RESPONSIVENESS SUMMARY
HUDSON RIVER PCBs SITE RECORD OF DECISION

JANUARY 2002

For

U.S. Environmental Protection Agency
Region 2
and
U.S. Army Corps of Engineers
Kansas City District

BOOK 1 OF 3

COMMENTS & RESPONSES

TAMS Consultants, Inc.

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ACGIH	American Conference of Governmental Industrial Hygienists
ACHP	Advisory Council on Historic Preservation
AGC	Annual Guideline Concentration
AOC	Administrative Order on Consent
ANOVA	Analysis of Variance
APEG	Alkaline (Alkali Metal Hydroxide) Polyethylene Glycol
ARAR	Applicable or Relevant and Appropriate Requirement
ARCC	Adirondack Regional Chambers of Commerce
ARCS	Assessment and Remediation of Contaminated Sediments Program
ATSDR	Agency for Toxic Substance and Disease Registry
AWQC	Ambient Water Quality Criterion
BAT	Best Achievable Technology
BBL	Blasland, Bouck, and Lee
BCD	Base-Catalyzed Decomposition
BMR	Baseline Modeling Report
CADD	Computer-Aided Drafting and Design
CDF	Confined Disposal Facility
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CIP	Community Interaction Program
CLU-IN	Hazardous Waste Clean-up Information (EPA web site)
COC	Chemical(s) of Concern
COPC	Chemical(s) of Potential Concern
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CT	Central Tendency
CWA	Clean Water Act
CZM	Coastal Zone Management
DEIR	Data Evaluation and Interpretation Report
DMR	Discharge Monitoring Report
DNAPL	Dense Non-Aqueous Phase Liquid
DOC	Dissolved Organic Carbon
DOSM	Depth of Scour Model
DOT	Department of Transportation
DRE	Destruction and Removal Efficiency
ECD	Electron Capture Detector
ECL	Environmental Conservation Law (New York)
EE/CA	Engineering Evaluation/Cost Analysis
EEC	Extreme Effect Concentration
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ESA	Endangered Species Act
ETWG	Engineering/Technology Work Group
FAIR	Farmers Against Irresponsible Remediation

FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FR	Federal Register
FRTR	Federal Remediation Technologies Roundtable
FS	Feasibility Study
FSSOW	Feasibility Study Scope of Work
FWIA	Fish & Wildlife Impact Analysis
g/m^2	Grams per meter squared
GAC	Granular Activated Carbon
GC	Gas Chromatography
GCL	Geosynthetic Clay Liner
GE	General Electric Company
GIS	Geographic Information System
GLNPO	(EPA's) Great Lakes National Program Office
GRA	General Response Action
HDPE	High Density Polyethylene
HHRA	Human Health Risk Assessment
HHRASOW	Human Health Risk Assessment Scope of Work
HI	Hazard Index
HMTA	Hazardous Materials Transportation Act
hp	Horsepower
HQ	Hazard Quotient
HROC	Hudson River PCB Oversight Committee
HSI	Habitat Suitability Index
HTTD	High Temperature Thermal Desorption
HUDTOX	Upper Hudson River Toxic Chemical Model
IBI	Index of Biotic Integrity
IRIS	Integrated Risk Information System
ITT	Innovative Treatment Technologies (database)
kg	Kilogram
KPEG	Potassium polyethylene glycol
LOAEL	Lowest Observed Adverse Effect Level
LRC, LRCR	Low Resolution Sediment Coring Report
LTI	LimnoTech, Inc.
LTTD	Low Temperature Thermal Desorption
LWA	Length-Weighted Average
MANOVA	Multivariate Analysis of Variance
M&E	Metcalf and Eddy
MBI	Macroinvertebrate Biotic Index
MCA	Menzie-Cura and Associates
MCACES	Cost Estimating Software (USACE)
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDEQ	Michigan Department of Environmental Quality
MDPR	Molar Dechlorination Product Ratio
MEC	Mid-Range Effects Concentration
mg/kg	Milligrams per Kilogram (generally equivalent to parts per million, or ppm)
mg/L	Milligrams per Liter (generally equivalent to ppm)
MNA	Monitored Natural Attenuation
MPA	Mass per Unit Area

MS	Mass Spectroscopy
NAAQS	National Ambient Air Quality Standards
NAICS	North American Industry Coding System
NAS	National Academy of Sciences
NCP	National Oil Spill and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
ng/L	Nanograms per Liter, parts per trillion
NHPA	National Historic Preservation Act
NiMo	Niagara Mohawk Power Company
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NPL	National Priorities List
NRC	National Research Council
NTCRA	Non-Time Critical Removal Action
NYCRR	New York Code of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOL	New York State Department of Labor
NYSDOT	New York State Department of Transportation
NYSPDES	New York State Pollutant Discharge Elimination System
O&M	Operation and Maintenance
OPRHP	Office of Parks, Recreation, and Historic Preservation
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response (EPA)
OU	Operable Unit
PCB	Polychlorinated Biphenyl
PCRDMP	Post-Construction Remnant Deposit Monitoring Plan
PEL	Probable Effects Level
PMCR	Preliminary Modeling Calibration Report
ppm	part(s) per million (mg/kg or mg/L)
PRG	Preliminary Remediation Goal
PSG	Project Sponsor Group
PVC	Polyvinyl Chloride
RAMP	Remedial Action Master Plan
RAO	Remedial Action Objective
RBC	Risk-Based Concentration
RBMR	Revised Baseline Modeling Report
REACH IT	Remediation and Characterization Innovative Technologies (EPA database)
RfD	Reference Dose
RI/FS	Remedial Investigation/Feasibility Study
RI	Remedial Investigation
RIMS	Remediation Information Management System
RM	River Mile
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SAV	Submerged Aquatic Vegetation
SEC	Sediment Effect Concentration
SHPO	State Historic Preservation Office
SITE	Superfund Innovative Technology Evaluation Program
SPDES	State Pollution Discharge Elimination System

SQRT	Screening Quick Reference Tables
STC	Scientific and Technical Committee
T&E	Threatened and Endangered
TAG	Technical Assistance Grant
TAGM	Technical Assistance Guidance Memorandum (NYSDEC)
TBC	To-be-considered
TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin
TCP	2,4,6-Trichlorophenol
TEC	Threshold Effect Concentration
TEF	Toxicity Equivalency Factor
TEQ	(Dioxin-like) Toxic Equivalent Quotient
TI	Thompson Island
TID	Thompson Island Dam
TIN	Triangulated Irregular Network
TIP	Thompson Island Pool
TLV	Threshold Limit Value
TOC	Total Organic Carbon
TOGS	Technical and Operational Guidance Series (NYSDEC)
TOPS	Trace Organics Platform Sampler
TQ	Toxicity Quotient
TR	Target Risk
TRV	Toxicity Reference Value
TSCA	Toxic Substances Control Act
TWA	Time-Weighted Average
UCL	Upper Confidence Limit
UET	Upper Effects Threshold
µg/kg	Micrograms per Kilogram, (generally equivalent to parts per billion, or ppb)
µg/L	Micrograms per Liter, (generally equivalent to parts per billion, or ppb)
USACE	United States Army Corps of Engineers
USBEA	United States Bureau of Economic Analysis
USBLS	United States Bureau of Labor Statistics
USC	United States Code
USDOC	United States Department of Commerce
USDOD	United States Department of Defense
USDOE	United States Department of Energy
USDOI	United States Department of Interior
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VISITT	Vendor Information System for Innovative Treatment Technologies (EPA Program)
VLDPE	Very Low Density Polyethylene
WHO	World Health Organization

Hudson River PCBs Site Record of Decision
Responsiveness Summary

EXECUTIVE SUMMARY

INTRODUCTION

Since its inception in 1990, EPA's Reassessment Remedial Investigation/Feasibility Study (RI/FS) has had the benefit of an extensive public-involvement program. Even before the initiation of the formal public comment period on the Proposed Plan for the Hudson River PCBs Superfund Site and the supporting analysis and information, there had been over 65 meetings/forums with the public, involving many issues, people, and places. It was through this extensive effort that EPA determined that local landfilling of dredged materials would not be an option in the event that a dredging remedy were selected.

EPA opened the formal public comment period with the release of the Hudson River PCBs Superfund Site Proposed Plan on December 12, 2000. The Proposed Plan presented EPA's preferred remedy and the rationale for its selection. The preferred remedy consisted of removal (targeted dredging) of 2.65 million cubic yards of contaminated sediments containing over 150,000 pounds of PCBs from the Upper Hudson River using environmental dredging techniques that would minimize adverse environmental impacts, including the resuspension of sediments. The comment period, originally scheduled to close on February 16, 2001, was extended to April 17, 2001. During the comment period, EPA chaired 11 public meetings that were attended by thousands of individuals, several hundred of whom provided oral comment. By the close of the comment period, EPA had received 73,215 discrete submissions of comments, of which nearly half were e-mails. As multiple individuals signed some submissions, the number of commenters is recorded as over 90,000 individuals.

The results of this public involvement program and EPA's response to the concerns raised are clearly evident in the Record of Decision (ROD), which is being released at this time. Some of the more notable examples of decisions that reflect public comment on the Proposed Plan include:

- A commitment to develop (with input from the affected public) a comprehensive public involvement program to be employed throughout the design and construction phases of the project.

- A commitment to develop, during the design phase (with input from State and federal agencies, as well as the public), performance standards for key project aspects, including sediment resuspension and dredging production rates.

- A commitment to perform the construction in a phased manner whereby a first phase of construction (one construction season) will precede the full-scale, five-year construction period.

- A commitment to include in the first phase, in addition to project shakedown, the field verification of various project assumptions.

- A commitment to move dredged materials and backfill within the Upper Hudson River area by barge or rail to ensure that disruption of traffic patterns in neighboring communities does not occur.

The aforementioned are some of the more significant aspects of the decision or ROD that have been aimed at responding to concerns raised throughout the public comment period. Other quality-of-life factors, such as noise, odor, maintenance of navigation, water supply protection, construction lighting, air quality, aesthetics, maintenance of recreational opportunities, and impacts on farm activities, also have been taken into account within the selected remedy and are addressed in detail within this Responsiveness Summary (RS). What follows in this Executive Summary is an abbreviated discussion of some of these issues. For each, a more detailed discussion can be found within the main body of the RS.

PUBLIC INVOLVEMENT IN DESIGN AND CONSTRUCTION

A number of comments dealt with the necessity of developing and implementing a comprehensive and detailed public involvement plan for the remedial design and implementation phases of the Hudson River PCBs Site cleanup.

Since the beginning of the Reassessment, EPA has been committed to a public process that is fully open to any interested party. The original community interaction plan (CIP) was designed to be flexible so that it could be modified in response to changes dictated by the project or requested by the participants. Since 1990, EPA has modified not only the CIP but also certain aspects of the RI/FS itself, as well as the selected remedy, based on public input.

EPA continues to be committed to involving the public, this time throughout the project's design (including development of performance standards and the sediment processing/transfer facility siting process) and construction phases. In the near future, EPA will involve the community in the development of a project-tailored public process that allows for incorporation of public involvement throughout the design and construction phases of the project and fully considers input received.

RESUSPENSION

Many comments addressed the potential for PCB release to the water column during remedial dredging operations. Concerns over the extent and impact of releases caused by resuspension of contaminated sediments on public health and the environment have been raised. In reviewing these concerns, EPA agrees that such releases must be carefully balanced with impacts associated with ongoing PCB releases to the water column from the sediments and existing impacts to the aquatic biota. After a thorough review of available dredging equipment, EPA concludes that conventional hydraulic cutterhead dredges and enclosed environmental bucket dredges are best suited to the selected remedial dredging activity. Data from projects using these dredges were used as the basis for estimating water quality impacts that would result during dredging operations. These data show loss rates adjacent to the dredge head of 0.35 percent (by mass of fine sediments) for a conventional

hydraulic cutterhead dredge and 0.3 percent (by mass of fine sediments) for an environmental bucket dredge.

During the first year of project design, with input from State and federal agencies as well as the public, EPA will develop the details of performance standards and performance monitoring that will be utilized during the first phase of project construction to field verify and modify, as appropriate, project operations.

PROJECT SEQUENCE AND SCHEDULE

Many commenters questioned the viability of EPA's schedule for accomplishing the selected remedy. EPA will begin the initial steps toward implementation once the ROD is signed. These pre-remediation activities, including project design, are scheduled for completion by Spring 2005, and many of these activities will be performed simultaneously. They include the following:

- Development of performance standards.
- Additional sediment sampling and analysis.
- Evaluation and selection of dredging technologies.
- Selection of contractor(s).
- Sediment processing/transfer facility siting and construction.
- Finalization of agreements with landfills, rail companies, backfill material suppliers, and energy providers.
- Mobilization (*e.g.*, assembling of equipment, planning the materials-handling operation, and arranging for sediment transportation and disposal).

Dredging operations will commence during the 2005 canal season.

Some commenters requested that EPA consider smaller, more focused projects, or perform a demonstration dredging project, to determine the feasibility of the selected remedy. EPA did, in fact, consider the possibilities of a short-term demonstration project and smaller-scale remedial efforts in the Upper Hudson River. Modeling indicated that smaller-scale efforts would not substantially reduce the PCB concentrations in fish.

In the Proposed Plan for this project, EPA proposed a five-year schedule for the work, beginning in the year 2004. However, given the concerns expressed by commenters, the Agency has decided to implement the project using a phased approach. Performing dredging operations in this manner provides the opportunity to evaluate overall project performance more intensively at the beginning and, as appropriate, refine the operations, which are now planned over a six-year period.

The selected remedy will be conducted in two phases over the six-year schedule. The first phase of dredging, to begin in 2005, will be implemented during the first construction season. The dredging during that year will be implemented initially at less than full-scale operation, and will include an extensive monitoring program based on performance standards that will address (but may not be limited to):

- Resuspension rates during dredging.
- Production rates.
- Residuals after dredging.
- Community impacts (*e.g.*, noise, air, odor, navigation).

Data gathered during this first phase will enable EPA to determine if adjustments are needed to operations in the succeeding phase of dredging or if performance standards need to be reevaluated. The current schedule assumes that, after the phased-in operations of 2005, dredging operations will proceed at full scale in the years 2006, 2007, 2008, and 2009, with completion of remaining work in 2010.

Similarly, commenters questioned the plausibility of achieving targeted dredging rates with the dredging equipment selected. EPA considered available technologies in combination with a series of Site-specific factors such as sediment characteristics, river geometry, in-river transportation systems, and environmental constraints in arriving at likely production rates. EPA concludes that the production rates generated by examination of these factors are considered practical and attainable.

Commenters also compared EPA's productivity estimates to lower rates actually attained at other Superfund sites. EPA believes that project scale and Site-specific conditions render such comparisons technically invalid.

QUALITY OF LIFE FACTORS

With regard to concerns expressed about the potential for negative impacts to the quality of life of people residing near or utilizing the river in the vicinity of the remediation, EPA has made every effort to fully assess and address such issues. They are summarized below in the categories of traffic, noise, construction lighting, air quality, odor, aesthetics, and recreation.

While there may be short-term impacts with respect to some of these issues, the project will follow strict guidelines to minimize and mitigate potential impacts to the maximum extent practicable.

It is EPA's belief that any temporary impacts are manageable and far outweighed by the long-term benefits of the remediation on human health and the environment.

Traffic

Commenters raised concerns about the ability of the existing infrastructure to accommodate project-related increases in vehicular and truck traffic, and the potential disruption to regional roadways that could result from these increases. In response to these concerns, EPA has determined that dredged materials will be taken from the Site by barge and/or rail, rather than by truck. Likewise, material used for project backfill will be transported within the Upper Hudson River area by barge and/or rail. While the location(s) of the sediment processing/transfer facilities have not yet been determined, for purposes of the FS and Responsiveness Summary, northern and southern facility sites were assumed.

Impacts from vehicle and truck traffic caused by both worker commutation and construction of dredged-material processing facilities were the key elements of concern remaining, once trucking of dredged material and backfill was eliminated. At the southern sediment processing/transfer facility site, impacts will be easily manageable, because much of that locale is currently highly industrialized and experiences much greater activity than would be generated by project operations.

For the northern facility, estimates of the project-related road traffic were evaluated in the context of current traffic volumes and road capacities. During peak traffic conditions, it was concluded that employee traffic generated by the project will not be disruptive to the area's local communities, because the volume increase on nearby roadways will be minor (*i.e.*, less than 10 percent). Given that this increase in road usage is relatively small, it is unlikely that there will be an escalation in road hazards or a need for increased road maintenance as a result of implementing the selected remedy.

Noise

The short-term noise associated with construction of the sediment processing/transfer facilities and hydraulic and mechanical dredging operations will not exceed the New York State Department of Transportation- (NYSDOT) established construction impact guidelines.

With respect to noise associated with operation of the sediment processing/transfer facilities, such noise levels will comply with applicable federal and State criteria, including the Federal Highway Administration (FHWA) Noise Abatement Criteria (NAC). While the long-term noise associated with stationary booster pump operations under the hydraulic dredging option could, if not mitigated, exceed FHWA NAC in areas within an 800-ft radius of the booster, a series of mitigation measures (*e.g.*, noise attenuation shrouds, optimizing locations of the booster stations to avoid populated areas to the extent practicable, or use of electric pumps) can be implemented as appropriate to mitigate the impact.

Construction Lighting

Artificial lighting systems will be used to illuminate nighttime dredging and in-river transport operations, as well as land-based sediment processing/transfer facility operations. EPA has examined the types of artificial lighting that will likely be used in support of the project. Positioning of lights, brightness, and direction are key factors in minimizing the potential for off-site impacts.

While nighttime lighting requirements for the proposed work will conform to established industry safety standards, it will not be necessary to use high-mast lighting systems at dredging sites or at the sediment processing/transfer facilities. The lighting required for in-river transport will conform to the Coast Guard and New York Navigation Law standards for commercial towboats and barges and is not expected to be disruptive. Lighting at the land-based sediment processing/transfer facilities will meet OSHA standards for construction. Lighting will be directed toward work areas and away from neighboring properties. In addition, the use of low-mast lights will limit off-site glare.

Odor

The two potential sources of odor from the project are the construction equipment and the dredged material from the river itself.

Nuisance odors from construction equipment are not anticipated to be a significant problem, because such equipment is used routinely on most construction projects with few complaints. Although sulfur in a reduced form is present in the river sediments, concentrations are sufficiently low so as to preclude the generation of noticeable and persistent odors from hydrogen sulfide in dredged material. Further, no significant ammonia-related odor will be generated during dredging operations. Should any odor be encountered, strategies will be implemented to mitigate adverse effects.

Air Quality

The total concentration of pollutants from the dredging and sediment processing/transfer facility operations will not exceed the National Ambient Air Quality Standards (NAAQS) established by EPA to protect public health. It is not anticipated that the project will have a significant air quality impact.

The cancer risks associated with inhalation of volatilized PCBs in air by residents living near the river or near the sediment processing/transfer facilities are projected to be about an order of magnitude *below* the most stringent acceptable level. With respect to workers at the Site, the estimated cancer risk is within the acceptable risk range. Air monitoring, engineering controls, appropriate personal-protection equipment for workers, and standard safety procedures will be used to protect the on-site workers and nearby communities.

With the public involved, EPA will develop and implement a comprehensive community health and safety plan, including air monitoring, to address any potential risk associated with dredging and processing of the PCB-contaminated sediment.

Aesthetics

Potential aesthetic and visual impacts from the dredging will apply to only a small portion of the 40 miles of river and, where they do occur, will be very temporary. Such potential impacts from the sediment processing/transfer facilities will be limited by the siting of these facilities in industrial or commercial regions and apply only to areas of close proximity; these impacts will be minimized, to the extent practicable, by careful siting and design of these sites. For travelers on the river or moving along adjacent roadways, project-generated visual intrusion will be short-term and limited to within several hundred feet of the work area.

Recreation

Because of the relatively small area of the river that will be affected by dredging at any given time, the recreational experience on the river will remain substantially unaffected in areas not immediately adjacent to the dredging operation. In fact, it is expected that the project will improve recreational conditions. Few adverse impacts are anticipated for recreational boaters during implementation of

the selected remedy. A significant portion of the dredging is oriented to navigational dredging that, when completed, will provide an expanded and safer capacity for recreational use of the river.

The risk of swimming in the Hudson River, as discussed in the baseline Human Health Risk Assessment (HHRA), is considered to be within the acceptable range. It is anticipated that during the remediation project, PCB concentrations in the river will remain at or near current levels. Therefore, during the project, as now, the risk of swimming in the river will remain within the acceptable range.

It is anticipated that the impact on recreational fishing will be minimal during the remediation. Anglers will be able to find alternate sites to fish where the dredging and backfill operations are not proximate; impacts to fish habitat will be temporary and will affect only limited areas and certain species; and minor, temporary resuspension of PCBs during dredging should not affect catch-and-release fishing. In fact, the PCB remediation offers long-term prospects of renewed and enhanced recreational fishing.

SEDIMENT PROCESSING/TRANSFER FACILITY SITING AND DESIGN

EPA has not yet determined the location(s) of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the FS, example locations were identified from an initial list of candidate sites based on screening-level field observations that considered potential facility locations from an engineering perspective. In the FS, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoil Area site and another at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the Upper Hudson River area and farther downstream, are possible.

The example facility locations presented in the FS have also been used in this Responsiveness Summary in order to clarify material presented in the FS and Proposed Plan and in connection with additional noise, odor, and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after EPA performs additional analyses and holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, all information provided in this Responsiveness Summary relative to potential impacts of the sediment processing/transfer facilities on communities, residents, agriculture, the environment, and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during design.

The general engineering characteristics that can be useful in identifying a potential site include a waterfront location so that barges and other floating equipment may be accessed; an existing heavy-duty bulkhead; fairly level topography to keep transfer operations, material processing, and rail facilities at approximately the same elevation; an industrial or commercial site, to avoid impacting residential, recreational, and institutional land uses; access to areas for storage of project-related

equipment; roadway access for both construction equipment and employees that avoids densely populated residential communities; two-lane roadways to accommodate truck traffic, or direct connection to such routes; and rail access to facilitate hauling and reduce overall transportation costs.

Already-developed industrial areas are preferable for consideration in siting these facilities. It is not anticipated that residences will be affected by processing/transfer of dredged material at these sites.

Potential impacts from the facilities on surroundings will be mitigated by attention to facility design and layout; lighting; screening and buffering of the facility; and minimization of truck traffic, among other considerations. Although it is expected that these facilities will be land-based, water-based facilities will also be evaluated.

PCB TRENDS IN FISH AND WATER COLUMN

While it is true that levels of PCB contamination in all Upper Hudson River media have declined relative to the early 1980s, most of the decline was prior to 1985. In recent years there has been limited improvement and, in fact, PCB levels have remained relatively consistent. The conditions in the river were extremely poor in the late 1970s, largely due to events such as the breaching of the Fort Edward Dam. After the resulting massive influx of PCBs, EPA has documented that PCB levels in the river declined until 1985, which was approximately the time the Agency issued its original plan for the river – no action – in the hope that levels would continue to decline.

Since that time, however, the rate of improvement has leveled off, and substantial further improvement via natural attenuation does not appear to be occurring. For this reason, EPA has concluded that active remediation is needed to restore the Hudson River to a healthy ecosystem. To support this conclusion, further information on PCB concentrations in specific media is presented below.

- Water column concentrations: In general, PCB concentrations in the water column declined between 1991 and 1995 due to source control but, due to the continued, unabated input of PCBs from the sediment, little change has occurred over the past five years.

- Sediment concentrations: While sediment PCB concentrations have slowly declined on average, the response is very heterogeneous and does not solve the contamination problem. Even though concentrations have declined in some areas, high concentrations remain at or near the surface in many of the *hot spots*. The stability of PCBs that are currently buried in sediment cannot be assured, and it is the position of both EPA and an independent peer-review panel that the sediments of the Upper Hudson River do not represent a secure location for the long-term storage of PCBs.

  Examination of PCB stability in sediment is complicated by the fact that modeling cannot accurately compensate for the variety of conditions within a river reach. For example, while the Thompson Island Pool is considered to be net depositional, specific highly contaminated areas are clearly not consistently depositional. Further, the presence of deposition does not ensure the stability and sequestration of the PCBs contained within the contaminated sediments. Evidence from multiple sources indicates that PCBs are not being safely buried to

a degree sufficient to remove them from interaction with the Hudson River.

- Fish concentrations: Despite the leakage of unweathered PCB oil from the vicinity of the GE Hudson Falls facility having been largely controlled, PCB concentrations in fish tissue have shown little decline in recent years (up to the year 2000). Sampling studies and modeling of such concentrations indicate continuing exposure through sediment food-chain pathways.

BENEFITS OF PROJECT

EPA's decision to pursue the selected remedy balanced short-term impacts against long-term benefits. In doing so, the Agency examined three active remediation alternatives and two more-passive options: the No Action and the Monitored Natural Attenuation (MNA) Alternatives.

Under the "overall protection of human health and the environment" criterion (40 CFR § 300.430[e][9][iii][A]), EPA evaluated the degree to which the remedial alternatives provide adequate protection of human health and the environment from unacceptable risks posed by PCBs at the Site, and compared the relative protection afforded by each alternative.

Based on the comparative analysis of alternatives, EPA determined that active remediation of contaminated sediments is necessary in order to significantly reduce the human health and environmental risks at the Site. Unlike the selected remedy, the alternatives that do not require removal of PCB-contaminated sediments are not sufficiently protective. Similarly, EPA's analysis of the more extensive remedy (REM-0/0/3) found the differential in protection from that afforded by the selected remedy was insufficient to justify the greater cost of REM-0/0/3. There may be short-term impacts as a result of implementation of the selected remedy, including potential transportation, noise, odor, and lighting impacts, as well as potential impacts from construction and operation of the sediment processing/transfer facilities. However, these temporary impacts are expected to be manageable through appropriate controls. Consequently, EPA has determined that the potential short-term impacts of the selected remedy, which can be minimized, are substantially outweighed by the remedy's benefits to human health and the environment.

Projected PCB Trends in Fish

Because PCBs bioaccumulate in fatty tissue, PCB levels in fish of the Hudson River has been a critical factor in this project and a critical issue for the public. Commenters frequently asked how many years would be required to attain the preliminary remediation goal (PRG) for human health, which is 0.05 ppm (mg/kg) PCBs in fish or other target levels. Commenters also observed that, and at times questioned why, this goal is 40 times stricter than the US Food and Drug Administration's commercial fish limit of 2.0 ppm. Others asked when the fish would be 'edible.'

Attainment of Target Levels

The time it takes to achieve the Remediation Goal of 0.5 mg/kg PCBs in fish fillet and other risk-based PCB concentrations in fish (i.e., 0.4 mg/kg and 0.2 mg/kg) is species- and location-specific. Some fish will achieve these concentrations sooner than others, based on feeding and habitat preferences. The modeling projects that the selected remedy will attain the PCB concentration of 0.4

mg/kg in fish fillet, which is protective of the average adult who consumes one Hudson River fish meal every two months, in River Sections 1 and 2 within 20 years after the start of active remediation and earlier for River Section 3. The modeling also projects that the target PCB concentration of 0.2 mg/kg in fish fillet, which is protective of an adult who consumes one fish meal from the Hudson River per month, is expected to be attained in River Section 2 within 35 years of the start of active remediation. These time periods are significantly shorter than the time periods projected for attaining these targets under the No Action and the MNA Alternatives. Moreover, the actual time differentials may be greater than those calculated by EPA's models, as evidenced by the trend analysis of recent PCB concentrations in fish tissue.

The selected remedy is projected to meet the Remediation Goal for human consumption of fish, 0.05 mg/kg, in River Section 3 within 41 years of completion of active remediation. As a result, the remediation goal of 0.05 mg/kg, or one fish meal per week for an adult, also is expected to be attained in the majority of the Lower Hudson River within this time frame, due to the lower initial concentration of PCBs in the Lower Hudson compared to the Upper Hudson. Because of the continuing Tri+ PCB load of 2 ng/L assumed after implementation of the source control action in the vicinity of the GE Hudson Falls plant, the PCB concentration in fish averaged over the Upper Hudson is expected to be reduced to a range of 0.09 to 0.14 mg/kg within the 70-year modeled time period, which is slightly above the PRG of 0.05 mg/kg. However, the protectiveness of the selected remedy is further enhanced through continuation of institutional controls, such as the fish consumption advisories and fishing restrictions. In the ROD, EPA has adopted the 0.05 mg/kg concentration in species-weighted fish fillet as a final Remediation Goal for the Site.

If upstream source control is more successful than currently projected (*i.e.*, less than 0.025 kg/day), then the time frames identified above would be shorter and the Remediation Goal of 0.05 mg/kg may be met within the modeling time period in River Sections 1 and 2.

FDA Limit/Establishment of Target Level

The FDA tolerance level of 2.0 ppm is based on a "market basket" of commercially caught fish obtained from supermarkets. The "market basket" concept assumes that fish purchased from a market come from varied sources, rather than from a sole source, such as fish taken from the Hudson River. The 2.0 ppm tolerance level in commercially marketed fish is an average PCB concentration, and assumes that consumers are buying a variety of different species from a variety of different locations.

The Remediation Goal of 0.05 mg/kg PCBs in fish fillet represents an average PCB concentration in fish and takes into account the specific expected reasonable maximum exposure (RME) consumption rate of anglers who consume fish caught only from the Hudson River. These consumption rates reflect the habits reported by anglers in New York State and what would be expected in the absence of fish consumption advisories. It should also be noted that the Remediation Goal of 0.05 mg/kg is consistent with the Great Lakes Sport Fish Advisory level, which is used by the eight states bordering the Great Lakes.

Downstream Transport

PCBs are transported from the Upper Hudson River to the Lower Hudson River (*i.e.*, south of the

Federal Dam at Troy). The mass of PCBs transported over the Federal Dam to the Lower Hudson declined from about 3,000 to 4,000 kg/year Tri+ PCBs (6,610 to 8,820 lbs/year) in the late 1970s to about 150 to 500 kg/year Tri+ PCBs (331 to 1,100 lbs/year) by the late 1980s or early 1990s. The most recent estimate of Tri+ PCBs, based on 1998 GE data from a monitoring station at Schuylerville, is 214 kg/year (472 lbs/year); the estimated (modeled) average for the 1990s is about 290 kg/yr (639 lbs/year) over Federal Dam, with a modeled daily average Tri+ PCB water column concentration of 30 ng/L. It is projected that the selected remedy will reduce downstream transport by approximately 40 percent.

GE SOURCE CONTROL ACTIVITIES

Over a 30-year period, GE discharged a significant amount of PCBs into the river from its Hudson Falls and Fort Edward plants. At the Hudson Falls plant location, leakage of PCB-bearing oils through bedrock to the river continues to be a source of PCB contamination.

The selected remedy accounts for the fact that some source control measures are already in place near the GE Hudson Falls plant. Additionally, pursuant to a Consent Order with the NYSDEC, additional source-control work is to be carried out by GE near its Hudson Falls plant because PCBs continue to leak from that facility into the Upper Hudson River. Therefore, the selected remedy also assumes reasonable further reduction in PCBs entering the river through bedrock at Bakers Falls near the Hudson Falls plant, as a result of the implementation of these additional source control measures.

Through detailed monitoring, EPA found that PCB levels in the water column (and consequently, PCB mass load) increase more than threefold as the water passes through the Thompson Island Pool. The PCB source available in this location is the contaminated sediments that lie on the pool's bottom.

Concerns about Identification of Additional Sources

As reflected in the Phase 1 Report, EPA recognized the importance of upstream sources of PCBs from the outset of the Reassessment. From an analysis of sampling data gathered by GE's monitoring program in accordance with an EPA Consent Order, EPA has established that the GE facilities are the only significant external source of PCBs to the Upper Hudson River. Modeling efforts, including use of the HUDTOX and FISHRAND models, indicate that control of upstream sources is critical. However, recognition of these upstream sources does not in any way negate the findings of recent EPA reports noting that the sediments continue to release large amounts of PCBs.

As described in the FS, control of the upstream source is an important adjunct to the active remediation of the contaminated river sediment. The anticipated controls at GE's Hudson Falls facility and remediation in the vicinity of the Fort Edward 004 outfall should reduce that input within the next few years. EPA acknowledges the importance of further remediation of upstream sources and will work with NYSDEC and GE to control these sources to the extent practicable. However, given existing PCB sediment loads, complete control of these upstream sources is not necessary prior to sediment removal.

WHY A MORE AGGRESSIVE REMEDY WAS NOT SELECTED

EPA's analysis found that:

- The incremental increase in water column loading from the sediments decreases as the water moves downstream from the Thompson Island Pool. This suggests that there is less sediment involved in PCB release in the downstream river sections relative to the Thompson Island Pool.

- The model forecasts showed little improvement in recovery of the river for REM-0/0/3 as compared to the selected remedy. This analysis suggests that little benefit comes from the additional dredging.

- As described in the FS and in this Responsiveness Summary, the targeted areas include more than 85 percent of the areas with PCB concentrations greater than 10 ppm and more than 75 percent of the areas with PCB concentrations greater than 3.2 ppm. Going beyond this one would encounter problems such as greater access limitations and shallow underlying bedrock, which greatly increase costs while yielding little additional public health or environmental benefit.

After considering all these factors, EPA decided upon the selected remedy as an appropriate balance among these issues, reconciling the desire to remove contamination with the uncertainties associated with each river section. Note, however, that the final areas and boundaries will be refined during remedial design.

RAIL TRANSPORT

EPA is committed to avoiding large increases in the volume of heavy truck traffic in communities of the Upper Hudson River valley. The selected remedy provides for rail transport or barge transport. The necessity for rail access at sediment processing/transfer facility sites has been incorporated into the facility-planning process.

In studying rail transport of the processed materials, EPA estimated the rail movement that will occur in order to implement the selected remedy in the context of the capacity and current operation of the regional rail line operated by the Canadian Pacific Railroad (CPR).

Increased train volumes are not expected to impact passenger or non-project-related freight service in the region. There are currently six passenger trains and up to 14 freight trains per day (through and local) operating along the Fort Edward/Albany rail corridor. This level of activity does not approach the capacity of the line. After speaking with representatives of the CPR, it has been determined that the current Fort Edward/Albany rail line, dominated by freight service, has additional capacity available on the line.

With regard to rail-yard requirements for the northern processing/transfer facility, it would be necessary to store 16 gondola cars on-site. There would be daily pickups of these gondolas by the railroad. It is expected that existing rail yards in the project vicinity can be used to store rail cars and

assemble larger trainloads for movement to remote landfill sites; CPR has indicated that their existing rail yard facilities can accommodate gondola cars generated by the project, as well as the daily transport and assembly of these railcars into unit trains.

No new rail yards are expected to have to be constructed in the region to support the proposed activities. The availability of rail cars/gondolas in the region has also been assessed, with the determination that the number of gondolas required for the project can be obtained by leasing them on the open market; therefore, CPR will not necessarily provide them. It has also been determined that current rail car leasing costs are low due to market demand; many are actually being scrapped at this time. The shipping of three commodities, specifically Toxic Substances Control Act (TSCA)-regulated materials, non-TSCA materials and backfill, adds moderately to the project's complexity, but will be manageable.

