal above the overlying bedrock was difficult and time consuming and that it was not possible to remove the 3 in of residual sediment effectively with the dredge equipment being utilized. Different removal techniques would need to be implemented to capture this sediment at other dredge sites with similar conditions.

With regard to the water quality impacts of dredging, it was concluded that dredging could be conducted adjacent to a water intake structure without adversely impacting the quality of the intake water. Turbidity and sediment resuspension results from water quality monitoring during dredging indicated that resuspension and sediment downstream transport were insignificant and resulted in little impact to water quality. It was also stated that no real correlation existed between PCB water column concentrations and TSS/turbidity data collected during dredging.

> *Dredging can be conducted adjacent to a water intake structure without adversely impacting the quality of the intake water.*

Lastly, this project demonstrated that sediment dewatering technologies were capable of meeting stringent requirements specified by landfills. In addition, a local landfill was capable of meeting regulatory and technical requirements to accept and dispose of non-TSCA, PCB-contaminated sediments. The treatment system was capable of treating water separated from dredge solids to acceptable levels for disposal back into the river in accordance with WPDES permits.

> *Sediment dewatering technologies were capable of meeting stringent requirements specified by landfills. The treatment system was capable of treating water separated from dredge solids to acceptable levels for disposal back into the river.*

4.21 Fox River SMU 56/57 Phase I (1999), Wisconsin

4.21.1 Site Background and Description

Dredging of a nine-acre area containing PCB-contaminated sediment, identified as sediment management unit 56/57 (SMU 56/57), was conducted on the Fox River adjacent to the Fort James Plant. Dredging began in the year 1999 (Phase I) and continued through the year 2000. Approximately 80,000 cyds of contaminated sediment were targeted for removal with a hydraulic dredging system (horizontal auger). Depths of removal were established based on a PCB residual concentration following dredging of 1 ppm. The total mass of PCBs within SMU 56/57 was estimated to range between 4,600 pounds and 6,600 pounds of PCBs. The entire dredge area was divided into 100 x 100-ft subunits. Each subunit was assigned a depth to dredge based on sediment data characterizing the vertical delineation of PCBs using GIS.

4.21.2 Site Characteristics

Sediment within SMU 56/57 consisted of high plasticity organic silts with some sand and gravel overlying low to medium consolidated native clay. The average PCB concentration was 53 ppm, with PCBs found at depths ranging from 2 to 16 ft. Water depths within SMU 56/57 ranged from 2 ft near the shore to 14 ft at the outer edge of the dredge area. The most contaminated sediment was located between the depths of 4 and 7 ft. Annual flow velocities at this location ranged between +/- 2.5ft/sec, based on data from the USGS gauge station. It should be noted that the negative velocity represents flow reversal from strong winds that come from the northeast. River velocities measured within the dredge area during dredging ranged from 0 ft/sec to 0.6 ft/sec.

4.21.3 Remedial Action

Hydraulic dredging with a round cutter head dredge was initially selected as the removal technology due to the small amount of debris and obstructions that existed within SMU 56/57. It should be noted that little debris was expected since a trackhoe was used prior to dredging to remove debris and loosen sediment. In addition, it was thought that the hydraulic dredge would operate more efficiently within the shallow water depths. After one week of dredging, this dredge was replaced with an IMS 4010 Versi Dredge equipped with a 10-in pump discharge. The change in equipment was made to increase the solids content in the dredge slurry.

This dredge was again upgraded one week later to utilize a 12-in pump discharge and a larger booster pump. This upgraded dredge had a six-cylinder diesel engine rated at 250 HP and 2,200 rpm. The dredge pump was equipped with a 9.75-in diameter intake and a 19.25-in diameter impeller. The flow rate was 5,000 gpm at 850 ft vertical head with a speed of 800 rpm. The booster pump was an 8-in MXT Pekor Pump rated at 250 HP.

One month into dredging, the IMS 5012 Versi Dredge with 12-in pump was upgraded again with the addition of a nine-foot wide horizontal auger cutter head. This configuration was used for the remainder of dredging. Dredging was carried out over a period of 15 weeks between August and December 1999.

Prior to dredging, optimum productivity rates were established to be 200 cy/hr, assuming one dredge would take 12 years to remove 11 million cy of sediment, operating at 80% available time with 20% down-time for eight months per year. During dredging, the average achieved production rate was 294 cy/day, or 60 cy/hr. Dredging was conducted in an east to west direction, perpendicular to the shoreline, from the northern limit of the target area southward. The dredge was situated on a spud barge and was repositioned using a travel cable windlass as it moved from deeper water toward the shoreline. This cable was stretched between a second cable anchored on shore and a third cable anchored east of the dredge area, forming an “I” configuration. The reported depth of cut per dredge pass ranged from one to 24 in, with an average cut of one ft per dredge pass. It was stated that multiple passes were required at each location to meet the target dredge depths/elevations and that the dredge moved at a rate of 0.5 to 4 ft/min.

Bathymetric surveys were conducted to verify that the dredge was meeting target elevations. The first survey indicated that the target elevation was not being achieved. Many ridges of undredged sediment were being left behind between dredge cuts. As a result, production dredging was halted and the dredge was repositioned in the previously dredged area to remove the ridges and meet the required target elevations.

Dredge slurry removed from the Fox River was conveyed to the shore-side processing facility where it was directed through a series of holding tanks and then processed by means of flocculation, settling, and activated carbon. Treated wastewater was then discharged back into the Fox River in accordance with a WPDES permit. A total volume of 75,256,500 gallons of water was treated in the system, which had an optimal operating capacity of 900 gallons per minute.

Solids removed from the water treatment process were mixed with lime and then mechanically dewatered in a series of plate and frame filter presses, which had a capacity of 800 cf. The dewatered filter cake contained approximately 55% solids. The slurry processing train proved to be a constraint on achieving desired productivity rates. To improve the situation, additional filter presses were added to the slurry processing system. Dewatered solids were then transported to and disposed of in a sub-cell at the Fort James industrial landfill, under a permit modification from WDNR.

A woven geotextile perimeter permeable silt curtain was used to control turbidity. The silt curtain was placed around SMU 56/57 and was anchored to the river and the shore. Buoys and lights were placed on the curtain to aid navigation in accordance with Coast Guard requirements. At the conclusion of Phase I, it was stated that the curtain functioned well under typical river velocity conditions ranging between 2 and 3 ft per second. However, the barrier system experienced some damage during a storm event when velocities approached 4.5 feet per second. At the end of Phase I, this curtain was left in place over the winter season.

By the end of Phase I, dredging was completed in four subunits. At this time, an additional clean-up pass was made in each completed subunit to remove an additional 6 in of sediment to remove residuals and to meet target elevation requirements. The project was planned this way. It was thought that all subunits would be dredged to their target depth minus 6 in. Then, at the end of the project, the final pass would be made. One post-dredge sample was then collected from each subunit and an average thickness of 8 in of sand was placed over all of SMU 56/57 at the end of Phase II (year 2000 dredging); no backfill was placed at winter shutdown at the end of Phase I.

4.21.4 Residual Verification Activities

Monitoring before and after dredging included bathymetric surveys and sediment core sampling. A single-beam sonar was used to collect water depths on range lines spaced at 50-ft intervals in directions parallel and perpendicular to the shoreline across the project area. Before the USACE predredge survey and installation of the silt curtain, predredge cores were collected at the center of most of the subunits. Post-dredge cores were collected in the subunits where dredging had occurred, as close as possible to the predredge core locations. The post-dredge sediment elevation was computed, and was compared to the predredge sediment elevation. If the difference was more than approximately 1 ft, a post-dredge core was collected.

Cores were collected through a center well in a 16-ft-long, flat-bottom aluminum boat. Sampling tubes of 4- in. diameter Schedule 40 PVC were manually pushed into the sediment until refusal, and then were driven a few more in with a sleeve hammer to seat the bottom of the tubes in firmer sediment. A piston assembly inside the sample tubes aided in sample recovery. Core samples were processed in descending intervals from the top of 0 to 4 in, 4 to 12 in, and 1-ft intervals thereafter. The samples were sent to EnChem for analyses of PCBs (SW846 8082), mercury (SW846 7471A), percent solids (SM 2540G Mod), and total organic carbon (SW 846 9060M).

Post-dredge surface PCB concentrations were measured within about two weeks of the end of dredging activities, while the silt curtain still enclosed the project dredge area. Predredge surface PCB concentrations averaged 4 mg/kg, and the highest measured concentration of all cores in the work area was 650 mg/kg. Surface PCB concentrations in post-dredge samples (range of non-detectable to 2.0 mg/kg) were less than predredge concentrations (2.3 to 3.3 mg/kg) in three of the four locations where a dredge cleanup pass was performed. In the fourth location where a clean-up pass was performed, the post-dredge PCB concentrations (4.5 to 17 mg/kg) were elevated compared to the measured predredge concentration (2.7 mg/kg). In areas where a clean-up pass was not performed, surface PCB concentrations were higher because dredging was incomplete in these areas (i.e., dredging did not reach target elevations).

4.21.5 Resuspension Monitoring

Following deployment of the silt curtain, real-time turbidity monitoring was conducted at six locations, situated as follows:

- Upstream of the dredge area outside the silt curtain (USO)
- Upstream of the dredge area inside the silt curtain (USI)

- Side stream of the dredge area outside the silt curtain (SSO)
- Downstream of the dredge area outside the silt curtain (DSO)
- Downstream of the dredge area inside the silt curtain (DSI)
- Fort James water intake (FJI)

A YSI 6820 self-cleaning turbidity sensor was installed at each location, suspended inside a perforated PVC pipe at approximately 0.5 to 0.6 of the river depth. The turbidity sensors were connected to a YSI 6200 data collection platform. The two upstream turbidity sensors shared a common data collection platform installed at the USO location via cabling on floats to the USI location. The two downstream sensors were installed in the same fashion. The SSO and FJI locations had their own data collection platforms. Each data collection platform included a solar panel and battery, a two-way radio transceiver, and a directional antenna. Data collected in the river was transmitted by radio to an antenna and YSI 6250 base station unit at Montgomery Watson's trailer. The base station transmitted the data to a personal computer, where it was stored on the hard drive and displayed in real time using YSI's EcoWatch software.

Monitoring data indicated that dredge-induced turbidity was minimal to negligible tens of feet from the dredge.

Values were recorded at 15-minute intervals whether or not dredging was occurring. In summary, the evaluation of manually collected turbidity data generally showed that turbidity downstream of the dredge was higher than upstream of the dredge. On the other hand, the evaluation of extensive real-time turbidity data within and outside the silt curtain showed inconsistent, and generally insignificant, differences. The data indicates that dredge-induced turbidity was minimal to negligible at a distance tens of feet to a few hundred feet from the dredge. Often the dredge-induced turbidity near the silt curtain could not be readily discerned from the background variability of turbidity during non-dredge periods.

Water samples were collected by the United States Geological Survey (USGS) for PCB analysis during dredging. These samples were collected at the upstream and downstream monitoring stations. Because the daily seiche in Green Bay can reverse the flow direction on occasion, the USGS attempted to collect PCB water samples at times when the flow was not reversed and it was in a predominantly downstream direction to minimize this influence. Results were compared between upstream and downstream direction.

Generally, average PCB water column concentrations prior dredging were similar at the upstream and downstream stations (53 ng/L and 52 ng/L, respectively) and, on average, were higher downstream then the upstream during dredging (51 ng/l and 90 ng/L, respectively). This data indicates that downstream water column PCB concentrations were 1.76 times greater than upstream concentrations during dredging.

4.21.6 PCB Loading as a Result of Dredging

The PCB load resulting from SMU 56/57 Phase I dredging operations was computed as a function of the flow rate and the measured PCB water column concentrations discussed previously. The average daily river flow was measured at the USGS Oil Tank Depot gauging station (#040851385), which is located at the river's mouth. The average daily river flows during dredging was 1,956 cfs, with a range of –409 cfs (due to seiche and reverse flow) to 5,930 cfs, as recorded at the USGS station.

Daily PCB loads were computed only for days in which PCB water column data was measured/available. The average daily upstream PCB load was computed to be 186 grams/day, and the average daily downstream PCB load was computed to be 415 grams/day, representing a net loss of 229 grams/day from the dredge site. The total PCB load added to the river during dredging was computed by multiplying the average daily load by 96 days (Phase I dredging duration). This results in an estimated addition of 22 kg of PCBs added to the river as a result of dredging.

4.21.7 Results/Conclusions

Phase I dredging provided important information with regard to dredge productivity and operation. The optimum productivity rate was never achieved, despite the fact that the dredging equipment was switched three times. It was thought that the percent solids achieved in the dredge slurry, 4.4% -7.5%, could have been increased with a different dredge such as a swinging ladder dredge or if a larger dredge pump could have been installed. It is thought that these modifications may have increased the production rate and helped to make the project goals attainable. It was also noted that the need to conduct a clean-up pass resulted in the treatment of a significant quantity of water when compared to the additional six in of sediment obtained.

Monitoring indicated it may not be cost effective to employ silt curtains due to the time and cost per linear footage for deployment.

Turbidity monitoring indicated that there was little change in the turbidity inside and outside the silt curtain. This suggests that it may not be cost effective to employ silt curtains due to the time and cost per linear footage for deployment. Additionally, this particular silt curtain required repair when storms and high flows caused damage. It was thought that a different anchoring system consisting of piling or larger concrete dead men may be more effective at holding the curtain in place during such conditions. The spacing of the curtain can be varied to help the curtain withstand changing lateral forces from the river current. Also, the integrity of the curtain needs to be inspected frequently to prevent tears and possible sediment transport through holes.

By the end of Phase I, approximately 31,346 cyds of sediment were removed, compared to the anticipated 80,000 cyds. Both USEPA and WDNR believed residual sediment left behind still contained unacceptably high PCB concentrations.

4.22 Fox River SMU 56/57 Phase II (2000), Wisconsin

4.22.1 Site Description and Background

Phase II dredging was performed using a horizontal auger dredge. Three dredges were available for use during the project, and each was equipped with a submersible pump. The program was designed to redredge subunits from Phase I (1999) and then, depending on the level of success in achieving a concentration of 1 ppm PCBs in dredged areas and meeting the required side slopes and production requirements, the project would progress into the remaining subunits located within SMU 56/57, pending WDNR and USEPA approval. Dredging began in late August, and was completed by late November. Approximately 50,000 cyds of contaminated sediment were removed, and it was stated that the project was completed two weeks ahead of schedule.

4.22.2 Site Characteristics

Sediment within SMU 56/57 consisted of high plasticity organic silts with some sand and gravel overlying low- to medium-consolidated native clay. The average PCB concentration was 53 ppm, with PCBs found at depths ranging from 2 ft. to 16 ft. Water depths within SMU 56/57 ranged from 2 ft near the shore to 14 ft at the outer edge of the dredge area. The most contaminated sediment was located between the depths of 4 in and 7 ft. Annual flow velocities at this location ranged between +/- 2.5ft/sec, based on data from the USGS gauge station. It should be noted that the negative velocity represents flow reversal from strong winds that come from the northeast. River velocities measured within the dredge area during dredging ranged from 0 ft/sec to 0.6 ft/sec.

4.22.3 Remedial Action

Prior to the commencement of dredging, a new perimeter silt curtain was placed around SMU 56/57. This curtain was anchored in place using sheet pile, screw anchors, and chains. Three additional silt curtains were employed within the perimeter silt curtain. These curtains were installed sequentially as dredging progressed from north to south. They were used to divide the dredge area into four work sections and to provide additional protection for completed work areas.

Dredging began in late August and continued for 69 days. Dredging activities were conducted 7 days per week for 24 hours per day. The average daily productivity rate was 723 cy/day, with the maximum production rate of 1,599 cy/day recorded in late October. It was noted that the production goal set for this project was 833 cy/day to meet a 60-day dredging cycle.

Debris removal activities were performed within each sub-site prior to dredging using divers and a barge-mounted backhoe. Divers marked out debris that was then removed by the extended arm backhoe. Debris consisted of logs and concrete weights. All debris was disposed of with dredged sediment.

Dredged slurry was conveyed through a pipeline to the shore-side processing plant. The slurry passed through a vibrating shaker screen, hydrocyclones, and an agitated pump tank. Separated solids were then conveyed to plate and frame filter presses. At this time, polymer was added to the solids to aid in dewatering. Disposal criteria stated that sediments must contain 50% solids and have a strength of 0.4 tons per square foot. Following mechanical dewatering, the sediment was placed into 1,000-cyd piles on an asphalt pad until solids testing and free liquid testing was completed. This material was then loaded into dump trucks, transported to, and off-loaded into cell 12A of the Fort James facility landfill. It should be noted that trucks were only allowed to travel on a pre-approved route and only during daylight hours for 6 to 7 days per week.

Water separated from the solids passed through a water surge tank, cloth bag filters, sand filters, a carbon adsorption system, and a final set of cloth bag filters. The effluent was then sampled and ultimately discharged back into the Fox River in accordance with the Wisconsin Pollution Discharge Elimination System (WPDES) permit.

Following the completion of dredging and post-dredge confirmation sampling, backfill consisting of sand was placed to a minimum thickness of 6 in over the entire dredge area.

4.22.4 Residual Verification Activities

Confirmation sampling of river bottom sediment was performed to determine whether cleanup objectives had been achieved after dredging had been completed to target elevation. Five separate sampling events comprised the sediment confirmation work. Prior to sediment sampling, bathymetric surveys were conducted to document that target elevations had been achieved. At some locations dense native river bottom (clay) was encountered at elevations above the target elevations. In those instances, dredging was terminated since project data had shown the native clay was not contaminated with PCBs.

Post-dredge sediment sampling locations were determined by dividing each subunit into 20 ft by 20 ft grids. Since the subunits were 100 ft by 100 ft, this resulted in 25 grid cells per each subunit. Using a random number generator, one primary and four secondary grid cells were chosen in each subunit to be the primary and secondary sample locations,.

A 16-ft-long aluminum flat-bottomed boat was used to sample the river bottom sediment. The sampling boat was maneuvered to each sample location and anchored for stabilization. Using a geodimeter with 360-degree prism, the boat was then maneuvered precisely into place by adjusting the anchor lines. Sampling locations were recorded to the nearest 0.1ft. After the boat was secured at each sampling location, the depth of water was measured and recorded using a graduated rod with a 1-ft by 1-ft rigid Plexiglas plate on the bottom end. The sediment core sampling device (sampler) consisted of a Wildco™ stainless steel hand corer with 2-in diameter CAB core tubes.

The sediment cores were received and processed in the on-site Foth and Van Dyke lab. A Dremel saw was used to vertically cut open the CAB liners to expose the sediment. The sample was then cut into sections consisting of the top 4 in of sediment and 6-in segments thereafter. Each segment was homogenized and sent to laboratory for analysis.

PCB concentrations in the top 4 in of post-dredging sediment ranged from "non-detect" to 9.5 ppm, with an average concentration of 2.2 ppm PCBs. Eleven out of 28 samples (about 40%) were less than 1 ppm PCB and 24 of the 28 samples (86%) were below 4 ppm PCBs. Post-dredge sampling results are presented in Figure 4-13.

4.22.5 Restoration

Backfill placement began on September 23, 2000 following the receipt of PCB sediment data. The sand backfill was placed using a clamshell bucket mounted on a barge. The sand was placed in a radial pattern around each barge set-up. The sand was released at the water surface. Divers directed the placement to the extent and thickness required. The depth of backfill placement was measured by recording the depth of water above the sand with a graduated rod, and then by pushing the rod into the sand until refusal. The rod was then pulled out with a recovered sand core sample in the tube and measured to confirm that the backfill had been placed in the appropriate thickness.

A minimum of four sand thickness verification measurements was completed per 100 x 100 ft subunit. In addition, USEPA performed Ponar dredge sampling of the sand cover to verify that sand was placed over the entire SMU 56/57 dredge area. By the end of the project, 13,500 cyds of sand backfill with an average thickness of 8 in and a thickness range of 6 to 14 inches had been placed over 7.4 acres.

4.22.6 Resuspension Monitoring

During dredging, turbidity monitoring was conducted at three locations, using both portable and stationary turbidity meters:

- M1, the Fort James water intake (upstream)
- M2, 10 ft downstream (north)
- M3, 50 ft downstream (north) of the perimeter silt curtain

The upstream location, M1, was measured with a stationary meter (YSI, Model 6820). The downstream locations, M2 and M3, were measured using a portable turbidity meter (YSI, Model 6820) from a 16-ft long aluminum, flat bottom boat.

During seiche periods, the upstream location was used as the downstream monitoring point. A reduction in the frequency of monitoring occurred as dredging progressed, from twice daily to twice a day, every other day. In addition, throughout the project, USEPA representatives took a considerable number of turbidity readings at various river locations and did not report elevated turbidity readings due to dredging. The monitoring locations were marked with buoys.

The action level for turbidity was reached or exceeded if the downstream turbidity reading was two or more times higher than the upstream reading and the cause of the increase was determined to be dredging. If the action level was exceeded, the dredge contractor was to be notified and dredging operations modified to minimize resuspension of sediment.

Upstream and downstream turbidity values never varied by a factor of two or more, showing that dredging activities did not cause significant sediment resuspension.

In reality, the upstream and downstream turbidity values never varied by a factor of two or more. Therefore, the turbidity monitoring data showed that dredging activities did not cause significant sediment resuspension. It should be noted that turbidity was not monitored inside the silt curtain enclosure.

4.22.7 PCB Loading as a Result of Dredging

In accordance with the approved monitoring plan, river water quality testing for PCBs was not performed since no exceedances of turbidity resulted from dredging activities.

4.22.8 Results/Conclusions

In mid-September 2000, the contractor was not meeting the 833 cy/day production goal. The contractor determined that dredge downtime and mechanical dewatering of sediment at the shore-side processing facility were the limiting factors. As a result, the contractor brought in an additional dredge and replaced the smallest press (94 cu ft) with two larger presses (220 cu ft). Within two weeks of adding the second dredge and increasing the press capacities, project production rates increased and a production rate of 1,599 cy/day was achieved at the end of October.

Approximately 51,613 tons of dewatered sediment was transported to the Ft. James landfill during Phase II dredging in 2000. The dewatered sediment had an average percent solids concentration of 59%, and accounted for the removal of approximately 670 pounds of PCBs from SMU 56/57. Combining the 1999 and 2000 dredging operations, a total mass of 2,111 pounds of PCBs was ultimately removed from SMU 56/57.

4.23 Fox River Deposit N and SMU 56/57, Wisconsin: Analysis of PCB Loading to the Water Column

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

4.23.1 Abstract

Suspended sediment and PCB concentrations in the water column were measured upstream and downstream of the dredging operations as part of a larger PCB mass balance study for both the Deposit N and SMU 56/57 dredging projects. Both studies had a three-month duration and generated impressive data sets. Composite suspended solids samples were collected at four to five stations across Fox River cross sections upstream and downstream of the dredging area; equal volumes of water at 20 percent and 80 percent depths were composited from each station to form a single sample later analyzed for TSS concentration.

A single PCB composite sample for the entire cross section was obtained by compositing equal volumes from the same depths at all locations; *i.e.*, 8 or 10 equal volume samples were combined to obtain a single PCB composite sample for the cross section. The resulting data set included 22 data pairs (TSS and PCB) from Deposit N and 36 data pairs from SMU 56/57 during dredging operations. The average of the Deposit N data pairs shows a TSS *loss* across the area of 1.7 percent and a PCB *gain* of 10.6 percent (FRRAT 2000). USGS (2000) reports that similar results from SMU 56/57 show a TSS *loss* across the area (a specific rate is not mentioned) and a PCB *gain* of 2.2 percent.

4.23.2 Discussion of Analysis

4.23.2.1 Load-Gain Estimate and Cross Section Location

The load-gain estimate is based on a cross-section that is located too close to the dredging area. The cross section is also located in an area that is a likely backwater (it is in a turning basin, with a nearby coal boat canal). It should be noted that sampling activities during boat activity showed higher PCB concentrations and were included in estimates of releases. Thus, flows through the cross section are unlikely to be consistent. The proximity of the cross-section to the dredging area also increases the likelihood that the sampling will not be representative of the total load, since the input from dredging will be poorly mixed.

4.23.2.2 Sample Compositing Strategy

The sample compositing strategy, designed to reduce the number and cost of PCB analyses, was contrary to the mass flux analysis attempted. The equal volume composites do not allow consideration of flow variation across the cross-section. USGS (2000) states that stagnant areas and even reversed flows were observed during sampling operations, confirming the errors associated with the composite PCB samples. The TSS sample composites induce less error and provide a more accurate estimate of downstream TSS flux, yet they showed an unexplained decrease in suspended sediment across the dredging operation. The decrease is almost certainly an artifact of errors associated with compositing equal volume samples from 20 percent and 80 percent depth. Even though it has long been established that velocity measurements from these depths represent the average velocity in an open channel, there is no justification for suggesting that a composite sample from these depths represents the average concentration along the profile. This is particularly true in deeper water where the two samples represent 25 feet or more of water depth.

4.23.2.3 PCBs

Collection

The method of PCB collection is not documented, but it appears that it inaccurately represents the dissolved and suspended matter fractions, based on the lack of change in PCB pattern across the dredging area. The load gain is attributed to a large gain in dissolved PCBs, but this is inconsistent with the PCB congener pattern. A large dissolved-phase PCB contribution from the sediments, either by pore water displacement or sediment-water exchange, should yield a gain whose pattern is similar to the filter supernatant. The fact that the congener pattern is unchanged across the study area would suggest a direct sediment addition, yet the suspended solids data documents no increase in suspended sediments.

Total PCB Concentration

Similarly, the total PCB concentration of the suspended matter doubles, yet there is no change in the suspended matter loading. Given the proximity of the downstream sampling cross section to the source area, it is unlikely that the majority of the TSS in the river could be directly affected by dredging-induced resuspension.

PCB Loading

A review of the PCB loading over the dredging period shows that PCB loads were relatively low for the first 2.5 months of operation, when dredging took place at the more upstream end of the targeted area. During this period, the estimated release was only 3 kg, or about 1.2 kg/month. This changed dramatically during the last month of operation, when the loading rate increased to about 13.5 kg/month. During this latter period, the dredging took place at the downstream end of the targeted area, very close (the closest station less than 80 ft) to the sampling cross-section, near areas with higher PCB concentrations.

Another significant factor, as discussed in the USGS paper that may have caused elevated PCB concentrations in the downstream profile was increased water flow velocities. Proximity of dredging to the deposit or water flow could have been significant contributing factors for increased PCB concentrations observed in the downstream profile. To conclude that observed increases are only related to dredging fails to consider these and other potential influences. Additionally, a lack of comparable transect data for PCB water column concentrations for predredging (*i.e.*, "natural") and during dredging also contributes to the uncertainty evaluating dredging surface water contributions.

PCB Loss

The fact that significant loss of PCBs only occurred when the dredging area was close to the sampling cross section suggests that settling of any resuspended matter occurs within a short distance of the dredging operation. Only when the monitoring location was close to the dredging could this signal be found. This suggests that the loads obtained by this study do not represent PCB released for long-distance transport. Rather, the PCBs appear to be quickly removed from the water column a short distance downstream. As such, it is inappropriate to use these results to estimate downstream transport from a dredging site.

4.23.3 Conclusion/Summary of Analysis

Although substantial data sets resulted from the Fox River dredging demonstration projects at both Deposit N and SMU 56/57, the sampling approach and compositing strategy induced errors that mask the results. A close review shows the study results can only be considered inconclusive and should not be used as the basis for estimating resuspension for any future dredging operations.

The sampling approach and compositing strategy induced errors that mask the results, which should therefore not be used as the basis for estimating resuspension for any future dredging operations.

4.24 Sheboygan River, Wisconsin

4.24.1 Site Location and Description

Approximately 14 miles of Sheboygan River sediments became contaminated when PCB-contaminated soils used to construct a flood protection dike eroded. Historical industrial activities were cited as the source of contamination. After conducting a RI/FS, the PRP proposed and implemented a pilot program to remove certain sediment deposits (4,000 cy) closest to their facility and to armor additional nearby deposits via capping.

4.24.2 Remedial Action

The removal was performed using mechanical dredging equipment that consisted of a sealed clamshell bucket and a backhoe. The armoring for the cap involved placement of a geotextile fabric over the deposit, followed by placement 1 ft of gravel and the addition of another layer of geotextile. The top layer of geotextile fabric was anchored in place with gabions and then covered with rip-rap.

In-river testing was conducted both prior to the pilot remedial work and after it was completed. Results of the sampling program were inconclusive, with some parameters improving somewhat (sediment loads) and others showing little observable trend (fish levels). Approximately four years after remedial work was completed, observations were made of the physical condition of the armoring cap system. Armoring along the banks appeared to be stable, though armoring systems within the river experienced a loss of riprap and gravel in some cases. It was concluded by the WDNR that the condition of in-river armoring systems was difficult to ascertain and that their overall performance and longevity raised numerous questions. Observed damage to the armoring system and continued water column PCB levels were factors in WDNR's assessment.

The USEPA subsequently issued its FS report for the site in 1998, the proposed plan in May 1999, and the ROD in May 2000. The ROD called for removal of approximately 21,000 cyds of sediment from the upper river and 53,000 cyds from the inner harbor, which totals 14 river miles from the Sheboygan Falls Dam to and including the inner harbor area.

The USEPA, using health and ecological risk methods, initially determined that the selected alternative should remove sufficient river sediment to provide a residual sediment PCB level of 1 ppm after 30 years. However, the ROD was revised to state that the required cleanup level/residual concentration must be 0.5 ppm PCBs, with the lower 1 mile of the river to be dredged to a depth of 2 ft and to include bank-to-bank removal from the Pennsylvania Avenue bridge to the 8th Street bridge. Total costs for remediation within the river are estimated to be approximately $35 million. A 30-year monitoring plan of sediment and fish tissue concentrations is planned following implementation of the remedy.

A dredging technology has not yet been selected for removal of river sediments, but the USEPA anticipates using a clamshell dredge for removal work and then stabilizing the sediments before they are hauled to the final disposal location. The USEPA project manager has been contacted for more detailed information with regard to dredging equipment, schedule, productivity, and current status, but updated information has not been obtained to date.

4.25 Commencement Bay, Washington

This Superfund site consists of nine sub-sites located on the coast of the state of Washington, where remedial dredging or capping has occurred or is planned for the future. The USEPA project manager for remediation in the Sitcum Waterway and for remediation of a hot spot within the Hylebos Waterway was contacted. Mechanical dredging had been conducted previously in the Sitcum waterway, but an environmental bucket (closed bucket) was not used. This project was completed in 1995 and was listed and summarized in Appendix A of the Hudson River FS report. Additional information was not obtained specifically for this sub-site, however, since environmental dredging will be employed in the Hudson River. It was noted that water quality monitoring was conducted for heavy metals to verify that resuspension levels were not exceeded during dredging within the Sitcum waterway. However, more details were not available from the USEPA manager contacted.

4.26 Hylebos Waterway Hot Spot Dredging: Commencement Bay, Washington

4.26.1 Site Background and Remedial Action

Dredging work is expected to begin in October 2002 at a hot spot in the tidal Hylebos Waterway. This dredging will be conducted with a Toyo pump. This equipment was selected instead of mechanical or hydraulic dredging equipment due to the nature of the contaminants. The sediment contains elevated levels of VOCs, and it was thought that mechanical or hydraulic equipment would cause releases directly into the water column as the dredge makes its cut.

The Toyo pump is submersed into the river bottom and simply sucks the sediment directly into a pipeline with no turning motion. In addition, the Toyo pump was selected over a cutter head hydraulic dredge due to the high solids content in the pump effluent. Thus, a smaller water treatment system would be required on the other end of the operation. Another factor in selection of the Toyo pump was its low resuspension rate and high production rate. It was also noted that dredging is being conducted in the open without the deployment of silt barriers or sheet piling.

The target production removal rate for this hot spot dredging is 600 cy/day, with work expected to begin on October 1, 2002 and continue for approximately three months. The only foreseeable problem/limiting factor in meeting the target removal rate, as indicated by the USEPA project manager, is sediment processing at the transfer facility.

4.26.2 Resuspension Monitoring

Once dredging commences, TSS, DO, and metals will be monitored in the water column at the edge of and within the mixing zone. The mixing zone is a discrete area surrounding the dredge where environmental impacts are permitted. Typically, the mixing zone represents an area around the dredge with a radius of 300 feet. Monitoring will be conducted near the dredge, 300 ft distant, and downstream of the dredge along the boundary of the mixing zone. Allowable resuspension levels were established based on allowable DO and turbidity surface water criteria and marine water quality standards for heavy metals, as defined by state surface water regulations.

The contingency plans to be put in effect if resuspension levels are unacceptably elevated are:

- Decrease the rate of dredging.

- Increase the size of the mixing zone (this would change the location where turbidity, DO, and metals are being measured in the water column to a distance farther from the dredge).

- Analyze the daily period in which the dredge/Toyo pump is operating and alter based on the tidal schedule, with dredge operations occurring before and after, but not during, tidal changes.

4.27 Hylebos Waterway Full-Scale Removal: Commencement Bay, Washington

4.27.1 Site Description

A larger dredging project was planned for the Hylebos Waterway in 2003 and consists of removal of approximately 850,000 cy of sediment contaminated with PCBs, PAHs, metals, and organic compounds.

4.27.2 Remedial Action

Removal operations are divided into two tasks or sub-projects for this waterway. The first task includes the removal of 400,000 cy of sediment, scheduled to begin in July 2003. The USEPA anticipated the removal of 200,000 cy of sediment in the first dredge season (2003) followed by removal of the remainder of the sediment in the year 2004. Dredging for the first task was to be conducted with an open bucket, clamshell mechanical dredge. It was indicated that 90% of the design is complete for this part of the project.

The second task, currently in the design phase, also includes the removal of sediment contaminated with PCBs, PAHs, metals, and organic compounds. The design was 30% complete as of November 2002, and was being completed by the dredge contractor, Bean, and the PRP.

Sediments removed are to be disposed in a local landfill. The design initially called for removal with a clamshell bucket with a 2-ft tolerance with regard to meeting the required dredge cut. However, since local landfilling was selected as the final option for the handling of dredged material, project personnel decided to minimize the amount of extra sediment removed to reduce disposal cost. Therefore, a mechanical dredge with a hydraulically controlled environmental bucket and a digitized GPS system was selected, since it has been demonstrated that this piece of equipment can meet the required dredge cut with a tolerance of 1 to 2 in. It was indicated that the use of this equipment would reduce the dredged volume of sediment by 900-1,000 cy.

Dredging will be completed in 50 x 50-foot dredge management units that are located in a narrow waterway with an average width of 100 ft, characterized by thick sedimentation and shoaling along the banks. The dredging program is designed to use a 2-pass approach: the first pass will utilize a clamshell bucket to remove accumulated sediments along the banks and within the shoals, and the second pass will be performed with the hydraulically-controlled mechanical dredge previously described. It is expected that the two dredges will be utilized simultaneously. Site-specific clean-up levels were established for each contaminant of concern. However, it was indicated that since issuance of the ROD and establishment of the site-specific clean-up standards, the state of Washington has established generic sediment clean-up criteria.

The dredging construction season within the Hylebos Waterway is limited to 6 months, due to constraints set by the Endangered Species Act. Project goals for the second task, utilizing the two-pass dredge approach with the hydraulic excavator designed by Bean, include the removal of 450,000 cy of material in one construction season. Bean has been brought on board for the design phase of this project to ensure this schedule is achieved. Dredging activities will include the following:

- Removal/active dredging 24 hours per day, 7 days per week
- 30-day allowance for down times associated with equipment repairs, repositioning, etc.
- 10 days assumed for project mobilization
- 10 days assumed for project demobilization
- 153 days of actual dredging to remove the 450,000 cy of contaminated sediment

This schedule currently meets a seven-month program. The contractor and the design group are currently evaluating ways to complete the project one month ahead of schedule, in one construction season, either by adding an additional dredge or increasing productivity, as possible (while meeting resuspension/water quality guidelines).

Once sediment is removed from the waterway, it will be placed in barges and brought to a berthing area where the material will be unloaded from the barges and loaded directly into rail cars for transport to and disposal at the Eastern Washington landfill. It was explained that dewatering prior to placement in the rail cars is not required based on landfill requirements, as this landfill is very dry and needs the additional water entrained in the sediments to assist with methane generation and/or control. It was indicated that the land-based transfer site already has a rail spur to transport the wastes, thereby speeding project mobilization.

4.27.3 Resuspension Monitoring

Dredging will not be conducted in a contained area. The state of Washington regulates the majority of its dredging projects through use of an identified monitoring area called the mixing zone, which establishes the boundary for water column monitoring. Typically the mixing zone consists of a 300-ft area surrounding the dredge. In this case, monitoring is conducted at the dredge head and at the limit of the mixing zone, or 300 ft from the dredge. It should be noted that other dredge projects completed or in the planning phase utilize this concept of the 300-ft mixing zone.

For this project, the USEPA project manager indicated that they were trying to get approval for the entire dredge area to be defined as the mixing zone so that flexibility will exist with regard to the location of the dredge. Because dredging is planned in 50 x 50-foot areas, and the waterway is very narrow and utilized significantly by large ships, it is anticipated that the dredge would need to be repositioned periodically based on ship movements. In the event the dredge needs to relocate, it would move to a different 50 x 50-foot dredge management area. Monitoring could continue at the perimeter of the entire dredge area as opposed to 300 ft from the dredge head. Project personnel hope to use an adaptive management practice in the field with best management practices to ensure completion of the project in accordance with set residual and water quality guidelines. This would allow for the continuous monitoring of all open areas.

Water quality concerns are focused around turbidity and dissolved oxygen levels for this project. The waterway currently has low dissolved oxygen concentrations, and the USEPA does not want the system to become further depressed as a result of dredging. Regarding turbidity, standards are being evaluated and will be set at either 50 NTUs or 20 NTUs over background levels. Background water quality levels are currently being established with sensors set up in the waterway.

4.28 Thea Foss, Wheeler and Osgood Waterway, Commencement Bay, Washington

The USEPA project manager for this sub-site was contacted with regard to dredging expected to begin in 2003. It was indicated that dredging was on schedule to begin in August 2003 for removal of 525,000 cy of PAH-contaminated sediment. The project was in the conditional approval phase where the contractor was selecting the dredging equipment and preparing the construction work plan and associated technical specifications.

It was not known at this point if mechanical or hydraulic dredging equipment will be selected. However, it was thought that mechanical dredging equipment would be chosen. Resuspension will be monitored with a 300-ft mixing zone, as defined above. This monitoring will occur near the dredge and at a maximum distance of 300 ft from the dredge, based on the location of the dredge within the mixing zone. A resuspension monitoring plan (water quality monitoring plan) was also being prepared. It was indicated that dredging is not being conducted “to ‘clean’ sediment,” but that the required cleanup goal is equivalent to/dictated by allowable PAH concentrations in sediment promulgated by the state of Washington. Thus, dredging will be completed to levels below the authorization limit. Additional information was not available at this time since the project was still in the design phase.

4.29 Wyckoff Company/Eagle Harbor, Washington and Pacific Sound Resources, Washington

This harbor area is located in Seattle, Washington, and is contaminated as a result of wood treatment and shipyard operations at industries located along the shore of the harbor. A 500-acre site contaminated with 40,000 gallons of creosote resulted in PAH and heavy metal contamination in the harbor sediments. Between 1994 and 2001, 54 acres of the harbor were capped by USACE and USEPA. Although literature available for this site on the Internet stated that a portion of the harbor would be dredged, the USEPA project manager indicated that dredging was not performed and that the entire contaminated area was capped. Since capping began, monitoring has revealed a return of benthic organisms and aquatic species, a result that implies an improvement in the health of the aquatic water system. The remediation has been considered a success as a result of the return of the aquatic community.

4.30 Portland Harbor, Oregon

This site was added to the NPL on December 1, 2000 due to the detection of elevated levels of PCBs, metals, and petroleum products in harbor sediment. Remedial investigation activities were expected to begin in fall 2002.

4.31 United Heckathorn, San Francisco Bay, California

4.31.1 Site Location and Description

The United Heckathorn Superfund Site is located in the Richmond Harbor area, an inlet of the San Francisco Bay. Approximately 15 acres of sediment are contaminated with DDT and dieldrin from past operations at the United Heckathorn facility. Operations at the United Heckathorn facility consisted of the receipt of technical grade pesticides from chemical manufacturers, the grinding and mixing these pesticides with other materials, and the packaging and shipment of the mixtures off-site. Documentation available from previous site visits while the facility was in operation indicated that pesticides were observed to be leaking from drums and pipelines, and spilled during facility operations and waste discharges into the Lauritzen Channel.

4.31.2 Site Characteristics

A RI conducted in 1994 determined that the contaminated sediment consisted of two geologic units: a younger bay mud consisting of very soft to soft clay, silt, and fine-grained sand with a high water content, which was overlying the older bay mud that consisted of dry, consolidated silts and clays with some sand. Sampling of the marine sediments indicated that the underlying older bay mud has not been affected by DDT and dieldrin contamination.

4.31.3 Remedial Action

The final selected remedy issued by the USEPA for the contaminated marine sediments called for the dredging of all soft bay mud from the Lauritzen Channel and the Parr Canal. The clean-up goal for DDT in the sediments was established at 590 ug/kg. The clean-up goal was based on the National Academy of Science action level for DDT in fish and was intended to ensure the protection of fish-eating birds, including endangered species. Placement of 6 in of clean fill and subsequent five-year monitoring of water, biota, and sediment to verify the effectiveness of the remedy would follow completion of dredging.

Dredging commenced in the Parr Canal, a shipping inlet, in August 1996. A silt barrier was placed at the mouth of the canal to isolate this area from the Santa Fe Channel and ultimately the San Francisco Bay. By the end of August 1996, 2,620 cy of sediment had been removed from the Parr Canal. The younger bay mud was removed with two excavators mounted on each side of the shore. The excavators worked in tandem, moving northward toward the head of canal. Following excavation, approximately 18 in of clean sand were placed over the entire excavated area to promote vegetation regrowth and restore the ecosystem. DDT sediment concentrations decreased from 840 ug/kg to 200 ug/kg following dredging.

Removal within the Lauritzen Channel, another shipping inlet, occurred between September 1996 and March 1997, using a cable arm bucket wherever possible. A silt curtain was placed at the mouth of the Lauritzen Channel, and it was noted that the curtain was damaged and replaced multiple times throughout the course of the project; dredging was suspended when the silt curtain was under repair. Generally, dredging was conducted from the outer to the inner part of the channel to minimize contamination of clean areas.