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INTRODUCTION TO THE RESPONSIVENESS SUMMARY

By the conclusion of the public comment period on April 17, 2001, EPA received nearly 73,000 separate, individual statements providing comment on its December 2000 Proposed Plan for the Hudson River PCBs Site. This number includes several thousand replicate statements, which are identical pieces submitted by multiple individuals, or petitions signed by multiple individuals, but does not include carbon copies or duplicates of the same message sent to multiple recipients within EPA or to other agencies. Of these 73,000 statements, approximately 35,000 were in the form of e-mails directed to EPA's project team. The remainder was received in the form of letters (some typed, but many handwritten), post cards, form letters, multi-page documents and technical reports, videotaped statements, and petitions on various media. A number of the technical reports contain appendices covering specific issues in depth. The largest body of comment was received from General Electric Company and occupies 19 volumes.

Given these circumstances, three basic steps have been followed in preparing a Responsiveness Summary that is responsive to all significant public comments received during the public comment period: (1) all comment documents were reviewed and catalogued, (2) the material was organized for content, all significant comments were identified, and each such comment was either individually adopted as a "master comment," or was combined with other significant comments (addressing similar issues) which were then collectively distilled into a single master comment, and (3) a response was prepared for each master comment.

A quality assurance program was implemented to verify that the full body of significant comment is accurately represented in the master comments, the responses are technically sound and the entire summary is internally consistent. The process by which these three steps and the attendant quality assurance processes were accomplished is summarized as follows.

Each of the comment letters and other documents was reviewed, and individual significant comments within each comment document were delimited (*i.e.*, identified). A single comment document may contain as few as one or as many as several hundred delimited comments. Each of the unique comment source documents was assigned a bar-coded identification number which was affixed to the document[1] and was then scanned as an image into an electronic file compatible with *Adobe Acrobat Reader*™ software (*i.e.*, "pdf" format), effectively creating an electronic "photocopy." Approximately 18,000 unique significant comments were delimited from the source documents.[2] Because of the large number of comments to manage, each of the delimited comments was also assigned representative keywords (or key phrases) and entered into an electronic database for sorting and processing.

[1] Only a single example of each set of perfectly identical submittals (*i.e.*, replicates – for example, postcards provided to its members by an organization) was bar-coded for entry to the database. However, a record was compiled of the names and, where supplied, addresses of all commenters. Such mailings were individually bar-coded in those instances where additional comment was added to the text by the commenter. True duplicates (*i.e.*, multiple copies of the same document sent by the same individual, sometimes transmitted to multiple recipients) were bar-coded only once and the identity of the commenter recorded only once.

[2] While some documents yielded multiple delimited comments, others were replicates of other identical documents which together yielded a single comment. This total represents the number of "unique" significant comments.

Some comments were received electronically or could readily be scanned (via optical character recognition, or OCR) for entry into the database. Many delimited significant comments, however, required manual entry. Quality assurance reviews were conducted to ensure that all comments were entered in the database. There is a high degree of confidence that all significant comments were identified and captured.

Due to the large volume of comments received, it is not possible to present these documents as physical (hard copy) attachments to the Responsiveness Summary, as has customarily been done for previous Hudson River PCBs Site Responsiveness Summary reports. Each comment is, however, provided in electronic format on a set of CDs in Appendix D, along with tables identifying authors and showing the relationships between authors, delimited significant comments and master comments. For copies of the Responsiveness Summary provided entirely on CD, the comments are included as separate files.

Similar or related delimited comments were combined into master comments in various topical areas capturing the significant issues raised by each of the source comments.[3] A total of 274 master comments were synthesized from the roughly 18,000 comments initially delimited. These master comments were then reviewed for accuracy and thoroughness to ensure that they represent each of the associated delimited comments. In addition, a review was conducted to verify that all delimited comments were associated with at least one master comment. Because of the several threads of thought sometimes inextricably combined, an individual delimited comment may be, on occasion, associated with multiple master comments. This process has provided a means for all significant comments to be included and to receive due consideration in preparing the Responsiveness Summary.

Master comments have been organized according to topical areas for presentation in this volume (Book 1) of the Responsiveness Summary, as shown in the Table of Contents. A response has been prepared for (and is presented immediately following) each of the master comments, drawing from material presented in the Proposed Plan, the FS, or other previous project reports, other literature, remedial projects and individuals, and EPA policy, as well as additional technical analyses performed specifically to address comments or questions raised during the public comment period.[4] Methodologies used and results obtained from additional technical analyses are presented as “white papers” in a separate volume (designated as Book 2 of this document). These papers cover a variety of topical areas, providing more in-depth analysis and supporting detail concerning topics addressed in various comments. Many responses draw upon these white papers and may utilize the conclusions or quantitative results of various modeling efforts (for noise or air emissions, for example) or extended series of calculations, without encumbering the text with voluminous detail. Each of the responses and white papers has been reviewed for technical quality by senior professionals within the project team.

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[3] Master comments were assigned a three- or six-digit identification number by the database program sequentially upon creation; these numbers are used to identify the master comments, the associated responses, and any companion tables and figures throughout the Responsiveness Summary, regardless of the final order of presentation in the document. White papers are similarly identified.

[4] Additional technical analyses were performed for several reasons, including refinement or clarification of work performed in the FS, gathering and evaluating additional data from outside sources and other projects to clarify or support conclusions or statements made in the FS, and providing information not ordinarily presented in an FS but which is appropriate to address public comment germane to the community acceptance criterion of the remedy selection analysis.

While some smaller tables have been embedded in the text of a response or white paper, most larger tables and figures have been placed in a separate volume dedicated to that purpose (designated as Book 3 of this document). This allows the reader (if using the printed version of the document) to view the associated tables and figures alongside the text, without having to turn back and forth in the document. Book 3 also contains Appendices to the Responsiveness Summary. These include a Preliminary Wetlands Assessment (Appendix A), a Preliminary Floodplains Assessment (Appendix B), and a Stage 1A Cultural Resources Survey (Appendix C). These Appendices provide additional information relating to potential impacts of the selected remedy on wetlands, floodplains, and cultural resources. The Appendices also are pertinent to issues addressed in Book 1 of the Responsiveness Summary. Appendix D is described below.

Significant effort has been made to make this document as user-friendly as practicable, while covering the full body of significant comment. It is anticipated that many readers will want to find where their particular comment or concern is addressed. An important tool in this search is the Index at the end of this volume. The Index allows a reader to identify master comments and responses of interest, based on keywords or key phrases. While an attempt has been made to cover a comprehensive range of subjects and as much detail as practicable in the Index, it is not intended to be exhaustive. Despite the topical arrangement of the document, and provision of the Index, some readers may need to resort to the comment database to identify the code associated with a comment of interest, and then track this code through a table of associations between delimited significant public comments and master comments provided on CD# D1 in Appendix D in Book 3 of the Responsiveness Summary. While neither the Index nor the table of associations is a perfect tool, together they provide a reliable means of finding the responses to particular comments. Appendix D, Compendium of Public Comments, provides a compilation of the public comments in electronic database form. Appendix D consists of a set of instructions to the database as well as a set of six CDs, which contain the database of authors and comments (Disk D1) and scanned images of the public comments (Disk D2 to D6).

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1. LEGAL AND POLICY ISSUES

1.1 ARARs and TBCs

Master Comment 375

Commenters argued that EPA inappropriately usurps NY State's responsibility for issuing fish consumption advisories in New York waters. It is arbitrary and capricious for EPA to select a risk-based remedial goal of 0.05 ppm fish PCB concentration, and fish PCB target concentrations of 0.4 and 0.2 ppm because such levels are inconsistent with the FDA tolerance level of 2 ppm, and with the State fish consumption advisories, which also are triggered at 2 ppm PCBs in fish.

Response to Master Comment 375

In accordance with CERCLA and the NCP, EPA has determined that the Remediation Goal of 0.05 mg/kg total PCBs in fish fillet is protective of human health based on the reasonable maximum exposure (RME) consumption rate of about one half-pound fish meal per week. The target concentration of 0.2 mg/kg total PCBs in fish fillet is protective of human health at a fish consumption rate of about one meal per month, and 0.4 mg/kg total PCBs in fish fillet is protective of the average (central tendency [CT]) angler, who consumes about one fish meal every two months.

EPA also has determined that a concentration of 0.3 to 0.03 mg/kg total PCBs in largemouth bass (whole fish) is protective of the environment based on the LOAEL and NOAEL for consumption of fish by the river otter, an upper-trophic level piscivorous mammal that was found to be at greatest risk (Hudson River PCBs Reassessment RI/FS Phase 3 Report: Feasibility Study [EPA 2000a], Section 3.2 [Calculation of Risk-Based Concentrations for Human Health and Ecological Receptors]). EPA's remedial action objectives for PCB concentrations in fish were developed in accordance with the Agency's obligation under CERCLA Section 121(b)(1) to select remedies that are protective of human health and the environment. EPA's decision does not usurp or otherwise affect New York State's responsibilities with respect to establishing fish consumption advisories.

A remedial action objective of 2 ppm in fish would not be protective of human health or the environment at the Site. Using the RME exposure presented in the Revised Baseline Human Health Risk Assessment (EPA, 2000b) and PCB concentration in fish fillet of 2 mg/kg, the calculated total cancer risk exceeds 1×10^{-3}, or more than one in one thousand. This excess cancer risk is more than 1,000 times greater than EPA's goal of protection, and more than 10 times higher than the highest cancer risk level allowed under the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR § 300.430(e)(2)(i)(A)(2)). For non-cancer health effects at the RME exposure level, a 2 ppm PCB concentration in fish fillet yields a hazard index of 71 for a child, which is 71 times higher than EPA's reference level (hazard index [HI]) of one. As per 40 CFR § 300.430(e)(2)(i)(A)(1), for systemic toxicants, acceptable exposure levels shall represent concentration levels to which the human population may be exposed without adverse effect during a lifetime or part of a lifetime, incorporating an adequate

margin of safety. For adolescents and adults, the 2 ppm level results in hazard indices of 49.5 and 45.6, which are 49.5 and 45.6 times higher, respectively, than EPA's reference level of one. A 2 ppm PCB concentration in fish fillet, therefore, is not protective of human health. A 2 ppm PCB concentration in whole fish also is not protective of the environment, because it would exceed the risk-based remedial action objective of between 0.3 to 0.03 ppm total PCBs in largemouth bass (whole fish), which EPA has determined is protective of the environment.

Moreover, the commenter misconstrues the significance of the 2 ppm FDA tolerance level. The FDA's tolerance level (codified at 21 CFR § 109.30) is not a purely risk-based standard, but was based on weighing the results of a risk assessment against the magnitude of potential food loss (*i.e.*, fish that could not be sold in interstate commerce) that would result from a lower tolerance level (44 Fed. Reg. 38330, 38334 [June 29, 1979]). The FDA level was developed under different legislation and regulatory responsibilities in 1979 using FDA guidance, and is not based on current toxicity information for PCBs. The Preamble to the FDA's Final Rule establishing the 2 ppm tolerance level states that the 2 ppm level is intended to apply to fish and shellfish that are shipped in interstate commerce, and may not be adequately protective of individuals who consume above-average amounts of locally caught fish from contaminated waters (44 Fed. Reg. 38334-35). Consistent with the NCP and EPA policy, the Revised Baseline Human Health Risk Assessment conducted for the Reassessment evaluated consumption of fish from the Upper and Mid-Hudson River, which are the parts of the river most affected by Site-related PCBs.

The fact that EPA's risk-based remedial action objectives for the Site are lower than the FDA tolerance level, or that the State of New York may consider the 2 ppm FDA level (among other factors) when establishing consumption advisories, does not preclude EPA from establishing lower risk-based levels in order to protect human health and the environment at the Site in accordance with CERCLA. Neither the FDA tolerance level nor the State's policy of considering the 2 ppm level when establishing fish consumption advisories is an applicable or relevant and appropriate requirement (ARAR) for the Site, and therefore need not be met (or waived) as part of EPA's remedy selection process. The FDA tolerance level is not an ARAR for the Hudson River PCBs Site because the statute under which the FDA tolerance level was promulgated, the Federal Food, Drug and Cosmetic Act, 21 U.S.C. 301-393, is not a Federal environmental law or a State environmental law or facility siting law. The New York State Department of Health's policy of considering the 2 ppm level when establishing fish consumption advisories is not a "promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard...," and is, therefore, not a State ARAR (42 U.S.C. § 9621(d)(2)). The State's authority to set consumption advisories and regulate fisheries will not be impacted by the selected remedy.

Where ARARs do not exist for an exposure medium (such as at the Hudson River PCBs Site, where there are no ARARs for PCB levels in fish), EPA must use other information to set remediation goals that will ensure protection of human health and the environment as required by statute. Development of such remediation goals will focus on EPA-developed toxicity information (cancer potency factors and the reference doses for noncarcinogenic effects) (55 Fed. Reg. 8666, 8713 [March 8, 1990]). The Hudson River PCBs Site remediation goals for PCB levels in fish were developed using toxicity and exposure information as described in the FS (Section 3.2).

Moreover, even if the 2 ppm level were an ARAR (which it is not), EPA is required by CERCLA and the NCP to select remedies that are protective of human health and the environment, and may select remedies with remedial action objectives that are more stringent than even the most stringent federal and State ARARs (40 CFR 300.430(f)(1)(i)(A): all CERCLA remedies must be protective of human health and the environment *and* comply with ARARs [unless a specific ARAR is waived]). EPA's risk-based remedial action objectives for the Site, therefore, are not arbitrary and capricious, as the comment argues, but rather are consistent with EPA's obligation to select protective remedies under CERCLA and the NCP.

One comment argues that EPA's "Guidance for Assessing Chemical Contaminant Data for Use in Fishing Advisories, Volume 3: Overview of Risk Management" (EPA 823-B-96-006) (EPA, 1996) requires EPA to consider "social, economic, cultural, and nutritional aspects of limiting fish consumption" when establishing remedial action objectives for PCB concentrations in fish at the Site. EPA's Guidance for Assessing Chemical Contaminant Data for Use in Fishing Advisories was developed to provide State, local, and tribal agencies with risk-management guidance for developing fish advisories. It is, therefore, not applicable to the development of remedial action objectives for the Site.

References

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

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

USEPA. 1996. Guidance for Assessing Chemical Contaminant Data for Use in Fishing Advisories, Volume 3: Overview of Risk Management" (EPA 823-B-96-006).

Master Comment 381

Commenters argued that the Feasibility Study does not adequately address requirements of the Federal Farmland Protection Policy Act and the New York Agriculture and Markets law.

Response to Master Comment 381

The dredging called for in the ROD will not result in the conversion of farmland to nonagricultural uses, and therefore is not subject to the Federal Farmland Protection Policy Act (7 CFR § 658.3(c)). In connection with the remedy, EPA also does not expect to locate any dewatering/transfer facilities in areas that will result in the conversion of farmland to nonagricultural uses.

The New York State Agriculture and Markets Law does not contain provisions that are applicable to the federal government. Further, that law is not an ARAR for this project. First, it is not an environmental or facility siting law for purposes of CERCLA § 121(d)(2). Second, it was not identified by the State of New York as being an ARAR for this project. In any event, as noted above, EPA does not intend to convert any agricultural land to non-agricultural uses in the performance of the selected remedy at this Site.

Master Comment 383

A commenter argues that "the Agency must use the best available science, a standard that is properly measured according to Daubert v. Merrell Dow Pharmaceuticals, Inc., [509 U.S. 579 (1993)], and its progeny, *e.g.*, General Electric Co. v. Joiner [522 U.S. 136 (1997)] . . . These cases are relevant to EPA's assessment of PCB toxicity because, in many decisions, the courts have applied these standards to reject claims that PCBs have caused injuries in humans. See *e.g.*, *Joiner*, 522 U.S. at 518-19 (rejecting expert testimony claiming correlation between PCB exposure and alleged injuries); Nelson v. Tennessee Gas Pipeline Co., 2001 WL 227426 (6th Cir. 2001) (same); In re: Paoli Railroad Yard PCB Litigation, 2000 WL 274262 (E.D. Pa. 2000) (same); Mercer v. Rockwell Int'l, 24 F.Supp.2d 735 (W.D. Ky. 1998) (finding no scientific basis for expert opinion that any additional PCB exposure increases risk to human health)." The commenter argues that, based on these court decisions, when measured against the Daubert standards, the science suggesting that PCBs cause injury in humans fails to pass scientific muster.

Response to Master Comment 383

EPA's cancer and non-cancer toxicity values for PCBs are based on a weight-of-evidence approach that considers both human epidemiological evidence and animal bioassay data, and are scientifically valid. The Agency's toxicity values were developed in accordance with Agency cancer and non-cancer guidelines which had undergone external peer review, review by the EPA Science Advisory Board, and internal Agency review (USEPA, 1976, 1984, 1986a-c, 1991, 1992, 1994b, 1996a,d,e 1998). The EPA PCB toxicity values for cancer were themselves subjected to external peer review in 1996, as was EPA's reference dose for PCB Aroclor 1016 (USEPA, 1994a, 1996b-c). EPA's conclusion that exposure to PCBs at the Site through consumption of PCB-contaminated fish can cause adverse cancer and non-cancer health effects on humans is amply supported by the Revised Baseline Human Health Risk Assessment and other scientific information in the administrative record for the Site (White Paper – PCB Carcinogenicity and White Paper – PCB Non-Cancer Health Effects).

EPA disagrees that the cases cited in this comment support a conclusion that "the science suggesting that PCBs cause injury in humans fails to pass scientific muster." The US Supreme Court's decision in Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579 (1993), addresses the standard for admitting expert scientific testimony in a federal trial, and is not relevant to the issue of whether information contained in the administrative record for the Hudson River PCBs Site supports EPA's determination that exposure to PCBs through

consumption of fish from the Site presents unacceptable human health and ecological risks. The commenter's conclusion likewise is not supported by any of the post-Daubert cases cited in the comment. Each of the cited cases addresses the admissibility and/or adequacy of evidence offered by plaintiffs in support of particular claims for damages resulting from PCB exposure. None of those decisions held, as a general matter, that PCB exposure cannot result in unacceptable risks to human health and the environment. EPA also notes that the National Research Council's report, "A Risk-Management Strategy for PCB-Contaminated Sediments" (March 2001), which includes a discussion of recent information on PCB toxicity, supports EPA's conclusion that exposure to PCBs may result in chronic effects in humans and/or wildlife.

References

USEPA. 1976. Interim procedures and guidelines for health risk and economic impact assessments of suspected carcinogens. Federal Register 41:21402-21405.

USEPA. 1984. Proposed guidelines for carcinogen risk assessment. Federal Register 49:46294. November 23.

USEPA. 1986a. The Risk Assessment Guidelines for 1986. Office of Health and Environmental Assessment, Washington, D.C. EPA/600/8-89/043, July.

USEPA. 1986b. Guidelines for carcinogen risk assessment. Federal Register 51:33992-34003.

USEPA. 1986c. Guidelines for the Health Assessment of Suspect Developmental Toxicants. Federal Register 51 (185) 34028-34040. September 24.

USEPA. 1991. Guidelines for Developmental Toxicity Risk Assessment. Federal Register 56 (234) 63798-63826. December 5.

USEPA. 1992. Guidelines for Exposure Assessment. Federal Register 57 (104) 22888-22938. May 29.

USEPA. 1994a. Report on the Technical Review Workshop on the Reference Dose for Aroclor 1016. USEPA, Risk Assessment Forum, Office of Research and Development, Washington, D.C. EPA/630/R-94/006. November.

USEPA. 1994b. "Report on the Workshop on Cancer Risk Assessment Guidelines Issues." Office of Research and Development, Risk Assessment Forum, Washington, D.C. EPA/630/R-94/005a.

USEPA. 1996a. Proposed guidelines for carcinogen risk assessment. Federal Register 61 (79) 17960-18011. April 23.

USEPA. 1996b. "Report on Peer-Review Workshop on PCBs: Cancer-Dose Response Assessment and Application to Environmental Mixtures." National Center for Environmental Assessment, Office of Research and Development, Washington, D.C.

USEPA. 1996c. "PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures." National Center for Environmental Assessment, Washington, D.C. USEPA/600/P-96/001F. September.

USEPA. 1996d. Revisions to the cancer guidelines (proposed). Federal Register 61 (79):17960-18011.

USEPA. 1996e. Guidelines for Reproductive Toxicity Risk Assessment. Federal Register 61 (212) 56274-56322. October 31.

USEPA. 1998. "Guidelines for Neurotoxicity Risk Assessment. Federal Register 63 (93) 26926-26954, 14 May 1998.

Master Comment 385

A commenter argued that EPA should conduct analyses required by the Regulatory Flexibility Act and the Unfunded Mandates Act, and Executive Order 12866. The siting of dewatering/transfer facilities raises takings implications under Executive Order 12630. EPA's decision to establish remedial action objectives for the Site using risk-based concentrations may violate Executive Order 13132.

Response to Master Comment 385

Regulatory Flexibility Act

The Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement Fairness Act of 1996, 5 U.S.C. §§ 601 - 612, requires agencies to prepare for public comment a regulatory flexibility analysis describing the impact of a proposed rule on small businesses whenever the agency is required by Section 553 of the Administrative Procedure Act (APA) or another law to publish general notice of proposed rulemaking for any proposed rule. 5 U.S.C. § 603(a). EPA's selection of a remedy for the Hudson River PCBs Site is not an agency rulemaking, however, and the RFA is therefore inapplicable to the remedy selection process (United States v. Iron Mountain Mines, 987 F. Supp. 1250, 1259 (E.D. Cal 1997): remedy selection under CERCLA does not involve rulemaking).

Unfunded Mandates Reform Act

The Unfunded Mandates Reform Act of 1995 (UMRA), Pub.L. 104-4, 109 Stat. 48 (codified in scattered sections of 2 U.S.C.) requires, among other things, that federal agencies prepare and consider estimates of the budgetary impact of regulations containing federal mandates upon State, local, and tribal governments and the private sector before adopting such regulations. 2 U.S.C. § 1501(7)(B). As indicated above, the remedy selection process for the Site is not an agency rulemaking. The UMRA is therefore inapplicable to the remedy selection process for the Site.

Executive Order 12866, Regulatory Planning and Review (September 30, 1993)

Executive Order 12866 requires federal agencies to, among other things, assess the costs and benefits of intended regulations. This Executive Order does not apply to the CERCLA remedy selection process because, as indicated above, selection of a remedy under CERCLA is not an agency rulemaking.

Executive Order 12630, Governmental Actions and Interference with Constitutionally Protected Property Rights (March 15, 1988)

Executive Order 12630 requires Executive Branch departments and agencies, as part of their internal management processes, to assess the takings implications of proposed policies and actions on private property interests protected by the Fifth Amendment. The commenter suggests that the siting of dewatering/transfer facilities raises takings implications under this Executive Order. EPA has not yet determined dewatering/transfer facility location(s), and will only select such locations as part of the public process outlined in the ROD. As appropriate, EPA will conduct a takings assessment as part of the dewatering/transfer facility site selection process.

Executive Order 13132, Federalism (August 4, 1999)

Executive Order 13132 applies to rules with federalism implications, defined in the Order as "substantial direct effect[s] on States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government." The commenter argues that EPA's decision to establish remedial action objectives for the Site based on risk-based concentrations may violate this Executive Order by inappropriately "usurp[ing] New York State's responsibility in this area."

EPA's remedial action objectives for PCB concentrations in fish were developed in accordance with the Agency's obligation under CERCLA Section 121(b)(1) to select remedies that are protective of human health and the environment, and do not usurp or otherwise affect the State's responsibilities with respect to establishing fish consumption advisories. In any event, EPA consulted with the State of New York in the development of the selected remedy for the Site.

Master Comment 387

A commenter noted that additional water quality criteria, which were not identified in the Feasibility Study, have been developed pursuant to the Clean Water Act. According to the 1998 Federal Register (Vol 63, No. 237, Dec. 10, 1998), the criteria continuous concentration (chronic) for PCBs is 0.014 μg/L in freshwater and 0.03 μg/L in saltwater. The criterion for protection of human health from consumption of water and organisms or organisms only is 0.00017 μg/L.

Response to Master Comment 387

The federal water quality criteria (FWQC) cited in the comment were published by EPA in the Federal Register (63 Fed. Reg. 68354 [December 10, 1998]) pursuant to Section 304(a)(1) of the Clean Water Act. Section 304(a) requires the Agency to develop and publish, and from time to time revise, criteria for water quality accurately reflecting the latest scientific knowledge. Section 304(a) criteria provide, among other things, guidance to States and tribes in adopting water quality standards that ultimately provide a basis for controlling discharges or releases of pollutants. Criteria continuous concentrations are water quality criteria to protect against chronic effects in aquatic life.

The State of New York has promulgated enforceable water quality criteria (WQC) at 6 NYCRR § 703.5 which have been identified as ARARs for the Site. The New York State WQCs for PCBs are 0.09 μg/l [90 ng/L] (New York State standard for protection of human health and drinking water sources); 1.2×10^{-4} μg/l [0.12 ng/L] (New York State standard for protection of wildlife); and 1×10^{-6} μg/l [0.001 ng/L] (one part per quadrillion total PCBs) (New York State water quality standard for the protection of the health of human consumers of fish). Two of the New York State WQC (*i.e.*, the New York State standard for protection of wildlife and the New York State water quality standard for the protection of the health of human consumers of fish) are not expected to be met by any of the alternatives during the 70-year forecast period of EPA's model, and are therefore being waived for the selected remedy based on technical impracticability (Declaration and Section 14.2 of the ROD and Response to Master Comment 401 in Chapter 1 of this Responsiveness Summary).

The FWQC criteria cited in the comment are nonenforceable guidance, and therefore are not applicable requirements for the Site. At the same time, the 0.014 μg/L [14 ng/L] FWQC in freshwater and 0.03 μg/L [30 ng/L] FWQC in saltwater are relevant and appropriate under the circumstances at the Site, and are therefore ARARs for the Site, because there are no comparable New York State WQC for protection of aquatic life that are more stringent than the FWQC. (CERCLA Section 121(d)(2) and 40 CFR 300.400(g)(2): Identification of applicable or relevant and appropriate requirements.) The FWQC of 0.00017 μg/L [0.17 ng/L] for protection of human health from consumption of water and organisms or organisms only is not an ARAR for the Site because New York State has promulgated a more stringent water quality standard for the protection of the health of human consumers of fish (0.001 ng/L), which is an ARAR for the Site.

Master Comment 391

Commenters requested that EPA identify ARARs and other regulations concerning artificial lighting that are applicable to the project, and asked whether the remedy would comply with "laws, regulations, guidelines, permit requirements, and ordinances" regarding artificial lighting.

Response to Master Comment 391

Lighting is addressed in OSHA regulations at 29 CFR 1926.56 (Occupational Health and Environmental Controls) and US Coast Guard regulations at 33 CFR 154.570 (Facilities Transferring Oil or Hazardous Material in Bulk). 33 U.S.C. § 2020 (Inland Navigational Rules) and the New York State Navigation Law § 43 address the lighting requirements for vessels. These laws will be complied with during implementation of the selected remedy. Local regulations are not ARARs under CERCLA. However, EPA will consider pertinent local regulations concerning lighting impacts (if such regulations exist) during the design phase for the sediment processing and transfer facility(ies).

Master Comment 393

A commenter requested identification of the applicable federal, State, and local laws and regulations that govern the emission of nuisance level odors. The commenter further asked whether EPA's remedy would comply with such requirements.

Response to Master Comment 393

EPA has identified the New York State Environmental Conservation Law Article 19, Title 3 - Air Pollution Control Law (promulgated pursuant to the federal Clean Air Act, 42 U.S.C. § 7401, *et seq*.) as an ARAR for the Site. Regulations issued under this provision (6 NYCRR § 211.2) prohibit the emissions of air contaminants to the outdoor atmosphere which are injurious to human, plant or animal life or to property, or which unreasonably interfere with the comfortable enjoyment of life or property. The selected remedy will comply with applicable or relevant and appropriate provisions of the Air Pollution Control Law. EPA has not identified any federal or State permit requirements regarding nuisance level odors. In any event, in accordance with CERCLA Section 121(e), no federal, State, or local permits are required for CERCLA response actions that are conducted on-site, although the selected remedy will comply with substantive federal and State requirements, including those pertaining to air emissions. Any dredging activity and sediment processing/transfer facility for the Hudson River PCBs remedy would be considered "on-site."

Local laws, ordinances and regulations are not ARARs under CERCLA. However, EPA will consider pertinent local laws, ordinances and regulations concerning odors (if such regulations exist) during the design phase for the sediment processing/transfer facility(ies).

Master Comment 395

Commenters argued that EPA has arbitrarily selected applicable or relevant and appropriate requirements (ARARs) and TBC (to-be-considered) criteria to support a predetermined remedy, and that EPA's ARAR development and evaluation is inadequate.

Response to Master Comment 395

EPA disagrees that its ARARs development and evaluation for the Site was arbitrary or inadequate. The ARARs were identified consistent with CERCLA Section 121(d). EPA identified the ARARs and TBCs for the Site after review of potentially applicable laws, regulations, and other criteria. Consistent with the NCP, EPA also solicited a list of potential State ARARs from the New York State Department of Environmental Conservation (NYSDEC). Moreover, EPA published a list of potential ARARs in the FS for public comment before determining the ARARs for the selected remedy in the ROD. EPA's selected remedy complies with ARARs (or waives them), and is protective of human health and the environment.

Master Comment 495

A commenter noted that regulatory requirements should include outflow water discharging to surface water (citing Feasibility Study page 4-80, section 4.3.8.1 [sic]).

Response to Master Comment 495

The referenced FS section does not exist; EPA could not locate the piece of text on which the comment was based. Therefore, no specific response is possible.

However, the FS Report (Section 2.3.1 [Federal Chemical-Specific ARARs] and Section 2.5.3 [Action-Specific Criteria, Advisories, and Guidance to be Considered]) includes requirements that would apply to discharges to the Hudson River. Tables 2-1a, 2-3a, and 2-3b of the FS identify several laws and regulations that would be potentially applicable to discharges to the Hudson River or to wetlands, to control contravention of water quality criteria, and other deleterious effects. These include, but are not limited to:

Chemical-Specific ARARs (FS, Table 2-1a): 40 CFR § 129.105(a)(4) (promulgated pursuant to federal Clean Water Act, 33 U.S.C. §§ 1251 - 1387); 40 CFR § 141.61 (promulgated pursuant to federal Safe Drinking Water Act, 42 U.S.C. §§ 300f-300j-26); and 6 NYCRR Parts 700 through 706 (promulgated pursuant to New York State Environmental Conservation Law (NY ECL) §§ 3-0301(2)(m), 15-0313, 17-0301, 17-0303, 17-0809).

Action-Specific ARARs (FS, Table 2-3a): 40 CFR Parts 230 (promulgated pursuant to federal Clean Water Act, 33 U.S.C. § 1344(b)); 40 CFR Part 231 and 33 CFR Parts 320, 323, and 325 (promulgated pursuant to federal Clean Water Act, 33 U.S.C. § 1344(c)); 6 NYCRR Part 608 (promulgated pursuant to NY ECL §§ 3-0301(2)(m),15-0501, 15-0503, 15-0505, 17-0303(3)) and 6 NYCRR Parts 750 - 758 (promulgated pursuant to NY ECL Article 3, Title 3 and Article 17, Titles 1, 3, and 8).

The commenter is also referred to Tables 14-1, 14-2, and 14-3 of the Record of Decision, in which EPA has identified the ARARs for the selected remedy, including ARARs regarding discharges to surface water.

Please note that two additional chemical-specific ARARs (0.014 µg/L total PCBs criteria continuous concentration (CCC) Federal Water Quality Criterion (FWQC) for freshwater; and 0.03 µg/L total PCBs CCC FWQC for saltwater) were identified after the Proposed Plan and FS were issued for public comment in December 2000 (Response to Master Comment 387, above).

Further discussion of discharge water quality is provided in White Paper – Potential Impacts to Water Resources and further information on the water treatment facility may be found in White Paper – Example Sediment Processing/Transfer Facilities.

Master Comment 497

A commenter requested that the original investigator be cited for National Oceanic and Atmospheric Administration's (NOAA's) Screening Quick Reference Table (SQRT) values.

Response to Master Comment 497

Table 2-1b of the FS contains screening levels for PCBs in freshwater sediment and cites the NOAA SQRT for Organics as the source. While the NOAA SQRT does contain the screening values, the original source for these values is a 1996 EPA document entitled, "Calculation and evaluation of sediment effect concentrations for the amphipod *Hyalella azteca* and the midge *Chironomus riparius*," (EPA 905-R96-008, Chicago, IL). The screening values were also published in a peer-reviewed scientific journal, in a paper with the same title by C.G. Ingersoll, P.S. Haverland, E.L. Brunson, T.J. Canfield, F.J. Dwyer, C.E. Henke, and N.E. Kemble (*J. Great Lakes Res*. 22:602-623).

Master Comment 313682

Several commenters argued that, according to the FS, there would be no difference between the MNA Alternative and EPA's preferred remedy in meeting chemical-specific applicable or relevant and appropriate requirements (ARARs) for the Site. Two chemical-specific ARARs for surface water would be met by both MNA and the preferred remedy, while the remaining three chemical-specific ARARs for the surface water would not be met by either alternative within the 70-year modeling time frame.

Response to Master Comment 313682

Although it is correct that two chemical-specific ARARs for surface water identified in the Feasibility Study and Proposed Plan (federal Safe Drinking Water Act MCL of 0.5 µg/L [500 ng/L] and 0.09 µg/L [90 ng/L] New York State standard for protection of human health and drinking water sources) are projected to be met by both MNA and the selected remedy, while three of the chemical-specific ARARs for surface water identified in those documents (1 ng/L federal Ambient Water Quality Criterion; 0.12 ng/L NYS standard for protection of wildlife; and 0.001 ng/L NYS standard for human consumers of fish) are not projected to be met by any of the remedial alternatives that were evaluated in the Detailed Analysis of Alternatives (FS, Chapter 8)

within the 70-year modeling time frame, the modeling indicates that there will be a considerable improvement in the water quality (by almost a factor of two) for the dredging options relative to MNA throughout the 40-mile stretch of the upper river for 20 years of the forecast period. It is very clear that source control alone is not as effective in improving water quality as the dredging options (Figures 6-33 through 6-37 in Book 2 of the FS Report). This conclusion does not change materially under the new model runs presented in White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River. For example, at the Thompson Island Dam in 2008, the concentration of total PCBs is projected to be approximately 30 ng/L for the MNA Alternative, whereas the concentration of total PCBs is projected to be approximately 16 ng/L for REM-3/10/Select.

After the Proposed Plan was issued in December 2000, EPA identified two additional chemical-specific ARARs for the Site: the 14 ng/L criteria continuous concentration (CCC) Federal Water Quality Criterion (FWQC) for freshwater; and the 30 ng/L CCC FWQC for saltwater. Both of these FWQC ARARs will be met by the selected remedy.

Master Comment 313765

A commenter noted that the statement from Page 29 of the Proposed Plan ("The preferred alternative, REM-3/10/Select, is similar to the REM-0/0/3 alternative in terms of reductions of risk to human health and the environment") downplays the additional reduction in PCB loading over the Federal Dam and the halving of time to reach 0.4 ppm PCBs in fish in the Upper Hudson achieved with the REM-0/0/3 Alternative.

Response to Master Comment 313765

EPA agrees that Alternative REM-0/0/3 provides an additional reduction in the PCB load over the Federal Dam, based on EPA’s modeling, and a halving of the time to reach the target concentration of 0.4 ppm PCBs in fish as compared to Alternative REM-3/10/Select. It was not EPA's intent to downplay these reductions, which are also described in other portions of the Proposed Plan (pages 19 and 20). EPA was referring to the tables on page 28 (Cancer Risks and Non-Cancer Health Hazards for Adults from Fish Ingestion, and Ecological Toxicity Quotients - River Otter and Mink) when making the statement on page 29. Nevertheless, EPA has determined that the additional reductions in PCB load over the Federal Dam, and the time to reach PCB target levels under REM-0/0/3, do not justify the additional $110 million cost for that alternative.

Master Comment 358464

A commenter argued that EPA has failed to conduct the consultation procedures required by the Federal Endangered Species Act (ESA). CERCLA Section 121(e) does not exempt EPA from the consultation requirements of the Federal Endangered Species Act. The commenter argues that EPA has failed to comply with the ESA because: (1) EPA has not prepared a biological assessment analyzing whether the proposed plan may adversely affect federally-listed threatened

or endangered species, which include the short-nosed sturgeon and bald eagle; and (2) the proposed remedy may adversely affect these species' habitat and mating behavior, resulting in a "take" under the ESA. Likewise, EPA also has not complied with the New York State Endangered Species Act, and implementation of the remedy may result in a "take" under NYS law in the vicinity of processing facilities.

Response to Master Comment 358464

CERCLA requires EPA to comply only with the substantive, and not the procedural, requirements of other environmental laws for CERCLA response actions that are conducted on-site (Response to Master Comment 475, Section 1.2.1). The consultation requirements of the Endangered Species Act are procedural/administrative requirements from which on-site CERCLA response actions are exempt. The substantive requirements of the Endangered Species Act are an ARAR for the Site, however, and the selected remedy will comply with such requirements.

EPA initiated informal consultation with the National Marine Fisheries Service (NMFS) and the Fish and Wildlife Service (FWS) by letters dated October 16, 1991. FWS responded to EPA by letter dated November 13, 1991, in which FWS indicated that no federally listed or proposed endangered or threatened species under FWS jurisdiction were known to exist within the project impact area (*i.e.*, the Upper and Lower Hudson River). In an October 21, 1991 letter to EPA, NMFS indicated that the range of the shortnose sturgeon (*Acipenser brevirostrum*) includes the Hudson River PCBs Site, and that the shortnose sturgeon is at risk from PCBs in the surface sediments and in faunal organisms. NMFS recommended that EPA consider the potential impacts of remedial action (which at the time had not been proposed) on the shortnose sturgeon.

After issuing the Proposed Plan, in a February 16, 2001 letter EPA contacted NMFS again, and requested a written statement from NMFS as to whether EPA's preferred remedy for the Site may result in impacts to the shortnose sturgeon or its critical habitats. In a May 7, 2001 letter to EPA, NMFS requested additional information about whether resuspended contaminated sediments will be carried past the Federal Dam and into sturgeon habitat under the preferred remedy, and on any post-dredging monitoring of downstream areas.

On June 29, 2001, EPA reinitiated informal consultation with FWS under the Endangered Species Act to determine whether additional species have been listed as endangered since 1991. EPA provided FWS with details concerning the preferred remedy, and requested a written statement from FWS as to whether any endangered species that are listed or proposed to be listed are located in the project area. EPA also requested the range of territory covered by any federally listed endangered species that may be found in the area, and whether the proposed remedial action may impact endangered species or their critical habitats. In an August 17, 2001 response, FWS identified the bald eagle (*Haliaeetus leucocephalus*) as a federally-listed threatened species that is known to occur in the area of the proposed Hudson River remediation, and the Karner blue butterfly (*Lycaeides melissa samuelis*) and Indiana bat (*Myotis sodalis*) as federally-listed endangered species that may be found within or adjacent to the project area.

EPA will conduct biological assessments (BAs) for the bald eagle and shortnose sturgeon, as they have been identified as being in the project area. Because the sediment processing and transfer facilities have not been sited or designed, it cannot be determined at this time if the Karner blue butterfly or Indiana bat, or potential suitable habitat for either species, may be affected by the selected remedy. Nevertheless, once the locations for the transfer facilities and other necessary land-based infrastructure have been established, EPA will evaluate the habitat that will be affected to determine if it is suitable to support either species. If suitable habitat is found, additional biological assessment work will be conducted for these species.

Any completed BAs will include an effects determination, which will state what conclusions regarding potential impacts to the local population of the species discussed can be supported from the information presented in the BAs. The BAs will be submitted to the FWS or NMFS for review and a final determination of effect. The BAs will be completed before remedial construction, and the remedial design will reflect appropriate measures to protect these species that result from the consultation process.

The New York State Endangered Species Act prohibits the “taking, importation, transportation, possession or sale of any endangered or threatened species” without a permit (NY ECL § 11-0535). On-site CERCLA response actions, however, are exempt from federal, State, and local permit requirements under CERCLA Section 121(e)(1). CERCLA requires EPA to comply only with the substantive, and not the procedural, requirements of other environmental laws for CERCLA response actions that are conducted on-site (see first paragraph of this Response to Master Comment). The permit requirement of the New York State Endangered Species Act is a procedural requirement from which EPA’s on-site response activities are exempt. Nevertheless, if EPA determines, during remedial design, that implementation of the selected remedy may cause a "taking" of any endangered or threatened species, EPA will consult with NYSDEC with respect to the substantive requirements that NYSDEC would consider in determining whether to issue a permit in similar circumstance.

Copies of EPA’s informal consultation letters to FWS and NMFS, and the associated responses, are included in the Administrative Record.

Master Comment 313723

Commenters expressed concern that there had been an alleged lack of analysis of short-term impacts such as risks to workers, community, and the environment from the project. According to one comment, the alleged failure to analyze these issues with respect to the short term is “particularly surprising” given the fact that the various alternatives provide similar long-term effectiveness in protecting human health and compliance with ARARs.

The comment also notes that EPA’s Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA states that short-term effectiveness and the other balancing criteria generally "require the most discussion because the major tradeoffs among alternatives will most frequently relate to one or more of these five [balancing criteria]" (EPA 1988, Section 6.2.5).

Response to Master Comment 313723

EPA disagrees with the underlying premise of the comment that EPA's Feasibility Study failed to analyze potential short-term impacts of the preferred remedy to workers, the community and environment. Please see the analyses of short-term impacts presented in the Feasibility Study (FS Section 8.5.2.5 (short-term impacts of REM-3/10/Select) and 9.5 (comparative analysis of short-term impacts of remedial alternatives). Please also see Response to Master Comment 421 in Chapter 11, and the additional analyses of various community impacts that have been prepared by EPA as part of this Responsiveness Summary (*e.g.*, responses to comments in Chapter 8; White Paper - Socioeconomics; White Paper - Project-Related Traffic; White Paper - Rail Operations; White Paper - Example Sediment Processing/Transfer Facilities; White Paper - Remobilization of PCBs during Dredging; White Paper - Potential Impacts to Water Resources; White Paper - River Traffic; White Paper - Odor Evaluation; and White Paper - Noise Evaluation).

EPA also disagrees with the statement that "the various alternatives provide similar long-term effectiveness in protecting human health." As explained in Section 11.3 of the ROD, there are substantial differences in the long-term effectiveness and permanence afforded by the selected remedy as compared to the No Action or the Monitored Natural Attenuation Alternatives. The No Action and MNA Alternatives result in a continuation of the degraded condition of the sediments and surface water quality of the Upper Hudson River, especially in the Thompson Island Pool, for at least several decades, regardless of any reduced PCB concentrations in the upstream water quality. The No Action and MNA Alternatives do not remove any PCBs from the river (although the MNA Alternative assumes additional control of the continuing release of PCBs at Hudson Falls), and fish PCB target concentrations are not met within a reasonable time under either MNA or No Action Alternatives.

For the selected remedy, risk is reduced through the removal of 2.65 million cubic yards of sediments containing approximately 150,000 lbs (70,000 kg) Total PCBs over an area of 493 acres. The reduction in cancer risks through fish consumption ranges from 76 percent to 85 percent compared to the No Action Alternative and from 50 percent to 80 percent compared to the MNA Alternative. The reduction in non-cancer hazard indices ranges from 71 percent to 79 percent compared to the No Action Alternative and from 58 percent to 75 percent compared to the MNA Alternative. EPA has determined that the potential short-term impacts of the selected remedy, which are either insignificant or can be minimized, are substantially outweighed by the overall protection of human health and the environment afforded by the selected remedy (Responses to Master Comments 421 and 485, Chapter 11).

Master Comment 397

Some comments argue that remedial alternative REM-0/0/3 is more cost-effective than REM-3/10/Select because the increased cost of REM-0/0/3 over REM-3/10/Select is only 24 percent, whereas relatively greater health risk reductions (*e.g.*, 30-40 percent) and greater PCB removal (approximately 50 percent) would be obtained.

Response to Master Comment 397

It is true that, based on EPA's modeling, REM-0/0/3 provides approximately 30 percent more cancer risk reduction as compared to the REM-3/10/Select Alternative for the RME individual, and approximately 42 percent more non-cancer risk reduction when compared to REM-3/10/Select for the RME individual. However, EPA believes a more appropriate comparison would be to evaluate REM-3/10/Select and REM-0/0/3 against a common baseline (i.*e.*, the MNA Alternative) in order to compare the relative risk reduction that would be achieved under each remedial alternative after considering the effects of the separate source control action to address the Hudson Falls source of PCBs.

Using the approach outlined in the preceding paragraph, EPA has determined that the selected remedy is more cost-effective than the REM-0/0/3 Alternative. For example, compared with the MNA Alternative, REM-0/0/3 provides 63 to 85 percent reduction in cancer risks to the RME individual, while REM-3/10/Select provides 50 to 80 percent reduction, according to EPA's model. Thus, REM-0/0/3 provides an incremental reduction in cancer risks of only approximately five to 13 percent over the selected remedy, when compared to the MNA Alternative.

For non-cancer health hazards, REM-0/0/3 yields hazard indices that offer 72 to 83 percent reduction compared to the MNA alternative, while REM-3/10/Select yields hazard indices that offer 58 to 75 percent reduction compared to the MNA Alternative, according to EPA's model. REM-0/0/3, therefore, provides approximately eight to 14 percent greater reduction in non-cancer hazard indices than REM-3/10/Select, compared to the MNA Alternative.

The selected remedy is approximately $110 million less expensive than REM-0/0/3, without substantial improvement over the selected remedy in the amount of human health or ecological risk reduction. EPA has determined that the incremental improvement in risk reduction for cancer and non-cancer health effects projected under REM-0/0/3 does not justify the additional $110 million cost of that alternative.

Commenters have stated that REM-0/0/3 is more cost-effective than REM-3/10/Select based on the fact that the more aggressive remedy removes approximately 40 percent more PCBs, for approximately 24 percent greater cost. As explained above and in the Response to Master Comments 369451 and 595 in Chapter 4, EPA believes that REM-3/10/Select is a more appropriate remedy than REM-0/0/3. In particular, refined estimates of PCB mass removal show that REM-0/0/3 would double the area affected, while only increasing the PCB mass removed by 20 percent more than the mass removed under REM-3/10/Select (see Master Comment 369451 and White Paper – Sediment PCB Inventory Estimates).

Master Comment 399

A commenter stated that New Yorkers have a common-law right to fish, which implicitly includes the right to eat the fish one catches. Recent studies show that despite the existence of

New York State Department of Health advisories, recreational anglers regularly eat fish from the river and that many share the fish with family members. This activity increases with distance down river: that is, downstate anglers are more likely to eat the fish than upstate anglers are. A study undertaken by the New York State Department of Health found that between Catskill and the Tappan Zee Bridge, almost half of the anglers fishing said food was one of their reasons for fishing, with 15 percent stating that catching fish for food was their primary reason for fishing. A third of the anglers conceded that they kept some of the fish caught: that they ate fish from the Hudson: and that they shared their catch with others. Further, a 1992 study conducted by the Hudson River Sloop Clearwater showed that approximately 50 percent of downstate anglers reported sharing Hudson River fish with the most at-risk population, women and children.

Response to Master Comment 399

EPA has determined that it is necessary to remove PCB-contaminated sediments from the Upper Hudson River in order to protect human health and the environment as required by CERCLA Section 121. EPA made this determination pursuant to CERCLA, and not State common law. Nevertheless, the studies cited in the comment that conclude that people continue to consume fish caught from the Hudson despite the fish consumption advisories are evidence that there is not complete compliance with the advisories, and that the risks to human health from the Site persist despite the existence of the consumption advisories. Thus, EPA has determined that the selected remedy, which reduces PCB levels in fish more quickly than remedial alternatives that do not include active remediation of contaminated sediments, is necessary. The selected remedy will reduce PCB concentrations in fish to levels at which the consumption advisories and fishing restrictions may be relaxed or lifted.

Master Comment 401

A commenter said that CERCLA Section 121(d)(2) requires EPA to select a remedial approach that maximizes the probability that ARARs will eventually be achieved. EPA should select a remedy that comes as close as reasonably possible to achieving New York State Water Quality Standards promulgated at 6 NYCRR Part 703.

Response to Master Comment 401

Four chemical-specific ARARs for surface water (federal Safe Drinking Water Act MCL of 0.5 µg/L [500 ng/L]; 0.09 µg/L [90 ng/L] New York State standard for protection of human health and drinking water sources; 0.014 µg/L [14 ng/L] criteria continuous concentration (CCC) Federal Water Quality Criterion (FWQC) for freshwater; and 0.03 µg/L [30 ng/L] CCC FWQC for saltwater) would be met by all remedial alternatives that were evaluated in the Detailed Analysis of Alternatives (FS Chapter 8), although three chemical-specific surface water ARARs (1 ng/L federal Ambient Water Quality Criterion; 0.12 ng/L NYS standard for protection of wildlife; and 0.001 ng/L NYS standard for human consumers of fish) are not expected to be met by any of the alternatives during the 70-year forecast period of EPA's model. These three chemical-specific ARARs are being waived for the selected remedy based on technical impracticability (Declaration and Section 14.2 of the ROD).

Nevertheless, the selected remedy achieves a more rapid decline in PCB surface water concentrations than remedial alternatives that do not include active remediation of contaminated sediments, and EPA believes that this is an important factor in why active remediation of the sediments is a better choice than either No Action or MNA. The benefits of active remediation of the sediments are readily apparent in the differences in the rates of decline for the selected remedy and the MNA and No Action Alternatives. During the first 20 years of the forecast period (between 2006 and 2025), the PCB water column concentration for the selected remedy is substantially improved when compared to the water column PCB concentrations under the No Action or MNA scenarios. As expected, the water quality is best for the REM-0/0/3 Alternative and substantially improved for the selected remedy (REM-3/10/Select) and the CAP-3/10/Select Alternative. While the water quality is projected to be improved under REM-0/0/3 relative to REM-3/10/Select, EPA selected REM-3/10/Select based on the nine criteria for Superfund remedy selection in the NCP.

Master Comment 403

A commenter argued that the determination by Hudson River Trustees that the Hudson River fishery has suffered "injury" within the meaning of the statute should be a factor in EPA's remedy selection (*i.e.*, to reduce future duration of the injury).

Response to Master Comment 403

The remedial action objectives for the selected remedy include (i) reduce the cancer risks and non-cancer hazard indices for people eating fish from the Hudson River by reducing the concentration of PCBs in fish; and (ii) reduce the risks to ecological receptors by reducing the concentration of PCBs in fish (see ROD Section 9.1). By reducing human exposure to PCBs due to the consumption of fish, EPA's selected remedy is expected to allow fish-consumption advisories to be relaxed as conditions improve. This will provide benefits to the industries of both recreational and commercial fishing (see the Response to Master Comment 399, above).

Master Comment 407

A commenter argued that failure to dredge may violate the Equal Protection Clause of the 14th Amendment.

Response to Master Comment 407

The comment is unclear as to why the commenter believes that failure to dredge may violate the Fourteenth Amendment. Nevertheless, EPA has selected a remedy that requires dredging.

Master Comment 503

A commenter argued that failure to dredge may violate the Fourth Amendment.

Response to Master Comment 503

The comment is unclear as to why the commenter believes that failure to dredge may violate the Fourth Amendment. Nonetheless, EPA has selected a remedy that requires dredging.

Master Comment 365246

A commenter argued that EPA's proposed remedy is not likely to comply with laws and regulations regarding wetlands protection, including 40 CFR Part 230, 33 CFR Parts 320-329, Executive Order 11990, and the New York State Freshwater Wetlands Act. The Monitored Natural Attenuation Alternative is a practicable alternative to the selected remedy with far fewer adverse impacts on the aquatic ecosystem.

Response to Master Comment 365246

EPA has determined that active remediation of PCB-contaminated sediments at the Site is necessary in order to address, within an acceptable time frame, the unacceptable risks to human health and the environment from consumption of PCB-contaminated fish by human and ecological receptors. As discussed in the FS, the ROD, and elsewhere in this Responsiveness Summary, the No Action and MNA Alternatives, which do not include active remediation of contaminated sediments, are not sufficiently protective of human health and the environment and thus would not be consistent with CERCLA. EPA also has determined that remedies that include capping of contaminated sediments are not appropriate because of, among other things, long-term operation and maintenance concerns associated with maintaining a cap in perpetuity. EPA therefore has determined that there is no practicable alternative to the selected remedy that would not require access or discharge to special aquatic sites in the Upper Hudson River, including wetlands (*i.e.*, the selected remedy is "water-dependent"), or which would have less adverse impact on the aquatic ecosystem, within the meaning of 40 CFR § 230.10(a). The dredging called for by the ROD, and the placement of backfill material in the Upper Hudson following the dredging thus are not prohibited by 40 CFR § 230.10(a).

In addition, as discussed in the ROD and elsewhere in this Responsiveness Summary, EPA has determined that the selected remedy's benefits to human health and the environment outweigh its potential short-term impacts, including potential impacts to the river ecosystem (33 CFR § 320.4(b) and Response to Master Comment 421, Chapter 11). EPA notes that one objective of its backfill program for the selected remedy will be to assist in the restoration of wetlands of the Upper Hudson River following dredging. Nevertheless, in accordance with 40 CFR Part 230, EPA will undertake appropriate measures to minimize adverse impacts of any discharge on the aquatic ecosystem and to mitigate impacts to wetlands after dredging.

Implementation of the selected remedy will result in unavoidable impacts to wetlands, although most, if not all, of such impacts would be temporary because of the restoration measures to be undertaken following dredging. In accordance with Executive Order 11990 and 40 CFR Part 6, Appendix A, EPA will avoid, to the extent possible, adversely impacting wetlands through implementation of the remedy and/or through appropriate restoration measures. The selected remedy includes a habitat replacement program that is intended to restore wetlands impacted by the remedy to conditions that existed before remediation. This program is expected to include, during remedial design, the collection and documentation of extensive hydrology, soil, and biological data on the pre-remediation conditions of the wetlands, including the physical, chemical, and biological components of the aquatic environment in accordance with 40 CFR § 230.11. EPA will also conduct a wetland delineation, if appropriate, for the dewatering/transfer facility location(s) after such location(s) are determined, so that potential adverse impacts (if any) to wetlands associated with such facilities can be avoided or minimized.

Measures to restore the Hudson River environment after dredging are presented in Appendix E.8 (Technical Memorandum: Habitat Replacement/River Bank Restoration Concept Development) and Appendix F (Habitat Replacement Program Description) of the Feasibility Study.

All dredging performed in order to implement the selected remedy, as well as the sediment processing/transfer facilities that are necessary to implement the remedy, will be considered "on-site" for purposes of the permit exemption of Section 121(e)(1) of CERCLA, 42 U.S.C. § 9621(e)(1). The permit requirements of the New York State Freshwater Wetlands Act (NY Environmental Conservation Law § 24-0107) therefore do not apply to implementation of the selected remedy. The selected remedy will comply with applicable or relevant and appropriate substantive requirements of the New York State Freshwater Wetlands Act.

Master Comment 358807

A commenter argued that EPA has not demonstrated compliance with the Coastal Zone Management Act.

Response to Master Comment 358807

The Federal Coastal Zone Management Act (CZMA) requires federal agencies that conduct or support activities that directly affect a coastal use or resource to support or conduct those activities in a manner that is consistent, to the maximum extent practicable, with approved State coastal zone management programs.

New York State's coastal zone along the Hudson River extends from Federal Dam in Troy to New York City. In accordance with the CZMA and CERCLA, EPA will ensure that on-site response activities, including the dredging and transfer facilities, will comply to the maximum extent practicable with substantive requirements of the State's Coastal Zone Management (CZM) program, including local policies that are part of State-approved Local Waterfront Revitalization

Programs. New York State's Department of State (NYSDOS) has developed and manages the New York CZM program.

EPA is not required to comply with the consultation requirements of the CZMA with respect to on-site CERCLA response actions. CERCLA requires EPA to comply only with the substantive, and not the procedural, requirements of other environmental laws for CERCLA response actions that are conducted on-site (*e.g.*, Section 121(d)(2)(A) of CERCLA, 42 U.S.C. § 9621(d)(2)(A); Section 121(e) of CERCLA, 42 U.S.C. § 9621(e); 40 CFR 300.5 [definitions of "applicable requirements" and "relevant and appropriate requirements"]; and *State of Ohio v. U.S. E.P.A.*, 997 F.2d 1520, 1526 [D.C. Cir. 1993] [ARARs include only substantive, and not procedural, requirements]). The consultation requirements of the CZMA are procedural/administrative requirements from which on-site CERCLA response actions are exempt.

NYSDOS and NYSDEC believe it would be premature to perform a CZM consistency analysis at this juncture, although the State believes that such an analysis should be performed after the ROD is issued, but before the remedial design is finalized. Nevertheless, EPA has reviewed the selected remedy against applicable NYSDOS policies in the White Paper – Coastal Zone Management, and has determined that the dredging component of the selected remedy will be consistent with New York State CZM programs. In this analysis (which EPA has shared separately with NYSDOS and NYSDEC), EPA indicates that there will be no significant short-term impacts on water quality in the coastal zone as a result of the dredging, and that in the long-term the remedy will have a beneficial impact on the coastal zone, because the remedy will reduce the water column PCB load to the coastal zone. A CZM analysis as to the sediment processing/transfer facility(ies) will be done after the locations of those facilities are determined, but before the remedial design is finalized.

Master Comment 358802

A commenter argued that EPA has not complied with the Fish and Wildlife Coordination Act.

Response to Master Comment 358802

CERCLA requires EPA to comply only with the substantive, and not the procedural, requirements of other environmental laws for CERCLA response actions that are conducted on-site (see, for example, Response to Master Comment 358464). The coordination requirements of the Fish and Wildlife Coordination Act, 16 U.S.C. §§ 661-666c, are procedural/administrative requirements from which on-site CERCLA response actions are exempt (55 Fed. Reg. 8666, 8756 [March 8, 1990]) ("administrative requirements include the approval of, or consultation with, administrative bodies, issuance of permits, documentation, and reporting and recordkeeping"). Any dredging activity and dewatering/transfer facility for the Hudson River PCBs remedy would be considered "on-site" (40 CFR 300.400(e)(1): "The term *on-site* means the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action."). The selected remedy will comply with substantive requirements of the Fish and Wildlife Coordination Act.

Nevertheless, during the Reassessment RI/FS, EPA consulted with the Biological Technical Assistance Group, which includes representatives of the US Fish and Wildlife Service (FWS) and NYSDEC, on issues including potential environmental impacts of various remedial alternatives (including dredging and No Action). EPA will also voluntarily engage in appropriate future consultation with FWS and NYSDEC under the Fish and Wildlife Coordination Act in the development of measures to prevent, mitigate, or compensate for project-related losses of fish and wildlife resources (CERCLA Compliance with Other Laws Manual: Part II, Section 4.5). The purpose of such coordination will be to determine how substantive requirements of the Fish and Wildlife Coordination Act will be met at the Site. Measures to prevent, mitigate, or compensate for project-related losses of fish and wildlife resources are expected to include backfilling of dredged areas and replacement of river bank habitats, rooted aquatic vegetation, emergent wetlands, and marshes (FS, Appendix F).

Master Comment 407625

Commenters asked whether the selected remedy will satisfy New York State requirements which are more stringent than federal regulations (*i.e.*, State requirements concerning spills, handling of waste, waste disposal, permits etc.).

Response to Master Comment 407625

CERCLA remedial actions must comply with applicable or relevant and appropriate requirements (ARARs), which include State environmental or facility siting laws that are (i) promulgated; (ii) more stringent than Federal laws; and (iii) are identified by the State in a timely manner (CERCLA Section 121(d)(2)(A)). ARARs may be waived in six specific circumstances in accordance with CERCLA Section 121(d)(4). The selected remedy will comply with New York State applicable or relevant and appropriate requirements for the Site that are identified in Tables 14-1, 14-2 and 14-3 of the Record of Decision, except for two chemical-specific New York State ARARs (0.12 ng/L - New York State standard for protection of wildlife, and 0.001 ng/L - New York State standard for protection of human consumers of fish), which are waived in the ROD because of technical impracticability. New York State ARARs with which the selected remedy will comply include applicable, or relevant and appropriate provisions of 6 NYCRR Part 376 (Land Disposal Restrictions) and 6 NYCRR Part 373 (Hazardous Waste Management Facilities). EPA will conduct appropriate monitoring of the implementation of the selected remedy in order to ensure compliance with ARARs.

In accordance with CERCLA Section 121(e), no federal, State or local permits are required for remedial actions that are conducted entirely on-site. The dredging and sediment processing and transfer facilities required for the selected remedy will be considered "on-site" for purposes of the permit exemption of CERCLA Section 121(e). Nevertheless, EPA does intend to comply with the substantive requirements of NYSDEC permits that, but for the CERCLA permit exemption, would be required for the remedy.

1.2 Policy Issues

1.2.1 CERCLA Requirements and Issues

Master Comment 413

Commenters stated that EPA must consider the impacts to the tidal, estuarine (160-mile) portion of Site. There were several comments regarding the need for protection of the mid- and lower river ecosystem and its inhabitants; commenters also noted the greater human population (2-3 million persons, not including NYC) in the lower river region.

Response to Master Comment 413

EPA has considered the impacts of remediation on the Lower Hudson River. The Agency calculated the relative human health and ecological risks in the Mid- and Lower Hudson River, respectively, under the various remedial alternatives (Response to Master Comment 799, Chapter 6). Consistent with EPA guidance, risk assessments are used to calculate risk to an individual human or ecological receptor, rather than to a population. The overall findings for the Mid- and Lower Hudson are consistent with those for the Upper Hudson River: the REM-3/10/Select and other active alternatives show substantial human health and ecological risk reduction compared to the No Action and MNA Alternatives, and the selected remedy is protective of human health and the environment.

EPA identified REM-3/10/Select as the preferred alternative in the Proposed Plan based on a detailed analysis of remedial alternatives (FS, Chapter 8) and a comparative analysis and cost sensitivity analysis (FS, Chapter 9), as required by CERCLA and the NCP. Consideration of the human health and ecological risk reduction in the Mid- and Lower Hudson River, respectively, does not change the results of the evaluation of alternatives presented in the FS, or the conclusion that REM-3/10/Select is the most appropriate alternative for the Site under the criteria prescribed in CERCLA.

Master Comment 475

Commenters argued that EPA's FS did not comply with the requirements of the National Environmental Policy Act (NEPA). The FS also is not the functional equivalent of a NEPA Environmental Impact Statement because it does not provide details concerning, or provide adequate opportunity for public comment on, among other things, potential noise, light, odor, air emission, and transportation impacts of the preferred remedy, or the locations of potential dewatering/transfer facility(ies). The FS also does not comply with the NY State Environmental Quality Review Act (SEQRA).

Response to Master Comment 475

CERCLA requires EPA to comply only with the substantive, and not the procedural, requirements of other environmental laws for CERCLA response actions that are conducted on-site (Section 121(d)(2)(A) of CERCLA, 42 U.S.C. § 9621(d)(2)(A); Section 121(e) of CERCLA, 42 U.S.C. § 9621(e); 40 CFR § 300.5 [definitions of "applicable requirements" and "relevant and appropriate requirements"]; and *State of Ohio v. U.S. E.P.A.*, 997 F.2d 1520, 1526 [D.C. Cir. 1993] [ARARs include only substantive, and not procedural, requirements]. See also EPA guidance document CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes and State Requirements (OSWER Directive 9234.1-02 [August 1989], p. 4-1). NEPA's requirements are procedural, and, therefore, do not apply to on-site CERCLA response actions. Any dredging activity and dewatering/transfer facility for the Hudson PCBs remedy would be considered on-site (40 CFR 300.400(e)(1): "The term *on-site* means the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action.")

Moreover, EPA considers the procedures established by CERCLA for investigation and response at hazardous waste sites, which are further detailed in the NCP, and which were complied with during the Hudson River PCBs Reassessment, to be the functional equivalent of NEPA. This consideration is based on the extensive analysis of alternatives and environmental impacts, and the aggressive community involvement program, established by CERCLA. As a number of courts have held, where the authorizing statute (in this case, CERCLA) already provides for a detailed analysis of environmental impacts, EPA will satisfy necessary environmental review requirements by following CERCLA, and will not have to separately comply with NEPA (*e.g.*, *State of Alabama ex rel. Siegelman v. EPA*, 911 F.2d 499 [11th Cir. 1990]).

Functional equivalence does not mean structural or literal equivalence, and does not require EPA to consider every point or issue that would otherwise be addressed in an environmental impact statement (*State of Alabama ex rel. Siegelman*, 911 F.2d 504-505). CERCLA's substantive and procedural requirements, followed here, nevertheless ensure that EPA considers appropriate environmental issues relating to remedy selection, and allows the public to participate in the remedy selection process.

Some comments argue that CERCLA and the NCP require EPA to provide detailed analyses of potential noise, odor, lighting, transportation, and resuspension impacts of the preferred remedy, and to identify the locations of the proposed dewatering/transfer facility(ies), and that such information should have been included in the FS in order to satisfy the functional equivalence standard. The analysis of potential short-term impacts of the preferred remedy in the FS, however, was performed in accordance with CERCLA and the NCP, and is, therefore, functionally equivalent to a NEPA analysis. EPA's analysis of potential short-term impacts was also consistent with EPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (OSWER 9355.3-01) (October 1988).

Response to Master Comment 421, Chapter 11, contains additional information concerning EPA's analysis of potential short-term impacts of the preferred remedy. Response to Master

Comment 313728, Section 1.3 contains details concerning the information provided by EPA to the public in order for the public to provide comments on the preferred remedy.

With respect to the comment that EPA should prepare an environmental impact analysis under the New York State SEQRA, SEQRA requires State and municipal agencies to prepare environmental impact statements for actions they propose or approve which may have a significant effect on the environment. This law does not apply to actions that are proposed or approved by the federal government (NY ECL §§ 8-0105, 8-0109).

Master Comment 415

Several comments argue that the Hudson River PCBs Site is limited to the 40-mile stretch of the Hudson River between Hudson Falls and Troy, New York.

Response to Master Comment 415

The Hudson River PCBs Superfund Site includes the Hudson River from Hudson Falls to the Battery in New York Harbor, a stretch of nearly 200 river miles (322 km), and is not limited to the 40-mile reach of the river between Hudson Falls and the Federal Dam at Troy, New York. EPA has consistently defined the Site to include the Lower Hudson River (south of Troy) since at least 1984, when the Agency issued its first Feasibility Study for the Site and before the Site was placed on the National Priorities List (codified at 40 CFR Part 300, Appendix B).

In its September 25, 1984, Record of Decision, EPA defined the Site as the entire 200-mile stretch of the Hudson River from Hudson Falls to the Battery in New York City, plus the remnant deposits. In addition, during the Reassessment RI/FS, EPA has consistently defined the Site as including the Upper and Lower Hudson River *(e.g.,* Scope of Work for the Hudson River Reassessment RI/FS [December 1990] and the Phase 1 Report for the Reassessment RI/FS [August 1991]).

Master Comment 721

Commenters argued that EPA has, at various times, described "on-site" for the Hudson River Superfund Site as including "a corridor that extends two miles" from the east and west banks of the Hudson River. There are concerns that EPA in this way will attempt to avoid its obligation to obtain needed permits for the proposed processing facilities. Other concerns are that with the four-mile swath of land along the river being defined as "on-site," many private land parcels within this area will bear the stigma of being identified as part of a Superfund Site. One commenter asked EPA to define "off-site" for purposes of the remedy.

Response to Master Comment 721

The NCP defines "*on-site*" as "the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action" (40

CFR § 300.5). Any dredging activity and dewatering/transfer facility for the Hudson PCBs remedy would be considered on-site for purposes of this definition, and for the permit exemption of CERCLA Section 121(e)(1). See 40 CFR § 300.400(e)(1): "The term *on-site* means the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action." EPA has not, however, defined the Hudson River PCBs Superfund Site as including a two-mile corridor on either side of the Upper Hudson River, nor has the Agency defined this corridor as "on-site" for purposes of CERCLA Section 121(e)(1) and 40 CFR § 300.400(e)(1).

In the Feasibility Study Scope of Work (FSSOW), EPA used the term "on-site" to refer to land extending for two miles from either bank of the Upper Hudson River. As explained in the Responsiveness Summary for the Phase 3 FSSOW, "on-site" was used in the FSSOW as a synonym for "near-river" in describing potential locations for processing/transfer facilities that may be needed for remedies which include the removal of PCB-contaminated sediments from the Upper Hudson River. The two-mile corridor was based on engineering considerations (because it represents an area that encompasses a variety of locations for such facilities located within a reasonable hauling distance from the river), and was not intended to define the boundaries of the Hudson River PCBs Superfund Site, or to provide a legal definition of "on-site" for purposes of the permit exemption of CERCLA Section 121(e)(1).

"Off-site" areas are those locations that EPA has determined are not (i) within the areal extent of the contamination, or (ii) suitable areas in very close proximity to the contamination necessary for implementation of the response action.

Master Comment 362908

EPA has received a number of comments regarding funding of, and liability for, implementation of the project. Some comments argue that the federal and State governments, to the extent that they allowed GE and others to discharge PCBs, should share in some reasonable proportion the cost of improving the public health and the environment. Other comments argue that GE should bear the full cost of implementing the remedy, while others assert that GE is not the only company that disposed of hazardous substances in the Hudson River, and therefore should not be the only company to shoulder the burden of implementing or funding the remedy. Still other comments asked whether EPA has the authority to implement the selected remedy, and suggested that EPA should fund the project.