The amount of buried debris presented a large problem during dredging. Recovered debris included buried barges, storage tanks, cables, and approximately 187 tons of metal. The unexpected amount of debris encountered resulted in damage to the dredging equipment, unanticipated downtime, and low overall project productivity.

Sediment removed from the channel was placed into barges and towed to the landside processing facility. Initially, the plan was to pump the sediment from the barge; however, broken pumps resulting from debris encountered made this system impractical. As a result, the barges were unloaded with a clamshell bucket. Sediment was then dewatered, stabilization with Portland cement, and loaded into rail cars. It was noted that rail car unavailability, result of complications in tracking rail cars leaving the site for the ECDC facility in Utah, caused dredging to halted on numerous occasions.

By the completion of dredging within the Lauritzen Channel, 105,000 cy of sediment had been removed, equating to approximately three tons of DDT. Predredge DDT sediment concentrations were 47,000 ug/kg, on average, and following dredging the average DDT concentration was 263 ug/kg. The entire channel was backfilled with sand to a thickness of 18 in. Backfill was placed underwater using a hydraulic pump.

4.31.4 Residual Verification Activities

Following completion of removal activities in the Lauritzen Canal, a post-dredge survey and investigation was conducted to verify that all younger bay mud had been removed and that the new surface consisted of the older bay mud. Sediment samples were collected from the upper 10 cm of the sediment to verify that the DDT residual concentration of 590 ug/kg had been achieved. Remote locations were found to exceed the 590 ug/kg DDT residual goal and not to have been dredged to the older bay mud. Subsequently, these areas were redredged and then backfilled.

4.31.5 Post-Dredge Monitoring

Monitoring of water quality, sediment, and biota followed the completion of dredging. Sediment samples collected four months after completion of dredging indicated the deposition of fine silt and clay and an increase in DDT concentrations. A 40-fold difference/increase in DDT sediment concentrations was identified during this four-month period, attributed to the transport and deposition of fine-grained contaminated sediment into the dredged area.

In addition, post-dredge monitoring revealed that sediment contamination is highest/hottest in deeper sediments. Sediment samples collected by the USEPA at the completion of dredging represented the interval of 0-10 cm, while sediment samples collected four months following dredging were collected from the interval 0-2 cm.

4.31.6 Results/Conclusions

The remedial action implemented for the marine sediments as part of the United Heckathorn Superfund Site has been considered unsuccessful. It is thought that the lack of reduction in DDT concentrations over the entire dredge area over time is a result of incomplete dredging and removal of contaminated sediment. Due the presence of debris, docks, and pilings, not all areas were dredged as initially planned. The areas not dredged were capped with sand; however, the integrity of this cap was not tested, monitored, or evaluated prior to placement. Sand as a capping material was planned for habitat restoration only, not contaminant immobilization. In addition, dredging was completed within the center of the channel but not along the banks where docks and pilings existed. This left a steep slope of contaminated sediment behind and it is thought that the placement of sand may not have been effective in covering this steep slope. As a result, contaminated sediments from these banks may be sloughing off into the center of the channel, resulting in the accumulation of fine-grained material over the sand cap and an increase in DDT sediment concentrations.

5.0 Hudson River Data Collection

Hudson River water quality data provide the backdrop for evaluation of the impacts of dredging via resuspension. The data available must be used to assess the inherent variability in water quality conditions prior to any dredging operation so that the impacts of dredging, if any, can be quantitated. Dredging will add to the existing loads and concentrations in the water column, but its magnitude will likely be of the same scale or smaller than the existing conditions. Thus, resolution of the dredging-related releases relies on knowing the underlying "baseline" condition well.

Water quality data has been compiled for use in the performance standard development analyses. The data from the USEPA Hudson River Database, last released in October 2000 (USEPA, 2000), has been supplemented with new monitoring data. The June 2001 release of the GE data was used in place of the GE data in the October 2000 release. This will allow any changes that were made to the GE data since the version of the data that was included in the October 2000 release of the USEPA Hudson River Database to be reflected in these analyses. Discharge and water quality data have been requested from USGS, but because of the delay in receiving these data, the data available on the USGS web site has been downloaded for use in the analyses. Finally, the most recent database release of fish monitoring data from the NYSDEC was selected for use in the data analysis. Descriptions of the data are given below.

5.1 Data Descriptions and Collection

5.1.1 GE

The dataset collected by GE for the water column monitoring program is an important component of the analysis for the performance standard because it provides a measure of the contaminant variability in the river. Table 5-1 lists the range of dates for each of the monitoring locations and the number of analyses for each analyte. PCB congeners and water column measurements of total suspended solids are the parameters of interest. The latest database release from GE was used (GE, 2001). PCB congener data is available from April 1991 to May 2000. The largest number of samples was collected at the Thompson Island Dam station, with the performance of 580 PCB congener analyses. The samples which were taken during construction activities near the GE plants prior to the implementation of effective source controls may not be used in the analysis, however, there is still a substantial amount of data that can be used for the performance standards development.

5.1.2 Flow

USGS flow data will be used to calculate contaminant loads and determine the flow dependencies of contaminants in the water column. The data from the last release of the Hudson River database (USEPA, 2000) will be used and supplemented with data downloaded from the USGS web site (USGS, 2002). Table 5-2 lists the number of flow measurements per year at each station. PCB congener data is available from some of the water column monitoring stations, including Fort Edward and Stillwater, for the entire ranges of dates (1991-2001). The discharge rate for stations that are not monitored by the USGS will be estimated. This analysis will be included in the final report.

5.1.3 NYSDEC Sediment

The NYSDEC has released a draft report of trace metals and dioxin contamination in the Hudson River (NYSDEC, 2001). This report has an analysis of six coring locations in the Upper Hudson. Table 5-3 lists the number of analyses per river mile. These high resolution cores were dated using cesium-137 concentrations, which allow the concentrations of the post-excavation sediments for these compounds to be examined relative to the concentration of the pre-excavation surface sediments and the average contamination in the sediments to be removed.

5.1.4 NYSDEC Fish

NYSDEC has a large set of fish concentration data from monitoring programs in the Hudson River. The latest release of the database from NYSDEC was reviewed (NYSDEC, 2002). This data will be used to get an indication of the non-PCB contaminant concentrations in the water column. Table 5-4 lists the number of measurements for parameters of interest for stations located in the Upper Hudson River. The most measurements are for mercury, which was measured at almost all stations. There are measurements at some of the stations for a group of metals, with the exception of chromium and zinc. PCDD/Fs were measured in a smaller number of samples (2 to 9 measurements per station).

6.0 References

BBL Environmental Services, Inc. 1996. St. Lawrence River Sediment Removal Project Remedial Action Completion Report, General Motors Powertrain, Massena, New York. Prepared for General Motors Powertrain. June 1996.

BBL Environmental Sciences, Inc. 1995. Non-Time Critical Removal Action Documentation Report, Volume 1. Grasse River Study Area Massena, New York and Aluminum Company of America, Massena, New York. December 1995.

Bechtel Associates Professional Corporation/Bechtel Environmental, Inc. 2002. Draft Interim Completion Report for the St. Lawrence River Remediation Project at the Alcoa, Inc., Massena East Smelter Plant, New York, Volume 1, Revision 0. Prepared for Alcoa. March 2002

Bechtel Environmental, Inc./Metcalf and Eddy, Inc. 2000. Final Dredging Program Design Report for the River Remediation Project at the Reynolds Metals Company, St. Lawrence Reduction Plant, Massena, New York, Revision 3. Prepared for Reynolds Metals Company. May 2000.

Earth Tech, Inc. 2002. Grand Calumet River Section 401 Water Quality Certification Work Plan. Prepared for US. Steel. July 2002.

Fox River Group, 2000. Fox River Dredging Demonstration Projects at Sediment Deposit N and Sediment Management Unit 56/57 Environmental Monitoring Report. Prepared by BBL Environmental Services. July 2000.

General Electric (GE), 2001. Database Release. Personal communication from John Haggard (GE) to Ed Garvey (TAMS). June 2001.

New York State Department of Environmental Conservation (NYSDEC). 2002. Draft Final Construction Certification Report, Cumberland Bay Sludge Bed Removal and Disposal Contract (OU1), April 1999 – July 2001. Prepared by Earth Tech, Latham, New York. April 2002.

NYSDEC. 2002. Draft Report, Hudson River Sediment Consultation, Trace Metal and Dioxin Analyses of Dated Sediment Samples from the Upper Hudson River. Prepared by Edward Shuster, Richard Bopp and Erika Zamek, Rensselaer Polytechnic Institute, Department of Earth and Environmental Sciences, March 2002.

NYSDEC. 2002 Database Release. Personal communication from M. Keane (NYSDEC) to Ed Garvey (TAMS/Earth Tech). May 2002.

Thibodeaux, Louis J. of the South and Southwest Center for Hazardous Waste Research Louisiana State University. 2000. The Effectiveness of Environmental Dredging: A Study of Three Sites Final Report. Prepared for Environmental Science and Technology

Development Environmental Health Sciences Services North America ALCOA. January 2000.

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

Reference: USEPA Region 2, 2002. Grasse River Study Area National Remedy Review Board Remedy Selection Briefing Package. Prepared by TAMS Consultants, Inc. March.

Wisconsin Department of Natural Resources, 2000. Summary Report Fox River Deposit N. Prepared by Foth and Van Dyke. April 2000.

Wisconsin Department of Natural Resources and Fox River Group of Companies. Final Summary Report Sediment Management Unit 56/57 Demonstration Project Fox River, Green Bay, Wisconsin. Prepared By Montgomery Watson. September 2001.

Wisconsin Department of Natural Resources and United States Environmental Protection Agency, 2001. Final Report 2000 Sediment Management Unit 56/57 Project Lower Fox River, Green Bay, Wisconsin. Prepared by Fort James Corporation, Foth and Van Dyke and Hart Crowser, Inc. January 2001.

United States Environmental Protection Agency (USEPA). 2000. Hudson River Database Release. October 2000.

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

United States Geological Survey (USGS). 2002. Data downloaded from www.usgs.gov. September 2002.

Tables

Table 3-1
Case Studies
General Description of Dredge Sites

Site Name and Location	Project Description and Year Work Conducted	Figures	Geological Setting	Range of Water Depth (ft)	Range of Water Velocities (ft/s)	Sediment Characteristics	Area Dredged (acres)	Volume Dredged (cy or tons)	Dredge Equipment Used	Variation in Dredge Equipment for Clean-up passes to meet RI goals	Lessons Learned- Goals Achieved, if not reasons
Black River, Ohio	Removal of PAH contaminated sediment over a 1-mile stretch of river in 1989-1990	Provided inCase Study Appendix	Riverine Setting that is part of the Great Lakes Area of Concern; the east and west branches of the river join and form the main channel which flows 16-miles and ultimately discharges into Lake Erie	Dredging occurred in water depths ranging from 12 ft to 20 ft	Not Available	Fine material consistent with clays and silt and some sand with an underlying layer of hard shale bedrock	River width 500-ft; possibly dredged entire width over 1-mile stretch of the river	45,000cy	Mechanical Dredging with a clamshell bucket equip with a cover made out of a thick rubber mat to prevent spillage	None- dredged to hard shale bottom; would have used same dredge if needed to re-dredge remote areas	The goal of dredging was to remove PAH-contaminated sediment to decrease sediment PAH concentrations and ultimately reduce liver tumors in the brown bullhead; Main problem of project associated with in-river transport of dredged sediment-ultimate method of transport consisted of welding 7 barges together and then securing dump trucks on top. Sediment was then loaded directly into the trucks. Trucks were then barged back to the unloading area where they were detached from the barge and then drove directly to the on-site landfill; Dredge spoils placed directly into on-site landfill. Entrained water drained out through bottom of landfill through liners and french drains where it was then conveyed to a pump station which directed the water to the on-site water treatment plant
Manistique River and Harbor, Michigan	Removal of PCB contaminated sediment over 1.7 miles from 1995 to 1999. Dredging in 1995 was completed as a pilot study because EPA initially planned to cap hot spots however dredging proved successful and cost-effective ROD revised; Dredging from 1995-1999 consisted of two hot spots in the river and one large hot spot in the harbor area.	Provided inCase Study Appendix	Riverine setting that is part of the Great Lakes Area of Concern; Manistique river ultimately discharges into Lake Michigan	Not indicated in the literature reviewed	Not Available	Average thickness of sediment was 3-feet and contained a large amount of woodchips and saw dust. Literature reviewed did not specify exact geotechnical characteristics of the sediment		approximately 150,000cy	Hydraulic cutter head dredge with a dual pump system and 10-icnh vortex pump	Diver assisted dredging with a suction pump utilized to remove residuals	Sediment clean-up goal of 10ppm or less met site-wide. Success stated to be result of diver assisted removal of residuals and operation of the dredge at low speeds which is stated to have produced low resuspension. It should be noted that dredging exceeded the land based handling and water treatment capacity in 1997 causing dredging times to be reduced to 1-2 hrs/day; Dredge custom designed with high torque blades to cut through wood debris and as equip with short pumping head to obtain maximum vacuum dredging operation.
Fox River: Kimberly, Wisconsin	Deposit N: Removal of PCB contaminated sediment from Nov. 1998 - Oct. 1999 (Phase I)	Provided inCase Study Appendix	Riverine Setting located in Wisconsin; part of the Great Lakes Area of Concern	Removal occurred in water depth of approximately 8-feet	at 20% depth: avg v = 0.47 ft/s at 80% depth: avg v = 0.59 ft/s Average velocity of system ranges from 0.09-0.87 ft/s	1% Gravel/ 54% Sand/ 27% Silt/ 18% Clay/ 37% Solids; generally classified as silty-clay and sandy loam; sediment depth 3 ft overlying fractured bedrock at most locations	3 acres	11,000 cy contaminated sediment; targeted 65% or 7,1500 cy due to presence of bedrock; ultimately removed 7,149 cy by end of project	Hydraulic Swinging Ladder Dredge: Model Moray/Ultra; sediment pumped through a 8-inch HDPE pipeline; This pipeline initially encased in a 18-inch HDPE pipeline; double casing eliminated during 1999	Same dredge used however the suction pipe was extended inside the cutterhead to decrease area of the mouth by 15% and increase the dredge vacuum pressure	
Fox River:Green Bay, Wisconsin	SMU 56/57- Removal of PCB contaminated sediment Phase I 1999	Provided inCase Study Appendix	Riverine Setting located in Wisconsin; part of the Great Lakes Area of Concern	Ranged from 2-ft near shore to 14-ft at outer edge of dredge area	In project area during dredging (Dec 1999) ranged from 0-0.6 ft/s; annual range at USGS gauge station of (-2.5)to (+2.5 ft/s)	High plasticity organic silts with some sand and gravel overlying native clay; sediment depths containing PCBs ranged from 2 ft to 16 ft; largest conc. PCBs ranged from 4 inches to 5-7 feet	9 acres	31,350 cy removed and sent off-site from Aug 30, 1999 - Dec 15, 1999; net volume moved was 33,350 cy however 2,000 cy was re-deposited or relocated in dredge area during remediation; approx. 1,441 pounds PCBs removed	Hydraulic 9-ft wide horizontal auger dredge with 12-inch pump; began project with 12-inch hydraulic cutterhead	None-planned to use same dredge if required	Hydraulic dredging selected due to little debris, dredge area close proximity land side processing area, shallow water depths and depth to dredge; measured dredge productivity with a Versa Flow Doppler Flow meter manufactured by TN Technologies and was installed near dredge pipeline (measured slurry density, flow rate, and total flow); Did not perform clean-up pass of 6-inches following dredging-concluded that not meeting required cuts can leave more highly contaminated sediment exposed; Differences in turbidity measurements inside and outside barrier not greatly different-suggests that barrier may not be necessary and cost-effective for future dredging projects
Fox River: Green Bay, Wisconsin	SMU 56/57- Removal of PCB contaminated sediment Phase II 2000	Provided inCase Study Appendix	Riverine Setting located in Wisconsin; part of the Great Lakes Area of Concern			Silty-sand; sediment containing PCBs ranged from 0-12 feet	7.5 acres	50,000 cy or 670 pounds of PCBs removed	Hydraulic horizontal auger dredge	None-planned to use same dredge if required	Difficulty meeting productivity performance standard of 833 cy/day due to dredge rate and mechanical dewatering at processing plant; added on another dredge and replaced smaller press (94 cf) with two large presses (220 cf)

Table 3-1
Case Studies
General Description of Dredge Sites

Site Name and Location	Project Description and Year Work Conducted	Figures	Geological Setting	Range of Water Depth (ft)	Range of Water Velocities (ft/s)	Sediment Characteristics	Area Dredged (acres)	Volume Dredged (cy or tons)	Dredge Equipment Used	Variation in Dredge Equipment for Clean-up passes to meet RI goals	Lessons Learned- Goals Achieved, if not reasons
Reynolds Metals: St. Lawrence River, Massena. NY	Removal of PCB-contaminated sediment at Reynolds Metals Company from April 2001 through November 2001	Site Location Map. sheet 01000-100 in Final Dredging Program Design Report for the River Remediation Project	in the St. Lawrence River adjacent to the Alcoa (formerly Reynolds Metals Company [RMC]) St. Lawrence Reduction Plant in Massena, New York	Water depths vary from 4 to 37 feet.	The main St. Lawrence river current has flow velocity of 8 fps or better. But current speeds in the near-shore area adjacent to the RMC plant were found to be mostly less than 1 fps with an average of 0.5 fps.	the project area is composed of sediment overlying a clay-till soil. Sediment overlays a till layer at depths ranging from 1.5 to 30 ft below river bottom.	21.8 acres	estimated 51,500 yd3 and actually 86,600 yd3 were removed containing an estimated 20,200 lbs of PCB	derrick barge equipped with Cable Arm Environmental Buckets	The conventional rock bucket and hydraulic clamshell of the Cat 350 were used to remove the rock and till sediment that could not be removed by the Cable Arm buckets. It was also utilized for additional removal of material in 4 Hot Spots (1,3,4, and 7)	Overall the remediation is success in term of the PCB mass removed and PCB contaminant level reduction. Considerably more dredging efforts were required than originally planned, due primarily to the difficulties in attaining the sediment cleanup goals for PCBs.
GM Massena: St. Lawrence River, Massena, NY	Removal of PCB-contaminated sediment at General Motors-Massena Superfund site from May (March) 1995 through December 1995 (January 1996). Dewatering and excavation of the cove area were not carried out as of the report date due to unsettled access issues.	Post-Dredging PCB Concentration Isopleths: Fig. 4-1 Final Sediment Sampling Results: Fig. 4-2,	The remediated portion of the St. Lawrence River consists of a shallow bay area; bottom of bay forms a shallow shelf extending ~ 250 ft into the river.	Normal high water elevation: 156.0 ft (International Great Lakes Datum, 1955). Normal low water elevation: 153.0 ft. Water level fluctuations: generally less than 1 ft (I.e., 154.0-155.0).	velocity range: 2.75-4.42 ft/s, mean velocity: 3.65 ft/s in the main channel upstream of the mouth of Raquette River. Lower velocities where sediment removal activities were conducted.	Clay, silt and fine-grained sand, containing gravel, cobbles and large boulders at the bottom, underlain by glacial till. In situ water content: 10-60%.	10 acres (Phase I-Quadrants 1-5 (5 acres); Phase 2-Quadrants 5-6 (5 acres).	13,800 cy	Horizontal auger dredge. Hydraulic dredging of sediments using horizontal auger dredge. Mechanical removal of debris, rock and boulders using a barge-mounted backhoe, with assistance from divers. Bucket of the backhoe contained openings that allowed for debris ~ 3 inches or less in diameter to pass.	Hydraulic dredging of sediments by a horizontal auger dredge used perpendicular to shore. Additional alternatives used in Quadrant 3: a vacuum dredge head (that did not contain an auger) with a metal shroud that collected sediment by negative pressure utilizing the dredges intake pump; a horizontal auger dredge used parallel to the shore.	During Phase 1 dredging limited exchange of turbid water was observed in some areas where certain sheet piles were driven below water surface. To correct this problem filter fabric, used to filter exchanging water, was draped over the openings and anchored with steel cable ballast. In Phase 2 many of the low sheets were raised, and short lengths of steel sheeting (8-12 inches) were installed to close the openings. Final PCB levels did not achieve the 1 ppm goal in all cases. Except for Quadrant 3 subarea, residual concentrations averaged approximately 3 ppm, with no single sample exceeding 10 ppm. In Quadrant 3, residual concentrations were higher, but a sediment capped, approved by USEPA, was installed over the area.
Cumberland Bay: New York	Removal of PCB-contaminated sludge bed (OU-1) at Cumberland Bay Wilcox Dock Sludge Bed site, and debris removal from public and private beaches (segment of OU-2), in the Town of Plattsburgh, Clinton County, New York, from April 1999 to November 2000.	Soil Sampling Locations: Fig -3 1999 Work Zones: Fig. 4-4 2000 Work Zones: Fig. 4-5	Sandy lake bottom	Depth: generally <10 ft; max. 20 ft Elevation range: 95-97 feet above mean sea level (1999)		Sludge consisting of low density silt, clay and wood fiber (wood chips and paper pulp). PCB concentrations up to 13,000 ppm (Mudflats/Breakwater areas: 33 ppm, Dock area: 431 ppm). Sludge thickness ranges from 0.25 to 16 feet (max. in Dock Sludge area).	57 acres	Based on pre- and post-dredging hydrographic surveys 195,000 cy	Hydraulic cutterhead: horizontal auger type dredges manufactured by ESG Manufacturing (Model Nos. MDS-177-10 and MDS-210-12; 8-foot wide cutter heads, 8-inch diameter auger with dredge mounted pump; equipped with Differential Global Positioning System control, and WINOPS computerized positioning system). Each pass removed 2-ft thick layer of sludge. Lateral overlaps during dredging: 2 ft. Excavation of dry sludge or sludge in shallow water.	Type of hydraulic dredging equipment used in the Dock Sludge area was modified to hand held suction lines operated by divers to remove pockets of sludge created by depressions (as deep as 6 feet) in the lake bottom from historic navigational dredging operations. Auger would bridge over these areas.	A "hard crust layer" originally interpreted as natural lake bottom was found to be compacted sand, silt, and paper pulp. This layer (10-16 ft below water surface) could not be penetrated by dredging equipment, was penetrated by divers and the underlain sludge (up to 4 ft thick) was removed. A change order was issued for this work.
United Heckathorn: Parr Canal and Lauritzen Channel on the San Francisco Bay	Removal of DDT and dieldrin contaminated sediment from August 1996 through March 1997	Provided inCase Study Appendix	Dredging located in the Richmond Harbor Area within two shipping inlets	Water depths as great as 32 to 34 feet	Not Available	Sediment consists of a top layer of younger bay mud consistent with soft clay, silt and fine sand overlaying older bay mud consistent with dry, consolidated silts and clays with some sand	15 acres	2,620cy from Parr Canal; 105,000cy from Lauritzen Channel	12-cy Cable Arm bucket and 7-cy clamshell bucket in areas containing obstructions or requiring debris removal	None- re-dredged with same equipment in areas requiring additional removal to meet RA goals	Large problem consisted of the amount of buried debris encountered (approximately 187tons of metal were recovered); Dredging halted on numerous occasions due to rail car unavailability-unable track rail cars traveling to the ECDC facility in Utah-not planned for since initially secured a local landfill however not used during project due to strong public opposition; unable dredge near docks and banks as planned-placed sand fill over these areas however not "true "cap capable of immobilizing contaminant and as a result the dredged area has become re-contamainted by sloughing of this bank material into the channel; Project not considered successful