Response to Master Comment 362908

The purpose of this Responsiveness Summary is to respond to significant public comments on EPA's preferred remedy for the Site, and not to address funding- or liability-related issues concerning implementation of the ROD. EPA notes, however, that the overwhelming majority of General Electric Company's PCB discharges to the Upper Hudson River did not occur pursuant to a federal or State permit. These unpermitted discharges include the continuing release of PCBs to the river from bedrock in the vicinity of GE's Hudson Falls facility.

EPA has the legal authority to implement remedial actions under CERCLA.

Master Comment 365240

A commenter noted that EPA expects that technical impracticability ARAR waivers will be required for three chemical specific ARARs, the federal Ambient Water Quality Criterion, New York State's standard for protection of wildlife and the New York State standard for protection of human consumers of fish. According to the commenter, waiving the ARARs should not be done for several reasons. Since the ARARs apply to water bodies, waiving ARARs would remove any need to take action to reduce PCB concentrations in the water body because there would be no standards in effect for that water body. This is obviously contradictory to what is trying to be accomplished. Waiving ARARs also presents a dilemma for NYSDEC since the substantive conditions for a discharge permit are the effluent limitations that in part are based on water quality standards. The commenter wondered, if EPA waives the water quality standards, how NYSDEC will derive the effluent limitations that EPA desires to implement the remedy, or whether EPA is expecting NYSDEC to put on blinders and calculate effluent limitations as if the standards still exist. The commenter wanted to know if that is the case then why EPA would waive the standards to begin with.

Response to Master Comment 365240

The selected remedy will comply with the location-specific and action-specific ARARs identified for the Site, as well as four of the seven identified chemical-specific ARARs. Although the selected remedy will reduce water column PCB concentrations and approach some of these numbers, three of the chemical-specific ARARs are not expected to be met because the Tri+ PCB contamination entering the Upper Hudson River from above Rogers Island (even after source control at Hudson Falls) will likely exceed those ARARs. Therefore, technical impracticability ARAR waivers are required for three chemical-specific ARARs (1 ng/L federal Ambient Water Quality Criterion; 0.12 ng/L New York State standard for protection of wildlife; and 0.001 ng/L New York State standard for protection of human consumers of fish). Even the most aggressive removal alternative, REM-0/0/3, would require these same waivers.

It is not correct that waiving the three ARARs referred to above would remove any need to take action to reduce PCB concentrations in the Hudson. Regardless of the ARAR waiver, EPA still is required by CERCLA to select a remedy that is protective of human health and the environment, and this Record of Decision does so.

The portion of the comment that deals with NYSDEC's future issuance of water discharge permits is beyond the scope of this Responsiveness Summary. EPA's waiver of the three aforementioned ARARs has no impact on the validity, force, and effect of these standards for any purpose other than the selected remedy for this Superfund Site.

Master Comment 424915

Several commenters asked how EPA will acquire access to land required for the sediment processing and treatment facilities, and whether EPA will acquire such property through eminent domain.

Response to Master Comment 424915

Issues concerning access to land required for the sediment processing/transfer facilities will be addressed during remedial design. EPA will not determine the final location(s) of the facility(ies) until after the ROD is issued, and after the public process described in Section 13.3 of the ROD. Public input will be considered in connection with facility siting decisions.

Master Comment 424920

A commenter argues that EPA's decision to exclude disposal of sediment in local facilities because of local unpopularity, prior to issuance of the Proposed Plan, is inconsistent with the remedy selection provisions of the NCP.

Response to Master Comment 424920

EPA determined in the FS that construction of a PCB landfill in the Hudson River Valley may not be administratively feasible in accordance with 40 CFR § 300.430(e)(9)(iii)(F), under which EPA considers, among other things, the time required to obtain any necessary approvals and permits from other agencies for off-site response actions when evaluating remedial alternatives. In the Feasibility Study, EPA concluded that, while technically feasible, the siting of a new landfill to receive PCB-contaminated sediments from the Hudson River may not be administratively feasible given local opposition to a dredged material disposal facility in this area and the need to obtain New York State Hazardous Waste Facility Siting Board approval for a new facility in New York State, if such a facility is not located "on-site" as defined in 40 CFR § 300.5 (FS, Section 4.3.8). Because the need to acquire approval for, and to construct, a disposal facility in the Hudson Valley could significantly delay implementation of any remedial action that includes disposal of PCB-contaminated sediments, EPA determined that a disposal facility in the Hudson Valley may not be administratively feasible. The FS therefore did not further consider the use of such facilities (FS, Section 4.3.8).

Master Comment 424926

A commenter argued that under the NCP, land disposal should consistently rank at the bottom of remedial alternatives because land disposal is not treatment, but is simply mass transfer and entombing. The proposed remedy moves the PCBs from point A to point B at a tremendous cost and risk relative to even the No Action Alternative.

Response to Master Comment 424926

EPA is not precluded from selecting remedies that include land disposal without treatment. In addition, EPA disagrees with the comment that REM-3/10/Select "moves the PCBs from point A to point B at a tremendous cost and risk relative to even the No Action Alternative." EPA has determined that remedial alternatives that do not include removal of PCB-contaminated sediments from the Upper Hudson River are not sufficiently protective of human health and the environment (ROD, Sections 11.1 and 14.3). PCB-contaminated sediments can be safely transported to licensed off-site disposal facilities that are equipped with measures including special liners, leachate collection systems, and daily maintenance to prevent leakage and contamination in the area surrounding the landfill (see the Response to Master Comment 405890, Chapter 10). The off-site transport and disposal of PCB-contaminated sediments under the selected remedy therefore is not expected to result in any significant risks to human health or the environment.

The selected remedy permanently removes large volumes of PCBs from the river, although it does not satisfy the statutory preference for treatment as a principal element of the remedy. Given the volume of material to be removed, treatment of the dredged material prior to off-site disposal would not be cost-effective, other than the stabilization of the sediments for handling purposes. However, to the extent that some of the removed sediments could be put to beneficial use (*i.e.*, used for the manufacture of higher-value commercial products) if treated, then treatment of some of the removed sediments might be determined to be cost-effective and be carried out. Such a decision would be made during the remedial design phase.

Master Comment 423154

A commenter asked whether changes or clarifications to the Proposed Plan noted during public meetings will be memorialized in a written document that will be circulated for public comment prior to the issuance of the ROD.

Response to Master Comment 423154

Clarifications of the Proposed Plan that were noted during public meetings did not need to be and were not circulated for public comment prior to issuing the Record of Decision. EPA has determined that no significant changes to the remedy, as originally identified in the Proposed Plan, are necessary or appropriate. At the same time, the Record of Decision (Section 15) highlights certain items that were not included in the Proposed Plan. These items are not significant changes for purposes of Section 117(b) of CERCLA.

Master Comment 424247

Several commenters alleged that EPA's Reassessment Remedial Investigation/Feasibility Study and Proposed Plan are biased, punitive, pre-determined, or otherwise not impartial.

Response to Master Comment 424247

EPA strongly disagrees with these comments. The Proposed Plan, and the Reassessment Remedial Investigation and Feasibility Study upon which it is based, were conducted in a impartial, scientifically sound manner. The preferred remedy was neither biased, punitive, pre-determined, nor otherwise not impartial. Rather, after conducting a detailed analysis of remedial alternatives, EPA determined that the proposed remedy was the most appropriate response to the unacceptable risks to human health and the environment at the Site, based on the evaluation criteria set forth in CERCLA and the NCP. The remedy is well supported by the data collection and analysis performed for the Reassessment (Response to Master Comment 313799, Chapter 2). Moreover, EPA's major Reassessment reports were peer-reviewed by independent experts who generally agreed with EPA's science, or requested revisions. EPA issued Responses to Peer Review Comments for each of the peer reviews as well as a Revised Baseline Human Health Risk Assessment and a Revised Baseline Ecological Risk Assessment which include all changes made to address the peer review comments on those reports. EPA stands by the impartiality and science behind its reports and conclusions.

Master Comment 423426

Commenters asked who will be responsible for damages to real or personal property that directly result from implementation of the remedy.

Response to Master Comment 423426

In the unlikely event that implementation of the remedy results in accidental or other unintended damages to real or personal property, the question of compensation for those damages is a complex one that will depend on a number of factors, such as whether EPA or GE is performing the remedy, the nature and extent of the damages at a given location, and the specific circumstances that led to such damages.

Sometimes, it is necessary to remove or otherwise affect private real or personal property in order to implement a remedy under CERCLA. In such cases, it is EPA's general practice to replace or restore such property to its original condition to the extent practicable, or to require the potentially responsible party responsible for implementation of the remedy to do so.

1.2.2 Applicability of the NAS Report

Master Comment 409

A number of commenters called for the remedy to be implemented without delay. Some urged EPA to maintain or accelerate the schedule originally announced for issuing the ROD. Some asserted that implementation of a remedy was long overdue. At least one commenter was concerned that EPA not defer implementation to future generations. Some also contended that further delays would result in further negative consequences for the environment and for people

of the communities near the river. At least one comment stated that EPA should not delay a Record of Decision to consider the NRC/NAS report.

Response to Master Comment 409

EPA agrees with comments stating that there should be no unnecessary delays in the implementation of the selected remedy. It has not been necessary for EPA to delay issuance of the Record of Decision in order to consider the recommendations of the National Research Council Report "A Risk-Management Strategy for PCB-Contaminated Sediments" (NRC Report). As discussed in Response to Master Comment 411, immediately following, EPA carefully considered the NRC Report in the decision-making process for the Hudson River PCBs Site.

Master Comment 411

Several comments argue that EPA's remedial decision-making process for the Hudson River PCBs Site does not follow the recommendations of the recent National Research Council Report "A Risk-Management Strategy for PCB-Contaminated Sediments" (NRC Report). These comments assert that:

The FS and Proposed Plan do not include a balanced evaluation of multiple remedial options, including consideration of cost-effectiveness, or the uncertainties of the effectiveness of remedies in achieving remedial goals.

EPA's FS and Proposed Plan also do not adequately consider the risks of implementation associated with a dredging remedy including sediment resuspension, worker safety, and ecological damage

EPA did not consider the potential social and economic impacts of the preferred remedy, including potential impacts to the agricultural community that would result from the siting of a toxic waste dump in an agricultural district.

The NRC Report admonishes the EPA to listen to the concerns and desires of the river communities, the people most affected by their decision to undertake the most extensive, invasive and costly remediation plan in the EPA's history.

Response to Master Comment 411

EPA disagrees with comments suggesting that EPA's evaluation and selection of remedial alternatives for the Hudson River PCBs Site has been inconsistent with the recommendations of the National Research Council's report, "A Risk-Management Strategy for PCB-Contaminated Sediments" (March 2001) (NRC Report). EPA carefully considered the NRC Report's recommendations before making a final remedial decision for the Hudson River PCBs Superfund Site.

EPA agrees with the NRC Report's conclusions that "exposure to PCBs may result in chronic effects (*e.g.*, cancer, immunological, developmental, reproductive, neurological) in humans and/or wildlife," and that "the presence of PCBs in sediments may pose long-term public health and ecosystem risks." NRC Report at p. 4. EPA also agrees with the NRC recommendation that there should be no presumption of a preferred or default risk-management option that is applicable to all PCB-contaminated sediment sites. EPA's selected remedy for the Hudson River PCBs Site includes a combination of remedial activities that were tailored to the conditions at the Site, including targeted removal of contaminated sediments using environmental dredging techniques, and monitored natural attenuation of residual PCB contamination in the remediated areas and unremediated areas until PCB concentrations in fish tissue are at an acceptable level. Institutional controls such as fish consumption advisories and fishing restrictions will remain in place (although perhaps in a modified form) until these acceptable levels are reached.

In the Feasibility Study, EPA conducted a balanced evaluation of remedial alternatives in accordance with CERCLA and the NCP. In the FS, EPA evaluated numerous remedial options to address the risks to human health and the environment at the Site including No Action, MNA, capping, and sediment removal (*i.e.*, dredging). In accordance with the NCP and EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (OSWER 9355.3-01) (October 1988), remedial action alternatives were screened in the Feasibility Study based on the criteria of effectiveness, implementability and cost in order to develop a list of five viable remedial alternatives (No Action, MNA, Cap-3/10/Select, REM-3/10/Select and REM-0/0/3) that were then reviewed against the remedy selection criteria of the NCP (40 CFR § 300.430(e)(9)) in the detailed analysis of alternatives (FS, Chapter 6 [Screening of Remedial Action Alternatives] and Chapter 8 [Detailed Analysis of Remedial Alternatives]). In the comparative analysis of alternatives (FS, Chapter 9), the five alternatives were compared against one another using the NCP's two threshold remedy selection criteria (overall protection of human health and the environment, and compliance with ARARs) and five balancing criteria (long-term effectiveness and permanence, reduction of toxicity, mobility, or volume through treatment, short-term effectiveness, implementability, and cost).

EPA's evaluation of remedial alternatives for the Site pursuant to the NCP was consistent with the NRC recommendations that management strategies should consider the relative risks to humans and the environment of each remedial alternative, including potential risks associated with PCB remobilization from resuspension, and should also consider the long- and short-term risks posed by remedial alternatives. Under the "overall protection of human health and the environment" criterion in the NCP (40 CFR § 300.430(e)(9)(iii)(A)), EPA concluded that the overall protection of human health and the environment afforded by remedial alternatives that include active remediation of contaminated sediments, including the selected remedy, is "considerably more than that achieved by the No Action and MNA alternatives." (see FS, Section 9.1.1.1).

Under the short-term effectiveness criterion for remedy selection (40 CFR § 300.430(e)(9)(iii)(E)), USEPA evaluated and compared the potential short-term impacts of the remedial alternatives, including (i) short-term risks that might be posed to the community during implementation; (ii) potential impacts on workers during implementation, including protective measures; (iii) potential adverse environmental impacts resulting from construction and implementation, and the effectiveness of mitigative measures; and (iv) time until remedial response objectives are achieved. The assessment of short-term effectiveness included general discussions of how certain short-term risks would be sufficiently mitigated during implementation of the remedy (FS, Sections 8.5.2.5 and 9.5.1). For example, potential occupational risks to workers would be addressed through a Site-specific health and safety plan, compliance with OSHA health and safety procedures, and use of appropriate personal protection equipment (FS, Sections 8.5.2.5 [Short-Term Effectiveness evaluation of REM-3/10/Select]and 9.5.1 [Comparative Analysis of Alternatives, Short-Term Effectiveness]). With respect to potential environmental impacts, the FS included an assessment of potential impacts to the environment of the selected remedy, including impacts associated with PCB resuspension (FS, Section 8.5.2.5.), in which EPA concluded that it appears unlikely that removal of PCB-contaminated sediments would yield significantly higher PCB concentrations in Upper Hudson River fish during remedial construction. Anticipated PCB resuspension during dredging operations was discussed in greater detail in Appendix E.6 of the FS (Semi-Quantitative Assessment of Water Quality Impacts Associated with Dredging Activities). The FS also included discussions of post-dredging site reconstruction and habitat replacement (FS, Section 5.2.6), and provided a proposed Habitat Replacement/River Bank Restoration Concept (Appendix E.8) and Habitat Replacement Program Description (Appendix F) for restoration of dredged areas following remediation.

We therefore disagree that the Agency did not evaluate project-related short-term risks as part of EPA's analysis of remedial alternatives. These issues are also discussed elsewhere in this Responsiveness Summary (*e.g.*, White Paper –Remobilization of PCBs during Dredging; White Paper – Potential Impacts to Water Resources; and Responsiveness Summary Chapter 8 [Community Impacts] and Chapter 9 [In-River Impacts]). EPA will also take potential short-term impacts into account in the preparation of the remedial design, and will give the public an opportunity to provide input into the ways that the remedy will address such possible impacts (Response to Master Comment 441, Section 1.3).

All CERCLA remedial actions must be cost-effective, which means that remedies must provide a degree of overall protectiveness that is proportional to their costs. In accordance with the NCP, EPA therefore evaluated the cost-effectiveness of remedial alternatives for the Site. For example, cost is one of the three screening criteria (in addition to effectiveness and implementability) used to screen remedial alternatives in Chapter 6 of the Feasibility Study. The "cost" criterion of the screening analysis was used to screen out alternatives that had much higher costs than other alternatives, without providing a comparative increase in protection (FS, Section 6.1.3). EPA further considered the costs of remedial alternatives in the detailed analysis of alternatives (FS, Chapter 8) and compared the relative costs of the five alternatives in Chapter 9. In addition, in the Proposed Plan and ROD, EPA determined that REM-3/10/Select is more cost-effective than alternative REM-0/0/3 because REM-3/10/Select is approximately $110 million less expensive

than the more aggressive alternative, without substantial differences in the amount of human health or ecological risk reduction.

EPA recognizes that there is some uncertainty in the ability of the various remedial alternatives to meet remediation goals. For this reason, EPA did not base the proposed remedy on a single analytical tool, but instead developed the remedy on a weight-of-evidence approach which incorporated several analytical tools and factual databases, including data projections, geochemical analyses, and mathematical modeling. Notwithstanding the uncertainties associated with these tools, each of the referenced analyses is consistent with and supports the Agency's conclusion that active remediation of PCB-contaminated sediments in the Upper Hudson River is necessary in order to reduce PCB concentrations in fish, and therefore protect human health and the environment at the Site, within an acceptable time frame.

EPA agrees with the NRC recommendation that "long-term monitoring and evaluation of PCB-contaminated sediment sites should be conducted in order to evaluate the effectiveness of the management approach and to ensure adequate, continuous protection of humans and the environment." The selected remedy includes monitoring of fish, water, and sediment to determine when remediation goals are reached. The first phase of implementation of the remedy will include an extensive monitoring program of all operations. Monitoring data will be compared to performance standards identified in the ROD or developed during the remedial design with input from the public and in consultation with the State and federal natural resource trustees. In the ROD, EPA has identified performance standards that address air and noise emissions from the dredging operations and the sediment processing/transfer facilities. Performance standards that will be developed during the remedial design phase will address (but may not be limited to) dredging resuspension, production rates, PCB residuals after dredging (or dredging with backfill, as appropriate), PCB air emissions, and community impacts (*e.g.*, odor).

The information and experience gained during the first phase of dredging will be used to evaluate and determine compliance with the performance standards. Further, the data gathered will enable EPA to determine if adjustments are needed to operations in the succeeding phase of dredging or if performance standards need to be reevaluated. EPA will make the data, as well as its final report evaluating the work with respect to the performance standards, available to the public. The second phase will be the remainder of the operation, which will be conducted at full-scale. During the full-scale remedial dredging, EPA will continue to evaluate performance data and make necessary adjustments.

Potential social and economic impacts of remedial alternatives is not one of the remedy selection criteria established by CERCLA or the NCP, and EPA therefore did not collect data on such issues prior to the Proposed Plan. Nevertheless, EPA can address public comments concerning potential social and economic impacts of a remedy under the "community acceptance" criterion, although community acceptance cannot be fully assessed until after the public comment period on the draft RI/FS and proposed plan is completed (55 Fed. Reg. 8666, 8719 [March 8, 1990]). Potential social and economic impacts of the preferred remedy are extensively addressed in Chapter 8 of this Responsiveness Summary, and in White Paper – Socioeconomics. As indicated in the white paper and Response to Master Comment 689 (Chapter 8), the selected remedy is likely to result in a notable improvement in the Upper Hudson River region's economy,

particularly with respect to recreation and tourism, expanding employment and earnings in the many sectors of the economy that relate to these activities. This in turn will likely improve the property values in the region and especially along the river. In addition, as explained in the Feasibility Study, EPA will not site a near-river facility for disposal of PCB-contaminated sediments (FS, Section 4.3.8). Disposal of dredged materials will occur only at licensed, off-site facilities.

EPA has listened to the concerns of affected communities throughout the Reassessment via the extensive community interaction program ("CIP") that was established for the Site at the beginning of the Reassessment in 1990. EPA's CIP is consistent with the NRC recommendation that all affected parties and communities should be involved early and actively in the process. The purpose of the CIP was to create a community participation program in which interested members of the public would have an opportunity to obtain information concerning the Reassessment and to express their opinions concerning the Reassessment directly to EPA. To this end, EPA held over 75 meetings to which the public was invited and provided with an opportunity to express their views. The participants in EPA's CIP included various levels of the public including citizens, environmentalists, farmers, elected officials, State and federal representatives, GE, and members of the scientific and academic community.

In addition, EPA conducted a number of one-on-one meetings with various CIP members including environmental organizations, individuals, and GE, often at their behest; took several fact-finding community interview trips; met with and briefed numerous federal and State elected officials; conducted availability sessions in which EPA made itself available to members of the public who wanted to meet with Agency personnel on a one-on-one basis; and sponsored several special events including a telephone call-in availability session utilizing a toll-free number and a riverbank sediment coring demonstration. EPA also issued each of the major Reassessment RI/FS reports for public comment, and published responsiveness summaries in which the Agency responded to public comments on those reports. This is above and beyond what is usually done at Superfund sites and what is required by CERCLA and the NCP. Moreover, the Agency has made information concerning the Site available to the public in sixteen information repositories, as well as on the internet at www.EPA.gov/hudson.

1.3 Public/Citizen Participation Process

Master Comment 427

Commenters asserted that EPA has deliberately kept its description of the project vague to unlawfully avoid close public scrutiny and comment. EPA refuses to disclose the location of the hazardous waste treatment, storage, and dewatering facilities so the public can comment and evaluate the impacts. EPA refuses to disclose the location of the source or sources of backfill for the river. EPA failed to provide an opportunity for meaningful public participation as required by the NCP because the proposed plan and FS lack sufficient detail to enable adequate comments.

EPA's failure to provide the public with detailed disclosure and analysis of impacts and risks deprives the public of meaningful public participation.

Response to Master Comment 427

Since the inception of the community interaction program, EPA has made numerous attempts to provide the interested public with the technical information needed for intelligent analysis and comment. The Proposed Plan grew out of the various assessments that EPA completed and documented in the final FS report.

EPA conducted studies and analyses required by CERCLA to enable development of this plan, and provided the public with sufficient information to provide meaningful comments on the Proposed Plan (Response to Master Comment 313728 in this section). Additional details such as the location of possible processing/transfer facilities and the acquisition of construction materials are correctly a part of the remedial design process, and will take into consideration various concerns identified by the public during the comment period on the Proposed Plan, as well as public input received during the remedial design phase.

EPA has not yet selected the sources of backfill needed for the remedy, and therefore did not identify such sources in the Feasibility Study. At least five large suppliers/distributors of sand and gravel were identified and contacted at various times during the course of the Reassessment, and there is sufficient backfill for the selected remedy available from existing commercial suppliers/distributors. No backfill mines will need to be created for this project, and backfill will not be excavated from agricultural land in the vicinity of the Site. According to the USGS report titled "The Mineral Industry of New York" the total sand and gravel annual production in the eastern part of New York State, north of Ulster and Duchess counties, is approximately 7,500,000 metric tons. The project backfill requirement represents only on the order of three percent of the regional production.

It is important to note that EPA has not yet determined the locations of sediment processing and transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the Feasibility Study, it was necessary to assume the locations of sediment processing and transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable bounding assumptions with regard to distance from the dredging work and cost. Other locations, both within the Upper Hudson River valley and farther downstream, are possible. As discussed in Response to Master Comment 313728 in this section, however, it was not necessary for the FS to identify the specific location(s) for the transfer facility(ies) that would be used for the targeted dredging remedy called for by the Proposed Plan.

The example facility locations presented in the Feasibility Study have also been used in the Responsiveness Summary in order to clarify material presented in the Feasibility Study and Proposed Plan and in connection with additional noise, odor and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after EPA holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, some of the information provided in this Responsiveness Summary relative to potential impacts of the sediment processing and transfer facilities on communities, residents, agriculture, the environment and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during the remedial design phase.

Master Comment 431

A commenter argues that EPA's failure to discuss key elements of the proposed plan until after the Feasibility Study is inconsistent with EPA's 1998 Contaminated Sediment Management Strategy (CSMS), in which the Agency states that it will "demonstrate the Agency's commitment and accountability to sediment management efforts through consistent involvement of the public in reviewing major actions under the [CSMS]," and "provide information at a level of detail that allows the public to formulate decisions."

Response to Master Comment 431

The level of information available in the FS is consistent with the public outreach principles articulated in EPA's 1998 Contaminated Sediment Management Strategy, including the Agency's intention to "provide public information [concerning the management of contaminated sediments] that allows the public to formulate decisions" (p. 89). As indicated previously in this section in Response to Master Comment 411, and further on in Response to Master Comment 313728, EPA sponsored over 75 meetings to which the public was invited during the Reassessment, sought and responded to public comments on all major Reassessment reports, and held eleven public meetings to accept comments on the Agency's preferred remedy. The level of public involvement during the Reassessment was therefore consistent with the CSMS recommendations cited in the comment. The analysis in the FS of potential short-term impacts of the preferred remedy, and of the available mitigation measures, is also consistent with the requirements of CERCLA, the NCP, and EPA policy, and provided the public with sufficient information upon which to provide meaningful comments on EPA's preferred remedy.

Response to Master Comment 313728, below, contains further specifics on the level of information provided in the FS.

Master Comment 437

Commenters argued that the "dark of night" siting process has eroded public confidence in EPA, as evidenced by 60 communities passing resolutions opposing EPA's approach.

Response to Master Comment 437

There has been no "dark of night" siting process. As discussed in Response to Master Comment 427, above, EPA has made numerous attempts to provide the interested public with the technical information needed for intelligent analysis and comment. As EPA has previously indicated, in the early stages of the FS, EPA conducted a screening-level survey of sites where a landfill or treatment facility could potentially be located should that become necessary as part of the selected remedy. The purpose of the survey was to determine, from an engineering perspective, whether there is land available that could potentially be used for the construction of disposal or transfer facilities for dredged river sediments. This information was needed for EPA's analysis in the Feasibility Study of whether a remedy that includes removal of PCB-contaminated sediments is feasible. Dredging and near-river treatment or disposal of dredge spoils was one alternative remedy for consideration from an engineering standpoint pursuant to CERCLA. Later, EPA rejected the option of siting a landfill in this area (see FS, Section 4.3.8).

While many municipalities have passed resolutions expressing opposition to a dredging remedy, many other municipalities have passed resolutions expressing support for it. EPA is committed to involving the public throughout the project's design, including the siting of sediment processing/transfer facility(ies), and during remedial construction. Following issuance of the ROD, EPA will develop a project-tailored community involvement program (Response to Master Comment 441, immediately following, and ROD Section 13.3).

Master Comment 441

Commenters stated that there is an urgent need to develop a comprehensive and detailed public involvement plan for the remedial design and implementation phases of the Hudson River PCB cleanup. EPA should incorporate this plan into the ROD. Some rethinking of the community interaction program (CIP) liaison group structure needs to occur to be sure all interested parties feel they can be a part of the implementation process. The views of the entire affected community must be considered, including the dense population in the middle and lower Hudson River regions to whom the river and its fish are vital resources. The CIP should not be dominated by any one stakeholder. Alleged public participation/CIP failures and shortcomings are documented in the NRC/NAS reports. In the public process for the next phase of the project, EPA should give special attention to those most at risk, including women and children and communities that subsistence fish (*i.e.*, rely on fish for food), primarily the environmental justice community (*i.e.* minority and/or low income populations that bear a disproportionate amount of adverse health and environmental effects); consider NRC/NAS report recommendations; and consider such suggestions as establishing local staffed public information centers and a revised oversight committee with working subcommittees.

Response to Master Comment 441

The original CIP was designed to be flexible so that it could be modified in response to changes dictated by the project or requested by the participants. Since 1990, EPA has, in fact, modified not only the CIP but also certain aspects of the RI/FS itself, based on public input. EPA is

committed to continuing to involve the public throughout the project's design, sediment processing/transfer facility siting, and construction phases and, upon issuance of a ROD, will develop a project-tailored public process to do so. As indicated in the ROD (Section 13.3), the post-ROD community interaction program will build on the existing, extensive public process used for the Reassessment RI/FS. EPA will hold a series of public meetings to discuss and take comment on a proposed post-ROD outreach program before it is finalized. The enhanced post-ROD community involvement program will remain active throughout the subsequent construction and post-construction monitoring phases of the project. EPA anticipates that the post-ROD community involvement program will include frequent and regular interaction with municipal governments and communities through general meetings as well as meetings focused on specific issues of concern (such as the sediment processing/transfer facilities and potential short-term impacts of the remedy), and a notable EPA presence in the upriver community (*i.e.*, a field office that will be established during the remedial design phase and be staffed on a full-time basis during the remedial construction period). EPA also will consider appropriate NRC/NAS Report recommendations in the development of this program. These measures will enable EPA to take municipal and community input into consideration during the remedial design and implementation.

Master Comment 445

Many commenters expressed support for EPA's proposed plan, including individual communities and municipalities; residents of the Upper Hudson Valley project area and citizens throughout the Hudson Valley; businesses; more than 150 organizations; environmental advocacy groups; State and regional labor leaders and union members; and State and federal agencies. Some commenters commended EPA for the extensive efforts it has made to engage the public in its Reassessment of the Hudson River PCBs Superfund Site, through public meetings, public availability sessions, and ample opportunity to have input to EPA reports.

Response to Master Comment 445

EPA acknowledges all the comments in support of its Proposed Plan. The Agency encourages all interested parties to remain involved and continue to provide frank and candid comments during the post-ROD community interaction program.

Master Comment 313749

Commenters suggested that in the event additional model runs change the outcome of the existing analysis, EPA should disclose the information to the public for review and comment prior to the issuance of the ROD.

Response to Master Comment 313749

EPA performed additional model runs in order to explore the implications of (i) dredging-induced resuspension of PCBs; (ii) upstream source control reducing future PCB loading to zero;

(iii) a revised schedule for implementation of the REM-3/10/Select Alternative which extends the remediation effort over six years, versus the five year schedule proposed in the FS; and (iv) a revised estimated 100-year flow of 61,835 cubic feet per second (CFS) based on concerns raised by NYSDEC regarding uncertainties in the development of the 47,330 CFS 100-year flood peak flow value used in the Revised Baseline Modeling Report, and the potential for a new licensing agreement between the State of New York and Orion Power Holdings, Inc. for operation of the Sacandaga Reservoir (renamed Great Sacandaga Lake), which would increase maximum Hudson River flood flows. The results of these model runs are presented in White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River and White Paper - Application of the Depth of Scour Model (DOSM) in the Thompson Island Pool for Alternative Flooding Assumptions. The additional model runs have not substantively changed the results of EPA's analyses that were performed for the FS, and EPA does not believe it was necessary or appropriate to issue the results of the additional model runs for public comment prior to issuing the ROD.

Master Comment 313728

Commenters argued that the Reassessment RI/FS did not provide the public with sufficient information upon which to provide meaningful comments on EPA's preferred remedy because the FS allegedly did not:

i. Contain adequate information concerning risks associated with the excavation, transportation, and redisposal, or containment of hazardous substances at the Site.
ii. Disclose the locations of potential transfer facilities and "soil/gravel extraction mines" necessary to implement the preferred remedy.
iii. Assess the impacts of the remedy on the community, such as those relating to transportation, noise, odors, and PCB resuspension.

One comment requests that EPA revise the Feasibility Study to include the information requested in this comment, and then re-issue the revised FS for public comment before issuing a ROD.

Response to Master Comment 313728

The analysis in the FS of potential short-term impacts of the preferred remedy, and of available mitigation measures, is consistent with the requirements of CERCLA, the NCP, and EPA policy, and provided the public with sufficient information upon which to submit meaningful comments on EPA's preferred remedy. The level of information available in the FS also is consistent with the public outreach principles articulated in EPA's 1998 Contaminated Sediment Management Strategy, including the Agency's agreement to "provide public information [concerning management of contaminated sediments] that allows the public to formulate decisions" (p. 89). EPA therefore does not believe it is necessary or appropriate to revise and reissue the Reassessment Feasibility Study for additional public comment.

EPA disagrees with comments suggesting that the FS did not contain sufficiently detailed information concerning the preferred remedy for members of the public to provide meaningful

comments on potential short-term impacts of the preferred remedy, including noise, odor, light, transportation, and such environmental impacts as resuspension and impacts to submerged aquatic vegetation. The FS includes, for example:

Proposed design requirements of transfer facilities (Section 5.2, Figure 5-1, Appendix E.9, Appendix H).

The number of dredges, barge loads/day, and rail cars/day expected to be needed for the proposed remedy under both hydraulic and mechanical dredging scenarios (Tables 8-10a and 8-10b, Appendix H).

Analyses of resuspension anticipated to occur during dredging (Section 8.5.2.5, Section 8.5.2.6, Appendix E.6).

Detailed summaries of the equipment requirements (including transfer facilities, dredges, barges, rail and truck) for implementation of the preferred remedy under mechanical dredging, hydraulic dredging and beneficial use scenarios (Appendices I.7, I.8 and I.11).

The FS also included two appendices that discuss habitat replacement and riverbank restoration to be implemented following dredging (Appendix E.8 and Appendix F). Information contained in sections of the FS such as those sections cited in this paragraph provided the public with a basis to provide meaningful comments on the noise, odor, and other potential short-term impacts of the preferred remedy.

EPA's evaluation of the short-term impacts of the preferred remedy is presented in Section 8.5.2.5 of the Feasibility Study. Section 9.5 of the FS presents a comparison of the potential short-term impacts of each remedial alternative that was evaluated in the Detailed Analysis of Alternatives (FS Chapter 8). In accordance with CERCLA and the NCP, EPA evaluated and compared the potential short-term impacts of remedial alternatives, including:

- Short-term risks that might be posed to the community during implementation.
- Potential impacts on workers during implementation.
- Potential adverse environmental impacts resulting from construction and implementation.
- Time until remedial response objectives are achieved (40 CFR § 300.430(e)(9)(iii)(E)).

The FS also describes ways in which potential short-term impacts of remedial alternatives, including impacts to the community, workers, and the environment, could be mitigated during implementation of the remedy (FS, Section 8.5.2.5). For example, the discussion of short-term effectiveness of REM-3/10/Select includes an analysis of potential adverse environmental impacts, including PCB resuspension, that may result from construction and implementation of that remedial option, and measures that would be taken to minimize such impacts. Additional analysis of resuspension is provided in FS Appendix E.9 (Technical Memorandum: Semi-Quantitative Assessment of Water Quality Impacts Associated with Dredging Activities), and a discussion of turbidity barriers available to control the migration of resuspended materials is discussed in Appendix E.5 (Technical Memorandum: Applicability of Turbidity Barriers for Remediation). Proposed measures to restore the river bottom after dredging are discussed in detail in Section 5.2.6 (Backfilling and Site Reconstruction), Appendix E.8 (Technical

Memorandum: Habitat Replacement/River Bank Restoration Concept) and Appendix F (Habitat Replacement Program Description). Transportation risks associated with the preferred remedy are addressed in Sections 6.2.4.2 (acknowledging risks associated with transportation of contaminated materials) and 8.5.2.5 (road traffic, barge traffic).

The analysis of alternatives in the FS is consistent with EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (OSWER Directive 9355.3-01, 1988) (RI/FS Guidance), and provides the Agency with "information sufficient to support an informed risk management decision regarding which remedy appears to be appropriate" for the Site (RI/FS Guidance at 1.1). The detailed information requested by some commenters in their responses to the Proposed Plan, including information concerning the specific State, county, and local roads that will be used in connection with implementation of the remedy, the rail lines to be employed to transport sediment from the treatment facilities to the disposal facilities and to transport backfill, and specific information concerning potential noise, "nuisance-level odor," and artificial lighting at the transfer facilities, is considerably beyond what is required for a feasibility study. Analysis of specific noise, odor, and lighting impacts would require EPA to (i) determine the location of potential transfer facilities prior to selection of the remedy, because noise, odor, and lighting impacts will depend on the locations of receptors in relation to the facilities, and then (ii) design each of the facilities, since the air, odor, and light emissions from the facilities also are contingent upon their design.

As stated previously, such information is appropriately developed during "remedial design," which is the post-ROD "technical analysis and procedures which follow the selection of remedy for a site and result in a detailed set of plans and specifications for implementation of the remedial action" (40 CFR § 300.5). Moreover, in view of the public's expressed interest in the locations of the proposed transfer facilities, EPA believes it would be more appropriate to determine the location(s) of the sediment processing/transfer facility(ies) in conjunction with a public process that the Agency will provide during remedial design.

In Chapter 8 and in several white papers of this Responsiveness Summary, EPA has provided analyses of noise, light, and other potential impacts of example transfer facilities in order to respond to public comments relating to such potential impacts. While the assumptions in the white papers regarding processing/transfer facility design are representative of the facility(ies) required to implement the selected remedy, EPA will not determine the final location(s) of these facility(ies) until after the ROD is issued, and after the public process as described in the ROD. EPA also will not finalize the design of the facility(ies) until after the Agency, as a matter of policy, accepts public input on design aspects of the facility(ies) related to potential noise, lighting, and other impacts, as also described in the ROD.

Moreover, as also stated previously, it was not necessary for the FS to identify specific location(s) for the processing/transfer facility(ies) that would be used for the targeted dredging remedy called for by the Proposed Plan. Prior to issuance of the Proposed Plan, EPA conducted a survey of properties along the Upper Hudson River to determine whether there is land available that would meet necessary engineering criteria should EPA select a remedy that requires the siting of a transfer facility(ies) (Memorandum entitled "Sediment Transfer and Processing Sites," prepared by TAMS Consultants, Inc. [January 17, 2001], a copy of which was made available to

the public during the public comment period for the Proposed Plan, and which has been included in the Administrative Record for the Site). Evaluating the availability of processing/transfer facility locations, but not selecting such locations in the FS, is consistent with 40 CFR § 300.430(e)(9)(iii)(F), which requires EPA to consider, as appropriate, the availability of services and materials, including off-site treatment capacity, during a feasibility study, without requiring EPA to actually identify such facilities before a remedy is selected.[1] In response to comments suggesting that the FS should have evaluated "soil/gravel mines necessary to implement the remedy," the FS did not include such an evaluation because, among other things, EPA believes that sufficient backfill material is available from existing commercial operations, and that no mines will need to be created for purposes of implementing the remedy (Response to Master Comment 653, Chapter 10).

EPA's community relations program for the Hudson River PCBs also complied with, and indeed far exceeded, the community relations requirements of CERCLA and the NCP. CERCLA and the NCP require the lead agency (in this case, EPA) to, among other things, publish a brief notice of a CERCLA proposed plan, make the proposed plan available to the public for comment for at least 30 days, and hold a public meeting at or near the Site during the public comment period (CERCLA Section 117(a) and 40 CFR § 300.430(f)(3)). For the Hudson River PCBs Site, EPA held more than 75 meetings to which the public was invited, including 11 public meetings for the Proposed Plan. The Agency also accepted public comments on nine Reassessment Remedial Investigation reports (not including the FS), and issued responsiveness summaries in which EPA responded to public comments received on those reports.

EPA disagrees with comments suggesting that the FS did not contain sufficiently detailed information concerning the preferred remedy for members of the public to provide meaningful comments on potential noise, odor, light, transportation, and environmental impacts of the preferred remedy. The FS includes, for example, proposed design requirements of transfer facilities (Section 5.2, Figure 5-1, Appendix E.9, Appendix H); the number of dredges, barge loads/day, and rail cars/day expected to be needed for the proposed remedy under both hydraulic and mechanical dredging scenarios (Tables 8-10a and 8-10b, Appendix H); analyses of resuspension anticipated to occur during dredging (Section 8.5.2.5, Section 8.5.2.6, Appendix E.6); as well as detailed summaries of the equipment requirements (including transfer facilities, dredges, barges, rail, and truck) for implementation of the preferred remedy under mechanical dredging, hydraulic dredging and beneficial use scenarios (Appendices I.7, I.8, and I.11). The FS also included two appendices which discuss habitat replacement and river bank restoration to be implemented following dredging (Appendix E.8 and Appendix F). Information contained in sections of the FS such as those cited in this paragraph provided the public with a basis to provide meaningful comments on the noise, odor, and other potential short-term impacts of the preferred remedy.

[1] EPA expects that the sediment processing and transfer facility(ies) will be considered "on-site" for purposes of the NCP and CERCLA Section 121(e)(1), 42 U.S.C. § 9621(e)(1). *See* 40 CFR 300.400(e)(1) ("The term *on-site* means the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action.") and FS Section 8.5.2.6.

One comment argues that the Reassessment RI/FS should have included detailed data regarding the extent of submerged aquatic vegetation (SAV) in the Upper Hudson River in order to evaluate and inform the public of the potential environmental impacts that could result from destruction of significant amounts of SAV as a result of the preferred remedy. This comment further argues that a lack of detailed data concerning the extent of SAV in the Hudson "undermines EPA's analysis" of potential impacts to SAV and the feasibility of restoring it, and that the functional equivalence doctrine and CERCLA require that [such data] be made available for public comment *before* a decision is made, not after" (emphasis in original).

In the FS (Section 5.2.6.3), EPA acknowledges that active remediation of river sediments may result in impacts to aquatic habitat, including loss of submerged plant communities, and includes a proposal to replace SAV and other habitat following remediation (FS, Appendix E.8, Habitat Replacement/River Bank Restoration Concept Development, and Appendix F, Habitat Replacement Program Description). The level of detail presented in the FS concerning potential removal of SAV and the Agency's habitat replacement program presented in the FS provide sufficient information upon which the public was able to submit meaningful comments on potential impacts to SAV that may result from remediation.

Moreover, the level of detail in the FS concerning potential impacts to SAV and available restoration measures provide sufficient information to support an informed risk-management decision for the Site, consistent with the NCP and EPA policy (*e.g.*, the RI/FS Guidance). EPA has determined that remedial alternatives that do not include active remediation of PCB-contaminated sediments are not sufficiently protective of human health and the environment at the Site.

Further, the potential impacts to SAV can be minimized through appropriate restoration measures (FS, Appendix F). Consequently, EPA has determined that the potential impacts to SAV from the preferred remedy, which can be minimized, are substantially outweighed by the remedy's benefits to human health and the environment, and do not justify the selection of a remedy such as MNA that provides substantially less protection of human health and the environment. EPA has provided additional information concerning potential impacts to SAV, and measures available to replace SAV that is removed during remediation, in Chapter 9 of this Responsiveness Summary.

Master Comment 313388

Many commenters expressed opposition to EPA's Proposed Plan, including some Hudson River area residents and activist groups, the PRP, elected officials, businesses, and organizations.

Response to Master Comment 313388

EPA acknowledges all the comments in opposition to its Proposed Plan. The Agency encourages all interested parties to remain involved and continue to provide frank and candid comments during the post-ROD community interaction program.

Master Comment 313333

Commenters suggested that EPA should provide at least two technical assistance grants (TAGs) so that different or divergent viewpoints can provide input. Issuance of a TAG grant to a downriver environmental group was evidence that EPA's public outreach/participation program did not sufficiently include Upper Hudson River communities.

Response to Master Comment 313333

No more than one TAG grant may be awarded for any site (40 CFR § 35.4085(c)). EPA announced the availability of a TAG grant at the first "kick-off" meeting on the Reassessment held in Saratoga Springs in December of 1990. EPA's Community Relations Coordinator for the Site discussed the availability of the TAG with members of Upper Hudson/TI Pool-area communities throughout the seven-year period before the grant was issued to Scenic Hudson and repeatedly encouraged groups to consider submitting an application. Scenic Hudson applied for and was issued a TAG in 1997, a full seven years after its availability was announced. Additionally, upon receiving Scenic Hudson's TAG application, EPA, in accordance with federal requirements, published public notices in Hudson Valley newspapers announcing the application in order to give other groups an opportunity to apply or share in the grant with Scenic Hudson. No indication of interest in obtaining a TAG was ever made to EPA by Upper Hudson groups prior to issuance of the TAG to Scenic Hudson.

Master Comment 713

A commenter argued that EPA proposes a massive data collection and analysis exercise as part of the remedial design for the project after it issues the ROD. In essence, EPA is attempting to conduct a new RI after it issues the ROD. This is a demonstration of the deficiency of EPA's work during the Reassessment and unlawfully deprives GE and the rest of the public of their statutory right to comment on the Agency's proposal. Had EPA collected the necessary data and conducted the required analysis, the only reasonable and supportable conclusion it could have reached would be that the adverse environmental and human health impacts of its project clearly outweigh its estimated benefits.

Response to Master Comment 713

EPA has conducted the Reassessment RI/FS in accordance with the 1988 RI/FS Guidance and the Scope of Work for the Reassessment. EPA disagrees with the statements that it has not collected the necessary data or has not conducted the required analyses. EPA also disagrees with the statement that GE and the public have been deprived of their statutory right to comment on the Agency's proposal. Throughout the Reassessment, EPA's documents have been peer-reviewed and numerous public meetings have been held near the Site to allow full participation by GE, the public, and other interested parties. For the Proposed Plan and FS, EPA held a public comment period which initially ran from December 12, 2000 to February 16, 2001, and was extended until April 17, 2001 in order to accommodate the significant public interest expressed on EPA's proposed remedy. EPA held eleven public meetings throughout the region during the comment

period. This is not typically done for most Superfund sites. The various Reassessment reports have also been posted on EPA's Hudson River PCBs website. EPA made sufficient information available in order for the public to provide meaningful comments on EPA's Proposed Plan (Response to Master Comment 313728, above) .

The future data collection referred to in the FS and this comment is not for the purposes of conducting another RI. The pre-design field studies as described in the FS are typically conducted at most Superfund sites after the ROD is signed; for example, to determine exact limits of contamination for preparing specifications for removal (excavation, dredging) operations. The same process will be followed by the Agency for this Site. EPA also disagrees with the premise of the comment that the adverse environmental and human health impacts of EPA's proposed remedy will outweigh the benefits. EPA's extensive analyses, which have been presented in the entire series of Reassessment RI/FS documents, including the environmental and human health risk assessments and the FS, clearly show that the long-term benefits far outweigh any short-term adverse impacts Responses to Master Comments 421 and 485 in Chapter 11. This view is also supported by the Trustees of this natural resource, NYSDEC, NOAA, and the US Fish and Wildlife Service (USFWS).

Master Comment 471

Several commenters argued that EPA's public outreach/participation program has failed. According to the comments:

EPA has failed to meet public outreach benchmarks of open-mindedness, keeping the public fully informed, inspiring confidence, fostering a reasonable dialogue between the Agency and those affected by the Proposed Plan, and providing the public with enough detail to allow meaningful comment.

EPA did not consult with Water Commissioners of the Town of Waterford as part of the community interviews required by 40 CFR § 300.430(c)(2)(i).

The Upper Hudson communities, including members of the agricultural community, were deprived of their right to have a voice in the remedy selection process. The Agricultural Liaison Group was burdened with review of technical studies far removed from agricultural issues or concerns, and attempts to provide meaningful input were diffused by EPA. EPA is being coerced by the downstate lobby of environmental elitists who have no personal or economic stake in the local impact of dredging. Only two of EPA's eleven meetings to take comment on the Proposed Plan were held near the affected communities.

EPA's press conferences to announce findings at major milestones were not open to the public, and were held only hours before the public meeting so the public had no time to understand or formulate questions on the information delivered. Responsiveness summaries may or may not contain responses to specific questions, and often misconstrued questions.

EPA is determining how the Upper Hudson will be managed for at least a decade, and it is doing so without understanding the wishes of those who should benefit from the management. There was no informative dialogue with the public; EPA made no effort to learn from the citizens those things that only those who use the Upper River and live near it could tell the Agency. The public, including GE, was limited to providing “passive” input on terms unilaterally established by the Agency.

Concerns of the elected officials within Saratoga, Washington, and Rensselaer Counties have been uniformly ignored.

The Government Liaison Group's voices have not been heard or considered. An arrogant federal government agency has gone through the motions of a community involvement program in order to get to its pre-ordained "promised land" of a dredging project.

Response to Master Comment 471

EPA's CIP has gone well beyond the requirements for community participation in Superfund. Throughout the 10 years of the Reassessment, EPA's CIP has provided an open and meaningful avenue of public participation for concerned parties. Particularly in reference to the liaison groups, numerous meetings were held with liaison group members in order to discuss and clarify technical issues. EPA has encouraged liaison groups to hold individual liaison group meetings, and several have done so, often inviting parties with opinions different from EPA's to give presentations and critique EPA's work.

The agricultural community has been especially active via the Agricultural Liaison Group, providing public comment on every major EPA report. EPA actively solicited agenda items from this group, as well as from the other liaison groups, for discussion at Liaison Group, Steering Committee, and Hudson River PCBs Oversight Committee (HROC) meetings. The Agricultural Liaison Group brought many of their specific issues to the fore at those meetings. EPA has also encouraged the group to meet on their own; the group has often done so, with EPA providing support in the form of mailing out meeting announcements to the membership at large.

EPA is committed to equal treatment of all interested parties through the CIP, and offered the same opportunities for involvement to environmental organizations as to agricultural groups. In addition, while the agricultural community cites concerns of negative impacts stemming from a clean up project as their economic "stake" in the Hudson – environmental organizations cite the loss of the commercial fishery in the Hudson south of Troy and the negative impacts to commerce and tourism due to health advisories on sportfishing in that portion of the river.

EPA held a total of eleven public meetings after the issuance of the Proposed Plan. Because the Site is delineated as the Hudson River from its outfall at Hudson Falls to the Battery in New York City, these public meetings were located throughout the delineated geographic area. As the upper 40 miles of the Hudson River is the area specifically being considered for remediation, five of these meetings were in Albany, New York, or areas to the north. Two meetings were held in Washington County, and one each in Saratoga, Albany, and Rensselaer Counties. It should also be noted that, throughout the project, EPA has held more than 75 public forums and numerous

individual interviews with members of the community, especially in Washington and Saratoga Counties. Also, public comment has been taken on all major reports issued by EPA throughout the Reassessment, as opposed to taking comment only with the issuance of a Proposed Plan, which is usual in the Superfund process.

EPA held press conferences open to members of the press and elected officials, including an elected official who is a member of the Agricultural Liaison Group. The press conferences were conducted to enable EPA to clearly explain its findings and supporting data and to take questions from the press. Although the general public was usually not invited to the press conferences, public meetings were held shortly afterward on the same day and public availability sessions were often scheduled for a week or two later so that the public could have time to read the report in question, digest the information given at the meetings, explore the reports in detail, and then speak with EPA individually regarding specific concerns and questions.

In accordance with 40 CFR 300.430(c)(2)(i), EPA conducted numerous interviews with "local officials, community residents, public interest groups, [and] other interested parties, as appropriate, to solicit their concerns and information needs" concerning the project, and to learn how and when citizens would like to be involved in the Reassessment. EPA regularly engaged the citizens of the Upper Hudson via the CIP for the ten-year duration of the Reassessment, with the bulk of CIP membership residing in the Upper Hudson community. This engagement took a number of forms – in addition to the over 75 public forums previously mentioned, EPA conducted dozens of individual community interviews with community members in their homes, on their farms, at local restaurants, at county offices, and even at the Washington County Fair. A Water Commissioner of the Town of Waterford joined EPA's Citizens Liaison Group early in the Reassessment, and has remained on EPA's mailing list for the Site since that time. EPA sends notices of public meetings to all Liaison Group members, and regularly published notices of public meetings in the Albany Times Union and Schenectady Gazette, both of which are available in Waterford. GE was included in the outreach program throughout the Reassessment, and was represented on and frequently made presentations at both Hudson River PCBs Oversight Committee and Scientific and Technical Committee meetings.

GE has often spoken at individual meetings of specific liaison groups for which EPA provided mailings of meeting notices on behalf of the Liaison Group involved, mentioning GE as a guest speaker. Elected officials at all levels throughout the Hudson Valley have been encouraged to participate in the Reassessment process. Many, in fact, have provided input to EPA during the project. EPA has met with many elected officials from the local level to State and federal representatives, and has specifically sought out officials from Washington and Saratoga Counties. A number of elected officials, particularly from northern counties, are members of the Governmental Liaison Group, although many chose not to participate actively in CIP meetings during the Reassessment. It should also be noted that despite criticisms of the CIP by some liaison group members, there are other liaison group members who support the CIP process.

EPA has given serious consideration to all public comments on the FS and Proposed Plan, as well as public comments submitted during the earlier public comment periods for the Reassessment. Also, as noted in Master Comment 445, some commenters commended EPA's community outreach program during the Reassessment.

Master Comment 433

One commenter argued that EPA failed to achieve goals of the draft Public Participation Policy. According to the comment, EPA did not (i) foster a spirit of mutual trust, confidence and openness between the Agency and the public; (ii) fulfill legal requirements imposed by CERCLA and the NCP; (iii) provide the public with information at a time and in a form that it needed to participate in a meaningful way; (iv) keep the public informed about significant issues; or (v) understand public goals and concerns, or was not responsive to them.

Response to Master Comment 433

EPA disagrees with this comment. As previously discussed in Response to Master Comments 313728 and 429, EPA has conducted an open process since the beginning of the Reassessment, regularly providing information on the project to the public through numerous reports, meetings, mailings, and fact sheets. EPA encouraged public comment throughout the project and, in fact, added new work and changed planned work at times based on those comments. The issues EPA addressed and presented to the public through the FS stage of the process fully met, and indeed far exceeded, the public participation requirements of CERCLA and the NCP. Additional issues naturally associated with the design phase, and concerns and questions raised by the public during the comment period on the Proposed Plan that concern the remedial design, will be addressed as part of that process.

Master Comment 429

Commenters contended that the FS does not contain a coherent description of the project; information appears to be disorganized, contradictory, and, in some cases, missing. Some say EPA's description of the project at public hearings has varied from its written description, causing confusion; if the statements at the public meetings are intended to modify the Agency's proposal, then EPA is not providing adequate notice and opportunity for full and informed public comment on its proposal.

Response to Master Comment 429

It is possible that oral remarks differed in presentation from written statements in the FS or Proposed Plan; many questions were asked that required answers that went beyond or built upon the written report. Some of the clarifications provided during the public meetings, such as the decision not to use trucks to transport backfill materials within the Upper Hudson River area, or to transport dewatered sediments for off-site disposal, were made in response to public comments. The basic information and conclusions noted at the public meetings, however, were consistent with the FS Report and Proposed Plan. During the four-month public comment period, EPA did not announce any significant changes to the scope, performance, or cost of the preferred remedy that would have impaired the public's ability to submit informed comments on the Proposed Plan.

The FS and the Proposed Plan were based in part on Phase 1 and Phase 2 work performed for the Reassessment. EPA provided the public with a continual flow of information on all work throughout Phases 1 and 2, in the form of reports, meetings of all types, fact sheets, telephone conversations with individual members of the public, press releases, and information repositories. In addition to the formal public comment period associated with the Proposed Plan, EPA has encouraged comment throughout the project so that the Agency could be aware at all times of any concerns, questions, or need for clarification raised by the public.

EPA disagrees with comments arguing that the FS Report was not coherent. The FS Report was prepared in accordance with EPA's RI/FS Guidance.

Master Comment 377

Commenters argued that there is no justification for abandoning the 1984 Record of Decision. They claimed that EPA must demonstrate that new information or conditions have fundamentally changed the basis for EPA's 1984 decision. The reasons that EPA gave to reject dredging in 1984 remain true today. The selected remedy will cause environmental devastation, the effectiveness and feasibility of dredging technology continues to remain unproven, the feasibility of constructing materials handling facilities remains as unlikely today as it was in 1984, and PCB levels in fish, water, and sediment continue to decline.

Response to Master Comment 377

EPA believes that No Action is no longer the appropriate remedy for PCB-contaminated sediments in the Upper Hudson River. EPA has determined that remedial alternatives that do not include active remediation of PCB-contaminated sediments in the Upper Hudson River are not sufficiently protective of human health and the environment. It has been approximately 17 years since the 1984 ROD was issued, and yet PCB levels in fish at the Site continue to remain at levels which present unacceptable risks to human health and the environment. The geochemical, mathematical modeling, risk assessment, and other studies performed for the Reassessment Remedial Investigation, and the evaluation of remedial alternatives and other analyses in the Reassessment Feasibility Study, provide reasoned bases for EPA's determination.

Reasons cited in the 1984 ROD in support of the interim No Action decision do not justify a No Action remedy for the sediments in the current ROD. Among other things, there are dredging technologies currently available that can effectively remove PCB-contaminated sediments without causing excessive resuspension of contaminants (FS, Section 4.2.6.2 and Table 4-7, responses to comments in Chapter 10 of this Responsiveness Summary, and White Paper - Remobilization of PCBs during Dredging), and operational controls and sediment resuspension barriers can further limit resuspension and the downstream migration of PCBs during dredging (FS, Section 8.5.2.6, Appendix E.5); PCB levels in fish remain at unacceptable levels, are not declining at the rapid rate seen in the late 1970s and early 1980s, and will not reach acceptable levels under either continued No Action or MNA within a reasonable time frame (FS, Section 1.3.5, Section 8.2, Section 9.1, Appendix D); and EPA has determined that the siting of necessary dewatering/transfer facilities is technically and administratively feasible (FS Section

8.5.2.6, ROD Section 11.6). There also is sufficient capacity at off-site landfills to accept sediments dredged from the Upper Hudson River (FS, Section 8.5.2.6, Appendix E.11).

In addition, the targeted dredging required by the selected remedy will not be “ecologically devastating” to the river. As explained in the FS (Sections 5.2.6 and 8.5.2.5, Appendix E.8, Appendix F), the ROD (Section 11.5), and responses to comments in Chapter 9 of this Responsiveness Summary, EPA believes that effective habitat restoration measures can be implemented following dredging. EPA also notes that the referenced statement in the 1984 ROD that “bank-to-bank dredging could be environmentally devastating to the river ecosystem and cannot be considered to adequately protect the environment" is taken from a discussion of the "option of bank to bank dredging *of the entire river*" (emphasis added). The selected remedy does not call for bank-to-bank dredging of the entire Upper Hudson River, but instead calls for targeted remediation of about 12.6 percent (approximately 493 of 3,900 acres) of the Upper Hudson River bottom. The 1984 ROD’s discussion of a more limited dredging program – in which 20 to 40 of the NYSDEC hot spots would be removed – did not raise similar concerns about environmental damage from dredging.

1.3.1 Peer Review Process

Master Comment 465

Commenters noted that the peer review criticisms (of the Ecological Risk Assessment) were based on the fact that there were insufficient data. This has since been addressed by new NYSDEC data that supports EPA's conclusions.

Response to Master Comment 465

Peer reviewers generally felt that more data should have been included in the Baseline Ecological Risk Assessment (USEPA, 2000a). To address this concern, the discussion of ecosystems/ecological resources of the Hudson River was expanded in the Revised Baseline Ecological Risk Assessment (RBERA) (Section 2.1; USEPA, 2000b) and new data from USFWS/NYSDEC were added (USEPA, 2000b, Sections 5.5.3.1 and 5.8.3.1). Additional avian and other ecological data are expected from USFWS/NYSDEC in the future.

At the time that the RBERA was released (November 2000), NYSDEC preliminary mink and river otter data were not yet released. These data may now be cited and are discussed in the response to comment 811 (Chapter 3). A comparison of the recently released NYSDEC data to National Academy of Sciences (NAS) toxicity reference values (TRVs) for total PCBs in otters shows that all river otters captured within five miles of the Hudson River exceeded TRVs (Responsiveness Summary Table 811-01). Two of these animals exceeded the LOAELs 20 to 40 times, and these high concentrations are observed in animals that were caught on land, closest to the river, rather than to a tributary. Responsiveness Summary Table 811-01 also shows a comparison of NAS referenced TRVs (Kannan *et al.*, 2000) to measured PCB concentrations in

mink liver from animals trapped within five miles of the Hudson River. Measured concentrations consistently exceeded the NOAEL, and two of the animals exceeded the LOAEL as well.

References

Kannan, K., A.L. Blankenship, P.D. Jones, and J.P. Giesy. 2000. Toxicity reference values for the toxic effects of polychlorinated biphenyls to aquatic mammals. *Human and Ecological Risk Assessment* 6(1):181-201.

USEPA. 2000a. Response to Peer Review Comments on the Baseline Ecological Risk Assessment, Hudson River PCBs Reassessment RI/FS. Prepared for EPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc. and Menzie-Cura & Associates, Inc. November.

USEPA. 2000b. Phase 2 Report, Further Site Characterization and Analysis, Revised Baseline Ecological Risk Assessment, Hudson River PCBs Reassessment RI/FS. Prepared for EPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc. and Menzie-Cura & Associates, Inc. November.

Master Comment 467

A number of comments presented opinions on the peer review process:

- EPA's peer review process did not provide a satisfactory method to ensure that the agency relied on the best science.

- The Agency "seriously constrained" the scope of the panelists' review to a circumscribed list of questions provided by EPA.

- The peer reviewers were not instructed to address what was the best science available to answer central questions, and were not permitted to review alternative hypotheses or science, such as GE's mass-balance models.

- The panelists were not given an adequate opportunity to interact among themselves or with the public.

- By having separate peer review panels review different reports, EPA limited the ability of the panels to understand the overall significance of what they were reviewing, or how individual reports may have conflicted with other Agency work.

- EPA did not tell the peer review panels that EPA's and GE's models demonstrate the stability of the sediments and contradict the findings of the Low Resolution Sediment Coring Report.

Several public comments suggest that EPA's analysis was not "supported by scientific evidence," while other public comments requested additional independent scientific review beyond that provided in the peer review process.

Response to Master Comment 467

EPA disagrees with the criticisms of the peer review expressed in this comment. In accordance with the December 1998 and December 2000 editions of EPA's Peer Review Handbook, the purpose of the peer review was to have independent experts review EPA's Phase 2 science in order to evaluate whether that science is technically adequate, competently performed, properly documented, and satisfies established quality requirements. (USEPA (2000a) at Section 1.2.3). The peer review accomplished this purpose. The peer review was never intended to be, and did not need to be, a forum in which reviewers would judge among several different scientific approaches to the Reassessment, or to offer advice on how they might have conducted the Phase 2 scientific analyses differently. Nevertheless, the expert panelists for the Revised Baseline Modeling Report (RBMR) peer review were provided with copies of GE's modeling for use as background information, in case the reviewers thought that consideration of GE's modeling report would assist their review of the RBMR. While EPA did not ask the panelists to review GE's modeling report as part of their review, EPA never instructed the reviewers not to review GE's report or any other materials that they believed would assist in their review of EPA's science. We also note that, after EPA publicly announced the names of peer review panelists, GE sent materials to them with a request that they consider GE's information as part of their review.

EPA also placed absolutely no constraints on the ability of the panelists to interact among themselves. EPA also provided the public with an opportunity to make presentations to each of the peer review panels. A five-minute time limit for individual public presentations was sufficient time for the public to express opinions to the panels without taking away time needed for the panelists to perform their work.

EPA's request that the peer review panelists respond to a list of specific charge questions is a normal procedure for scientific peer reviews, and is consistent with EPA's peer review policy (Section 3.2). The public was invited to submit proposed charge questions to EPA for consideration before the final charge questions were developed. In addition, each of the panels was given an "open" charge question in which they were invited to address other issues that were not specifically included in their respective charges. We therefore disagree that EPA "seriously constrained" the scope of the panels' reviews.

The statement in one comment that "[w]hen the panel members had questions about the reports, EPA typically refused to provide answers" is inaccurate. EPA and its consultants responded to essentially all requests for clarification from the panels.

The peer review panelists were selected from pools of qualified candidates by Eastern Research Group, a private firm that conducted the peer review under a contract with EPA. Each of EPA's Phase 2 Reports covers a range of scientific topics, and it is not reasonable to expect each peer review panelist to be an expert on every subject addressed in the reports. However, each panelist was a qualified expert in issues addressed by reports that they reviewed, and each of the Peer

Review panels as a whole provided a thorough review of the issues addressed by the charge for each peer review. In addition, each of the Phase 2 Reports addresses discrete issues that we believe were competently addressed by the respective peer review panels, without the need for the same experts to participate in multiple panels. Nevertheless, continuity among panels was provided by several independent experts who served on more than one peer review panel (Dr. Per Larsson [Geochemical and Revised Baseline Modeling Report peer review panels]; Dr. Ellen Bentzen [Modeling Approach and Revised Baseline Modeling Report peer review panels]; and Dr. Ross Norstrom [Revised Baseline Modeling Report and Ecological Risk Assessment peer review panels]).

EPA also disagrees with the comment that the peer review panel for the Revised Baseline Modeling Report was not asked to address the consistency of the findings of the Revised Baseline Modeling Report and the Low Resolution Sediment Coring Report with respect to sediment stability. Charge Question 11 for the Revised Baseline Modeling Report peer review specifically asked the reviewers to comment on whether there is "an inherent conflict between the modeling and the [Low Resolution Sediment Coring Report] conclusions [with respect to sediment stability in the Thompson Island Pool], or whether the differences are attributable to the respective spatial scales of the two analyses." In a presentation to the Revised Baseline Modeling Report Peer Review Panel, a GE consultant also argued that the Low Resolution Sediment Coring Report is "inconsistent with the [Baseline Modeling Report's] finding that ''PCBs are being buried'' without a 'significant redistribution of PCB inventory'" (USEPA, 2000b, Appendix F). The experts did not find any significant inconsistencies between EPA's modeling and the Low Resolution Sediment Coring Report.

EPA is confident that its decision is found on firm scientific evidence. This scientific evidence has been reviewed and validated by an extensive peer review process. Where shortcomings were identified during the peer review process appropriate changes have been made and documented in the responses to peer review recommendations. Selection of a remedy for this Site did not require additional independent scientific review beyond that already supplied in the peer review process.

References

USEPA 2000a, United States Environmental Protection Agency, Science Policy Council Peer Review Handbook, Second Edition (EPA 100-B-00-001) (December 2000)

USEPA 2000b, Report on the Peer Review of the Revised Baseline Modeling Report for the Hudson River PCBs Superfund Site. Prepared for EPA Region 2 by Eastern Research Group, Inc. May 10.

2. BACKGROUND AND REMEDIAL INVESTIGATION

Master Comment 459

One comment said that GE has been released by NYSDEC from further responsibility for PCBs in the Hudson River in exchange for $4 million and commitments to eliminate use of PCBs and reduce discharges of PCBs.

Response to Master Comment 459

The federal government was not a party to the 1976 settlement. The settlement is not binding on EPA or any other part of the federal government.

2.1 Sources of PCBs to the Upper Hudson River

Master Comment 573

Commenters claim that the EPA did not adequately investigate the benefits of source control as a stand-alone remedy. Commenters also state that all sources should be identified and controlled prior to dredging or instead of dredging, and that the remnant deposits and sediments in the vicinity of the GE Fort Edward Plant discharge pipe (004 outfall) may be sources and should also be removed. Some contend that EPA should take a more aggressive approach in removing sediment sources. Commenters questioned the age and/or the concentration of the surface PCBs based on the degree (or lack) of dechlorination, as well as these PCBs acting as a source to the water column. Comments suggested that there is a large pool of PCBs underneath the Fort Edward site that is not planned for remediation and that EPA should add "and the two GE facilities" to the last sentence of section 1.3.2.6 (page 1-30) of the FS.

Response to Master Comment 573

As noted in the Phase 1 Report (USEPA, 1991), EPA recognized the importance of upstream sources of PCBs from the outset of the Reassessment. However, recognition of these upstream sources does not invalidate the findings of the Reassessment RI/FS reports, which state that the sediments continue to release large amounts of PCBs. GE's historical and ongoing discharge of PCBs from its capacitor manufacturing plants in Hudson Falls and Fort Edward that has contaminated the Hudson throughout its length and breadth.

EPA has extensively documented the nature and magnitude of the sources upstream of Rogers Island. By requiring GE to monitor for PCBs at Rogers Island as well as locations upstream, a large database of information on PCB sources to the Upper Hudson has been established. This database represents over 10 years of monitoring results. Each of the Phase 2 sampling events examines PCB loads and concentrations originating above Rogers Island. From the analysis of these data as well as sediment coring results (USEPA, 1997), EPA has established that the GE facilities are the only significant external source of PCBs to the Upper Hudson. Additionally, the

data suggest that the current loads at Rogers Island are primarily derived from contamination originating at the Hudson Falls facility. In particular, the dearth of dechlorination products in the samples and their close similarity to an unmodified mixture of Aroclors 1242 and 1254 (USEPA, 1997, Section 3.3) indicates that the PCBs found at Rogers Island represents unaltered PCBs. The most likely source of this material is the bedrock seeps of PCB-bearing dense non-aqueous phase liquid (DNAPL) found at the base of the facility.

There is the possibility of other sources between Bakers Falls and Rogers Island such as the Fort Edward plant site and the remnant deposits but, based on hydrologic data, it is unlikely that these are currently as substantive contributors to the PCB load. These sources may become more significant to the load at Rogers Island subsequent to remediation of the river and improvements in source control in the vicinity of the GE Hudson Falls plant. Remediation of the Fort Edward 004 Outfall is being addressed by the State of New York. The identification of sources is also discussed elsewhere in Section 2.1 (Response to Master Comment 643).

The remnant deposits represent older sediments contaminated with PCBs. These materials do not contain the fresh "Aroclor-like" material found in the water measured at Rogers Island. Thus they do not represent a substantive source to the Hudson. Indeed, in light of the measures taken to secure the remnant deposits, the only available pathway to the river from these deposits is via groundwater (with the possible exception of Remnant Deposit 1 [which has not been remediated/controlled/capped] during flood events)**.** A groundwater pathway involving historical PCB deposits would not yield the patterns seen at Rogers Island. The remnant deposits (via groundwater) would be adding dissolved PCBs to the water column. The remnant deposits could be considered an “infinite reservoir” with respect to sediment-water partitioning; therefore the source would be constantly supplying the same PCB congener pattern. Therefore, if the remnant deposits were a significant source of PCBs at Rogers Island, a dissolved-phase pattern would dominate the entire PCB spectrum at this monitoring location. Data from Figure 3-43 of the Responsiveness Summary for the Low Resolution Coring (LRC) Report (USEPA, 1999) are reproduced as Figure 573-1. As shown in Figure 573-1, the patterns in the unfiltered sample and dissolved phase are not similar and therefore the remnant deposits cannot be considered a significant source of PCBs to the water column. Congener signatures are further discussed in Section 2.1 (Response to Master Comment 623).