Table 3-1
Case Studies
General Description of Dredge Sites

Site Name and Location	Project Description and Year Work Conducted	Figures	Geological Setting	Range of Water Depth (ft)	Range of Water Velocities (ft/s)	Sediment Characteristics	Area Dredged (acres)	Volume Dredged (cy or tons)	Dredge Equipment Used	Variation in Dredge Equipment for Clean-up passes to meet RI goals	Lessons Learned- Goals Achieved, if not reasons
Grand Calumet River, Indiana	Removal of PCB and VOC, specifically benzene, contaminated sediment from a 5 mile stretch of river; Dredging to begin at the end of November of this year (2002)	Provided inCase Study Appendix	Riverine Setting located in Gary, Indiana. River drains into Lake Michigan and is part of the Great Lakes Area of Concern	Not Available	Not Available	Dredging will be conducted to depths as great as 16-feet	Figure indicates bank to bank dredging over the 5-mile stretch. Width of river approximately 150ft from scaled figure.	To remove 800,000cy of PCB and VOC contaminated sediment	8-inch and 12-inch hydraulic swinging ladder dredge with a draft of 2.5-feet and working reach of 45-feet at a 30-degree angle. Also employ amphibious excavator for shallow sections and hard to access sections around structures.	EPA management stated that removal is not risk based and that sediment is being removed under RCRA to include all non-native material plus a 6-inch overcut; no planned residual dredging	Air Monitoring, Odor, water quality, and noise standards set for dredging; Noise levels in the range of 45-55dBA expected; Booster pumps to be enclosed with engineered mufflers; dredging pipe lines to be double sealed and positioned underwater along the shoreline; dredging to be conducted 24hrs/day, 6-7days/week with expected completion by July/August 2003; dredge slurry being pumped to an onsite CAMU (corrective action management unit);14 acres of wetlands being impacted and 32acres of dune and swale land being mitigated; bank stabilization issues-ran model to predict critical slope beyond which stabilization before dredging would be needed; determined cost of pre-stabilizing bank more than dredging costs.
New Bedford Harbor (Hot Spots), New Bedford, Massachusetts	Removal of PCB-contaminated sediments in hot spots located on the west side of the Acushnet River estuary between April 1994 and September 1995.	Site Location: Fig. 4-7	A shallow tidal estuarine area where the Acushnet River merges with upper New Bedford Harbor.			Fine sandy silt with clay (PCB concentrations exceeding 4,000 ppm)	5 acres	14,000 cy (estimated)	Ellicott 370 12-inch Cutterhead (selected via pilot program).		
New Bedford Harbor (Pre-Design Field Test), New Bedford, Massachuttes	A pre-design field test (mechanical dredging demonstration project) performed in August 2000. Dredging to commence in 2002.	Dredge Test Area: Fig. 4-8 Post-dredging sampling locations: Fig. 4-9 Site Location 4-10	A shallow tidal estuarine area where the Acushnet River merges with upper New Bedford Harbor.	Maximum depth less than 10 feet at high tide. Depth generally was 1-4 feet.	Maximum currents less than 0.5 ft/sec	Black organic silt surface layer underlain by native clean gray clay layer. Average pre-dredging concentrations: 857 ppm (0-1 ft) 147 ppm (1-2 ft) 26 ppm (2-3 ft)	1.3 acres (100 ft by 550 ft)	2,308 cy (in-situ volume)	Hydraulic excavator with a sealed clamshell bucket. Bean TEC Bonacavor hydraulic excavator (mechanical/hydraulic hybrid). Horizontal profiling bucket fitted to a hydraulic excavator equipped with an onboard digital geographic positioning control and monitoring system. Excavated sediments were re-slurried and pumped to shoreside ponds or cells.		Tested dredging equipment was found to be very efficient. Address recontamination due to sloughing during full scale operation: dredging from upslope to downslope; an understanding of tidal regime. Dredging operational approaches: return sweeps, tighter overlap of bucket grabs, slower retrieval of final bucket grab would provide cleaner bottom surface and reduce sloughing of adjacent areas.

Table 3-2
Case Studies
Resuspension Data for Dredge Sites

Site Name and Location	Project Description and Year Work Conducted	Study Completed on Variability of Baseline Levels for System	Resuspension Monitoring Sampling Plan				How were models Used to Develop the Monitoring Plan	Sampling Device and Analytical Methods	Impact on Downstream Water Supply Intakes	Estimate of Resuspension Rate and Flux of Contaminant Transported Downstream	Correlation Among TSS, turbidity, and contaminant	Technology used to Control Resuspension	Accidental Release Issues and Implemented Contingencies if resuspension Level exceeded	Biomonitoring	Comments/Observations/ Conclusions
			Sampling Locations	Monitored Parameters (TSS, Contaminant, and Turbidity)	Sampling Frequency	Action Levels and How They were Determined for Project									
Black River, Ohio	Removal of PAH contaminated sediment over a 1-mile stretch of river in 1989	Information not available in literature reviewed or from Ohio EPA or contractor personnel; separate consulting firm hired to collect environmental samples (Kiliam Associates out of Milburn, NJ)	Information not available in literature reviewed or from OhioEPA or contractor personnel; separate consulting firm hired to collect environmental samples (Kiliam Associates out of Milburn, NJ)	Information not available in literature reviewed or from OhioEPA or contractor personnel; separate consulting firm hired to collect environmental samples (Kiliam Associates out of Milburn, NJ)	Information not available in literature reviewed or from OhioEPA or contractor personnel; separate consulting firm hired to collect environmental samples (Kiliam Associates out of Milburn, NJ)	Information not available in literature reviewed or from OhioEPA or contractor personnel; separate consulting firm hired to collect environmental samples (Kiliam Associates out of Milburn, NJ)	Information not available in literature reviewed or from OhioEPA or contractor personnel; separate consulting firm hired to collect environmental samples (Kiliam Associates out of Milburn, NJ)	Information not available in literature reviewed or from OhioEPA or contractor personnel; separate consulting firm hired to collect environmental samples (Kiliam Associates out of Milburn, NJ)	None- no water supply intakes located downstream	Information not available in literature reviewed or from OhioEPA or contractor personnel; separate consulting firm hired to collect environmental samples (Kiliam Associates out of Milburn, NJ)	Information not available in literature reviewed or from OhioEPA or contractor personnel; separate consulting firm hired to collect environmental samples (Kiliam Associates out of Milburn, NJ)	Oil booms placed around dredged area	Literature reviewed indicated that a contingency plan existed in the vent of an oil spill however no spills occurred; details with regard to this plan not available	Conducted for brown bullheads; An increase in liver cancer in the bullheads was detected in 1992 and 1993, following dredging, however no liver cancer was found in 1994 bullhead samples collected of age 3. The incidence of liver cancer in brown bullheads continues to be low.	Sediment concentrations were reduced from 8.8-52 mg/kg to 1.6-3.7mg/kg two years after dredging
Manistique River, Michigan	Removal of PCB contaminated sediment over 1.7 miles from 1995 to 1999. Dredging in 1995 was completed as a pilot study because EPA initially planned to cap hot spots however dredging proved successful and cost-effective ROD revised; Dredging from 1995-1999 consisted of two hot spots in the river and one large hot spot in the harbor area.	Four water quality sampling studies completed prior to dredging in 1995. Average PCB concentration in water column reported for each study. This data was used as a comparison to PCB water column concentrations measured during dredging.	For 1997: seven samples from one station near dredge; one sample form upstream; six samples from a station downstream; and two samples from a station outside of the dredge area. For 1998: 9 samples from station upstream of dredge; 8 samples from locations downstream of dredge- distance and exact location not specified.	TSS, turbidity and PCBs	Not reported in literature reviewed	TSS concentration less than 2X the background turbidity within 50-feet of the dredge head; Literature reviewed stated that this level was achieved within 10-feet of the dredge head. PCB water quality threshold not stated in literature reviewed.	USACE TGU/EQUIL and RECOVERY models used to predict PCB water concentrations during and following dredging. Results of the model predicted a PCB water concentration of 460ng/L compared to a PCB water column concentration of 230ng/L collected during dredging in 1997 and 81ng/L in 1998. Within sediment, the models predicted PCB sediment concentrations to increase by 30ppm following dredging and then decrease to 10ppm by the year 2000 (assuming a depositional rate of 1inch/yr) however avg. [PCB] following 1997 dredge season was 18.1ppm and 7.06ppm in year 2000. It was concluded that these models overestimated dredging resuspension and sediment residual concentrations.	Not indicated in information reviewed; Detection limit for PCBs in water column was 0.05mg/L.	None- no water supply intakes located downstream	PCB loading from dredging provided for 1997 and 1998 as function of measured river flow, transport time of 24-hrs/day over 6-months and PCB water column concentrations. For 1997, PCB loading computed to be 75.8kg. For 1998, PCB loading computed to be 21kg.	Not stated in literature reviewed	In 1995, cofferdam and silt barriers with floating booms placed around dredge area; For 1996-1999, silt curtain was placed downstream of the downstream barge. Buoys used to keep the top of the curtain afloat and the curtain was not anchored to the bottom so it could rise and fall with the current. No barrier was placed at mouth of river so as to not impede river traffic. Further containment was not used due to the low dredge rate.	None stated in the literature reviewed; Pumps were sealed and dual pump design initiated to prevent spills/leaks and complications in the event of pump failure.	Information not provided in documents available for review	In 1997: avg. PCB water column concentrations outside dredge area was 0.37mg/L and avg. [PCB] downstream of dredge was 0.23mg/l compared to pre-dredge concentration of 0.001mg/L. The background sample collected during this event was 0.062 mg/L PCBs. In 1998: Avg. upstream [PCB] was 0.093mg/L and the average [PCB] downstream was 0.066mg/L. On average, it was stated that PCB concentrations detected in the water column ranged between 100-200ppt. It was noted that no visual resuspension occurred in 1995 during the pilot study. This was confirmed by divers who watched the dredge operation.
Fox River: Kimberly, Wisconsin	Deposit N: Removal of PCB contaminated sediment from Nov. 1998 - Dec. 1999 (Phase I); August 1999 to November 1999 (Phase II)	Yes- Ten River water samples were collected immediately upstream of Deposit N for TSS and turbidity; Samples collected with a Kemmerer water sampler from a boat during pre-design; Real time turbidity measured 7-days before start of dredging as well.	Real Time Turbidity monitoring at 6 stations: (1) upstream, (1) side gradient, (1) downstream, (1) at ILP water intake, (1) at the ILP effluent discharge, and (1) within the contained dredge area; Measured turbidity at 50% total water depth	Turbidity measured which was correlated to TSS	Turbidity measurements recorded on 15-minute intervals; average hourly turbidity computed from (4) 15-min samples each hour	Turbidity: Threshold limit based on hourly average value			Measured turbidity on intake and effluent at paper company; not net increase as result of dredging	Only turbidity data (NTU) available in reports reviewed; no TSS or PCB data measured or available	Performed Bench Scale tests to evaluate sediment resuspension and settling rates by collection of water samples from disturbed slurry column (set up 1-ft sediment layer under 5-ft river water and agitated system with forced air); Tests indicated following relationship: y= -1.27 + 1.313x with r2 = 0.988 and x=turbidity and y=TSS; allowed turbidity to be measured in field as estimate of TSS with this equation	Phase I (1998); 80 mil HDPE Turbidity Barrier installed around perimeter of Deposit N and a silt curtain was deployed within Deposit N ; modified for Phase II-IV (1999) and used only a silt curtain 150-ft or less downstream of the dredge (eliminated turbidity barrier around perimeter)	No accidental releases noted; pumped directly to land side processing plant	Caged Fish sampling	
Fox River: Green Bay, Wisconsin	SMU 56/57 - Phase I- Aug. 1999 to Nov. 1999	Performed water quality sampling prior to dredging; described in the EMQAPP report (Environmental Monitoring Quality Assurance Project Plan); will try to obtain report from contacts for the site (Oct 23, 2002)	Real time turbidity monitoring at 6 locations: (1) upstream dredge outside turbidity barrier;(1) upstream dredge inside turbidity barrier;(1) side stream dredge outside turbidity barrier;(1) downstream dredge outside turbidity barrier;(1) downstream dredge inside turbidity barrier; (1) at Fort James water intake - Each meter located in water column at 50-60% of the water depth for location	Turbidity measured as well as water depth and water temp. at each location; for the side stream dredge location, river current and direction was monitored with a Son-Tek Argonaut-SL acoustic doppler	Turbidity measurements recorded on 15-minute intervals; average hourly turbidity computed from (4) 15-min samples each hour			YSI 6820 self-cleaning turbidity sensor used at monitoring location; sensors connected to a YSI 6200 data platform and was transmitted by radio to a YSI base station unit at the job trailer on land	No Downstream water supply intake; only upstream supply existed	Only turbidity data (NTU) available in reports reviewed; no TSS or PCB data measured or available	None made for project; only measured turbidity; need to review the EMQAPP to see if any plan or relation was stated or would have been measured	Permeable turbidity barrier manufactured by Brockton Equipment/Spill dam, Inc.; equip with surface cell foam flotation wrapped in orange PVC coated polyester fabric with a skirt with 0.420-0.297 mm opening (40-50 US stnd. Sieve); skirt extended through water column to top of sediment	No reported accidental releases from dredging reported; pumped directly to land-side facility		Additional anchors needed to stabilize turbidity barrier during project due to wind and river currents; took several days to deploy the 1,700 ft of barrier (17 panels); used spare turbidity meter (hand held display unit) to perform weekly checks of the real-time turbidity meters by collecting a reading with spare unit adjacent to the real-time unit; then the real-time unit was disconnected from data collection platform and connected to hand held unit and a reading was taken and compared for accuracy
Fox River: Green Bay, Wisconsin	SMU 56/57 - Phase II- 2000	Not stated in report but evaluated turbidity values based on difference between the upstream and downstream sample collected	Real Time Turbidity Monitoring at 3 locations: (1) upstream of silt curtain at the Fort James water intake; (1) 10-ft downstream of the silt curtain; and (1) 50-ft downstream of the silt curtain	Turbidity measured upstream with stationary meter (YSI model 6820) and downstream with a portable meter (YSI model 6820); PCBs in water column were not measured since there were no exceedances of the turbidity value	Began project collecting twice daily measurements; down-graded to twice daily every other day in October since no turbidity exceedances had occurred from dredging to date	Turbidity: reached threshold if downstream turbidity reading was two or more times higher than the upstream reading and cause was related to dredging	No models discussed; seemed that meters placed upstream and downstream of dredging since small contained area	YSI model 6820 Turbidity meter used as a stationary and portable meter	Only upstream water supply intake existed; no downstream turbidity exceedances(thus no PCB resuspension according to report)	Only turbidity data (NTU) available in reports reviewed; no TSS or PCB data measured or available	PCBs in water column during dredging not measured since turbidity measurements did not exceed threshold; need to see QAPP/SAP to find out sampling plan and threshold for PCBs if turbidity would have been a problem	Permeable silt curtain with mesh size of 0.30 to 4.42 mm placed around dredged area; used three silt curtains within dredged area as dredging moved from north to south	No reported accidental releases from dredging; pumped directly to a land-side facility	Caged Fish sampling	
Reynolds Metals: St. Lawrence River, Massena. NY	Removal of PCB-contaminated sediment at Reynolds Metals Company from April 2001 through November 2001	Not stated in report but evaluated turbidity and contaminant values based on difference between the up current and down current sample collected	A fixed background station was set at the upperstream of remediation area. Samples were collected at different monitoring stations at different project phases. Installation of the sheetpile: 3 Turbidity monitoring stations, 1 upcurrent (100ft) and 2 downcurrent (200ft and 400 ft); 2 water column monitoring stations, one 100ft up current and another 200 ft down current. During dredging: outside the sheetpile closure, 4 monitoring stations, one upcurrent (100ft from the active dredge) and 3 down current stations (10, 150 and 300 ft from the sheetpile wall closest to the dredge being monitored. both turbidity and water column samples were collectd from these 4 stations; Inside the sheetpile enclosure, turbidity was monitored at 12 to 19 different stations; weekly filtered water column samples were collected at one station from June 10 thru Oct. 10. daily unfiltered water column samples were collected at three stations from Oct 15 thru November 20. During capping: turbidity was measured at five stations, all of them inside the sheet pile enclosure (background, 100ft up current, adjacent to barge, During sheetpile removal: turbidity and water colu	Turbidity and water column samples (PCBs , PAHs, and PCDFs) TSS was not measured in this project.	turbidity was monitored at 2 hours interval during sheet pile installation. A total of 111 water samples were collected during sheet pile installation (4/19/01-6/5/01). During dredging, at the stations outside of the sheet pile enclosure, turbidity was monitored at 2 hours interval and water samples were collected daily; inside the sheet pile enclosures, daily turbidity measurement were conducted and weekly or daily water column samples were collected at different stations for the certain period. Continous turbidity measurements were also collected at fixed locaion inside the sheet pile enclosure during dredging and measurements were collected every hour. During the 18 days of sheet pile wall removal activities, 1451 turbidity measurements, 113 PCB samples, 93 PAH samples, and 100 PCDF samples were collected and analyzed. In the EWP, it is	The action level for turbidity is 25 NTU above the background level, which is derived based on 28 NTU action level used in GM Massena: The action levels for water column samples are 2 ug/L of PCBs, 0.2 ug/L for PAHs and detectable PCDFs above the practical quantitation limit (PQL).	Current velocity and direction studies were conducted prior to and after completion of the sheet pile wall. Its results were used to guide the selection of monitoring locations. No model was used in developing the monitoring plan.	Turbidity measurements were collected with a direct-reading turbidity meter (Hydrolab). QC checks of the Hydrolab were conducted using a Hach turbidity measuring kit. A data-logging turbidity meter was also installed at a fixed location and recorded turbidity measurements. according to a defined schedule Analytical methods 8082A(PCB), 610 (PAHs) and 8290A(PCDFs)	Both treated and untreated water samples were collected from AMN, GM and RMC water plants. During dredging operations involving the removal of sediment with >500 ppm PCBs and removal of sheet pile wall, water samples were collected from the designated locations daily. Samples were collected on a weekly basis during other dredging activities. A total of 261 intake samples were collected and analyzed for PCBs and 117 samples for PAHs. The water quality action levels were non-detectable PCB and PAH concentrations, with detection limits of 0.065 ug/L and 0.2 ug/L, respectively. Except one samples	Flow was not monitored corresponding to the samples collected during the remediation activities.	TSS was not measured. As expected, it is found that the absence of turbidity in a sample generally resulted in a sample with no contamination, or least no contamination above the action levels.	Sheet pile wall enclosed the entire remediation area; silt curtains provided secondary containment for the more highly contaminated Area C and isolated uncontaminated portions of Area B from the dredging area; air gates created an air-bubble curtain that acted as a circulation barrier while allowing for barge and tugboat access to areas enclosed by the silt curtain and sheet pile wall.	No reported accidental release.	No biomonitoring	It is concluded in the completion report that there was no impact on St. Lawrence River and water intake due to dredging since exceedance to the action level was seldom observed during the project activities.

Table 3-2
Case Studies
Resuspension Data for Dredge Sites

Site Name and Location	Project Description and Year Work Conducted	Study Completed on Variability of Baseline Levels for System	Resuspension Monitoring Sampling Plan				How were models Used to Develop the Monitoring Plan	Sampling Device and Analytical Methods	Impact on Downstream Water Supply Intakes	Estimate of Resuspension Rate and Flux of Contaminant Transported Downstream	Correlation Among TSS, turbidity, and contaminant	Technology used to Control Resuspension	Accidental Release Issues and Implemented Contingencies if resuspension Level exceeded	Biomonitoring	Comments/Observations/ Conclusions
			Sampling Locations	Monitored Parameters (TSS, Contaminant, and Turbidity)	Sampling Frequency	Action Levels and How They were Determined for Project									
GM Massena: St. Lawrence River, Massena, NY	Removal of PCB-contaminated sediment at General Motors-Massena Superfund site from May (March) 1995 through December 1995 (January 1996). Dewatering and excavation of the cove area were not carried out as of the report date due to unsettled access issues.	No such study noted. Monitoring locations during dredging activities included one upstream station that remained in the same location throughout the the project.	Visual observations and real-time turbidity monitoring at 3 locations: 50 feet upstream of western extent of control system, two between 200 feet and 400 feet downstream of easternmost active installations. Measurements collected from 50% water depth. Water column sampling at the same two downstream locations as the turbidity measurements.	Turbidity PCBs, PAHs	Daily at 2-hour intervals until September 5, 1995, thereafter three times a day . If real time turbidity value downstream exceeded the upstream value by 28 NTUs for 5 mins or more, turbidity measurements downstream continued for at least 1 hour or until the exceedance stops. If the exceedance continued water-borne remediation activities would have to be modified until the problem was rectified. Two samples per day	Action level was selected based on a 1994 site-specific bench-scale laboratory correlation between TSS and turbidity, and experience in previous dredging projects. Downstream turbidity 28 NTUs above background corresponded to a downstream TSS of 25 mg/L above backgound. PCB: 2 ug/L (at downstream monitoring locations)		Turbidity: Horiba Water Quality Tester, Model U-10. PCBs: EPA 608 (MDL=0.5 ug/L), PAHs: EPA 625 (MDL=5.0 ug/L)	GM treatment facility original intake was in Phase 1 dredging area, extended beyond dredging area an additional 85 ft. SRMT treatment facility 1.5 miles downstream of GM facility. GM: 1 treated grab sample daily, SRMT: 1 raw & 1 treated grab sample daily (dredging of areas >500 ppm); weekly sampling (dredging of areas <500 ppm). SRMT: 2 out of 52 untreated water samples (PCBs 0.090 and 0.085 ug/L) others ND. GM: PCBs (0.27-0.54 ug/L, June 19-July 10, assumed to due to a leak into piping in dredging area) (two detections 0.12 & 0.14 ug/L, July 10-Dec. 22)		Based on bench-scale tests the following correlation was developed for overall conditions including elevated TSS results (i.e., >300 mg/L): Turbidity (NTU)=7.3745+(0.611058XTSS)+(0.000 94375XTSS2), r2=0.941. Based on a regression analysis for TSS <60 mg/L and Turbidity <60 NTU this equation was reduced to TSS (mg/L)=[0.63x(Turbidity in NTU)]+6.8, r2=0.43. Turbidity of 28 NTU would correlate to TSS of <25 mg/L.	Steel sheet pile walls.	18 out of 923 turbidity measurements were above 28 NTU action level (31-127 NTUs), at a depth of 1 ft below water surface (except for one measurement at 9 ft). Duration of exceedances: 2-8 minutes (two exceedances 15 mins and 45 mins). Cause of exceedances: overflows at low steel sheets (installed as per design to assure stability of the containment system during storms and high waves). Installation of filter fabric over low steel sheets, and additional short steel sheets over some low steel sheets, and mechanical raising of some sheets.		A Sampling Depth and Location Evaluation study was conducted during initial dredging operations to determine optimum sampling locations for the measurement of turbidity and collection of water column samples. Measurements were collected from three locations (and two additional locations along the outboard side of the control system) at intervals between 200-300 ft apart at ~ 7 ft, 15 ft and 22 ft below water surface (i.e., ~ 25%, 50% and 74% of measured water depths). Data were collected twice daily for three consecutive days, i.e. a total of 90 data points). Sampling locations and depths that exhibited highest values of turbidity were used for turbidity and water column sampling during dredging operations.
Cumberland Bay: New York	Removal of PCB-contaminated sludge bed (OU-1) at Cumberland Bay Wilcox Dock Sludge Bed site, and debris removal from public and private beaches (segment of OU-2), in the Town of Plattsburgh, Clinton County, New York, from April 1999 to November 2000.		Turbidity was used only to alert the operators for potential re-suspension problem, not associated action level. Operational Monitoring: Real-time turbidity monitoring in 2 locations: on dredge head and using a float that trailed behind the dredge (initially 25 feet later 50 feet behind the active dredge - changed based on material being dredged and turbidity-). Electronic recording on-board the dredge. Compliance Monitoring: Four OBS-3 sensor stations which changed for each active work zone one sensor in a background location (near breakwater) w/ a water depth approximating that in the work zone, three sensors outside the perimeter of the work zone silt curtain (an additional temporary sensor near Georgia-Pacific's industrial water intake). At mid-depth level of water column. Data telemetered to an off-shore control station and recorded electronically. Documentation Monitoring: Six fixed turbidity monitoring (TM) buoys (in 1999 outside perimeter turbidity curtain; 2000 locations different).	TSS, turbidity and PCB	Compliance Monitoring: TSS-Daily; twice a day during 24-hour dredging operations. PCB-occasional. Documentation Monitoring: TSS/Turbidity-Initially one sample per day; 24-hour dredging operations: one sample at the beginning of each 12-hour shift. PCB-one sample per week.	Operational Monitoring: TSS 25 mg/L above background. Compliance Monitoring (outside turbidity barrier): TSS 4 mg/L above background. When action level was exceeded dredging was suspended or modified.		TSS: Kemmer sampler; on-site testing (DL=4 mg/L) Turbidity: OBS-3 turbidity sensors. PCB: EPA Method 8082 (DL=0.065 mg/L)	Georgia-Pacific water intake was monitored prior to and during dredging. Two rows of permeable silt curtain were installed in front of Georgia-Pacific water intake for protection from suspended material. During dredging of Breakwater area Georgia-Pacific was placed on City water to prevent the possibility of PCB-contaminated sediments entering the system.		After a series of tests Earth Tech & NYSDEC concluded that no correlation exists between turbidity & TSS. Used turbidity only as an indicator and not in association w/ action level.	Temporary sheet piling (1,000 lineal feet 24,000 sq. ft.) and perimeter silt curtains (2,200 lineal feet 4-ft deep around the sheet piling) were installed to isolate the sludge bed. Previously planned floating boom replaced by silt curtain as per USACOE permit requirement.			Dredging progressed from shallower perimeter areas toward deeper areas to minimize possibility of undercutting the sludge bank that would lead to slumping and an increase in resuspension. Due to thick deposit and high organic content in the Dock Sludge area gases of decomposition caused chunks of sludge to break away and float to the surface. This material was captured using seine nets. Dredging with horizontal auger causes resuspension of fine sediments. The problem is exacerbated if the auger is rotated too rapidly, or if the equipment is advanced too quickly. The capture efficiency at the controls may have been better if provisions on the rate of auger rotation and advance were included in the specifications. Occasional high turbidities observed due to backflushing of dredge slurry when dredging operations were interrupted could be minimized as follows: "Instead of flushing the screen with dredged slurry residing in the dredge line, lift the cutter head off the bottom, and suck in enough clear water to displace the slurry in the piping and use it for screen backwash."
United Heckathorn: Parr Canal and Lauritzen Channel on the San Francisco Bay	Removal of DDT and dieldrin contaminated sediment from August 1996 through March 1997	Not Available but previous sediment and water quality studies completed by EPA during RI and design efforts	Four water quality sampling stations- Appears that locations were established both upstream and downstream of area being dredged and downstream/outside channel in the harbor and bay at both ends	TSS and Contaminants: DDT and Dieldrin standards set for dredging	Pre-remediation: Data provided as average of samples collected in Oct. 1991 and February 1992	Surface water: Dieldrin 0.14ng/L and DDT 0.59ng/L both based on EPA AWQ (Ambient water Quality criteria); based on human health standards	Literature reviewed did not indicate that models were used to develop WQ monitoring plan	Not Available in Literature reviewed	None- no water supply intakes located downstream; industrial area	Not Available in Literature reviewed	Information Not Available however literature reviewed stated that water is always very turbid due to the large amount of heavy marine activity from vessel and tanker delivery of raw materials	Silt barrier placed across mouth of canal for both Parr Canal and Lauritzen Channel dredging; it was thought that the use of Cable Arm would help reduce turbidity during dredging	None reported; no stated contingency plan in the event of a release	Measured concentration of DDT and dieldrin in tissue of mussels at 4 stations (same stations used for WQ monitoring); measured before and each year following dredging as part of the five year long term program	Collected DDT data indicates that current (1999) sediment concentrations exceed protection of human health criterion (590ug/kg); Current (2001) water samples collected indicate a high total DDT concentration of 142ng/L at the end of the Lauritzen Channel (RA goal of 0.59ng/L); At the same station a high dieldrin concentration of 8.49ng/L was measured (2001) compared to the RA goal of 0.14ng/L.
Grand Calumet River, Indiana	Removal of PCB and VOC, specifically benzene, contaminated sediment from a 5-mile stretch of river; Dredging to begin at the end of November of this year (2002)	Surface water quality exists for Grand Calumet river; IDEM (Indiana Dept. Env. Management) stated that 20 background WQ samples COULD be collected prior to dredging however USX (PRP) is anticipating adding an additional sampling location to the WQ monitoring plan to avoid the collection of background samples.	(1) upstream background sampling location; (1) located near mid-channel 200-yd downstream from open water dredge; (1) downstream sampling site below 5-mile dredge area; (1) proposed sample location for verification analysis located 200-yd upstream of open water dredging in cell c	Flow, total ammonia, specific conductance, DO, pH, sulfides, temp., and turbidity monitored daily (Level 1) by multi-parameter automatic data logger system; microtox chemical testing for acute and chronic toxicity (level 2); chemical monitoring for total ammonia, pH, sulfides, temp, free cyanide, hardness, oil and grease, TSS, dissolved aluminum, dissolved copper, dissolved lead, total mercury, dissolved zinc, select VOCs,	Collect flow, total ammonia, conductance, DO, pH, sulfides, temp and turbidity 24hrs/day; Microtox to be conducted every other day; Level 3 parameters collected once per month	IDEM chronic and acute state surface water criteria;	Model not used to develop monitoring plan	Water sample to be collected as composite from surface, 50% of water depth, and 80% of water depth	None-no water supply intake located downstream	Not yet known-project has not started	Not yet known-project has not started	Area A , B and C to be contained within cofferdams; then oil booms and silt curtains placed within cofferdams for each cell; Area D to be dredged in open water with no containment: Most-heavily contaminated area being contained	Contingency Plan set up if WQ adversely impacted from dredging; received copy of water quality work plan and flow chart; generally, if toxicity shown in level 2 monitoring then collect additional samples and if still get toxicity (acute) confirmed then begin analyzing for additional parameters and if all exceed or none exceed, then continue dredging; similar plan for chronic toxicity; for level 3, if all exceed or none exceed, then continue but if one sample exceeds, then sample at the verification station to confirm and if do not excee at verification location (upstream of dredging) then assume exceedance result of dredging and begin enhanced monitoring whic involves collecting one more sample per week for level 2 exceedance and three more samples per week for level 3 exceedance. End enhanced monitoring when samples less than criterion for 2months of consecutive samples.		To implement the following to alleviate exceedances: slow down dredging rate; install additional silt curtains, oil booms, or other control items; temporary suspension of dredging; conduct additional monitoring; and no-action if determine that exceedance is not result of dredging
New Bedford Harbor (Hot Spots), New Bedford, Massachusetts	Removal of PCB-contaminated sediments in hot spots located on the west side of the Acushnet River estuary between April 1994 and September 1995. (An additional goal was to minimize the transport of contaminants to lower harbor).	Yes.	Down current locations: 50 ft, 300 ft, 700 ft, and 1,000 ft. from dredging area. Background measurements: ~ 1,000 ft up-current of dredging operations. Sampling depth: ~ mid-depth in the water column.	PCBs (24-hr turn-around) and metals. PCBs (Total PCBs: dissolved and particulate tested separately and summed).	One sample (composite of 13 grabs) at each flood tide and one sample (composite of 13 grabs) at each ebb tide (6-inch rise and fall).	PCB water column concentration of 1.3 mg/L determined by a pilot study. Maximum cumulative transport (MCT) of PCBs during the entire operation at station NBH-2 (transition between upper-lower harbor) based on "that mass of PCBs transported out from the upper harbor, above background concentrations, that would increase the mean lower harbor sediment concentration by more than 1 ppm". Estimated mass of lower harbor sediments (biologically active upper 4 cm): 240x106 Kg (dry weight). Thus MCT: 240 Kg PCBs.				MCT for the entire period of operation (260 days) at NBH-2: 57 Kg (24% of max. allowed)		Silt curtains (abandoned due to heir continuous disturbance of the bottom).		Toxicity tests (sea urchin sperm cell test, 7-day mysid growth survival test, and red alga survival test) and bioaccumulation (mussels) at two stations (i.e., NBH-2 and NBH-4) (Fig. 8).	High suction, low auger rotation emphasized to control resuspension.

Table 3-2
Case Studies
Resuspension Data for Dredge Sites

Site Name and Location	Project Description and Year Work Conducted	Study Completed on Variability of Baseline Levels for System	Resuspension Monitoring Sampling Plan				How were models Used to Develop the Monitoring Plan	Sampling Device and Analytical Methods	Impact on Downstream Water Supply Intakes	Estimate of Resuspension Rate and Flux of Contaminant Transported Downstream	Correlation Among TSS, turbidity, and contaminant	Technology used to Control Resuspension	Accidental Release Issues and Implemented Contingencies if resuspension Level exceeded	Biomonitoring	Comments/Observations/ Conclusions
			Sampling Locations	Monitored Parameters (TSS, Contaminant, and Turbidity)	Sampling Frequency	Action Levels and How They were Determined for Project									
New Bedford Harbor (Pre-Design Field Test), New Bedford, Massachuttes	A pre-design field test (mechanical dredging demonstration project) performed in August 2000. Dredging to commence in 2004.		Monitoring station-2 300 ft away from dredge; additional sampling as required at 600 ft away from dredge. Background measurements ~ 1,000 ft up-current of dredging operations. Sampling depth: ~ mid-depth in the water column.	TSS, turbidity and PCBs (dissolved and particulate, PCB congeners)		PCB: Harbor background/ambient concentration in water column exceeded Federal surface water quality criteria. Therefore, no limit was set for PCBs. Maximum Cumulative Transport (MCT) at Monitoring Station 2 (at the limit of mixing zone 300 ft from the dredge): 400 kg PCBs throughout entire dredging project. Turbidity: 50 NTU above background at MS 2 (300 ft from the dredge); when this limit was exceeded bioassay test was conducted, and turbidity was measured at 600 ft from dredge (>50 NTU dredging would stop; but this was infrequent and since bioassay tests did not show any ecological impact, dredging was not halted).	Model was established from RMA2 (USACE hydrodynamic model) and SED 2D (USACE sediment transport model). Models were used to simulate the tidal system and sediment resuspension. The model assumed a prototype dredge and typical resuspension rate to predict how far downstream of the dredge the resuspended sediments would move prior to settling out. The model overestimated the distance the sediments would migrate before settling out, thus the location of monitoring stations.	Optical backscatter nephelometer with an underwater sensor (range 0-2000 NTU) manufactured by D&A instruments.			A general positive correlation was observed between TSS and particulate PCBs.			Bioassay sampling to determine if acute or chronic toxicity was occurring. Sea urchin fertilization, Mysid 48-hr mortality, Red alga 48-hr viability	Average production rate: 80 cy/hr

Table 3-3
Case Studies
Residual Data for Case Studies

Site Name and Location	Project Description and Year Work Conducted	Residual Target Clean-up Level	Summary of Post-Dredging Samples						Acceptable Residual Concentrations	Analysis Conducted	Analytical Methods (Field and Lab)	Thickness of Residual Sediment	Description of Bottom Layer (soft, rocky, etc.)	Sampling Technique to measure residuals (grab, core, probe)	Number of Passes made to be meet acceptable residual level	Type of Backfill/capping, if any	Engineering Contingency Plan Implemented	Special Equipment Used to Reduce Residual Levels	Comments/Special Observations from Project
			Number of Samples	Location of Samples	Method of sample Location in Field	Type of Samples Collected (depth, core, and grab)	Time of Collection	Goodness of Spatial Distribution Analysis											
Black River, Ohio	Removal of PAH contaminated sediment over a 1-mile stretch of river in 1989	No set quantitative goal; removal to be conducted to the hard shale bottom (removal of all sediment)	Data not available immediately following dredging; one year study performed 7-years after dredging (1997) consisted of 12 sampling locations	Not indicated immediately following dredging; for one year study (1997), samples located over 5-mile stretch of river near banks where depositional sediment is located with one upstream location for background	Not indicated	Sediment Core samples for depth of 0 to 10 cm. Analyzed upper 2-cm for PAH and froze remainder for historical analysis if needed in the future	Not Known following dredging; one year study (1997) conducted in October 1997)	Not known- there was no figure provided to identify sampling locations	No set residual concentrations: PAH concentrations after dredging ranged from 1.6 to 3.7mg/kg.	PAH analyzed for sediment	Not stated in literature reviewed	Not stated if any residual sediment existed since all sediment removed to reveal the hard shale bottom	Hard shale rock bottom	Residuals not measured; dredged to hard shale bottom	Not Applicable; dredged to hard shale bottom	No backfill placed following dredging	Dredging to be completed to the hard shale bottom	None	1997 one year study analyzed sediment, overlying water, and biota-results indicated that dredging was a success. A greater toxicity was found in historic sediments however it is thought that deeper sediments are exposed during resuspension events resulting from storms, high flow and heavy boat traffic but levels are much lower than PAH levels measured prior to dredging.
Manistique River, Michigan	Removal of PCB contaminated sediment over 1.7 miles from 1995 to 1999. Dredging in 1995 was completed as a pilot study because EPA initially planned to cap hot spots however dredging proved successful and cost-effective ROD revised; Dredging from 1995-1999	10 ppm or less in sediment	Data provided for post-confirmation dredging conducted after 1997 dredge season- for this period, 10 samples collected; Following completion of dredging in 1999, FIELDS team collected 400 samples to verify 10ppm or less met throughout area	Literature reviewed did not indicate where 10 samples were located following dredging in 1997. For FIELDS study, 400 samples located throughout entire river and harbor in unaligned grid	Not indicated	Sediment core sample collected from top 12-inches of sediment by FIELDS team	Not indicated in literature reviewed	Not know for 1997 sampling period; sampling by FIELDS team covered dredged area extensively	10ppm or less to be acceptable otherwise diver-assisted dredging occurred to remove residual to this level	PCB Aroclors	Not stated in literature reviewed	Not stated- all residual removed with diver assisted dredging	Not stated	sediment core sample from top 12-inches	Not stated	No backfill placed following dredging	None stated	Diver assisted dredging with suction pump	Pre-dredge sediment concentrations were 16.5ppm from 0-3inches; 77.5ppm from 3-24inches; 200ppm at depths greater than 24inches with an overall average of 85.5ppm; sampling following 1997 indicated sediment concentrations of 18.1ppm PCB (mean) and 7.2ppmPCB (median). Sediment data from the FIELDS team (1999) indicated an average site-wide PCB concentration of 7.06ppm with a 95% confidence interval from 4.40 to 9.72ppm.
Fox River: Kimberly, Wisconsin	Deposit N: Removal of PCB contaminated sediment from Nov. 1998 - Oct. 1999 (Phase I)	No set objective for post-dredge sediment bottom	30	Same as pre-dredge location; marked with a buoy; inside and outside the dredged area (within turbidity barrier as well as dredged area)		Collected both sediment core and grab samples to refusal	Not known	See Figure 10: 10 samples on grid in eastern lobe and 20 samples on grid in western lobe	No set residual limit for project; not objective of the project	PCB Aroclors, mercury, TOC, particle size, density, and water content; 13 random samples analyzed for PCB congeners (10 samples during design/pre-dredge)			Silty-sand overlying native clay - characteristic of Fox River	Divers used to collect core samples to refusal; sample segmented to 0-4, 4-12, and 12-refusal; Ponar grab samplers used for thinner sediment layers		None stated	None stated	None	
Fox River: Green Bay, Wisconsin	SMU 56/57 - Phase I-1999	1 ppm PCBs to depths ranging from 2 to 16-feet	13 (although 38 pre-dredge samples collected in this area); targeted subunits where majority dredging occurred; attempted take post-dredge sample in same location as pre-dredge sample	Located within 100 x 100 ft grided subunits-sample taken from center of the area	Differential GPS used to mark pre-dredge core locations (within 5-ft) in subunits where dredging occurred	Collected sediment core samples to refusal (0-4,", 4-12", 1-ft sections to refusal);	Not known	Sample locations associated with coordinates; in grid system; samples collected from center of each subunit (each subunit represents 100 x 100 sq. ft. area)	Set depth to dredge so all PCBs > 1ppm were targeted for removal; performed post-dredge survey and sampling at end of dredging	PCB Aroclors, mercury, density, TOC, %solids, and particle size	Lab Methods: PCBs (SW846 8082); mercury (SW846 7471A); % solids (SM 2540G Mod); TOC (SW846 9060M)		Silty-sand overlying native clay- characteristic of Fox River	Sampling tubes with 4-inch diameter Schedule 40 PVC manually pushed into sediment until refusal and then used sleeve hammer to drive tube a few more inches into firmer sediment	Four subunits required additional passes with dredge due to unacceptable PCB conc. from sample; conducted in 30 x 30 sq. ft. areas	None at this time; ultimately capped dredged area at conclusion of Phase II with 8-inches sand on average	Planned to re-dredge to remove any high residuals	None; Although dredging was halted due to winter, high residuals left behind since time not available to perform the clean-up pass as initially planned for (go back over entire dredge area at end and remove 6-inches of sediment)	Initially planned for a clean up pass following completion of production dredging to remove top 6-inches that may have been contaminated from any resuspended sediment that settled out
Fox River: Green Bay, Wisconsin	SMU 56/57 - Phase II-2000	Remove sediment to verified post-dredge elevation and sample and if-(1) [PCB]<1 ppm complete; (2) [PCB] 1 ppm-10 ppm, place 6" sand; (3) [PCB] >10 ppm, re-dredge until [PCB] <10 ppm and then cap as above	28	Collected 5-samples from 25 cells located within each 100x100 sf area	Graphically displayed on site map; used 16-ft aluminum boat and anchored in location of subunit; used geodimeter with 360-degree prism to adjust boat into 0.1 ft of sample location	Measured water depth at each location with graduated rod with 1ft by 1ft plexi glass plate on bottom; then sediment sampled with a Wildco stainless steel hand corer with 2-inch diameter CAB core tubes ; collected homogenized sample from 0-4inches and 6-inch segments thereafter	Not known	Divided each 100x100sf area into 25 cells, each 20 x 20 sf; used random number generator to determine one primary and four secondary units to be sampled	Remove PCBs to conc. 10 ppm or less; All post-dredge samples ranged from non-detect to 9.5 ppm PCB; 11 out of 28 samples (40%) < 1ppm PCB; 24 out of 28 samples (86%) < 4ppm PCB	PCBs	Samples cut open with dremmel saw and homogenized in steel bowls with steel spoons and placed in lab jar for analysis; Lab used USEPA SW 846 reference method 8082 to measure samples for PCBs	Not stated in report	Not stated in report however report indicated if clay present and post-dredge bathymetric survey indicated target depth not obtained, area not dredged anymore since clay native and all project data stated native clay not contaminated with PCBs	Collected sediment cores with a Wildco stainless steel hand corer with 2-icnh diam. CAB core tubes	Residuals met after required depth sediment removed; 0 extra passes needed	13,500 cy of sand was placed at a range of 6-14 inches over the entire dredged area (8-inch on avg). More sand was placed in locations where PCB residual was greater. Placed with a clamshell from above water surface, used divers to assist in even placement; placed radially; verified depth of placement in minimum of 4-locations per subunit (100 x 100 sf area)	Residual conc. Set up so that backfill depth was dependent upon residual conc.; if residuals exceeded 10ppm, then re-dredging was required until a conc. <10ppm PCBs was reported	None	