Due in part to the efforts of GE to stem the PCB leakage from the bedrock below the Hudson Falls facility, the total PCB load at Rogers Island from 1996 to 1999 represents just one-fifth of that originating from the sediments of the Upper Hudson between Rogers Island and Schuylerville. In fact, the annual load from the sediments as recorded by the regular monitoring at the TI Dam and Schuylerville is relatively consistent over the entire period of record, despite the occurrence and partial remediation of loads originating above Rogers Island. To illustrate the relative importance of the upstream source in controlling current conditions, Figure 5-1 from the Peer Review Responsiveness Summary for the Data Evaluation and Interpretation Report (DEIR) (USEPA, 2000) and LRC Report has been reproduced here as Figure 573-2. This figure clearly illustrates the small fraction of total PCB load currently contributed by the upstream sources, as well as the consistency of the sediment-derived loads. An initial analysis of data for 2000 suggests an even smaller contribution from upstream, with concentrations at Rogers Island largely non-detect and loads at TI Dam essentially unchanged.

The importance of upstream source control has also been extensively evaluated via the use of the HUDTOX and FISHRAND models. The MNA Alternative was presented and discussed throughout the FS. This alternative was shown to reduce PCB exposure but not as effectively or efficiently as sediment remediation. Time to achieve acceptable levels in fish typically lagged by a generation (20 years) or more. The importance of upstream control has been further examined in two of the white papers provided in Volume 3 of this RS, White Papers – Model Forecasts for Additional Simulations in the Upper Hudson River and Trends in PCB Concentrations in Fish in the Upper Hudson River, in which one of the additional modeling runs eliminates the upstream source contribution (R14S0). When the upstream source contribution is set to zero ng/L of Tri+ PCB, it can be seen that recovery times are dependent on interactions between the sediments and the water column.

Thus, EPA has extensively studied and considered the importance of the upstream load. As described in the FS, the selected remedy assumes control of the upstream source, at least to the level at which PCB concentrations in newly deposited sediments would be less than or equal to one mg/kg (1 ppm) Tri+ PCB in four inches of residual after dredging. As noted in White Paper – Relationship between PCB Concentrations in Surface Sediments and Upstream Sources, recently deposited sediments contaminated by sources upstream of Rogers Island are already close to this value (one to two mg/kg). Anticipated controls at the GE Hudson Falls facility and remediation in the vicinity of the Fort Edward 004 outfall should reduce this concentration within the next few years. EPA acknowledges the importance of further remediation of upstream sources and will work with NYSDEC and GE to control these sources.

(Note that although current loads at Rogers Island produce sediments at 1 to 2 mg/kg Tri+ PCB, these concentrations do not represent current surface concentrations. High concentrations of PCBs from historical deposition are already found at the surface sediments in some locations. In addition, processes such as resuspension and biological activity serve to renew the surface sediment PCB inventory with more contaminated sediments from below. Hence, surface sediment Tri+ PCB concentrations are well above the one- to two-mg/kg levels generated by the load at Rogers Island. Similarly, it is these same processes that have maintained the PCB load from the sediments at a relatively constant annual level despite the large reduction in PCB loads from upstream. Based on the evidence from water column, sediment cores, and fish, the PCB loads from the sediments appear largely unabated since the late 1980s.)

Given that current loads at Rogers Island yield sediments at 1 to 2 mg/kg Tri+ PCBs, complete control of these upstream sources is not necessary prior to sediment removal. EPA will consider remediation of other upstream sources if deemed appropriate at some future time. However, remediation of the other sources is not required prior to remediation of the Upper Hudson sediments.

References

US Environmental Protection Agency (USEPA). 1991. Phase 1 Report – Review Copy – Interim Characterization and Evaluation, Hudson River PCB Reassessment RI/FS. Prepared for USEPA Region 2 by TAMS Consultants, Inc. and Gradient Corporation. August.

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C – Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the US Army Corps of Engineers (USACE), Kansas City District by TAMS Consultants, Inc., The Cadmus Group, Inc., and Gradient Corporation. February.

USEPA. 1999. Responsiveness Summary for Volume 2C-A Low Resolution Sediment Coring Report (LRC Report), Addendum to the DEIR and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., and TetraTech, Inc. February.

USEPA. 2000. Response to Peer Review Comments on Volume 2C-(DEIR) and 2C-A-(LRC Report), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc. November 2000.

Master Comment 617

Most comments agree that the ultimate source of the majority of the PCB load in the Upper Hudson River is the historical and continuing discharge of PCBs from the GE facilities at Hudson Falls and Fort Edward, although some focused on the role of the removal of the Fort Edward dam in releasing contamination to the remainder of the river. Several comments addressed the characterization of pre-1990 releases: *e.g.*, downstream loads prior to the dam removal in 1973 were minimal; GE's PCB discharges were "almost all" Aroclor 1242 or Aroclor 1016. Other comments addressed the characterization of the releases in the 1990s associated with the failure of the gate structure at the Allen Mill, adjacent to GE's Hudson Falls plant: EPA did not adequately investigate the relationship of these releases to environmental PCB concentrations and did not demonstrate a sufficient understanding of the upstream releases to make a sound remedial decision. Finally, it was suggested that EPA has not adequately incorporated recent source control work by GE into the analysis and modeling.

Response to Master Comment 617

EPA concludes that the vast majority of the PCBs within the Upper Hudson River are ultimately attributable to discharges from the GE facilities at Hudson Falls and Fort Edward, New York. The two GE plants began to use PCBs in the mid-1940s and discontinued their use in 1977. Throughout this period the facilities discharged large amounts of PCBs to the Hudson River concomitant to the capacitor manufacturing process (USEPA, 1991). The discharges were essentially unregulated until 1975, at which time GE received a permit to discharge 30 pounds of PCBs per day. Discharges during the period 1957 to 1975 are believed to have been of a similar magnitude.

After 1977, PCB releases from the GE facilities continued, but were dominated by unpermitted releases, including erosion of contaminated soils and sediment, contaminated stormwater runoff, and seepage of PCB oils from bedrock. These releases are discussed in Section 2.2.1 of the FS. Response to Master Comment 643 in Section 2.1 of this Responsiveness Summary contains a discussion of other sources.

Historical (pre-1990) releases of PCBs from the GE facilities are difficult to quantify, as releases prior to 1990 are not well documented and in-stream water column monitoring is relatively sparse. Evidence on the patterns of historic PCB release is provided by the high resolution dated sediment cores collected by EPA and others, as well as the water column monitoring data. The DEIR (USEPA, 1997) summarized available information and concluded that the vast majority of PCB mass in the Upper Hudson River was derived from the GE facilities, either by direct release or through the remobilization of material stored in contaminated sediments and ultimately derived from GE.

Much of the PCB mass released by the GE facilities prior to 1973 was stored in the pool of the former Fort Edward Dam. A key event in the contamination of the Hudson River was the removal of the Fort Edward Dam in 1973, which facilitated the downstream movement of contaminated sediments. Unfortunately, neither the health risks associated with PCBs nor the extent of contamination in the former dam pool were well understood at the time the deteriorating dam was removed. It was not until after the dam removal that the extent of PCB contamination in the Hudson River was recognized.

Several comments on the FS, each of which are addressed in the following paragraphs, reflect an inaccurate picture of the earlier PCB releases. One comment claimed that "almost all" of the PCBs discharged from the GE facilities were Aroclor 1242 or Aroclor 1016. This is incorrect. As discussed by Brown *et al.* (1984), purchase records show that the GE facilities used predominantly Aroclor 1254 up through 1955, and continued to use small amounts of Aroclor 1254 (five percent or less) through 1971. Aroclor 1254 contains a higher percentage of highly chlorinated PCB congeners than Aroclors 1242 and 1016. The presence of Aroclor 1254 in the sediments stored behind the Fort Edward dam and later released from the dam pool contributed to an enrichment of more highly chlorinated PCB congeners in the downstream sediments. The congener composition of the sediments does show that the total PCB loading was dominated by Aroclor 1242 and Aroclor 1016, but the presence of smaller amounts of Aroclor 1254 in the mix should not be overlooked. The dated sediment core at RM 177.8 near Stillwater shows surface sediments contain a mixture of congeners that is equivalent to a mix of Aroclors 1242, 1254, and 1260 in a ratio of 82:16:2 (USEPA 1997, p. 3-145).

Another comment proposed that, "Until 1973, most of the PCBs discharged from the plants were trapped in sediments behind the Fort Edward Dam..." This characterization is also misleading. It is certainly true that massive quantities of PCBs were stored in sediments behind the Fort Edward Dam, but it is also clear that significant quantities of PCBs derived from the GE plants were transported downstream prior to 1973. As no water column monitoring is available for this period, the evidence comes from dated sediment cores.

Dated cores from the TI Pool (Figure 3-53 in USEPA, 1997) confirm that peak total PCB deposition into the sediment occurred after the 1963 Cesium-137 maximum, and apparently coincides with scour of contaminated sediment after the removal of the Fort Edward Dam. PCBs are, however, present in deeper, older sediments, and the occurrence of detectable concentrations of PCBs coincides approximately with the detectable presence of Cesium-137, dateable to approximately 1954. The evidence thus shows that PCB discharges from the GE facilities were contributing to increased environmental concentrations of PCBs in the Hudson River

downstream of the Fort Edward Dam from 1954 onward, in agreement with the earlier analyses of Bopp *et al*. (1982).

More recent (post-1990) releases of PCBs from the GE facilities have been dominated by the discharge of PCB oils from the bedrock surrounding the GE Hudson Falls plant. Frequent monitoring at low detection limits for PCBs in the water column of the Upper Hudson was commenced by GE in 1991 and augmented by EPA's Phase 2 sampling effort in 1993-1994. As described in the DEIR, monitoring data at the upstream (Rogers Island) and downstream (TI Dam) ends of the TI Pool show that a large total PCB load originated upstream of the TI Pool. Additional monitoring, primarily by GE, between Rogers Island and Bakers Falls confirmed that this PCB load came primarily from the area of the GE Hudson Falls plant. Releases in this area reached a peak following the reported failure of a wooden gate structure in a tunnel at the Allen Mill, adjacent to the GE Hudson Falls plant, in September 1991. GE subsequently identified and photographed direct seeps of PCB oils into the river within the Bakers Falls plunge pool. Similar releases were also likely occurring before 1991, although sufficient monitoring or visual observation is not available to confirm specific events.

A NOAA comment states that the important conclusion that upstream loads are dominated by the Hudson Falls source is poorly substantiated in the FS, and questioned whether loads might be in part derived from the remnant deposit areas. These issues are discussed in detail in the DEIR (USEPA, 1997) and Revised Baseline Modeling Report (RBMR, USEPA, 2000a), as well as by QEA (1999). EPA believes that the majority of the upstream load in recent years derives from the Hudson Falls facility, with only minor inputs from other sources between Bakers Falls and Rogers Island. Additional points of clarification on this topic are provided in the next paragraph.

GE's investigations in the reach between the GE Hudson Falls facility and Rogers Island suggested that loads upstream of Rogers Island are primarily due to the Hudson Falls facility. Average total and Tri+ PCB concentrations are found to increase between the station above the remnant deposits (RM 196.8) and Rogers Island (RM 194.3), but this may be a result of incomplete lateral and vertical mixing of the PCB NAPL load from the Hudson Falls source before flow reaches the remnant deposits. EPA concurs with GE's assessment (QEA, 1999) that upstream loads are dominated by the Hudson Falls source, because the congener pattern at Rogers Island predominantly reflects a "fresh," unweathered Aroclor 1242 pattern and does not show the weathered pattern expected for release from the remnant deposits. This is in sharp contrast to the shift in PCB congener pattern seen across the TI Pool.

EPA acknowledges that some additional PCB load could derive from the uncontrolled Remnant Deposit 1, but believes this is not a significant fraction of the total PCB load above Rogers Island (FS, Appendix A.3).

GE states that EPA "failed to conduct the monitoring necessary" to test the hypothesis that most PCBs in the river derive from the GE plants. In fact, the point of view that GE discharges are the ultimate source of the vast majority of the PCBs in the upper Hudson River is espoused and documented by GE's consultants (c.f. QEA, 1999), and is implicitly reflected in numerous other GE comments that emphasize the benefits to be obtained through GE source control in this area. Further, EPA did not itself need to conduct the detailed monitoring necessary to prove this

contention because GE did collect such data, and provided it to EPA. EPA's 1993 sampling generally confirmed the results reported by GE.

The same comment also suggests that EPA has treated the upstream source "in an inconsistent fashion," claiming that it is recognized by EPA as important to an evaluation of the validity of the model, but is "considered of limited importance in evaluating the trends in PCB concentrations." EPA has clearly represented that the upstream source is important to both the model and observed trends through evaluations in the DEIR (USEPA 1997), RBMR (USEPA 2000a), and the FS. The existence of intermittent upstream loads presented a considerable challenge to model calibration, and was therefore addressed in detail in the RBMR (USEPA 2000a). Trends in fish and the environment below Rogers Island reflect both the upstream source and loading derived from contaminated sediments below Rogers Island.

Upstream-downstream monitoring since 1991 (USEPA 1997, Section 3.4.4) demonstrates a strong and consistent load increase in water column total PCB concentrations across the TI Pool. One of the most notable observations for the period after the Allen Mill source was controlled (*i.e.*, post-1994) is that upstream loads to the TI Pool decreased dramatically, but the total PCB load gain across the TI Pool, total PCB concentrations in water at the TI Dam, and the total PCB concentrations in biota did not exhibit commensurate decreases.

Figure 617-1, PCB Load at Rt. 197 and Load Gain across the TIP (TI Pool), shows moving averages through estimates of upstream total PCB load at Rt. 197 and total PCB load gain across the TI Pool. These are derived from GE monitoring data through March of 2000 for the Rogers Island station at the upstream end of the TI Pool and the downstream station near TI Dam (TID-West). (It should be noted that there is some evidence that the load estimates derived from the TID-WEST station may be biased upward by about 17 percent or so (Response to Master Comment 623 in this section), but a correction for this bias, if needed, would not change the finding of a consistent load gain.) While the upstream total PCB loads into the TI Pool have decreased dramatically since 1993, the apparent total PCB load gain from within the pool has remained relatively stable, with some seasonal fluctuations. This discrepancy between upstream load control and environmental response is key to understanding the dynamics of PCBs in the Hudson River. These observations were taken into account in both the mass balance modeling and the geochemical analysis presented by EPA.

In sum, EPA's analysis fully recognizes that the Hudson Falls source has a major effect on downstream fish concentrations, which is in agreement with GE's comment, but also recognizes that reductions in the upstream source do not provide a complete explanation of subsequent observations in water, sediment, and fish. EPA disagrees that this represents an "inconsistency" in the analyses.

A related comment claims that "EPA appears to have made no specific evaluation of the results of GE work to date," and "does not appear to have made any adjustment to HUDTOX reflecting the fact that model calibration was made before GE source control was in effect." The first statement is simply incorrect: EPA worked closely with GE consultants, and made use of all data collected by GE that was provided to EPA in a timely enough fashion to incorporate it into the RBMR (USEPA 2000a). Response to Master Comment 627 in Section 2.7 contains further details.

It is true that model calibration had to rely primarily on data that were collected prior to the completion of GE's source control efforts at the Hudson Falls site. This is a simple result of data availability, as the majority of monitoring data was collected during periods in which GE failed to control the continuing release of PCBs from the Hudson Falls plant. EPA did, however, validate the model to conditions through December of 1999, well after the major source control efforts were in place. EPA's HUDTOX model provided an excellent fit to observed water column Tri+ PCB concentration data for this period (USEPA, 2000b, Appendix A). The model thus performs well both during periods in which the upstream source is documented to be active (1991-1993) and during periods in which the upstream source was largely controlled (1995-1999). This validation exercise shows that EPA's model calibration is acceptable, and that further adjustments to the calibration to account for source control are not needed.

References

Bopp, R.F., H.J. Simpson, S.R. Olsen, R.M. Trier, and N. Kostyk. 1982. Chlorinated hydrocarbons and radionuclide chronologies in sediments in the Hudson River and Estuary. *Environ. Sci. Technol.*, 16: 666-672.

Brown, J.F., Jr., R.E. Wagner, D.L. Bedard, M.J. Brennan, J.C. Carnahan, and R.J. May. 1984. PCB transformations in Upper Hudson sediments. *Northeastern Environmental Science*, 3(3/4): 166-178.

QEA. 1999. PCBs in the Upper Hudson River. Prepared for General Electric, Albany, New York by Quantitative Environmental Analysis, LLC.

USEPA. 1991. Phase 1 Report – Review Copy, Interim Characterization and Evaluation, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 by TAMS Consultants, Inc. and Gradient Corporation. August.

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C – Data Evaluation and Interpretation Report (DEIR), Hudson River Reassessment PCBs RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., The Cadmus Group, Inc., and Gradient Corporation. February.

USEPA. 2000a. Phase 2 Report, Further Site Characterization and Analysis. Volume 2D – Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc., January.

USEPA. 2000b. Response to Peer Review Comments on the Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc., November.

Master Comment 619

Comments presented opposing viewpoints as to whether the vast reserves of PCBs now stored within sediments of the river can be assured to remain sequestered from the food chain. For example, opposing comments were received that the stability of sediment PCB stores can/cannot be guaranteed and that there is/is not evidence of redistribution of buried PCBs into the bioavailable zone. Comments included the following:

- EPA's argument for lack of stability is based on the LRC analysis, which is open to question, subject to statistical bias, and does not provide insight on sediment stability.
- Interpretation of water column data does not provide evidence of instability.
- The "vast majority" of core data supports an interpretation that burial of PCBs is widespread (and presumably assured to be irreversible).
- Analysis of suspended sediment data does not indicate any significant change in bed erosion since the early 1980s, and the PCB-containing sediments are therefore sequestered and stable.
- EPA's concerns over sediment stability are in contradiction to both the EPA and GE modeling results.
- Scour features interpreted from the side-scan sonar results cover a relatively small area and do not indicate any significant long-term instability.

Response to Master Comment 619

Commenters raised several issues concerning the "stability" of the sediments of the TI Pool, suggesting that if the sediments could be shown to be "stable," they would not pose a long-term problem. It is EPA's position, and that of the peer review panel that reviewed the DEIR and LRC Report, that the sediments of the Upper Hudson do not represent a secure location for the long-term storage of PCB contamination. This issue is independent of the physical nature of the sediments themselves, although, as shown below, there is evidence to suggest reworking of the sediments over time as well.

EPA agrees that a significant proportion of the historically deposited PCB mass contained within Hudson River sediments is currently buried below the bioactive zone (an average depth of about 10 cm), and thus may not be actively contributing PCBs to the food chain at this time (Response to Master Comment 637, Section 2.3). There is also evidence that the TI Pool is, as a whole, net depositional. This means that on average, historical PCB-contaminated sediment should continue to be buried at a slow rate. However, a reach-averaged trend does not guarantee that all historically deposited PCBs in the sediment are sequestered from the food chain and can be guaranteed to remain sequestered from the food chain. There are several interconnected issues that must be addressed here:

- Reach-averaged versus point conditions.
- Potential for future destabilization of buried deposits.
- Stability of PCBs versus stability of sediment.

Reach-Averaged versus Point Conditions

The majority of comments on the issue of sediment stability appear to be based on the assumption that average conditions across a reach are applicable to all points within a reach. It is true that both the EPA and GE models suggest that most of the reaches of the Upper Hudson River are net depositional over time. This observation is borne out by the majority of the core data, which shows some sediment deposition over time. This does not mean, however, that PCB contamination is consistently being buried at all locations. For instance, both the EPA and GE models indicate significant variability in sediment scour/deposition patterns across the TI Pool. Further, neither PCB model has the spatial resolution or data support to accurately predict what happens at the scale of individual hotspots.

Core Data

Examples that demonstrate that not all historically deposited PCBs are being buried are readily available from the data. In 1998 GE undertook selective sediment sampling at a number of locations in the Upper Hudson (O'Brien & Gere, 1999). These included a large number of samples in the area near *Hot Spot* 14, opposite Griffin Island, which is one of the areas of the TI Pool where surface sediment concentrations were at their highest in 1984 (USEPA, 1997). GE sample BS-14F-200 (a composite of nine cores) showed total PCB concentrations of 129 mg/kg within the 0-2 cm top section. Of these PCBs, 72 percent were mono- and dichlorobiphenyls, indicating a strongly dechlorinated pattern. The combination of strong dechlorination and high concentrations compared to surface sediment in adjacent areas outside the *hot spot* (generally less than 15 mg/kg total PCBs) demonstrate that these concentrations are due to historically deposited PCBs. Similarly, at *Hot Sp*ot 8, sample BS-08F-200 had 42 mg/kg total PCBs in the 0-2 cm top section, of which 57 percent were mono- and dichlorobiphenyls. This sample was also subjected to radionuclide analysis, which found beryllium-7 to be non-detectable, indicating the lack of significant recent deposition. A sample from *Hot Spot* 10 (BS-10T-100) had 90 mg/kg total PCBs in the 0-2 cm top section, of which 72.9 percent were mono- and dichlorobiphenyls (radionuclides were not analyzed for this core).

Similar results are also found downstream of the TI Pool. For instance, GE focused sample FS-28-1, taken below Lock 6, had 53 mg/kg total PCBs (54.3 percent mono- and dichlorobiphenyls) and no detectable beryllium-7 in the 0-1 cm layer. Thus even the relatively limited sampling undertaken by GE in 1998 demonstrates that dechlorinated, historically deposited PCBs remain at the surface in a number of the hot spot areas; this sampling does not show evidence of active burial.

Comments received from Scenic Hudson support EPA's conclusions and summarize evidence that high PCB concentrations are not being universally buried in the river.

GE comments state that a majority of the PCB inventory in the TI Pool ("greater than 80% [sic]") is buried below 10 cm, with only "about 20% [sic]" of the inventory in the top 10 cm. This conclusion is based on finely segmented cores that were purposely selected to be from consistently depositional areas where radionuclide chronologies could be established, and thus are biased toward areas of enhanced burial rates. These cores serve an important purpose in establishing the history of PCB contamination in the Upper Hudson, but are not representative of

the TI Pool as a whole. In fact, they over estimate the fraction of the PCB mass that is buried below 10 cm because they are, by definition, located in consistently depositional areas. Further, even if the highly optimistic estimate that 20 percent of the fraction of the PCB inventory lies within the bioactive zone is accepted, this still amounts to an enormous mass of PCBs. The revised estimate of the Tri+ PCB inventory in the TI Pool in 1984 given in the FS is 14,500 kg (FS, p. 1-37), and 20 percent of 14,500 kg is still 2,900 kg (nearly 7,000 pounds). White Paper – Sediment PCB Inventory Estimates contains further details on the total PCB inventory in the TI Pool.

It should also be noted that a long-term average net-depositional pattern does not mean that PCBs are sequestered from the surface. Where the net deposition occurs as a sequence of erosive and depositional events, the end result is a mixing of PCBs toward the new surface level. This fits with both GE's and EPA's observations from core data that the PCB and Cesium-137 maximum is rarely found at the sediment surface, but in many hotspot areas, concentrations of weathered PCBs at and near the surface remain above what would be expected if burial were an effective mechanism of natural attenuation.

Side-Scan Sonar Data

Figure 3-8 in the FS identifies lineated sediment structures in the TI Pool that were revealed in the side-scan sonar survey. These are interpreted as areas likely to have been undergoing active scour in the period preceding the survey. The comment is correct in stating that these areas appear to constitute a small portion of the total surface area of the TI Pool. On the other hand, the lineated features include some of the sediment areas with the highest observed surface sediment total PCB concentrations (*e.g.*, *Hot Spot* 14), indicating that these areas should not be considered stable. In addition, the side-scan sonar results are a snapshot in time, representing the combined effects of hydrology and channel morphology in the period preceding the survey. The fact that an area did not exhibit lineated features in the side-scan sonar survey cannot be taken as an assurance that scour will not occur with other combinations of upstream flow and sediment load or following changes in channel morphology over time.

Potential for Future Destabilization of Buried Deposits

In many of the hotspot areas the maximum PCB concentration is found at a depth greater than can reasonably be assumed to be readily accessible to the food chain (*i.e.*, greater than 10 cm depth). Further, both EPA's modeling (USEPA, 2000) and GE's modeling suggest that much of the PCB mass buried in cohesive sediments in the TI Pool is unlikely to be exposed by hydrodynamic scour at flood flows up to 47,330 cfs, which was the estimated 100-year flood based on past gage data.

Some comments questioned whether the magnitude of the 100-year flood might actually be larger. In order assess this possibility more rigorously, an analysis of flood scour potential was conducted at a flow rate of 61,835 cfs (White Paper – Application of the Depth of Scour Model [DOSM] in the TI Pool for Alternative Flooding Assumptions). Modeling of this larger flood found only a small additional increase in sediment and PCB erosion beyond what might be expected for a reasonable range of annual peak flows.

In evaluating these results, it is important to note that the model analyses address only hydrodynamic scour. Other factors can also uncover buried sediments. Among these are mechanical abrasion by ship grounding, ice scour and uprooting of macrophytes by ice in shallow waters, mechanical scour by submerged logs, sloughing of submerged banks along the canal dredge cut margin, and (non-remedial) engineering/construction activities. Several public comments also raised the possibility of alteration of bed stability by earthquakes. In addition, there is a risk that model predictions of stability under hydrodynamic scour may be incorrect.

None of these factors is expected to affect large areas in any given year, but the cumulative effect over time could be important. In sum, although many of these buried deposits appear stable under current conditions, their future stability cannot be assured.

Also, as previously noted, there is a small, but non-zero, probability that much larger flood events could occur in response to unusual weather events or, in the worst case, dam failure (although no such events are known to have occurred since the installation of the gaging stations in the 1970s). Even if highly unlikely, such events could remobilize large quantities of PCBs that are currently sequestered from the food chain and spread them throughout the Hudson River. Were such an event to occur, in the aftermath it would be even more difficult to recover and remove the toxins from the river than under current conditions

Stability of PCBs versus Stability of Sediment

Several of the comments make the assumption that stability of the sediments is equivalent to stability of the PCB stores within those sediments. This is not correct.

Although PCBs are lipophilic and thus somewhat resistant to desorption, high PCB concentrations are found in sediment porewater. Results reported by GE (O'Brien & Gere, 1993) show total PCB concentrations in subsurface porewater up to 48 µg/L. As porewater can move in response to hydraulic head differences, the presence of high PCB concentrations in porewater provides a mechanism by which even deeply buried sediment may contribute to surface water. In addition, the movement of porewater through the sediment profile can replenish PCB concentrations in near-surface sediments. It is incorrect to conclude that stability of sediment ensures the stability of associated PCBs.

The average rate at which PCBs move to the surface from buried sediments may be quite slow, however, due to retardation of the concentration breakthrough, relative to the flux of water, in response to sorption to organic carbon in the sediments. The slow rate of propagation of the PCB concentration in porewater flux has two consequences: (1) the porewater flux from deeper sediments to the water column under present conditions is likely to be small, but (2) the flux is likely to increase in future decades as porewater reflecting the concentrations in the older, more highly contaminated sediments reaches the surface.

Stability and the LRC Analysis

GE states that EPA's concern over the stability of sediments is based on the low resolution coring (LRC) analysis, and that the LRC analysis is statistically biased. The issue of potential bias in the LRC analysis is addressed in detail in Response to Master Comment 625 in Section 2.2. EPA has

considered the comment and concluded that the findings of the LRC Report remain valid, but have been misinterpreted by various commenters. More to the point of this response, the analysis presented in the LRC Report is not the sole basis for EPA's concerns about stability of buried PCB stores, but only one among many lines of evidence.

What the LRC analysis shows is that the total PCB mass present within many of the *hot spot* areas appears to have declined since 1984. GE rightly points out that the estimated amount of mass loss from the *hot spots* is greater than the estimated PCB mass transported downstream. EPA therefore concludes that lateral redistribution or spreading of PCBs is occurring in many of the *hot spot* areas. This localized instability is not unexpected: areas that are characterized as *hot spots* include locations in which large masses of contaminated sediment were deposited following the removal of the Fort Edward Dam, altering the bottom topography of the river. These areas cannot be expected to exhibit the same degree of long-term stability as the gradually deposited cohesive sediments that are more typical of the river as a whole.

Evidence from Water Column Data

GE states that comparison of high-flow rating curves at Stillwater and Waterford "suggests that no significant change in bed erosion has occurred since the early 1980s," and claims this as evidence that "bed instability following removal of the Fort Edward Dam is not supported by the data." EPA has reviewed the rating curve analysis conducted by GE, and finds that it does not support this conclusion. The areas contained within PCB hot spots in the TI Pool constitute a small portion of the total bed area of the Upper Hudson River, and the sediment loads observed at high flow at Stillwater and Waterford are largely representative of tributary sediment loads during high flow events, with only a small portion due to the erosion of all sediments within the TI Pool. As shown in Figure 6-16 of the RBMR (USEPA, 2000) the total sediment load at Waterford is more than five times the load at the TI Dam. Sediment load gain within the TI Pool accounts for only about six percent of the total sediment load at Stillwater and three percent of the load at Waterford. Therefore, the comparison of rating curves provides essentially no evidence relative to the stability of the hotspots within the TI Pool.

GE states that high (total) PCB levels in the water column during the 1993 high flow event do not provide evidence that the sediment deposits are being eroded away, as they show a relatively undechlorinated pattern. EPA sampled two high flow events in 1993. Transect 3 represents a late winter transition from low flow to high flow, while Transect 4 represents spring flood high flow conditions.

EPA agrees that PCB congeners observed in the 1993 Transect 4 samples are not dominated by erosion of historic dechlorinated sediments from the TI Pool. The 1993 sampling took place during a period of elevated releases from the Hudson Falls plant, and the Transect 4 high flow samples from the pool predominantly reflect the movement of these newly-released, undechlorinated PCBs from the Hudson Falls area. Flows were already elevated at the start of this sampling event, and most of the erosion of in-place sediments associated with this spring flood had likely already occurred on the rising limb of the hydrograph.

Transect 3, collected in late winter, tells a somewhat different story. During this sampling event, the river flow was low when sampling occurred north of Schuylerville, but the flow increased for

sampling at locations south of Schuylerville. PCB congeners observed in the water column in the TI Pool area exhibited a predominance of mono- and dichlorobiphenyls, reflecting releases from in-place, dechlorinated sediments. Between Schuylerville and Stillwater the total PCB load doubled during this event, but the homologue pattern was little changed and continued to reflect a dechlorinated pattern. Thus, this sampling event appears to show scour of historically deposited, dechlorinated PCB congeners from the sediments on the rising limb of the spring hydrograph.

It should also be recalled, as previously, noted, that hydrodynamic scour at high flow does not appear to be the dominant factor in releasing PCBs from the sediments. Instead, it is under summer low flow conditions that the majority of weathered, historically deposited PCBs are released from the TI Pool sediments.

A detailed analysis of the total PCB load gain from the TI Pool sediments is provided in Response to Master Comment 623 (Section 2.1). Both the consistency of the load gain and analysis of the dechlorinated congener signature of the summer load from the TI Pool indicate that PCBs are derived from buried sediments

Summary

EPA agrees that the majority of the sediment areas in the TI Pool are net depositional. However, certain highly contaminated areas are clearly not consistently depositional, as shown by the evidence from 1998 GE cores in *Hot Spots* 8, 10, and 14 cited in the foregoing text. Further, the presence of deposition does not ensure the stability and sequestration of the PCBs contained within the contaminated sediments.

Evidence from multiple sources indicates that PCBs are not being safely buried to a degree sufficient to remove them from interaction with the Hudson River. There are also significant risks for future destabilization of buried PCBs by mechanisms other than hydrodynamic scour. EPA concludes that the sediments of the Upper Hudson do not represent a secure location for the long-term storage of massive amounts of PCB contamination.

References

O'Brien & Gere. 1999. 1998 Upper Hudson River Sediment Coring Program. Report to General Electric Company Corporate Environmental Programs, Albany, New York. O'Brien & Gere Engineers, Inc., January.

O'Brien & Gere. 1993. Data Summary Report, Hudson River Project, Sampling and Analysis Program, 1991 Sediment Sampling and Analysis Program. Report to General Electric Company, Albany, NY. O'Brien & Gere Engineers, Inc., Syracuse, NY, May.

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C - Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., The Cadmus Group, Inc. and Gradient Corporation. February.

USEPA. 2000. Phase 2 Report, Further Site Characterization and Analysis. Volume 2 - Revised Baseline Modeling Report, Hudson River PCBs RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc. January.

Master Comment 623

Some commenters said that the source of the load gain observed across the TI Pool is predominantly from freshly deposited PCBs and not from in-place sediment sources, based on an analysis of congener signatures and dechlorination status that differs from EPA's interpretation. Commenters contended that EPA's analysis of the composition of the PCBs in the water at the TI Dam is incorrect and requires an unrealistically high amount of sediment resuspension. Some said that EPA's analysis underestimates the importance of recently deposited PCBs in the load originating from the TI Pool.

Response to Master Comment 623

This response adds to the information provided in Response to Master Comment 621 (Section 2.1). It focuses on the congener signature interpretation from the PCB load gain across the TI Pool and provides evidence that the majority of the PCB load gain occurs from dechlorinated PCBs that generally lie within the top 10 cm of the TI Pool sediments.

GE's comments state that EPA claims that "PCBs in buried sediments migrate to the surficial sediments through some unidentified mechanism" that is a "deus ex machina." This characterization is incorrect. In fact, EPA's analysis, as explained in further detail below, does not require any mechanisms for sediment migration or mixing other than those that are included in GE's own fate and transport modeling. EPA's analysis of sources of PCB load within the TI Pool is entirely consistent with the theoretical modeling framework. EPA's position differs from that advanced by GE in that EPA provides evidence demonstrating that buried, dechlorinated sediments contribute the bulk of the load gain seen across the TI Pool, and that these apparent load gains cannot be passed off as simple transmission of pulse loadings of unaltered Aroclor 1242 from the Hudson Falls source.

Contrary to the characterization provided by GE, EPA does not claim that *deeply* buried sediments engage in direct exchange with the water column, although sediment at a depth of up to 10 cm (or more) may contribute PCB load via bioturbation. As is discussed further below, neither EPA's geochemical analysis nor modeling posit direct mixing of PCBs from below an average mixing depth of 10 cm, nor do they require the assumption of excessive sediment resuspension.

What is clear is that the TI Pool load gain arises in large part from PCBs that have been buried at a sufficient depth to undergo anaerobic dechlorination. EPA's analysis concluded that sediment stores of PCBs within the TI Pool are responsible for the major portion of the observed PCB load gain across the TI Pool. The primary lines of evidence supporting this conclusion are:

- PCB load gain across the TI Pool has been relatively constant over time since 1991, despite the initial rapid increase and subsequent control and decline in magnitude of the upstream source. As the cumulative load leaving the TI Pool over this whole period exceeds the load entering the TI Pool, additional load must be contributed by the PCBs already stored within the sediments of the TI Pool. Evidence for this contention is discussed in detail in Response to Master Comment 621 in this section.