Table 3-3
Case Studies
Residual Data for Case Studies

Site Name and Location	Project Description and Year Work Conducted	Residual Target Clean-up Level	Summary of Post-Dredging Samples: Number of Samples	Location of Samples	Method of sample Location in Field	Type of Samples Collected (depth, core, and grab)	Time of Collection	Goodness of Spatial Distribution Analysis	Acceptable Residual Concentrations	Analysis Conducted	Analytical Methods (Field and Lab)	Thickness of Residual Sediment	Description of Bottom Layer (soft, rocky, etc.)	Sampling Technique to measure residuals (grab, core, probe)	Number of Passes made to be meet acceptable residual level	Type of Backfill/capping, if any	Engineering Contingency Plan Implemented	Special Equipment Used to Reduce Residual Levels	Comments/Special Observations from Project
Reynolds Metals: St. Lawrence River, Massena. NY	Removal of PCB-contaminated sediment at Reynolds Metals Company from April 2001 through November 2001	removal of sediment containing greater than 1 ppm PCBs, 10 ppm PAHS, and 1 ppb PCDFs	A total of 532 immunoassay analyses and 566 lab analyses for PCB in sediment. 546 dredge passes in 268 cells. Verification samples were collected in the dredged cell after each dredge pass. Samples were also collected from "no-dredge cell" in order to verify that they were not impacted by nearby dredging. RMC collected samples from 43 dredge cells for PAH analyses and EPA sampled additional 53 cells for PAH analyses. A total of 32 final verification samples were collected for PCDF analyses.	Verification sampling locations in Area A and D were based on a triangular grid spacing of 70 ft; location in Area C were based on a triangular grid of 50 ft. The triangular grid was used to define contaminant baseline conditions in Areas A, B, and C in previous study.	It is mentioned in the Completion Report that the configuration of sampling grids was developed on the basis of earlier statistical studies and input from EPA (Bechtel, 1996). Is trying to obtain a copy of that report from Dino.	Verification samples were initially collected using a Ponar dredge sampler operated from the ATL sampling barge. The sampling technique was changed to the split-spoon method when it became apparent that the Ponar would not be able to generate samples representative of the 0-8 in. sediment interval.	The EMP stated that sampling will occur after "sufficient time" has elapsed to allow for settling of suspended solids, but does not specify a minimum time. Actually, some of the cells were dredged 3 days prior to sampling while other cells were dredged 2 days or 1 day prior. The redredging activities make the issue more complex than planned.	Sampling locations were obtained by digitizing Figure 3-46 in Completion Report. Thus, dataset is good for spatial analyses.	The remediation area was separated into three "evaluation areas". In each area, three conditions were required to complete the remediation requirements: (1) Requirements of the dredging procedures and flow sheet logic have been accomplished in all cells within the area;(2) The average PCB concentration of the area is less than or equal to 5 ppm, and (3) No individual grid within the area has PCB concentrations greater than 10 ppm.	PCB, PAHs and PCDFs	Immunoassay method for field d screening, in accordance with Method 4020 in EPA SW-846, using the EhviroGardTM PCB Soil Test Kit. PCB was analyzed in Alcoa Lab using SW-846 method 8082.	not stated in report	Sediment overlays a till layer at depths of ranging from 1.5 to 30 ft below river bottom. Sediment above the till layer ranged from low blow count mud to relatively competent sand, gravel, and clay.		Multiple, maximum of 10, passes were made in some cells in order to meet the acceptable residual level, 134 cells were remediated on a single pass while 56 cells required 3 or more passes. Eleven cells were dredged 7 or more times. It was found that no improvement occurred on residual PCB concentration after 5 passes.	As stated in the plan, any cell with the residual concentration greater than 10 ppm are capped. The cap is consisted of 6" separation layer, 12" containment layer, and >9' armor and bioturbation layer. By 2001, only the separation (gravel) layer was placed. Dividing the total volume of gravel placed over the area, the average thickness of the gravel layer was calculated to be about 2.2 ft.	Geotextile is included as contingency measure to control sediment resuspension and mixing during capping. Given the absence of soft sediment in the area to be capped, the bottom was not covered by geotextile prior to placement of gravel.	The conventional rock bucket and hydraulic clamshell of the Cat 350 were used as alternative dredge to dig the more resistant hard bottom material and remove rocks and gravel.	Cleanup goals were not attained in several cells as the limits of the dredging technology (given site condition) were reached.
GM Massena: St. Lawrence River, Massena, NY	Removal of PCB-contaminated sediment at General Motors-Massena Superfund site from May (March) 1995 through December 1995 (January 1996). Dewatering and excavation of the cove area were not carried out as of the report date due to unsettled access issues.	1 ppm	113	See Fig. 2	6-inch core samples	Minimum 24 hrs after finishing work at an area.	Core samples in areas exceeding 500 ppm: 50 ft x 50 ft grid; below 500 ppm: 70 ft x 70 ft	Average PCB conc.: 3 ppm Max.: 10 ppm (except for Quadrant 3 which was capped: avg.. 27 ppm max. 100 ppm)	Individual Aroclors	EPA 8080		Sediments containing gravel, cobbles and large boulders at the bottom, underlain by glacial till.	Core and grab	Typically 2 to 6 passes (perpendicular to the shore and sheet pile wall, advancing ~ 2-4 feet per minute, making a 3 to 12 inch-deep and 8-foot wide cut on each pass). 15 to 18 passes in Quadrants 1 and 3 to bring concentrations to below 500 ppm.	Sediment capping in Quadrant 3.				
Cumberland Bay: New York	Removal of PCB-contaminated sludge bed (OU-1) at Cumberland Bay Wilcox Dock Sludge Bed site, and debris removal from public and private beaches (segment of OU-2), in the Town of Plattsburgh, Clinton County, New York, from April 1999 to November 2000.	Complete removal of sludge bed; and 10 ppm PCBs for the underlying sand layer.	51 samples (out of 115 samples collected) were tested	See Fig. 3	Core samples. Additional grab samples.		Core samples: 50-foot on center grid. Sometimes allowed linear windrows of residual sludge to remain undetected until divers were deployed.	Average PCB concentration across sampling grid: 6-7 ppm, few areas exceeding 10 ppm one exceeding 18 ppm. Native sands below sludge had "little or no PCB-contaminated materials". "Taking into account the concentrations of PCBs in the sand, the average PCB concentration across the grid is 3 ppm."	PCBs	EPA 8082	All sludge was removed during dredging operations.	Sand lake bottom.	Core samples. Additional grab samples.			Problems arose when dredge was blown off-course, areas were undredged or deeper sludge would slump and create windows. These areas were identified by divers and re-dredged in 2000.//Extra work for installation of rip-rap on Georgia-Pacific embankment to prevent erosion and recontamination of Bay w/ PCBs.//Diving services provided by the Contractor.//Additional dredging//Additional soil and water sampling.	Hand-held hydraulic dredge lines used by divers to remove pockets of sludge.		
United Heckathorn: Parr Canal and Lauritzen Channel on the San Francisco Bay	Removal of DDT and dieldrin contaminated sediment from August 1996 through March 1997	Average DDT sediment concentration of 590ug/kg	Not Available in Literature reviewed however 45 pre-remediation sediment samples collected; possibly 10 samples collected within Lauritzen Channel and Parr Canal following dredging	Collected throughout dredged area only; not within harbor or Santa Fe Channel as collected during the pre-dredge period	Not Available	Samples collected and analyzed from 0-10 cm; type and method not indicated in literature reviewed	Not known- EPA collected sediment samples just prior to the completion of dredging	Appears samples collected on transects throughout the dredged area	Removal of all sediment down to the underlying layer of hard consolidated clay and silt; set RA goal for sediment at 590ug/kg, on average, based on ecological assessment	Max and mean DDT and max dieldrin determined from collected sediment samples		Not Available	Consolidated clay and silt with some sand	Samples collected represented 0 to 10 cm interval; no details regarding sampling provided	Remote/localized locations re-dredged where average DDT concentration exceeded 590ug/kg.	Sand placed over entire dredged area to a thickness of 18-inches; placed underwater with a hydraulic pump	None specified in the literature reviewed	None	Four months following dredging, sediment DDT concentrations showed a 40-fold increase; suspected re-contamination from areas under docks and piers where dredging was not conducted as planned and an adequate cap was not placed, just sand fill/cover; Increased DDT concentrations consisted of younger bay mud which indicated that area was re-contaminated since all younger bay mud was removed during dredging
Grand Calumet River, Indiana	Removal of PCB and VOC, specifically benzene, contaminated sediment from a 5-mile stretch of river; Dredging to begin at the end of November of this year (2002)	RCRA clean-up and is not risk based however within contained area (1.5mile hot spot), must meet 50 ppm or have to go back and re-dredge	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	No set residual except in hot spot area where must meet 50ppm requirement; overcut of 6-inches incorporated into dredge plan	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	No backfill planned to be placed in the dredged area	None specified to date	None planned	No comment
New Bedford Harbor (Hot Spots), New Bedford, Massachusetts	Removal of PCB-contaminated sediments in hot spots located on the west side of the Acushnet River estuary between April 1994 and September 1995.							<4,000 ppm PCBs											

Table 3-3
Case Studies
Residual Data for Case Studies

Site Name and Location	Project Description and Year Work Conducted	Residual Target Clean-up Level	Summary of Post-Dredging Samples						Acceptable Residual Concentrations	Analysis Conducted	Analytical Methods (Field and Lab)	Thickness of Residual Sediment	Description of Bottom Layer (soft, rocky, etc.)	Sampling Technique to measure residuals (grab, core, probe)	Number of Passes made to be meet acceptable residual level	Type of Backfill/capping, if any	Engineering Contingency Plan Implemented	Special Equipment Used to Reduce Residual Levels	Comments/Special Observations from Project
			Number of Samples	Location of Samples	Method of sample Location in Field	Type of Samples Collected (depth, core, and grab)	Time of Collection	Goodness of Spatial Distribution Analysis											
New Bedford Harbor (Pre-Design Field Test), New Bedford, Massachuttes	A pre-design field test (mechanical/hydraulic dredging demonstration project) performed in August 2000. Dredging to commence in 2002.	Since this was a pilot study a clean-up goal was not specified for this project. Criteria for Upper Harbor - PCBs: 10 ppm Criteria for Lower Harbor - PCBs: 50 ppm (average concentration over upper 1 ft.	31 cores, 31 grabs, ~24 additional grabs (estimated from Fig. 9)	See Fig. 9	2-ft deep push-cores, and grabs from upper 0.8 inch (2 cm)		30 sampling points in an area of 550 ft x 100 ft. Two-three locations in an area of 100 ft x 30 ft (estimated from Fig. 9).	A clean-up criteria was not set for this pilot study. Average PCB concentrations were reduced from 857 ppm to 29 ppm over the dredged area.	18 congeners selected by EPA EMAP program		Pilot study depth of cut: 1.7 to 1.8 ft.	Soft clay.	Core and grab						

Table 5-1

Summary of General Electric Water Column Data

Location	Number of Samples for Each Analyte						
	Ranges of Sample Collection Dates for PCB Congeners		PCB Congeners	Total Dissolved Solids	Total Organic Carbon	Total Organic Carbon (Filtered)	Total Suspended Solids
B.F.Br	4/12/91	11/17/99	98	69	89	69	518
BFI AREA	4/7/92	10/28/93	87		26		89
BOATLAUNCH	12/11/96	5/10/00	158				160
HRM 194.2E	4/22/92	4/4/00	58		5		60
HRM 196.8	3/18/92	9/4/96	152				208
PLUNGEPOOL	7/10/96	11/3/99	145				186
Rt.197 Br.	4/5/91	4/26/00	391	133	154	135	622
Rt.29 Br.	4/5/91	5/10/00	219	65	85	68	250
Rt.4 Br.	4/5/91	6/18/92	90	135	151	137	154
S.W.Br.	4/5/91	6/18/92	58	69	88	72	88
TID-PRW2	10/9/97	5/10/00	112				121
TID-WEST	4/5/91	5/10/00	570	135	158	135	633

Table 5-2

USGS Discharge Number of Measurements by Year

Stations	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
BOND	0	0	0	0	0	0	0	0	0	0	0	0
CORINTH	92	274	0	92	365	366	347	21	0	0	0	0
FTEDWD	365	366	365	365	365	366	365	365	365	355	324	245
GREENIS	365	253	365	365	358	358	265	74	15	47	0	0
HADLEY	0	92	273	92	365	366	353	365	365	345	365	240
HOOSIC	365	366	365	365	365	359	337	365	365	366	365	92
KAYADER	365	366	365	365	90	0	0	0	0	0	0	0
LHPETER	365	366	365	365	365	283	358	11	0	0	0	0
LOCK1	365	366	365	365	365	274	30	363	365	245	37	108
MOHAWK	92	366	365	365	365	364	365	365	365	366	365	245
SACANDAGA	92	274	0	92	365	366	358	365	365	366	365	245
SCHUYLER	0	0	0	0	0	0	0	0	0	0	0	0
STILLWATER	365	366	365	365	365	366	365	365	365	366	273	0
BATTENKILL	0	0	0	0	0	0	0	275	365	366	365	245
GLOWWN	365	366	365	365	365	366	365	365	365	366	273	0
WATERFD	365	366	365	365	365	366	365	365	365	366	365	245

Table 5-3

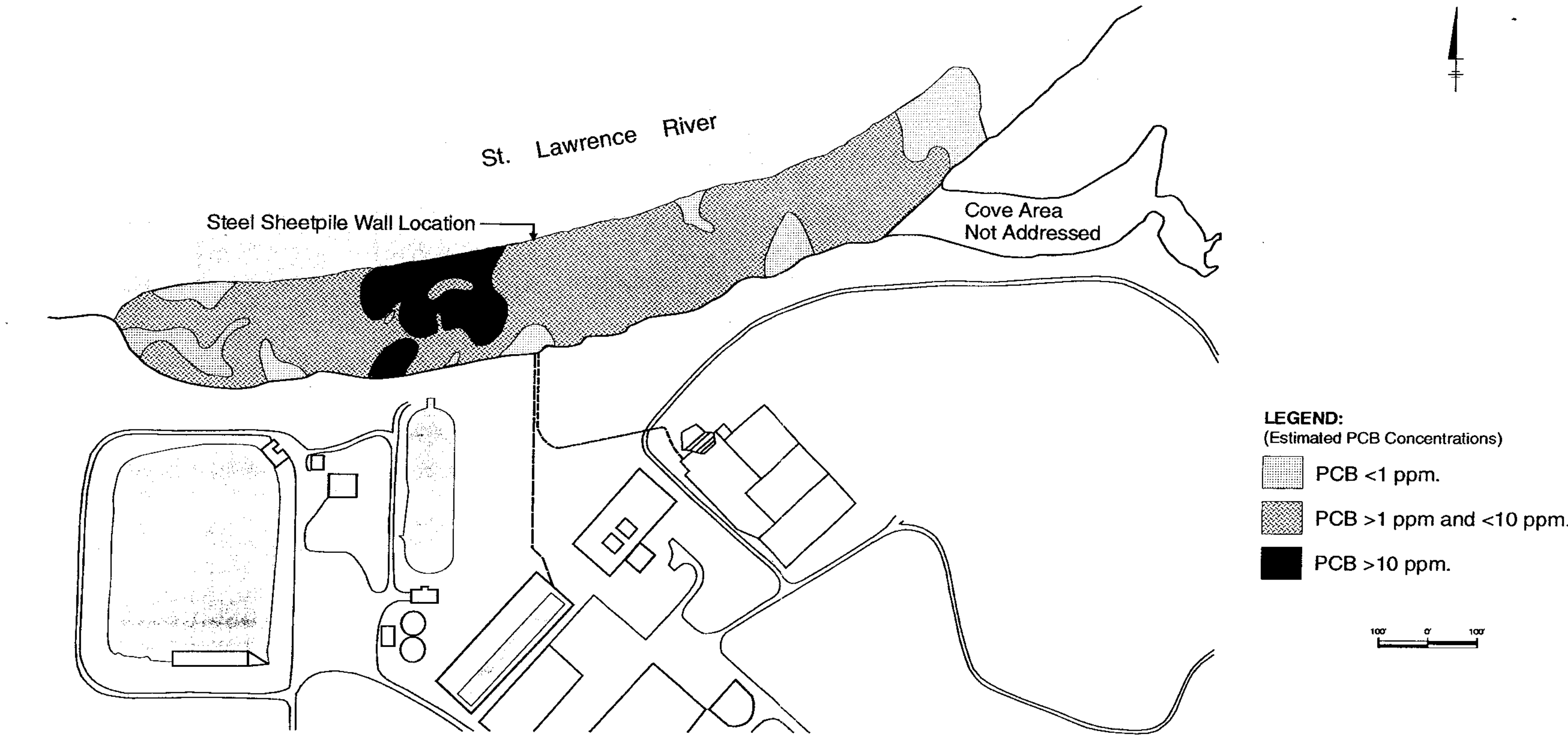
NYSDEC Metals and Dioxin Cores Number of Measurements

River Mile	Number of Samples for Each Analyte						
	Copper	Cadmium	Lead	Zinc	Chromium	Mercury	PCDD/F
202.7 and 202.8	11	11	11	11	0	3	3
193.8	21	21	21	21	0	0	0
188.5	26	24	24	26	21	0	0
188.6	9	9	9	9	9	3	13
177.6	0	0	0	0	0	0	6
163.6	37	44	44	39	39	4	12
152.6 and 157.7	32	35	35	29	29	3	9

Table 5-4
NYSDEC Biota Number of Samples with Measurement for Metals and Dioxins

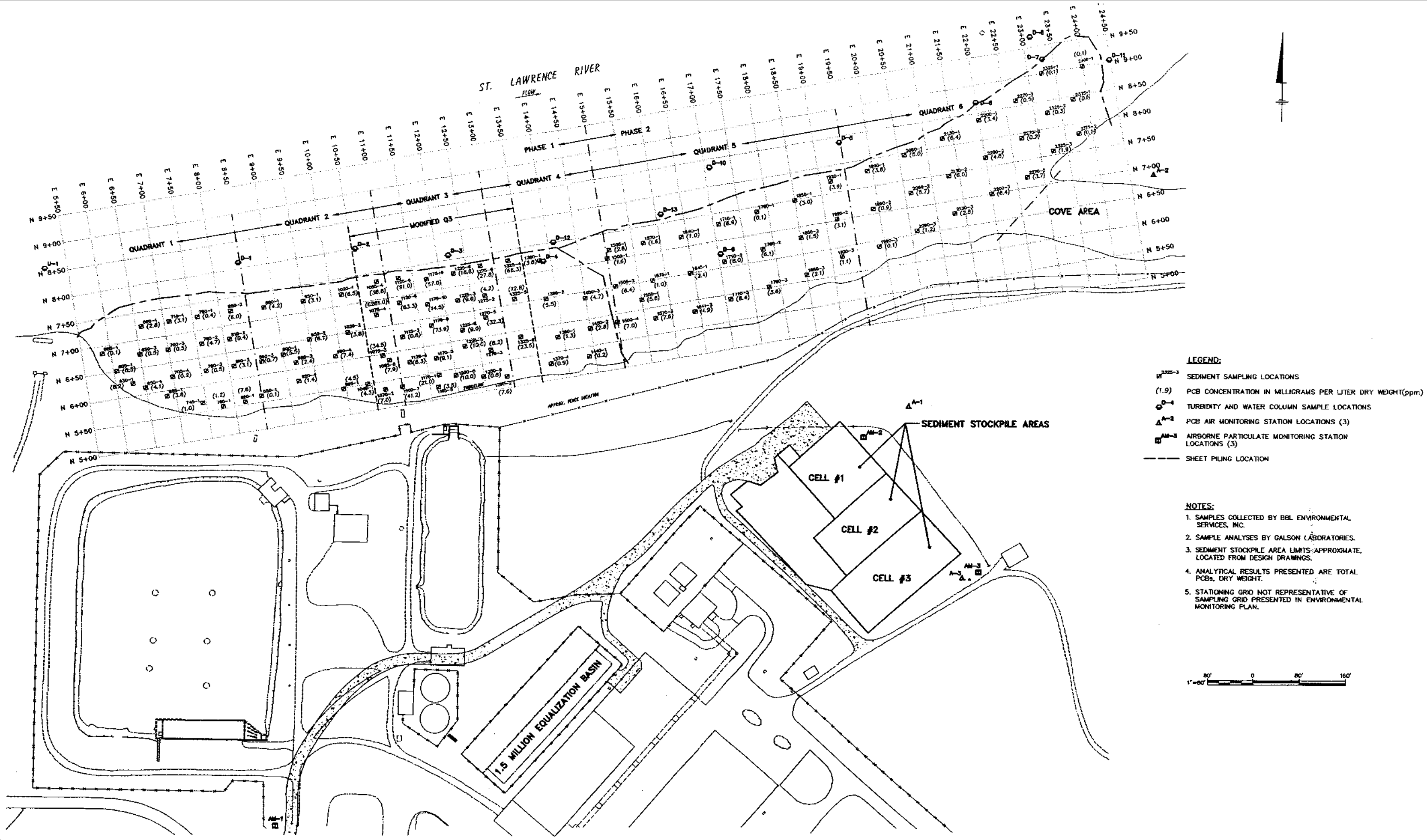
Station	RM	Cd	Cr	Cu	Pb	Hg	Zn	Ni	PCDD/F
Waterford	155.1					59			
Below Lock Campbell Island	157.6					14			3
Stillwater Above Lock C4 West Side Near Admls Marina	167.7					36			3
Stillwater East Side Just Above Lock C4	167.7					31			
Saratoga NHS Property	172.6	5	5		5	5			
Stillwater-Coveville	176	8				85			6
Coveville Channel Area	176.2	8			8	8			
Coveville Marsh Area	176.7	20			20	20			
Rt 4 Near Coveville-Roadside	176.7	2			2	2			
Fort Miller	185.1								2
Thompson Island	187.6					8			
Griffin Island / Saratoga Co.	189.1	3				109			9
Griffin Island East Side Of River	189.4					51			
Special Area 13 Boat Launch Ramp @ W River Rd Marina	192.7	5	5		5	5			
Fort Edward Below GE	193.3					25			
Remnant 4 0.2 Miles Upstream From North End Of Deposit	195.3	5	5		5	5			
Bakers Falls	196					4			
Ciba-Geigy Plant At Station 2	197.1	4	4		4	4		4	
Ciba-Geigy Plant At Station 3	197.2	10	10		10	10		10	
Ciba-Geigy Plant At Station 4	197.3	3	3		3	3		3	
Ciba-Geigy Plant At Station 6	197.4	6	6		6	6		6	
Ciba-Geigy Plant At Station 7	197.5	15	15		15	15		15	
Ciba-Geigy Plant At Station 8	197.6	2	2		2	2		2	
Glens Falls	198.1					7			
Ciba-Geigy Plant At Station 1	198.2	19	19		19	19		19	
Ciba-Geigy Plant At Station 5	198.3	22	22		22	22		22	
Below Feeder Dam	200					22			
Above Feeder Dam	201.1	5				132			2
Above Feeder (Ciba Control)	201.3	14	14		14	14		14	
Sherman Isl Pool Near Water Intake, Above Dam - Loc #3	209.5					16			
Queensbury At Site - Location #1	210					30			
Sherman Isl Pool, Across River Fr. Qnsbry Site - Loc #2	210.1					33			
Above Spier Falls Dam (Sfa) = Spier Falls Pool	211					16			
Below Boat Launch - Sherman Isl Pool - Loc #4	211.2					11			
Above Boat Launch - Sherman Isl Pool - Loc #5	212					15			
Below Luzerne State Boat Launch	219					44			
Lake Luzerne	222					10			
North Creek	259					4			
Blue Ledge	273					20			

Figures



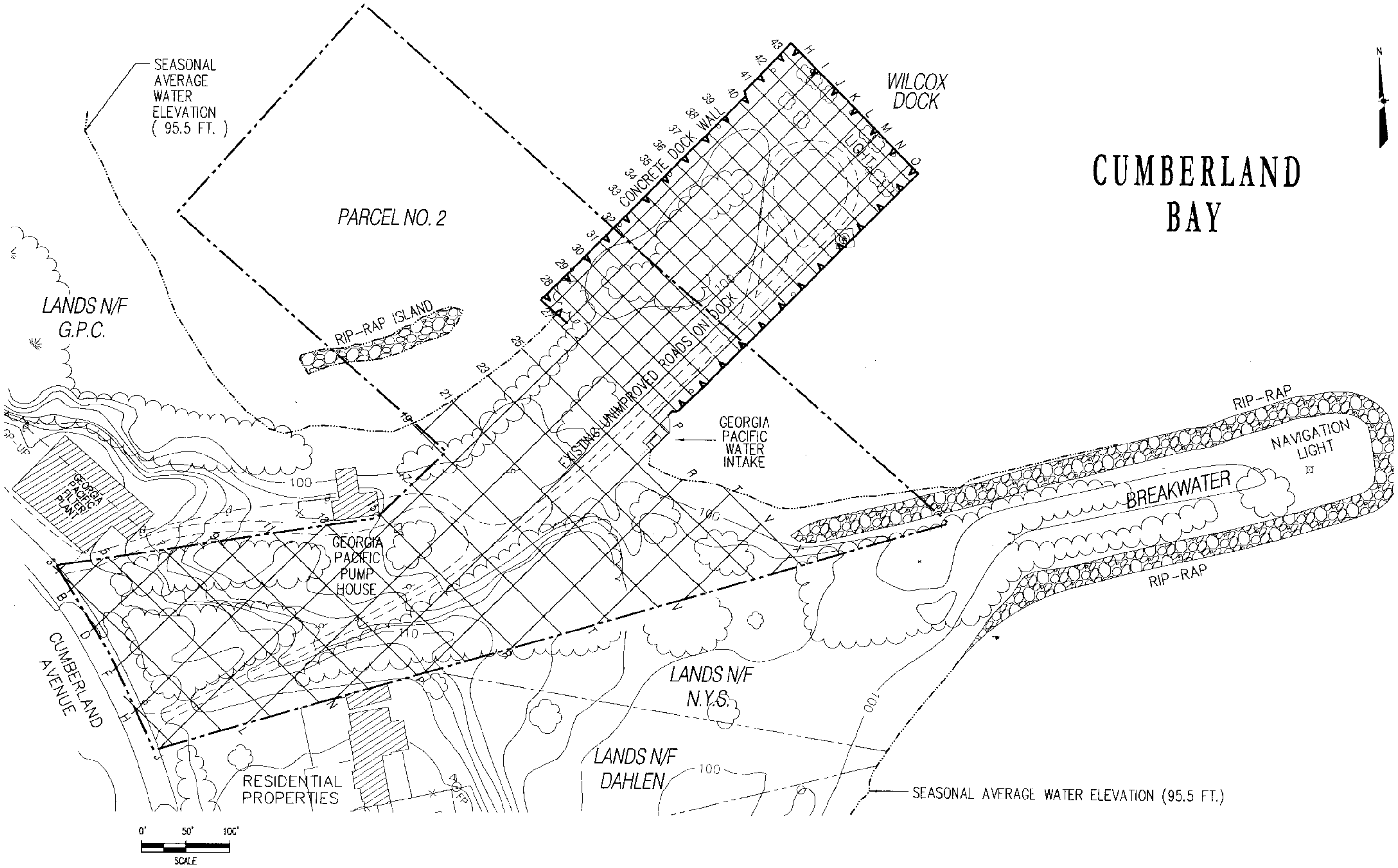
Note: Figure is from BBL Environmental Services, Inc. 1996. St. Lawrence River Sediment Removal Project Remedial Action Completion Report, General Motors Powertrain, Massena, New York. Prepared for General Motors Powertrain. June 1996.

Figure 4-1
GM Massena Post-Dredging Isopleths



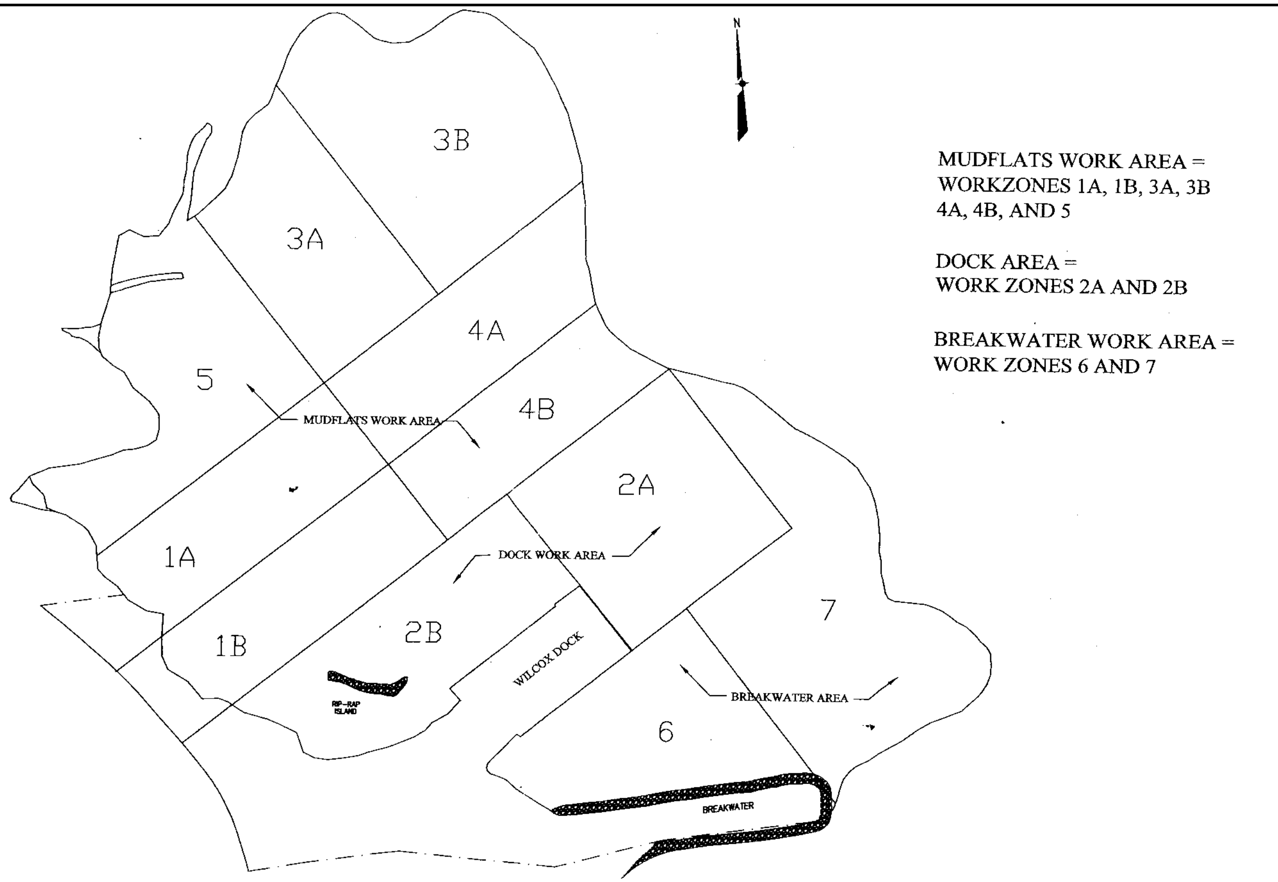
Note: Figure is from BBL Environmental Services, Inc. 1996. St. Lawrence River Sediment Removal Project Remedial Action Completion Report, General Motors Powertrain, Massena, New York. Prepared for General Motors Powertrain. June 1996.

Figure 4-2
GM Massena Final Sediment Sampling Analytical Results – Dry Weight



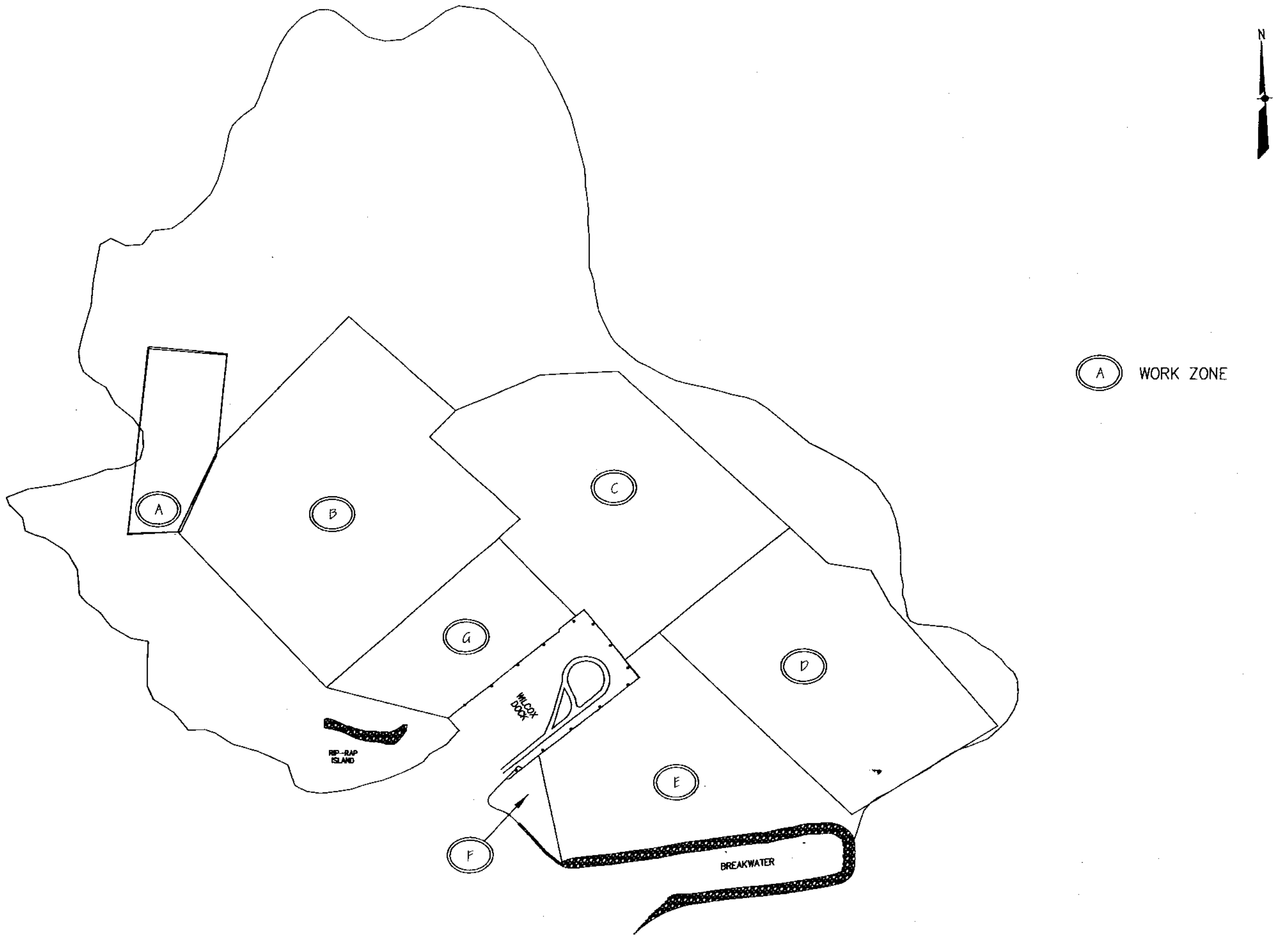
Note: Figure is from New York State Department of Environmental Conservation (NYSDEC). 2002. Draft Final Construction Certification Report, Cumberland Bay Sludge Bed Removal and Disposal Contract (OU1), April 1999-July 2001. Prepared by Earth Tech, Latham, New York. April 2002.

Figure 4-3
Cumberland Bay Pre-/Post –Operations Soil Sampling Locations, East Side – Wilcox Dock



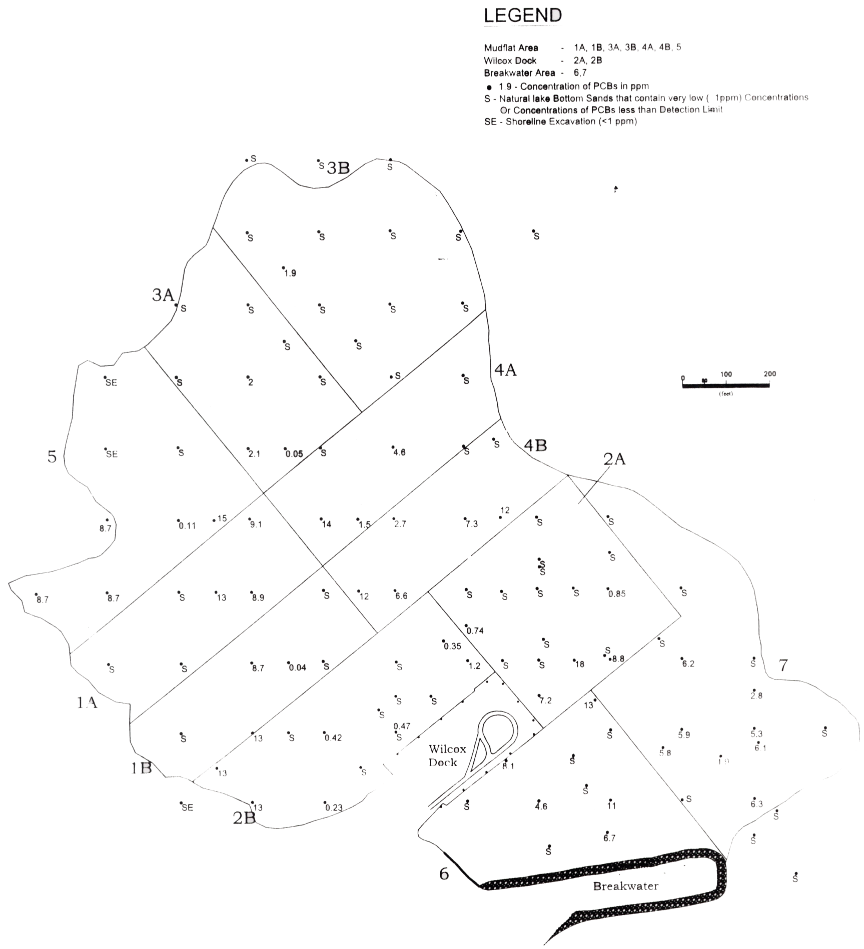
Note: Figure is from New York State Department of Environmental Conservation (NYSDEC). 2002. Draft Final Construction Certification Report, Cumberland Bay Sludge Bed Removal and Disposal Contract (OU1), April 1999-July 2001. Prepared by Earth Tech, Latham, New York. April 2002.