- The congener signature of the PCB load gain across the TI Pool is distinctive. Unlike the upstream source, which consists of relatively unweathered PCBs with a congener pattern similar to Aroclor 1242, the load gain from the TI Pool shows contributions from a highly weathered PCB source, consistent with loading from sediment-stored PCBs that have undergone anaerobic dechlorination.

GE comments, and accompanying detailed analysis on pp. 150-153, contend that the composition of PCBs entering the water column from the TI Pool sediments is consistent with the composition of PCBs within the porewater of the top 2 cm of sediment, with the implication that this porewater represents temporary storage of upstream PCB releases, but is not consistent with the bulk of the PCB inventory in the sediments. These comments do not directly address the question of whether the PCB load generated in the TI Pool consists of "new" PCBs arriving from upstream that will respond directly to source mitigation. Given the low rates of sediment deposition predicted for the TI Pool, much older, historically deposited PCBs may lie within several centimeters of the surface at many locations, and porewater can move PCBs from deeper to shallower sediments.

In fact, GE's analysis of PCB congener signatures in the TI Pool load gain is biased by the fact that the only means of transfer from the sediment that was considered was diffusive mass transfer of porewater, which does not account for bioturbation and other mechanisms of exchange. Further, GE's conclusions are supported only by the graphical presentation of back-estimated sediment source congener pattern interpreted as DB-1 gas chromatograph (GC) peaks, contrasted to 0-2 and 5-23 cm averaged sediment PCB data. While this presentation appears to show a better fit to the 0-2 cm data, it does not take into account important information contained in the ratios between different DB-1 peaks, nor does it consider the congener pattern exhibited in PCBs at shallower, but non-surface bioactive depths (*e.g.*, ca. 5 cm). Finally, the GE analysis ignores the role of competitive sorption to dissolved organic carbon (DOC), which has been shown to play an important role in the behavior of PCBs in porewater and the water column (USEPA 1997, Butcher *et al.* 1998).

EPA's detailed analysis of TI Pool congener signatures is based on summer 1997 data (June through August). Data from 1997 were selected for two reasons: First, observations are available for both the TID-West (nearshore) and TIP-18C (center channel) stations near the TI Dam, allowing examination of the importance of the potential sampling bias among stations. Second, upstream loads and concentrations at Rogers Island were very low during this period, enabling a more direct interpretation of the TI Pool load congener signal. Homologue patterns at Rogers Island (Rt. 197) and TID-West (TI Dam) during summer 1997 are shown in Figure 623-1, PCB Homologue Shift across the TIP, June-August 1997 GE Observations, and exhibit the typical strong shift to a mono- through trichlorobiphenyl pattern.

A quantitative comparison of the different PCB congener/homologue patterns can be made by examining the relative percent contribution of a set of key congeners. The GE/NEA DB-1 capillary column peaks used for this analysis, with constituent congeners, are listed in the table below entitled NEA Peaks and Associated Congeners used in Pattern Analysis. These peaks were chosen for comparison because (1) they are environmentally significant and (2) three-phase partition coefficient estimates are available. For each peak, the congener of most environmental significance in upper Hudson River sediments is listed first.

NEA Peaks and Associated Congeners used in Pattern Analysis

NEA Peak	Homologue Group	Congeners
Peak 2	Monochlorobiphenyl	BZ #1
Peak 5	Dichlorobiphenyl	BZ#4, BZ#10
Peak 8	Dichlorobiphenyl	BZ#8, BZ#5
Peak 14	Di/Trichlorobiphenyl	BZ#15, BZ#18
Peak 24	Tri/Tetrachlorobiphenyl	BZ#28, BZ#50
Peak 23	Trichlorobiphenyl	BZ#31
Peak 37	Tetra/Pentachlorobiphenyl	BZ#44, BZ#104
Peak 31	Tetrachlorobiphenyl	BZ#52, BZ#73
Peak 47	Tetrachlorobiphenyl	BZ#70, BZ#76, BZ#61
Peak 48	Penta/Tetrachlorobiphenyl	BZ#95, BZ#66, BZ#93
Peak 53	Pentachlorobiphenyl	BZ#101, BZ#90
Peak 69	Penta/Hexachlorobiphenyl	BZ#118, BZ#149, BZ#106
Peak 82	Hexachlorobiphenyl	BZ#138, BZ#163
Peak 75	Hexachlorobiphenyl	BZ#153

Across this set of peaks, the congener pattern at the TI Dam is remarkably similar during summer 1997, whether we examine raw concentrations at TID-West, concentrations at the "unbiased" center channel station TIP-18C, the difference in concentration between Rogers Island and TIP-18C, or the concentration at TID-West normalized to solids concentration (Figure 623-2, Summer 1997 Water Column Relative PCB Congener Concentrations near the TI Dam, Compared to Aroclor 1242). The pattern, however, is distinctly different from that of unaltered Aroclor 1242 (based on EPA's analyses). The similarity between the different water column measures, when evaluated as relative percentages, coupled with the near lack of upstream load,

removes a number of confounding issues (such as whether the TI Pool represents a net addition or a replacement of the upstream load) and greatly simplifies the analysis.

Measures of congener concentration in the TI Pool sediments are also available in a number of variations. Figure 623-3, Congener Pattern in TIP Sediment Compared to Aroclor 1242, compares, for the selected GE peaks, the congener pattern found in the surface 0-2 cm layer of USEPA Phase 2 cores 18, 19, and 20 (analyzed as sum of quantitated congeners associated with each GE/NEA peak); the pattern found in the top 0-5 cm layer of the GE 1991 composite sediment samples; and, as an example of a more extensively dechlorinated pattern, the 8-12 cm layer of Phase 2 core 18. The unweathered Aroclor 1242 pattern is also shown in this figure.

In this figure, the patterns in the Phase 2 and GE surface sediments are similar, except that the relative contribution of BZ#4+BZ#10 appears elevated in the GE results. The 8-12 cm layer of Core 18 is clearly more dechlorinated, as shown by the depletion of BZ#5+BZ#8, BZ#15+BZ#18, and BZ#28 relative to BZ#1 and BZ#4+BZ#10. More noticeable, however, is the fact that all the sediment patterns appear to be significantly dechlorinated relative to unweathered Aroclor 1242.

In addition to increased concentrations in dechlorination end products, many of the near-surface sediment samples show reduction in the more readily degradable congeners. This is best summarized through the molar dechlorination product ratio, or MDPR (USEPA, 1997), which gives the fraction of dechlorination end products in the total PCB concentration. MDPR values for the 1991 GE 0-5 cm samples from the TI Pool show a strong correlation to total PCB concentration (Figure 623-4, MDPR versus Total PCB Concentration for GE 0-5 cm Sediment Concentrations in the TI Pool). Those few samples with total PCB concentrations less than 4 ppm show MDPR values in the range of 0.2 to 0.3, which is consistent with recent deposition of a relatively unaltered Aroclor 1242 source. But most of the samples have higher PCB concentrations and higher MDPRs. Thirty-two percent of the samples have total PCB concentrations greater than 25 ppm, with a geometric mean MDPR of 0.54 (range 0.36 to 0.69).

Results from the 0-5 cm range for GE 1998 sampling in the TI Pool are almost identical: 28 percent of the samples had total PCB concentrations greater than 25 ppm, with a geometric mean MDPR of 0.52. Sediments with concentrations and MDPR this high are characteristic of historically deposited PCBs, likely dating prior to 1981 (USEPA, 1997, Figure 4-36). As exchange from the sediment to water is driven by concentration gradient, it is these old, highly weathered PCBs which continue to lie near the surface in the TI Pool that will dominate PCB releases to the water column.

Insights on the probable mechanisms of release can be obtained through analysis of the congener patterns in the water column, pore water, and sediment, using equilibrium partitioning assumptions. EPA's analysis used three-phase partitioning in the sediment, based on *in situ* partition coefficient estimates obtained from the GE 1991 data (O'Brien & Gere, 1993). Because of the analytical corrections made to the GE congener in mid 1997 (HydroQual, 1997), the three phase sediment partition coefficient estimates reported in the DEIR (USEPA, 1997) are no longer valid, and were re-estimated. Three different methods of fitting these coefficients were used in the DEIR. For application to the TI Pool sediment pattern matching, it appeared desirable to use estimates obtained by a consistent method. Accordingly, optimization method 3 (USEPA,

1997) was applied for all congeners (conditional optimization based on estimated two-phase $K_{OC,a}$). The resulting estimates are shown in the table below entitled Revised Three-Phase Partition Coefficient Estimates for PCBs in Sediment in the Freshwater Portion of the Hudson River. As has been noted previously, three-phase sediment partition coefficient estimates from the GE data are uncertain, due to problems with the sample handling and compositing procedures. It is believed, however, that the estimates of *in situ* partitioning provide the best available basis for attempting to match water column concentrations to sediment.

These partition coefficients can be used to estimate absolute and relative concentrations of congeners in porewater, given a total sediment concentration. They also may be used to back-calculate a total sediment concentration from water column gain, depending on the assumptions about the transfer mechanism from sediment to the water column. Results are presented below for two different sets of potential transfer mechanisms: (1) source originating from porewater and (2) source originating from a mix of porewater and bulk sediment transfer to the water column.

Revised Three-Phase Partition Coefficient Estimates for PCBs in Sediment in the Freshwater Portion of the Hudson River

PCB Congener (BZ #)	log K_{OC} (L/kg)	Log K_{DOC} (L/kg)	PCB Congener (BZ #)	log K_{OC} (L/kg)	log K_{DOC} (L/kg)
1	4.46	3.63	52+73	5.98	4.32
4+10	4.73	3.60	66+93+95	6.09	4.53
5+8	5.78	4.03	61+70+76	6.01	4.10
15+18	5.95	4.23	101+90	5.98	4.68
22+51	6.14	4.48	118+149+106	6.10	4.91
28+50	6.49	4.36	138+163	6.31	5.12
31	6.17	4.33	153	6.28	5.25
44+104	6.98	5.78			

Porewater Source

GE focused on diffusive transfer from sediment porewater as the main source of PCB loading from TI Pool sediments. Using the partition coefficient approach and pattern matching, the case of a pure porewater source, whether loaded to the water column via diffusion or advection, is easily examined.

At first glance, the relative concentration gain measured at TIP-18C looks quite similar to the relative concentrations in surface sediment porewater (Figure 623-5, Relative Percent Patterns in Water Column Gain at TIP-18C, Surface Sediment, and Surface Sediment Porewater). The apparent agreement is, however, largely due to the fact that BZ #4+10 dominates both patterns. For other congeners, there is much less agreement, as there is a substantially higher proportion of BZ#1 in porewater than in surface water, while the more highly chlorinated congeners have a relative contribution of 21 percent in the TIP-18C gain, but only 5 percent in porewater. Further, the tetra- and higher-chlorinated congeners show a pattern that looks more like sediment than porewater.

As noted above, congener concentration in porewater consists of both a truly dissolved and a DOC-complexed phase. Together these represent the *apparent* dissolved phase, denoted $C_{PW,a}$. For a pure porewater source, the congener pattern in the water column should be equivalent to the pattern in $C_{PW,a}$. Equation (623-1) (same as Equation 3-29 in USEPA 1997) states the equilibrium relationship between $C_{PW,a}$ and the particulate concentration, C_P, which is a close approximation to the total concentration within the sediment matrix:

$$C_P = \frac{f_{OC}\ K_{OC}\ C_{PW,a}}{P\left(1 + m_{DOC}\ K_{DOC}\right)} \qquad (623\text{-}1)$$

where

f_{OC} is the fraction of organic carbon in the solid phase
K_{OC} is the partition coefficient to organic carbon
P is the saturated porosity, or volume of water per volume of wet sediment
m_{DOC} is the mass of DOC per volume of porewater
K_{DOC} is the partition coefficient to dissolved organic carbon

This equation may be used to calculate a congener pattern in a sediment source, given a congener pattern in the assumed porewater flux to surface water. To apply the equation, physical characteristics for the sediment are assumed to be the average from 0-5 cm sections within the TI Pool (Reach 8) in the 1991 GE sediment data (O'Brien & Gere, 1993). This yields P = 0.386, f_{OC} = 0.01788, and m_{DOC} = 33.68 mg/L.

Figure 623-6, Sediment Congener Pattern Derived from Summer 1997 Gain at TIP-18C Attributed to Porewater Flux, shows the congener pattern for sediment concentrations driving a porewater source, as computed from the gain in concentration at TIP-18C in summer 1997, and compares this pattern to the pattern found in the 0-2 cm layer in Phase 2 Cores 18-20 and unweathered Aroclor 1242.

The computed sediment concentration pattern to support a porewater-only source appears to be quite different from that seen in the 0-2 cm layer of Phase 2 cores 18-20 (and the difference is greater when compared to the 0-5 cm layer of 1991 GE cores from the TI Pool). While there are some similarities in pattern, BZ#52 and BZ#28 are elevated in the water column relative to the derived sediment pattern, while BZ#1 through BZ#10 are depressed. The relative importance of these congeners, which tend to have lower partition coefficients and a greater concentration in the water phase relative to sediment phase, is diminished by the fact that large sediment concentrations of congeners above BZ#28 are required to account for the water column gain by a purely porewater mechanism.

As previously noted, during summer 1997 there is little difference in congener pattern (despite absolute differences in concentration) between observations at TID-West, TIP-18C, and the gain at TIP-18C relative to Rogers Island. As a result, the derived sediment concentration is similar regardless of which measurement is used as a basis for the analysis (Figure 623-7, Sediment Relative Concentrations Required to Support Observed Water Column Concentrations via Porewater Flux).

In sum, the available evidence contained in congener patterns does not appear to support a theory of near-surface porewater flux (either diffusion or advection) as the sole source of PCB load gain in the TI Pool, unless the congener pattern is strongly shifted in the water column by some unspecified mechanism. Clearly, porewater constitutes part of the source of PCBs to the TI Pool, but apparently not the only source. It also does not appear that unweathered Aroclor 1242 makes up the missing part of the source.

Source Originating from Mixed Porewater Flux and Sediment Exchange

During a typical summer period there appears to be insufficient shear stress at the sediment-water interface to scour significant quantities of PCB-contaminated sediment. Lack of significant erosion of pool sediments during summer is also consistent with observed solids concentrations. Nonetheless, the congener pattern observed in the water column is consistent with a source partially composed of PCBs on bulk sediment, rather than PCBs partitioned from sediment into porewater.

A mechanism alternative to hydrodynamic scour for introducing PCBs on sediments into the water column is provided by localized disturbances that result in mixing of contaminated sediment to the sediment water-interface or into the water column, followed by equilibration and exchange of PCBs between sediment and water. Data suggest that most of the sediment introduced into the water column at non-scouring flows settles out quickly, as there is little net increase in solids load across the TI Pool at low flow. Localized, non-hydrodynamic scour disturbances that mix sediment to the sediment water interface or into the water column during summer low flow periods include:

- Bioturbation by benthic organisms and demersal fish.
- Fish nesting.
- Mechanical scour by propwash and by grounding of boats and floating debris in shallow areas.
- Uprooting of macrophytes by flow, wind, or biological action.

The seasonal pattern of load gain, with a maximum in early summer and low values in the winter (USEPA, 2000), suggests that biological mechanisms play an important role in the exchange process. The availability of PCBs in subsurface sediments to biota is addressed in greater detail in Response to Master Comment 637 in Section 2.3.

To test this hypothesis, numerical experiments were performed to reproduce the observed water column concentrations by a weighted combination of near-surface sediment (0-5 cm) and surface sediment porewater concentrations. Direct combination of sediment and water, which would be consistent with net solids loading from TIP sediments to the water column coupled with porewater exchange, does not yield a close fit to the observed congener pattern. However, a very close fit is obtained under an assumption of direct sediment-sorbed PCB exchange with the water column at the sediment-water interface.

To provide a gross representation of the fractionation that occurs during the exchange process, it is simply assumed that, within the water column and at the sediment-water interface, sediment-

sorbed PCBs re-equilibrate to reproduce the average water column phase distribution shown in Table 3-8 of the DEIR (USEPA, 1997), following which the dissolved and DOC fractions remain in the water column. This fractionation would result in 91 percent of the BZ#4 desorbing from sediment and remaining in the water column, but only 22 percent of BZ#118.

Using these assumptions, water column concentrations observed at TID-West can be closely predicted as a mixture of porewater loading and water column exchange with shallow sub-surface sediments, using average 0-5 cm concentrations in the TI Pool for sediment and porewater from the GE 1991 data (Figure 623-8, Concentrations at TID-West Predicted as a Mixture of Porewater and Sediment Exchange). In contrast, porewater alone provides a much poorer fit. Very similar results are obtained by fitting a mixture to the estimated gain at the center channel station TIP-18C (Figure 623-9, Concentration Gain at TIP-18C Predicted as a Mixture of Porewater and Sediment Exchange). In the case of TID-West, the best fit coefficient on porewater concentration (ng/L) is 0.0034 and that on sediment concentration (µg/kg) is 0.0058; for gain evaluated at TIP-18C the coefficient on porewater concentration is 0.0011 and that on sediment concentration is 0.0038.

In sum, observation of congener patterns in the TI Pool load gain suggests that this load is driven by a mix of porewater flux (advection plus dispersion) and direct exchange of sediment with the water column. The sediment exchange portion is likely driven in large part by biomixing of sediments to the surface from a depth sufficient for anaerobic dechlorination to have occurred.

Application to 1991-1997 Observations

The discussions above suggest that a mixed sediment-porewater source derived from dechlorinated sediment deposits near, but not at the surface, is applicable to 1997 data. The same conclusions apply to other years. Summer concentration gain across the TI Pool varies widely from year to year, reflecting variations in flow and other conditions; however, examination of the relative percent concentration of congeners in the summer gain shows a high similarity from year to year (Figure 623-10, Relative Concentration Gain at TID-West, 1991-1997). The remaining variability is within the range of analytical and sampling uncertainty. Therefore, the multi-year series can be fit on a normalized (percent) basis. The optimized fit to a mixed porewater-sediment source provides a very close match to the composite congener fractions observed in the TI Pool gain from 1991 to 1997 (Figure 623-11, 1991-97 Composite Congener Concentrations in TIP Load Gain Predicted as a Mix of Porewater and Surface Sediment).

The sediment indicated as a source of the load gain has a dechlorinated congener pattern consistent with buried deposits of PCBs. It is not consistent with the congener pattern expected from temporary storage of recent releases of unweathered PCBs from the upstream source. At the same time, mass transport of PCBs out of the TI Pool has consistently been greater than the upstream input throughout the 1990s.

It therefore appears that the monitoring data from the TI Pool are consistent with PCB load gain from sediment stores of dechlorinated PCBs within the 10-cm sediment mixing depth represented by EPA's model. These sediment stores contribute PCBs to the water column via both porewater flux and sediment mixing (bioturbation) pathways. Further, the concentrations and dechlorination status of the sediment source are consistent with historically deposited PCBs,

and have exhibited little change between 1991 and 1998. The PCB load gain from the TI Pool cannot be adequately explained as a phenomenon of short-term storage and release of unweathered PCBs from the Hudson Falls source.

References

Butcher, J.B., E.A. Garvey, and V.J. Bierman. 1998. Equilibrium partitioning of PCB congeners in the water column: field measurements from the Hudson River. *Chemosphere*, 36(15): 3149-3166.

HydroQual. 1997. Development of Corrections for Analytical Biases in the 1991-1997 GE Hudson River PCB Database. Report to General Electric Company, Albany, NY. HydroQual, Inc., Camillus, NY, June.

O'Brien & Gere. 1993. Data Summary Report, Hudson River Project, Sampling and Analysis Program, 1991 Sediment Sampling and Analysis Program. Report to General Electric Company, Albany, NY. O'Brien & Gere Engineers, Inc., Syracuse, NY, May.

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C - Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., The Cadmus Group, Inc., and Gradient Corporation. February.

USEPA. 2000. Phase 2 Report, Further Site Characterization and Analysis. Volume 2D - Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc., January 2000.

Master Comment 643

Commenters said that significant sources of PCBs other than GE are ignored in the FS and that EPA failed to adequately identify all significant sources of PCBs to the Upper Hudson. Some contend that a remedial decision cannot be made until all external sources of PCBs are identified and controlled, and, as a consequence, EPA's planned remediation will not be effective.

Response to Master Comment 643

EPA has invested considerable effort in the attempt to identify other sources. These efforts have included inventorying potential sources (USEPA, 1991), sampling at numerous points along the length of the river, and sampling of tributaries (USEPA, 1997). Results are summarized in Section 1.3.2 of the FS. There is no evidence for other sources of PCBs to the Upper Hudson that are of significance relative to the loads discharged by GE (including both the ongoing discharges from the Hudson Falls plant and the re-release of historically discharged PCBs from contaminated sediments downstream of the GE facilities).

Potential loads from upstream of Bakers Falls were cited in several comments. GE observations at Fenimore Bridge, just above Bakers Falls (FS, Appendix A.2), revealed that 80 percent of observations from April 1, 1991 to March 8, 2000 were non-detect at a detection level of 11 ng/L total PCBs. A few higher-concentration spikes were observed, but all these occurred prior to December of 1995. Further, the PCB homologue distribution within the observations with detectable PCBs at Fenimore Bridge resembles Aroclor 1242, and is not characteristic of the more highly chlorinated PCBs found upstream at the Feeder Dam and Sherman Island Pool.

Given 1) the proximity of the Fenimore Bridge to the Hudson Falls plant, 2) the fact that sediments above Bakers Falls dam near the GE Hudson Falls pump house and former outfall were found to contain up to 22,000 ppm of PCBs, and 3) the record of historic discharges of PCBs from GE via the Village of Hudson Falls wastewater treatment plant, it appears that a significant portion of the load at Fenimore Bridge may also be attributable to GE operations.

The comment specifically cites as support a statement in Appendix A.3, p. 5 of the FS that refers to an unknown source in the Bakers Falls area. The commenter has taken this sentence out of context. The sentence refers to the state of knowledge in 1993 during GE's first phase Interim Remedial Measure at the Hudson Falls OU2A/B site. The source remained unknown only until GE’s investigations of 1994, which documented the seepage of PCB oil from the bedrock in the Bakers Falls wing dam area.

In sum, EPA is confident that all significant sources of PCBs to the Upper Hudson River have been identified. The information is sufficient to select an appropriate remedy.

References

USEPA. 1991. Phase 1 Report – Interim Characterization and Evaluation, Hudson River PCB Reassessment RI/FS. Prepared for USEPA Region 2 by TAMS Consultants, Inc. and Gradient Corporation, August.

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C – Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., The Cadmus Group, Inc., and Gradient Corporation. February.

Master Comment 422386

Comments suggested that GE continues to discharge PCBs without a permit. The commenters questioned if current leaks from GE are entering the water table and nearby soil. The commenters wanted to know if it was possible that the plants they consume may be contaminated.

Response to Master Comment 422386

There are ongoing PCB releases from GE’s Hudson Falls facility and its vicinity that are unpermitted. GE is currently working with NYSDEC and EPA to eliminate or significantly

reduce the leakages. In fact, EPA's selected remedy assumes that upstream source control will occur.

As discussed in Section 9.2 (Response to Master Comment 253421), the river is a region of net groundwater discharge and not recharge. Thus, contaminants released or discharged to the river tend to remain in the water or the sediments, which line the river bottom. Like the PCB contamination already coating the river bottom, it is unlikely that leakages from the GE facility into the river are significantly impacting groundwater in the vicinity of the river.

In addition, since the existing sediment contamination is so much greater than the level of sediment PCB contamination being generated by the leakages at the GE facilities, if any risk is posed to groundwater it would be due to the existing sediment burden and not the current leakages. This is further discussed in Section 9.2 (Response to Master Comment 253421). Given PCBs' great affinity for the sediment and soils, it is highly unlikely that significant groundwater contamination could be generated from riverine PCB contamination. It is therefore unlikely that crops or other plants will be contaminated by riverine PCBs via groundwater.

The main PCB groundwater contamination problems in the Upper Hudson are those around the GE facility themselves (*i.e.*, the discharges at Hudson Falls), where free PCB oil has saturated the local aquifers and continues to migrate to the river. In these areas, groundwater impacts may be severe but they are unrelated to the river and the riverine PCB contamination, and as such have not been addressed under the Reassessment.

Master Comment 313444

In connection with evaluation of the Contained Aquatic Disposal technology (FS, Section 4.2.9.2, page 4-55, paragraph 2), a commenter requested that the location of historic 'wet dump grounds' should be displayed on Figure 3-1 and noted when coincident with a NYSDEC *hot spot*.

Response to Master Comment 313444

The source of the information cited in the FS is a 1984 report by Malcolm Pirnie (Malcolm Pirnie, 1984) prepared for NYS Department of Transportation (at that time the overseer of the canal system) in regard to the proposed Maintenance Dredging Program for 1985 through 1995. The locations of some 16 historical wet dump grounds between Federal Dam and Fort Edward are shown on Table B-1B and an accompanying map having a scale on the order of 1/4 inch to the mile. The scale of the information prohibits transfer of the shape, size, or locations of the wet dump grounds to project mapping with an acceptable degree of accuracy or reliability. However, the information may be relevant in selecting sampling locations for refining target areas during remedial design. EPA will take this into consideration and will pursue more accurate information at that time for this purpose.

Reference

Malcolm Pirnie, Inc. 1984. New York State Barge Canal - Maintenance Dredging Program: 1985 – 1995. Volume 1 (Text) and Volume 2 (Appendices). Prepared for NYS Department of Transportation.

Master Comment 621

Commenters asserted that EPA presented insufficient data and analysis to credibly claim that the historically buried PCBs replenish the surficial layer. Some claimed that justification of EPA's sediment remediation is based on unsubstantiated conclusions that natural sedimentation and burial are ineffective in abating the sediment source, and that PCB-containing sediments are not stable. Some commenters contended that EPA's argument fails to address the PCBs source at Hudson Falls. An alternative interpretation of the mass balance was presented that involves greater replenishment of surface sediment concentrations in the TI Pool from the upstream source and continuous burial within the TI Pool, and contends that EPA's analysis relies on an unknown, unseen mechanism that brings buried PCBs to the sediment surface.

Response to Master Comment 621

This response addresses the specific issue of PCB release from TI Pool sediments, which is one of the common themes contained within all the associated comments. Other aspects of these comments are addressed separately in other responses. The reader is particularly referred to Response to Master Comment 623 (Section 2.1), which provides an analysis of the congener signature of the TI Pool load gain and documents evidence that this load gain occurs from buried sediments.

EPA's analysis demonstrates that a consistent gain in total and Tri+ PCB load and water column concentration occurs across the TI Pool (USEPA, 1997; USEPA 2000, Appendix 3; Response to Master Comment 577, Section 2.2). This load gain occurs regardless of whether the upstream source load is large or small in a given year, although its importance as a percentage of total load is obviously dependent on the magnitude of the upstream load. A consistent load gain is documented up through the most recent monitoring available (Response to Master Comment 631, Section 2.6, table entitled Recent Summer Water Column Total PCB Concentrations and Loads in the TI Pool). The contribution of TI Pool sediments to PCBs in the water column of the Hudson River is verified both by load gains and by the congener signature of the load passing the TI Dam.

As pointed out in comments, the statement on p. 1-43 of the FS that "PCB concentrations in water are driven by PCBs stored in sediments" is not completely correct. The statement should have said, "PCB concentration gain relative to the upstream boundary concentration is driven by PCBs stored in sediments..." In recent years under summer low flow conditions the bulk of the PCB load seen at TI Dam and downstream is indeed derived from PCBs in the sediments. As the upstream boundary concentration derived from the Hudson Falls facility decreases, the importance of the PCB release from the sediments becomes greater.

GE questions the importance of the TI Pool sediments on two grounds, stating (1) that the EPA position requires migration of PCBs from buried sediments that relies on "an unknown, unseen mechanism," and (2) that any load gain that does occur from TI Pool sediments is due to the storage and subsequent release of PCBs derived from the upstream source.

EPA believes that the existence of a consistent load gain across the TI Pool is firmly documented and provides incontrovertible evidence of the importance of contributions of PCBs from the TI Pool sediments (Response to Master Comment 631, Section 2.6), regardless of the mechanism. The two counter arguments advanced by GE are discussed in detail in the following text.

GE's first argument is based on a false dichotomy. While EPA analyses demonstrate the existence of PCB flux from buried sediments, EPA is not contending that *deeply* buried sediments are directly contributing PCBs to the water column. It is clear that sediment PCBs with a dechlorinated congener signature are contributing to the load from the TI Pool. These PCB loads must arise from below the oxic-anoxic boundary in the sediment to have experienced sufficient dechlorination, but this boundary can be only a few centimeters deep in cohesive sediments. Transport of PCBs from these sediments does not require any "unknown, unseen mechanism," although the primary mechanism does not seem to be hydrodynamic scour. Instead, the exchange occurs through a combination of the flux of porewater and localized disturbances that result in temporary mixing at the sediment-water interface, followed by equilibration and exchange of PCBs into the water column.

Localized, non-hydrodynamic disturbances that may mix sediment to the sediment-water interface in either cohesive or non-cohesive sediment areas during summer low flow periods include:

- Bioturbation by benthic organisms.
- Bioturbation by demersal fish.
- Mechanical scour by propwash.
- Mechanical scour by boats and floating debris in shallow/nearshore areas.
- Uprooting of macrophytes by flow, wind, or biological action.

In addition, during low flow periods, the daily changes in water level due to peaking hydropower releases from Lake Sacandaga may enhance PCB releases from nearshore sediments.

These mechanisms occur at too fine a spatial scale to be explicitly represented in reach-scale models, but this does not mean that they are not important. They are therefore represented in the model through use of an empirical mass transfer coefficient. Indeed, GE's consultant adopted a representation of "non-hydrodynamically-induced [sic] sediment-water exchange" that is nearly identical to that used by EPA. As stated in QEA (1999, p. 4-23): "While the processes controlling sediment-water exchange are generally understood, a mechanistic representation of each of these processes with appropriate Hudson River-specific parameterization is not feasible because data do not exist to support such representation in the model. Therefore, the combined effect of these sediment-water exchange processes was modeled empirically by a lumped sediment-water exchange coefficient that is calibrated to seasonal sediment PCB loadings under low flow conditions."

The second argument advanced by GE (that load gain across the TI Pool is due to storage and release of load from upstream) is not borne out by the available evidence. The empirical evidence available from GE monitoring data clearly shows that the TI Pool sediments remain an important source of PCB loading to the water column. Certainly, there is a possibility that some of the upstream PCB load will be stored in surface sediments of the TI Pool, although model results suggest that this fraction is small during the 1990s. Two lines of evidence show that the recent load gain across the TI Pool is not due primarily to upstream loading: analysis of cumulative load gain from the TIP and analysis of congener signatures.

Analysis of Cumulative Load Gain from the TIP

An estimate of the total PCB load gain across the TIP of 0.56 kg/d was presented in the DEIR (USEPA 1997). Minor revisions to this estimate are appropriate based on three considerations:

- Release of additional GE monitoring data.
- Revision by GE of certain PCB results to correct analytical biases.
- Potential corrections to account for sampling bias associated with the TID-West sampling station.

Analytical corrections to the GE monitoring data are documented by HydroQual (1997). These corrections address use of an inappropriate calibration standard and resolution of co-elution biases. One of the effects of these corrections is to increase the estimated concentration of mono- and dichlorobiphenyls. As the PCB signature from the TI Pool is enriched in these homologues, the net effect of these analytical corrections is to increase the estimated load gain across the TI Pool and to further emphasize the distinctive signature of the PCB load derived from the pool.

GE also determined that the nearshore observations taken at TID-West may be biased high relative to center-channel observations (Rhea, 1997), and might therefore over-estimate load leaving the TI Pool. GE collected a number of concurrent samples between 1996 and 1998 at TID-West, the center channel above the dam (TID-Center), and downstream of the dam (TIDPRW). EPA's analysis of these samples suggests that a bias between the nearshore and center channel stations exists primarily at low flow conditions when lateral mixing is minimized. Over the full set of 1996-1998 samples, the average ratio of total PCBs at TID-Center (or TIDPRW when TID-Center is not available) samples to TID-West samples is 0.86. (This is much higher than the ratio of 0.62 originally mentioned by Rhea (1997), based on limited preliminary data).

Total PCB loads were recalculated through November 2000 using the revised GE data and employing the averaging estimator as described in USEPA (1997). Results are omitted for February 1999 and December 2000 on, as flow estimates at Fort Edward are incomplete. Comparison of load estimates upstream of the TI Pool at Rogers Island with load estimates at the downstream end of the pool at TID-West for April 1991 through November 2000 yields an estimated average net total PCB gain across the pool of 0.85 kg/day (1.9 lb/d). If the factor of 0.86 for sample-location bias is applied, this number would be adjusted to 0.73 kg/d (1.6 lb/d). Thus, the net effect of the analytical corrections and sample bias corrections is an estimated load gain across the TI Pool greater than that reported in the DEIR (USEPA, 1997).

Figure 621-1 (Cumulative Total PCB Load at River Mile 194.2 [Rogers Island] and River Mile 188.5 [TID-WEST)] Estimated from GE Monitoring Data for April 1991-March 2000) shows cumulative total PCB loads at Rogers Island and the TI Dam, calculated from the GE data. The rate of increase in loads appears nearly constant across this period, as shown by the steady divergence of the two lines. Indeed, the total PCB load gain calculated for January 1997-November 2000 is 0.88 kg/d (0.76 kg/d with bias correction), which is nearly identical to that for the entire 1991-2000 time period. The fact that a steady load gain applies across the whole period of record strongly suggests that the increased output at the TI Dam is not due to short-term storage of load pulses from upstream.

In contrast, GE's comments (Figure III-13) imply that the Total PCB load gain across the TI Pool between August 1997 and December 2000 amounted to only 80 kg in total (0.15 kg/d), based on monitoring below the dam. It should be noted, however, that this estimate was created with non-detected values set to the GE reporting limit of 11 ng/L, whereas the convention is to set these values to half of the reporting limit (*i.e.*, 5.5 ng/L). During this period, PCBs were generally not detected in samples collected at Rogers Island, while PCBs were detected in most samples collected at the TI Dam. Assigning the upstream values to the reporting limit (11 ng/L) serves to artificially bias upward the estimated load at Rogers Island, and decreases the apparent load gain across the pool. In addition, the statistical methods used to convert point-in-time concentration measurements to continuous load estimates are not documented by GE.

Another comment compared both EPA's and GE's estimates of upstream PCB loading above Rogers Island with estimates of PCB load crossing the Troy Dam and concluded that, regardless of whether the EPA or GE calculations are used, there is a substantial incremental PCB load that must arise from the sediments of the Upper Hudson. EPA agrees with this analysis: while there is uncertainty in the exact magnitude of the load, the majority of the PCBs transported from the Upper to the Lower Hudson in recent years derive from PCBs stored in the sediments of the Upper Hudson River. Source control at the GE plant sites alone will not redress this condition; both source control and remediation of river sediments are necessary to facilitate the river's recovery.