Figure 4-4
Cumberland Bay Work Areas and 1999 Work Zones



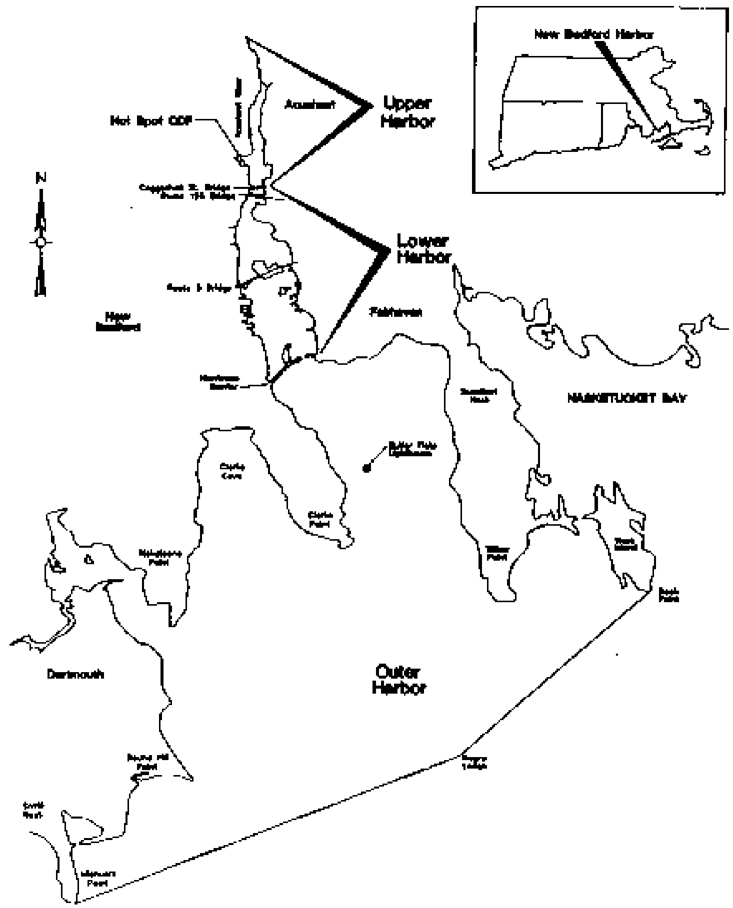
Note: Figure is from New York State Department of Environmental Conservation (NYSDEC). 2002. Draft Final Construction Certification Report, Cumberland Bay Sludge Bed Removal and Disposal Contract (OU1), April 1999-July 2001. Prepared by Earth Tech, Latham, New York. April 2002.

Figure 4-5
Cumberland Bay Work Areas and 2000 Work Zones



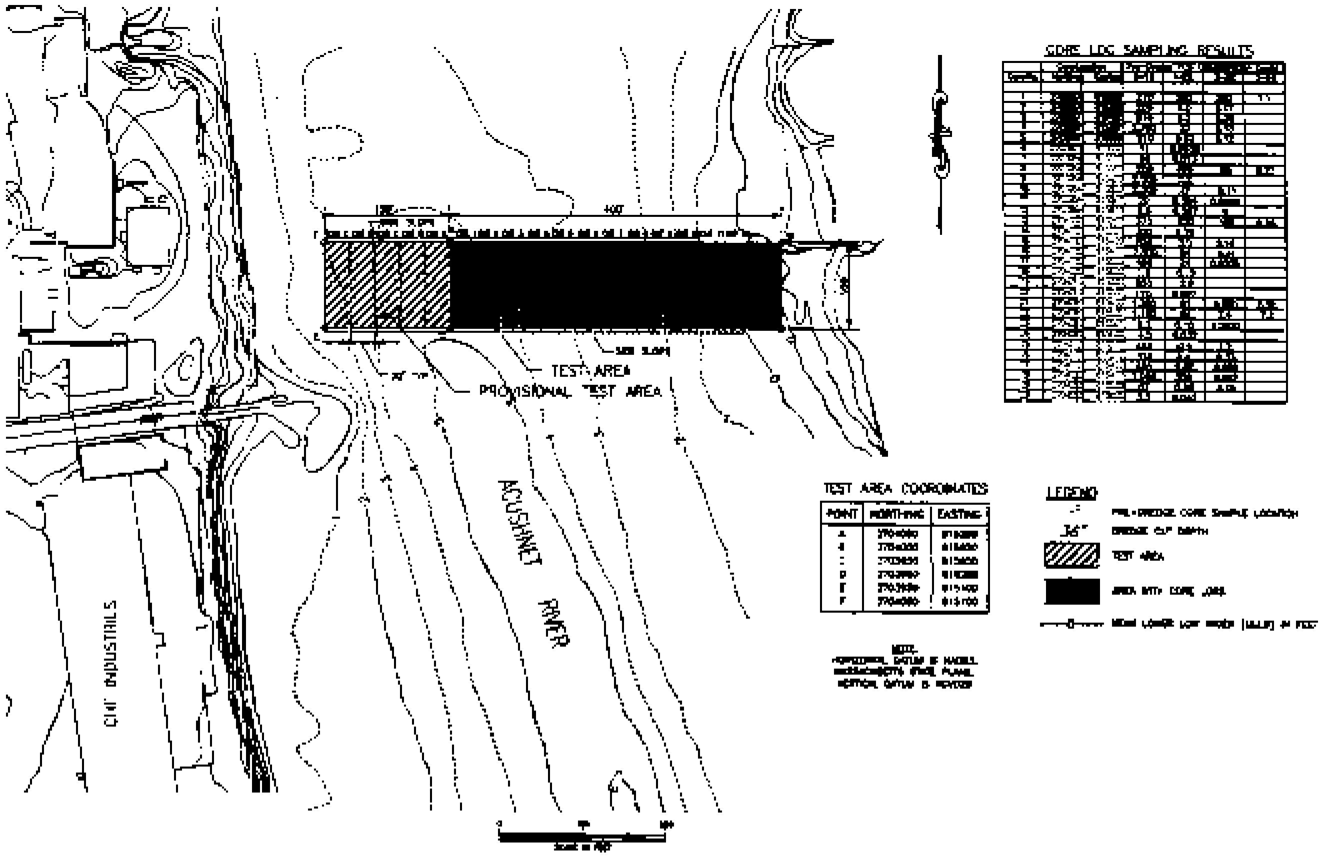
Note: Figure is from New York State Department of Environmental Conservation (NYSDEC). 2002. Draft Final Construction Certification Report, Cumberland Bay Sludge Bed Removal and Disposal Contract (OU1), April 1999-July 2001. Prepared by Earth Tech, Latham, New York. April 2002.

Figure 4-6
Cumberland Bay Phase IV Core Samples Results



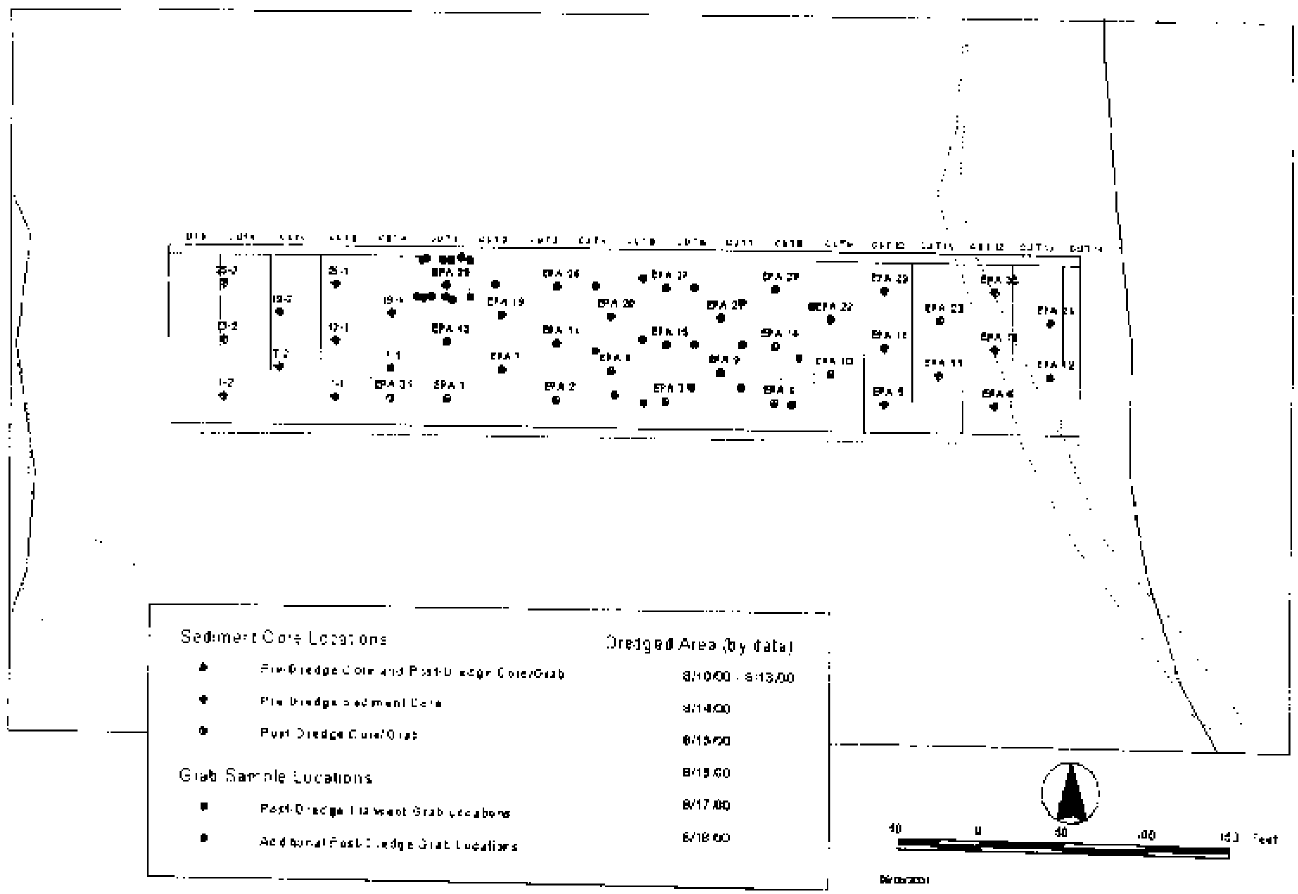
Note: Figure is from U.S. Army Corps of Engineers (USACE). 2001. Final Pre-Design Field Test Dredge Technology Evaluation Report, New Bedford Harbor Superfund Site, New Bedford, Massachusetts. Prepared by Foster Wheeler Environmental Corporation, Boston, Massachusetts. August 2001.

Figure 4-7
New Bedford Harbor Site Location Map



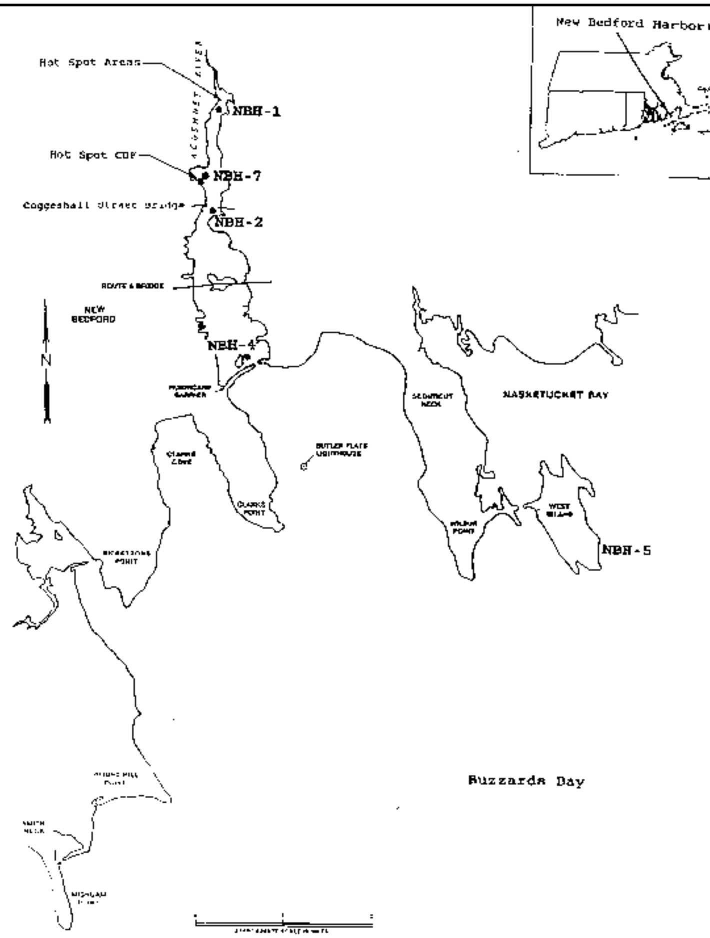
U.S. Army Corps of Engineers (USACE). 2001. Final Pre-Design Field Test Dredge Technology Evaluation Report, New Bedford Harbor Superfund Site, New Bedford, Massachusetts. Prepared by Foster Wheeler Environmental Corporation, Boston, Massachusetts. August 2001.

Figure 4-8
New Bedford Harbor Pre-Design Field Test Dredge Test Area



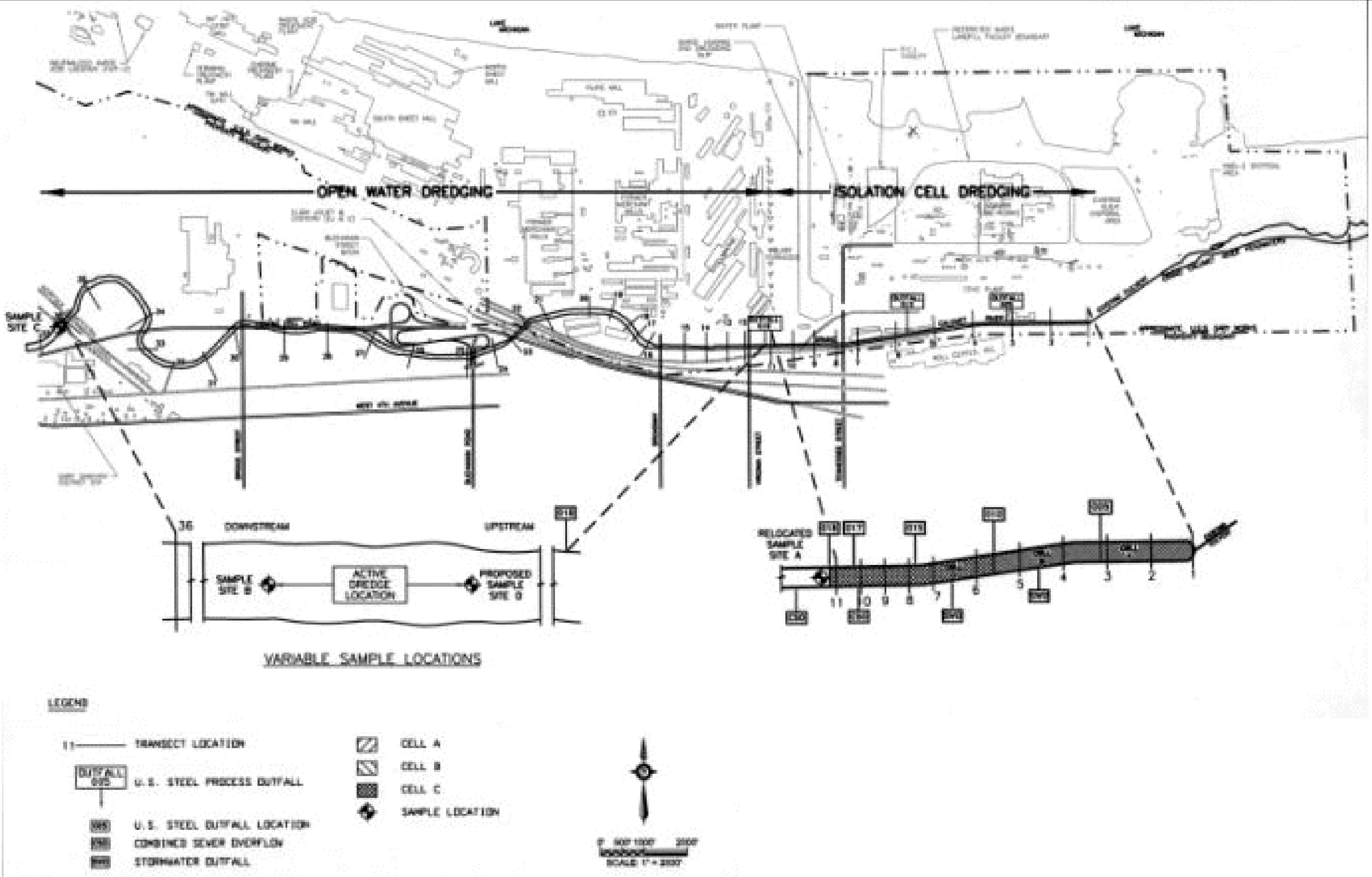
Note: Figure is from U.S. Army Corps of Engineers (USACE). 2001. Final Pre-Design Field Test Dredge Technology Evaluation Report, New Bedford Harbor Superfund Site, New Bedford, Massachusetts. Prepared by Foster Wheeler Environmental Corporation, Boston, Massachusetts. August 2001.

Figure 4-9
New Bedford Harbor Sediment Sampling Locations



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

Figure 4-10
New Bedford Harbor Monitoring Stations

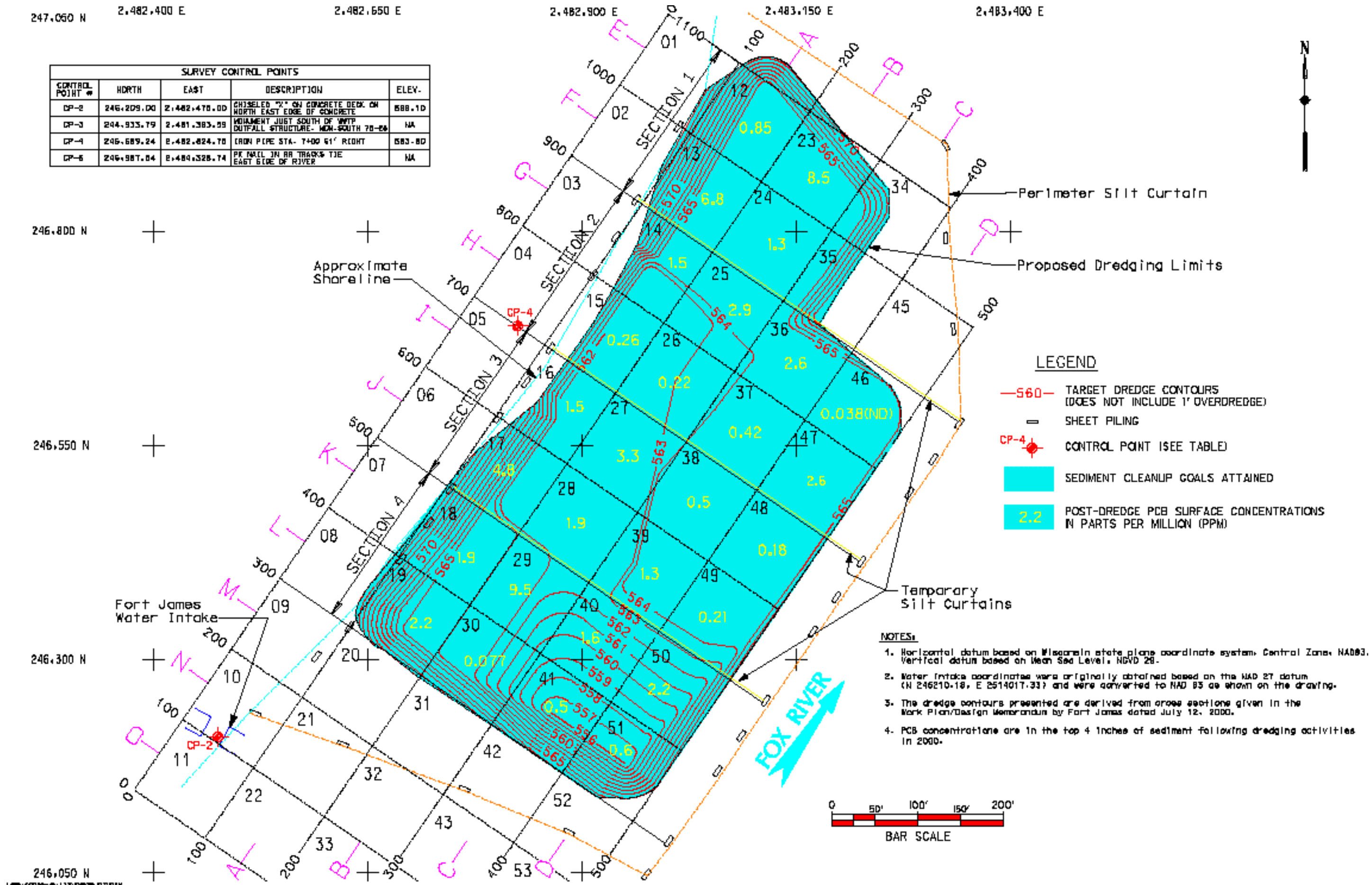


Note: Figure is from Grand Calumet Section 401 Water Quality Certification Work Plan. July 2002. Prepared for US Steel Corporation. Prepared by Earth Tech, Inc. 2002.

Figure 4-11
Grand Calumet Water Quality Sampling Sites

Wisconsin Department of Natural Resources, 2000. Summary Report Fox River Deposit N. Prepared by Foth and Van Dyke. April 2000.

Figure 4-12
Fox River Deposit N PCB Mass – Phase I (Post-dredge) IDW



Note: Figure is from Wisconsin Department of Natural Resources and United States Environmental Protection Agency, 2001. Final Report 2000 Sediment Management Unit 56/57 Project Lower Fox River, Green Bay, Wisconsin. Prepared by Fort James Corporation, Foth & Van Dyke and Hart Crowser, Inc. January 2001.

Figure 4-13
Fox River SMU 56/57Post-Dredge Sediment Sampling Results