Analysis of Congener Signatures

Examination of congener signatures or homologue patterns also indicates that the TI Pool sediments are a source of PCB load distinct from the upstream source. Throughout the period of GE monitoring, samples taken at TI Dam during summer low flow conditions show a strong shift to a less-chlorinated congener mixture, dominated by mono- and dichlorobiphenyls, relative to the upstream source. Typical results, for summer 1996, are shown in Figure 621-2 (Shift in PCB Homologue Pattern across the Thompson Island Pool, Summer 1996). At Fort Edward (Rt. 197) trichlorobiphenyl and tetrachlorobiphenyl homologues predominate, with almost no monochlorobiphenyl and small amounts of dichlorobiphenyl. In contrast, concentrations at the TI Dam (TID-WEST) are much higher, and shifted toward monochlorobiphenyl through trichlorobiphenyl homologues.

This shift in homologue pattern provides another line of evidence that the PCBs exiting the TI Pool are not the same as those entering the pool. Coupled with the increase in concentration and load across the pool, this indicates the addition of load from a relatively dechlorinated sediment

source, which must arise within oxygen-depleted sediments, and not simply through-transmission of the upstream, unweathered PCB source.

Interpretation of the congener signature of the TI Pool load gain is addressed in further detail in Response to Master Comment 623 in Section 2.1.

GE comments claim that EPA's interpretation of the importance of TI Pool loads is based on "a new and untested hypothesis: that water column PCB concentrations in the TI Pool during summer low-flow achieve a maximum concentration that is in steady-state with the sediment PCB levels." The comment claims that this cannot be so, because "if the water column PCBs were at steady-state with the sediment PCBs during summer low-flow conditions, both would have the same dissolved PCB concentration."

These comments reflect a misinterpretation of EPA's position. EPA does not contend that water column concentrations and sediment porewater concentrations should be equal, which is clearly at odds with the data. Instead, EPA has observed that summer low flow concentrations in recent years appear to be independent of the upstream load. A likely explanation is that the water column concentrations at low flow are controlled by rates of exchange with the sediment. This leads to a quasi-steady state equilibrium condition in which the water column concentrations remain approximately constant. Water column concentrations are not expected to be equal to porewater concentrations due to the large dilution expected for porewater entering the water column and the preferential affinity of PCBs for particulate matter in the sediments and dissolved organic carbon in the porewater.

EPA's observation regarding summer low flow concentrations also points out the continuing importance of in-place sediment PCBs in determining water column exposure concentrations. It is worth highlighting some of the information presented in Appendix D.1 of the FS that supports this contention, based on the monitoring data provided by GE. Figure 621-3, Summer Water Column Concentration at TID-WEST versus Monthly Average Flow at Fort Edward, 1996-1999 (a copy of Figure 11 in Appendix D.1 of the FS) shows the mean monthly total PCB and Tri+ PCB concentrations at the TID-West station for the summer of 1996 through 1999, plotted as a function of flow. This figure shows that, within any given month, the water column concentration remains approximately constant over time. This is clearly seen for July, August, and September. June exhibits slightly more variability largely due to conditions in 1998. Typically, concentrations vary about $\pm$20 percent while flow varies by more than a factor of three ($\pm$58 percent) for the 1996-1998 period.

These results indicate that the TI Pool water column PCB concentrations are effectively in equilibrium with sediment sources, given that flows remain relatively low. This system is able to maintain similar conditions over a relatively wide range in flow (1500 to 5500 cfs). This suggests in turn that this system is not undergoing a rapid rate of decline and has a sufficiently large reservoir of available sediment-bound PCBs such that no decline in surface water conditions is in evidence over the last four years. This is noteworthy given that the upstream loads have declined more than an order of magnitude during the period 1992 to 1999.

References

HydroQual. 1997. Development of Corrections for Analytical Biases in the 1991-1997 GE Hudson River PCB Database. Prepared for General Electric Company, Albany, NY by HydroQual, Inc. June.

QEA. 1999. PCBs in the Upper Hudson River. Prepared for General Electric, Albany, New York by Quantitative Environmental Analysis, LLC.

Rhea, J. 1997. Memorandum Re: TIP Time of Travel Surveys to J. Haggard, GE, October 6, 1997. HydroQual, Inc.

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C – Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., The Cadmus Group, Inc., and Gradient Corporation. February.

USEPA. 2000. Response to Peer Review Comments on the Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc., November 2000.

2.2 Validity of the Low Resolution Sediment Coring Report

Master Comment 577

Commenters raised several questions and issues with regard to the stability of the Upper Hudson River sediments. Commenters questioned whether the sediments were dynamic and unstable or net-depositional, sequestered, and stable. Comments suggested that greater than 80 percent of the Tri+ PCB inventory is below the biologically active depth of 10 cm. Commenters both agreed and disagreed with the analyses presented in the DEIR and LRC Report to support the EPA's conclusion that sediments in the TI Pool act as a source of PCB loadings to the water column. Commenters stated that sedimentation and burial are effectively reducing the contribution of PCBs from sediments to fish, and the net depositional nature of the Upper Hudson serves to sequester the PCB inventory from further interaction with the biota.

Response to Master Comment 577

The analysis of the security of the PCB inventory of the Upper Hudson River sediments presented in the LRC Report was questioned. Several issues were raised concerning the "stability" of the sediments of the TI Pool, suggesting that if the sediments could be shown to be "stable" then they would not pose a long-term problem. It is the conclusion of the EPA as well as the peer review panel for the LRC Report that the sediments of the Upper Hudson do not represent a secure location for the long-term storage of PCB contamination. This issue is

independent of the physical nature of the sediments themselves, although, as shown below, there is evidence to suggest reworking of the sediments over time as well.

Evidence that the sediments continue to release PCBs to the water column is quite strong. Evidence indicates that over the last five years (1996 to 2000) the sediments released approximately 1.5 pounds per day of total PCBs. This is the net release of PCB from the sediments above the 0.2 to 0.5 lb/day (average of 0.34 lb/day) coming from upstream. This sediment load clearly represents the dominant source of PCBs to the water column and to any downstream receptors. Over the same five-year period, the annual net release of PCBs from the sediments of the Upper Hudson has represented approximately 2,700 lbs, well over a ton of total PCBs. The upstream source contribution during this period amounted to less than a quarter of that from the sediments (615 lbs). Effectively, the sediments released over a ton of PCBs from the existing sediment inventory between 1996 and 2000. This is assuming that all upstream loads are merely transmitted through the river. To the extent that there is any storage of the upstream load within the sediments during this period, the actual sediment release is greater by the same amount.

Examining the entire period of record for GE monitoring, the picture remains the same. Using a ratio estimator calculation as was done in the DEIR (USEPA, 1997), it is possible to calculate the net load gain across the TI Pool from 1991 through 2000. During this period, the upstream loads, principally the leakage from the GE Hudson Falls facility, totaled approximately 5,600 lbs total PCBs. Note that this includes the entire Allen Mill event. During the same period, the net contribution from the sediments represented 4,800 lbs. Thus, over the period of time including the large Allen Mill event, the sediments were still responsible for 46 percent of the total PCB load originating in the Upper Hudson.

When examined on an annual basis, it is clear that the sediment source has continued largely unabated throughout the 1990s. Figure 577-1 shows the net load gain across the TI Pool based on the corrected results for the TI Dam monitoring station. While noting that there is some uncertainty in the use of this monitoring location, the results for the location strongly correlate with those observed at Schuylerville. Thus to the extent that the TI Dam West site is an upper bound on TI Pool loads, it is a fairly accurate representation of the loads at Schuylerville. This aspect of the monitoring station is discussed in the DEIR, the LRC Report Responsiveness Summary and Appendix D1 of the FS. Whether it represents TI Dam or Schuylerville most accurately is a minor issue since in either case it can be used to calculate the net sediment contribution. Figure 577-1 clearly shows some variation but no clear increasing or decreasing trend in the net contribution by the sediments over time. The contribution from the sediments has remained relatively constant at over one lb/day for the entire study period.

Thus, the sediment source to the river is largely unabated despite the dramatic changes seen in the upstream loads over the same period. It is important to note here that the figure represents the net gain from the sediments to the water column. That is, effectively, all of the PCBs released from the sediments from 1991 to 1999 were in fact deposited prior to 1991. The total PCB inventory of the TI Pool sediments declined by over two tons (4,800 lbs) during this period via release to the water column.

Evidence is available as recently as April 2001 showing the importance of the sediments (K. Farrar, pers. comm., 2001). The relatively small spring flood event (recurrence frequency of less than five years) lasted only three days but yielded over 70 pounds of total PCBs from the sediments. This release overshadows the contribution for the same period from upstream sources of 17 pounds of PCBs. From this most recent data alone it is clear that the sediment inventory of PCBs is not sequestered.

While it is clear that the sediments remain the most important source to water column and therefore to locations downstream, it is less clear how the release occurs. Several mechanisms are undoubtedly involved, including geochemical, biological, and hydrodynamic processes. While the modeling analyses have attempted to characterize these processes through various algorithms and expressions, these expressions represent simplifications of our understanding of the actual processes involved. Rather than dwell on the various nuances of our understanding, it is much more instructive to simply observe the conditions of the river and note their ramifications.

For example, mean surface concentrations on the river bottom are clearly above those that are produced by the upstream load at Rogers Island. This is discussed in detail in White Paper – Relationship between PCB Concentrations in Surface Sediments and Upstream Sources. For this response, it is sufficient to note that suspended matter at Rogers Island has averaged roughly 1 to 2 mg/kg Total PCBs. Thus, it would be anticipated that surface sediments originating from these solids would also contain 1 to 2 mg/kg. Variations in depositional area could possibly explain some localized variation in concentration, but it is EPA's opinion that this would yield individual concentrations varying by no more than an order of magnitude.

Both individual cores and core composites collected by GE in 1998 and 1999 clearly show surface concentrations higher than these values. These data indicate the presence of historical sediments at the surface. For example, the mean composite fine-grained sediment core result for 0-2 cm in 1998 was 24 mg/kg Total PCBs, well above the calculated mean of 1 to 2 mg/kg for the years 1996 and 1997, the two years prior to sample collection. Individual cores showed values as high as 625 mg/kg within the top 5 cm. These high values clearly exceed any values produced by the upstream load in the years immediately prior to the sample collection, indicating that the surface sediments represent historical sediment contamination.

The possibility remains that these materials might have been produced in the early 1990s during the Allen Mill event. This would still make these materials six to seven years old at the time of collection. Further review of the coring data suggests a much greater age for these materials. Specifically, the high resolution cores collected by the USEPA in 1992 and by GE in 1998 show no evidence of a major PCB release anytime during the 1990s. That is, these cores show a significant PCB peak associated with the early 1970s and a decline to a relatively low but recently constant value through the 1990s. Since these cores represent unique, continuously depositional environments, they record the nature of the PCB deposition over time. These cores do not reflect an order of magnitude increase and decrease in the upstream load over the 1990s. Rather, they show depositional concentrations to be relatively constant over this period. These results suggest that the internal (*i.e.*, inside the TI Pool) processes of sediment reworking and PCB release currently control the nature of PCB contamination in the Upper Hudson. Thus, it

can be concluded that the elevated PCBs levels found in the surficial fine-grained sediments probably represent historical materials first deposited in the 1970s and 1980s.

The assertion in a comment that the high resolution core profiles can be used as evidence to suggest that 80 percent of the Upper Hudson's PCB inventory lies below 120 cm is an inappropriate application of the core data. As extensively discussed in the DEIR, LRC Report, and related responsiveness summaries, these cores do not represent the vertical extent of PCB contamination in the river but rather the nature of the sediments being deposited. These cores typically represent small areas of high deposition, not typical of the remainder of the Upper Hudson. The only data set with a sufficient number of samples to assess depth of contamination was the LRC program. As discussed at length previously (USEPA, 1998), the results showed that the maximum PCB concentration layer was the top layer (typically 0 - 23 cm) for the areas studied. While these cores cannot be considered representative of all areas of the Upper Hudson, for the fine-grained areas they indicate that PCBs remain close to the surface. This is consistent with the surface concentrations described above which indicate that much of the surface inventory of PCBs had to have been deposited in the 1970s and 1980s.

Finally, one last observation should be made concerning the nature of the PCB deposits of the Upper Hudson. The fine-grained PCB-bearing deposits were not created as the result of a gentle and gradual deposition process as might normally occur in a river with run-of-the-river dams. While this system is certainly no series of reservoirs (the linear velocities frequently exceed several feet per second during high flow), the dams should serve to create more depositional environments than in a "normal" river. Nonetheless, it is important to note that the majority of the PCB inventory of the Upper Hudson was probably deposited in a two- to four-year period subsequent to the removal of the dam at Fort Edward. This massive movement of sediments and PCBs blanketed the Upper Hudson and affected PCB inventories throughout the Hudson, as can be seen in high-resolution cores obtained anywhere in the river. Thus it is incorrect to assert that these catastrophically created deposits are now safely sequestered when they are so new geologically and clearly in evidence on the sediment surface. EPA cannot ignore their potential for continued long-term contamination of the Hudson throughout its length.

Ultimately, it may be that the strongest evidence to be seen are the fish body burdens themselves, which show little improvement since the late 1980s. This evidence in conjunction with the issues discussed in the foregoing text indicates that the EPA cannot accept the premise that the PCBs of the Hudson have been or will soon be permanently sequestered within the sediments.

References

Farrar, Kevin. NYSDEC. 2001. Personal communication from Kevin Farrar to Doug Tomchuk, USEPA Region 2. Re: Resuspension of PCBs during high flow. June 21.

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C – Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., The Cadmus Group, Inc., and Gradient Corporation. February.

USEPA. 1998. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C-A, Low Resolution Sediment Coring Report. Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Gradient Corporation, and Tetra Tech, Inc. July 1998.

Master Comment 641

Commenters contended that the low-resolution coring (LRC) study conclusions are based on faulty statistical analyses and provide no credible insights about sediment stability. Some say that the LRC sampling plan resulted in a statistical bias that must be accounted for, and that EPA has not adequately quantified uncertainties in the LRC estimates of PCB inventory change. Faults cited include inadequate quantification of uncertainties and a sampling bias toward areas with high PCB mass. A "corrected" statistical analysis provided by GE (its Appendix F.1) concludes that the LRC data "do not provide a basis for inferring a statistically significant change at the TIP" between sediment PCB data collected in 1984 and 1994.

Response to Master Comment 641

Several criticisms of the LRC study conclusions are based on the analyses provided in Appendix F.1 of GE's comments. The primary theory advanced in GE's Appendix F.1 is that the locations selected for the LRC analysis are biased high relative to the bulk of 1984 sediment samples, resulting in a regression toward the mean. This phenomenon reflects the fact that, for any pair of measurements subject to uncertainty, initial high values will tend to decrease on resampling, while initial low values will tend to increase, as the resampled values are expected to be more like the local mean value than the original measurement. Further, a bias or difference in the mean of the sample relative to the population mean of the data will amplify this effect. This would cause an analysis of differences between 1984 and 1994 sediment data to show an apparent decline in high mass areas, and an apparent increase in low mass areas. GE Appendix F.1 characterizes this as "the principal statistical error," and provides a correction that purports to show no statistically-significant change between results for 1984 and 1994 in TI Pool sediments.

The "regression toward the mean" issue was initially raised in a more qualitative manner in comments on the LRC Report (USEPA, 1998), and was answered at length by EPA in response to comment LG-1.37 (USEPA, 1999). That response acknowledged the existence of the regression toward the mean problem, but concluded that it did not invalidate the LRC conclusions. Comments received from GE on the FS in GE Appendix F.1 differ from the earlier comments in that a more quantitative analysis was applied, and a correction proposed. The proposed correction takes the following form, based on analysis of a bivariate normal problem (Equation 2 in GE Appendix F.1, with streamlined notation):

$$\mathbf{E}(D) = \mathbf{E}(d) - b * (\mathbf{E}(X) - M_x)$$

in which

E is the expectation operator (equivalent to "estimate" or "ave" in the original notation of GE Appendix F.1,)

D is the "object of the comparison" defined as the difference between 1984 average values for the whole TIP and the 1994 average values for the whole TIP [log scale]
d is the observed difference between 1984 and 1994 values for matched sample pairs
X is the 1984 PCB value at a given location
M_x is the average value for the initial population, defined in GE Appendix F.1 as the average of all samples taken in the TIP in 1984 [log scale]
b is a bias correction factor.

From this equation, the expectation of the observed change in PCB mass must be adjusted by a bias correction that depends on the difference between the expectation or mean of the selected sample set and the average of the population of the starting data.

EPA agrees that the form of this proposed correction is appropriate (given the assumption of lognormality) for the problem that is posed in GE Appendix F.1. The construct is misleading, however, because the problem that is posed in GE Appendix F.1 is not the one that is addressed in the LRC. That is, *D*, "the object of the comparison," is defined as the difference between the 1984 and 1994 average values for PCB mass in the whole of the TI Pool (Table 1 in GE Appendix F.1). In fact, the objective of the LRC was never to completely reevaluate the sediment PCB inventory throughout the TI Pool. Rather, it was to assess whether the 1984 data were still appropriate for estimating sediment inventory through evaluation of changes in inventory documented in 1984 in specific locations. Therefore, the definition of *D*, which is at the heart of the analysis presented in GE Appendix F.1, is inappropriate and not relevant to the LRC results.

As is evident from Equation 2 in GE Appendix F.1, the bias correction disappears if **E**(*X*), the average value of sample locations selected for analysis, is equal to M_x, defined as the average value for the initial population. For the LRC, the correct interpretation of *D*, or the "object of comparison," is the difference in PCB mass not across the entire TI Pool but within the selected areas included in the LRC sampling. The majority of the LRC samples were selected to lie within selected PCB hotspots as defined by NYSDEC based on the 1984 sampling, specifically *hot spots* 8, 9, 10 14 and 16. Most of those samples that were not located in *hot spots* were still in fine-grained (cohesive) areas of the TI Pool. Sixty-three of the 70 cores obtained for the LRC program were classified as fine-grained (LRC Responsiveness Summary, Table A-3). In the absence of locational error, resampling at these sites has an expected value [**E**(*X*)] that is exactly equal to the population mean of the selected sites (M_x). Further, if PCB MPA within the boundaries of a given hotspot is considered to be randomly distributed, as appears reasonable, locational error within a hotspot introduces no bias, as **E**(*X*) is still equal to M_x. Given that some small locational error is unavoidable and the exact boundaries of the cohesive areas are subject to some uncertainty, some of the new (1994) samples may be from a different population than the original 1984 samples.

However, as discussed at length in prior responses, this issue was minimized in the selection of the sampling areas for study by the low resolution coring program, a fact that is ignored by GE's

comments. Specifically, the sites selected exhibited relatively low variability in PCB mass (typical range within a selected 1984 cluster was a factor of two between the minimum and maximum). Additionally, the 1992 side-scan sonar data were used to further refine the selected clusters so as to choose those clusters exhibiting a consistent sediment texture within the area enclosed by the 1984 sampling points. As noted in the DEIR (USEPA, 1997), the side scan sonar images are well correlated with the 1984 PCB measurements. Thus the cluster choices made by EPA served to minimize the variance within each cluster for both the 1984 and 1994 sampling, and thereby enable a direct comparison of the cluster results.

This would introduce a small amount of sampling bias, but should not effect the conclusions of the LRC unless a large proportion of the 1984 samples were mis-located relative to sediment boundaries defined by the side scan sonar survey, an unlikely occurrence given the noted correlation between the two results. Therefore, the "regression toward the mean" effect is not expected to have a significant effect on LRC conclusions, as long as these conclusions are properly framed as representative of temporal trends for specific sample cohesive sediment areas, rather than average changes across the TI Pool as a whole.

GE's analysis is also based on the difference in log space of the molar concentrations between 1994 and 1984, and thus differs from EPA's analysis, which was based on the relative fractional change in mass and moles per unit area with post-transformation to a logarithmic basis. Essentially, GE is examining the log transform of the ratio of 1984 to 1994 sample results, whereas EPA examined the log transform of the ratio of the arithmetic difference (1994 minus 1984) to the original 1984 result. Because GE's analysis does not address the same quantity as the EPA analysis in the LRC, its applicability to the EPA results is unclear.

Despite these fundamental differences in approach, GE applied the proposed bias correction method and concluded that the 95 percent confidence interval on *D* included zero, and thus concluded that "the bias-corrected conditional analysis of the survey data does not support rejection of the hypothesis of no change between 1984 and 1994." It is worth noting, however, that the central estimate of the range for *D* provided by GE is a loss of 22 percent. GE's analysis and redefinition of the target quantity of interest has thus expanded the confidence interval, reducing the statistical certainty of the result, yet still provides a best estimate result that is qualitatively consistent with EPA's analysis.

GE's Appendix 3.1 develops the bias correction factor based on a regression of the 1984 to 1994 change [log 10 scale] versus the 1984 MPA of a sample location [log 10 scale, evaluated as moles/m^2]. The relationship proposed by GE is shown in Figure 641-1 (Reproduction of Figure 3 from GE Comments, Appendix F.1). Examination of this figure is enlightening. First, the figure is structured so that a value greater than 0 on the y-axis is equivalent to a net mass loss from 1984 to 1994, and all samples with a 1984 MPA greater than -1.8 (log 10 moles/m^2) are shown to have an estimate loss of mass. GE fit a linear regression to these data, and determined a statistically significant slope, indicating a bias. It is obvious, however, that the statistical significance of the slope is due almost entirely to the high leverage exerted by three points, all of which had an initial log 10 MPA less than -2.3, and all of which were estimated to have experienced mass gains. These three points were, by definition, not hot spot samples, and are likely not relevant to analysis of change over time in the hot spot areas. (GE does not provide any leverage diagnostics or other careful examination relative to these influential points.) When

the right-hand half of the graph is examined (those points with initial MPA greater than -1.5), it is evident that the distribution against original MPA is nearly random, and that there is no significant regression slope. This would imply that *b* is actually near zero for all the hot spot samples, and thus the bias correction is also near zero. GE does present results for a high-low split of the data, but applies the single bias correction factor *b* to both groups. GE's figure clearly suggests that this is not appropriate.

GE's Appendix 3.1 also presents a similar "bias correction" analysis of the cluster mean data as a commentary on the alternative analysis of the LRC data presented by EPA in Appendix A of USEPA, 1999. (Note that the cluster mean analysis is clearly presented as "an alternate basis to examine the change in the PCB sediment inventory between 1984 and 1994" (USEPA, 1999, p. A-1) and does not replace EPA's earlier point-to-point analysis.) GE's analysis of the cluster mean data is subject to problems similar to those noted for the point-to-point analysis. Most importantly, the quantity of interest examined by GE (an estimate of the PCB inventory for the entire TI Pool) is not the one that is addressed in the LRC.

Part 6 of GE's Appendix 3.1 discusses a number of additional potential adjustments for data imprecision. The two issues addressed are the assignment of an effective contamination depth to grab samples and the assignment of PCB concentrations to mass spectrometer ranges. GE treats these two sources of uncertainty as multiplicative (additive in log space), although no justification for this error structure is provided. Because the majority of the grab samples and the majority of the core sections screened by mass spectrometry only represent analyses that have lower PCB concentrations than the mean, the effect of this is to increase the spread of the low mass sample points and decrease the overall mean value for the TI Pool.

Because GE's bias correction factor depends on the difference between the mean of the samples used in the LRC and the overall mean of TI Pool samples, inclusion of the proposed analytical errors results in an increase in the potential bias and a reduction in the estimated mass loss. But, as noted above, EPA believes that GE is focusing on the wrong "object of comparison" (*D*), and these calculations are thus not relevant to the LRC conclusions.

It is worth noting that Table 5 in GE Appendix F.1, which incorporates all of the statistical methodologies identified by GE for reducing the estimate of mass loss, still reports a central tendency estimate that loss has occurred ($D = 0.90$), although the value is not reported as significantly different from zero. Indeed, Appendix F.1 does not deny the existence of mass loss, but concludes that "the TIP did not experience a PCB change large enough to be detected by the survey design that was used." GE's key misconception is captured in the wording "the TIP." As noted above, the LRC does not purport to show a net mass loss from the sediments of the TI Pool taken as a whole. Rather, it should be interpreted as demonstrating mass loss from the specific cohesive sediment areas investigated in the LRC.

To the extent that the areas selected for study by the LRC are reflective of the fine-grained sediments of the TI Pool as a whole, PCB losses would be expected from these areas as well. This is not to say that the entire TI Pool has experienced PCB mass loss as a whole, since this issue was not examined by the LRC program. Nor can it be concluded that all fine-grained areas of the TI Pool have experienced PCB loss. Ultimately, the LRC analysis comes down to the following: 13 areas of the TI Pool were sampled and compared with historical data from the

same areas. All but three of these areas exhibited a mass loss of Tri+ PCBs. After correcting for dechlorination losses, the estimated average mass loss of Tri+ PCBs for the entire set of study areas was 43 percent, with 95 percent confidence limits on the mean ranging from a loss of 58 percent to a gain of 1 percent. The mean mass loss of Tri+ PCBs, excluding dechlorination, is statistically different from zero at the 90 percent confidence level (USEPA, 1999, p. A-10).

EPA has used the results of the LRC as one among several lines of evidence to conclude that the PCBs in the fine-grained sediments of the TI Pool have not been permanently sequestered. Response to Master Comment 619 in Section 2.1 contains a complete review of the evidence suggesting lack of sequestration of sediment PCB inventories. The PCB inventories in some, and perhaps many, fine-grained areas of the pool continue to decline with time. In fact, as noted in White Paper – Relationship Between PCB Concentrations in Surface Sediments and Upstream Sources, portions of the historical inventory of PCBs remain at the sediment surface and serve as a continuing source of PCBs to the water column and biota. Clear evidence for this provided by the observation that PCB concentrations in the water column during summer and in biota have remained approximately constant from 1995 to 2000, despite remedial actions to control the upstream sources (Response to Master Comment 631, Section 2.6; White Paper – Trends in PCB Concentrations in Fish in the Upper Hudson River).

References

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C – Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., The Cadmus Group, Inc., and Gradient Corporation. February.
USEPA. 1998. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C-A, Low Resolution Sediment Coring Report. Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Gradient Corporation, and Tetra Tech, Inc. July.

USEPA. 1999. Responsiveness Summary for Volume 2C-A, Low Resolution Sediment Coring Report. Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc. and Tetra Tech, Inc., February.

Master Comment 625

Commenters said that the conceptual design of the sampling plan for EPA's low-resolution sediment coring (LRC) effort was inadequate and not properly designed to evaluate changes over time. Commenters claimed that the interpretations and conclusions in the LRC and FS regarding loss of PCB mass from the hot spots are incorrect. Commenters also stated that mass balance analysis of PCB loading past the TI Dam conflicts with EPA interpretations of redistribution of PCBs out of previously-identified hot spot areas.

Response to Master Comment 625

This response is one of two addressing a set of comments on EPA's LRC effort. The focus of this response is on interpretation of the LRC results. Response to Master Comment 641 (Section 2.2) addresses comments regarding statistical procedures used in the LRC analysis.

Conceptual Design

GE states that "EPA collected 63 'low resolution' sediment cores with the intent of comparing these cores to the 1,109 cores and grab samples collected by NYSDEC in 1984 to measure any change in PCB mass during that period." The comment continues to state that "EPA took an insufficient number of samples to do a fair comparison to NYSDEC's large database." Further, the sampling was "biased to areas where high concentrations of PCBs had been found in 1984."

These statements are misleading, and have already been answered in USEPA, 1999. The objective of the LRC was never to completely reevaluate the sediment PCB inventory throughout the TI Pool. Rather, it was to assess changes in inventory documented in 1984 in specific locations.

In fact, the 60 LRC sample locations used for analysis in the TI Pool were located in 16 discrete areas of the pool and were collected at *exactly the same sampling density* as originally performed by NYSDEC, with samples collected at approximately the same locations as those occupied by NYSDEC.

These 16 areas were selected from throughout the TI Pool and represent a range of contamination and sediment textures, although they focus principally on fine-grained sediments. The data set is sufficient for the purpose for which it was intended, *i.e.*, assessment of the direction and approximate magnitude of the change in sediment inventory at these locations between 1984 and 1994.

EPA agrees that the sampling was focused on high concentration areas. This was intentional and does not represent a flaw, as the primary intention of the LRC was to examine changes in inventory within identified hotspot areas (and thus was "biased" toward these areas). EPA examined a representative subset of the previously quantified fine-grained sediment areas within the TI Pool, and the main conclusions of the LRC apply to such areas, and not to the pool itself. This point is clearly made both in the LRC Report (USEPA, 1998) and in the Responsiveness Summary (USEPA, 1999).

Sampling

GE states that "EPA attempted to take its cores from the same points where NYSDEC found higher concentrations. EPA was unable to take cores from exactly the same points at which NYSDEC took cores." The comment continues to state that EPA could not match its cores with "sufficient precision" to those taken by NYSDEC.

EPA agrees that it was not possible to exactly match LRC sample locations to the 1984 cores taken by NYSDEC, although the spatial error is believed to be low, with 93 percent of the paired

locations separated by less than eight feet (USEPA, 1999, Response to LG-1.9). The presence of a small amount of locational error is not a bar to the analysis, although it contributes to uncertainty.

Since EPA's evaluation is based on the average difference between the sixty 1984-1994 sample pairs, it is only necessary that the two data sets represent unbiased samples of the same underlying "population" of PCB concentrations in specific sediment areas. The use of geophysical information in screening sample sites helped to ensure that both the 1984 and 1994 members of sample pairs are indeed samples from the same sediment structure. Further, by examining the average difference of pairs and testing for its statistical difference from zero, the analysis is not dependent upon the absolute accuracy of any individual measurement.

Uncertainty

Comment 04-0287-016 states that the LRC "was not properly designed for any analysis of the components of variance, and consequently provided no estimates of error," citing comments of "several peer reviewers." "Overlapping subject studies by GE" are claimed to provide error estimates and "dispute all of the LRC conclusions."
The LRC was designed primarily for pair-wise comparison between 1984 and 1994 cores. Information on the uncertainty in LRC results is summarized in Table 4-7 of USEPA (1998) and is discussed at length in USEPA (1999). An alternative analysis, presented in Appendix A of USEPA, 1999, examined the data on a grouped or stratified basis. GE has submitted analyses that suggest that the magnitude of estimated PCB loss is over- estimated in both USEPA, 1998 and USEPA, 1999. However, the data continue to show a trend of loss of mass from hotspot areas in the TI Pool between 1984 and 1994. Response to Master Comment 631, Section 2.2, contains additional relevant discussion.

The reference to "overlapping subject studies by GE" is obscure, but presumably refers to GE's effort to reoccupy some of the LRC sites in 1998. In comments on the LRC (LG-1.17A), GE supplied a comparison between 1994 and 1998 estimates, but the data set used in the comparison was quite small (12 locations) and insufficient to estimate differences between 1994 and 1998. The extensive comments on the FS submitted by GE do not contain any additional attempts to estimate sediment PCB loss rates based on GE data.

LRC Conclusions

GE comment 11-0101-028 states that the conclusion of significant mass loss between 1984 and 1994 is "false and unsupportable" due to the use of incorrect statistical procedures.

The statistical issues are addressed in Response to Master Comment 641 (Section 2.2), which demonstrates that the statistical procedures are correct. As noted therein, EPA believes that the LRC data do indeed demonstrate a mass loss from sampled cohesive sediment areas in the TI Pool between 1984 and 1994.

The comment also characterizes the LRC conclusions as stating that 40 percent of the PCB mass in the TI Pool *hot spots* had been "lost," that there was no widespread burial of PCBs, and that

"PCBs were being redistributed within the sediments by some unidentified, magical mechanism."

The "40 percent" number presented in the LRC is a best estimate of an uncertain rate of PCB Tri+ mass loss between 1984 and 1994 that is acknowledged by EPA to have a wide range, but to be greater than zero. (The re-evaluation of the data in USEPA, 1999, Appendix A, presents a 95-percent confidence range on the mean change in PCB Tri+ inventory in the sampled areas from a loss of 58 percent to a gain of 1 percent. This re-evaluation notes, however, that the mean loss is significantly different from zero at the 90-percent confidence level.) The estimated mass loss correctly applies only to the cohesive sediment areas actually sampled by EPA in 1994.

EPA believes that lack of "widespread burial" is evident from multiple sources, including the EPA high resolution cores, the EPA low resolution cores, and the GE 1998 sediment sampling. Interpretation is subjective, however, depending on what is meant by "widespread" and what is meant by "burial." EPA's assertion should be understood to mean that high concentrations of historically deposited PCB mass remain near the surface and potentially bioavailable (within 10 cm) at many (but not all) of the PCB hot spots identified by NYSDEC in 1984. Further evidence for this assertion, based on the most recent GE sediment data, is provided in Response to Master Comment 637 in Section 2.3.
Finally, GE comment 11-0101-028 states that EPA did not collect data appropriate to determine changes in surface concentrations over time, whereas GE did collect such data, which "show a continuing decline in PCB concentrations in surface sediments." Comment 22-0019-23B notes that the LRC cores do not have sufficient resolution to determine surface PCB concentrations, and claims that EPA uses these cores to claim that the LRC cores "show the majority of the PCB inventory is in the active surface layer."

As discussed in Response to Master Comment 627 (Section 2.7), the database for the Reassessment RI/FS includes data collected by EPA, GE, NYSDEC, USGS, NOAA, and others. EPA used sediment data collected by GE as soon as such data were made available. The evidence contained in the GE 1998 sediment sampling does not clearly show a "continuing decline." Declines are evident in some sample locations, but other contaminated locations do not show a significant decline in surface sediment concentrations since the 1991 GE sampling. Indeed, some locations appear to show an increase. Responses to Master Comments 619 (Section 2.1), 621 (Section 2.1), 633 (Section 2.6), and 637 (Section 2.3) contain further details.

The LRC cores themselves do not show that the majority of the PCB inventory is in the "active" surface layer, if "active" is defined as the zone subject to bioturbation and ready exchange with the water column. Instead, the LRC cores merely show that a large portion of the PCB inventory in the sampled areas remains within a small distance of the surface. Other sediment data, with finer vertical resolution, confirm that high concentrations of PCBs do remain within the currently active surface layer.

Mass Balance Analysis of PCB Loads

GE comments 11-0103-034 and 11-0103-035 state that estimates of mass loss from the TI Pool obtained from GE's model for 1983 to 2000 account for about four percent of the entire

estimated 1984 Tri+ PCB inventory. This is contrasted to the LRC conclusions and presented as "strong contradictory evidence."

The LRC should not be construed to indicate that the PCB mass loss rate estimated for sampled cohesive sediment areas is equivalent to PCB mass mixed into the water column and transported downstream. The estimated mass loss rate from these selected areas cannot be applied to the whole TI Pool inventory and compared to water column mass transport estimates. This issue was addressed at length in USEPA, 1999.

First, EPA's mass loss estimates properly apply only to the types of sediment areas that were sampled in 1994, not to the entire inventory.

Second, EPA's conclusion was that PCB mass had moved out of many of the previously defined hotspot areas, not that it had been transported downstream. This includes PCBs redistributed by bulk movement of sediment and PCBs that were mobilized into the water column but redeposited within the TI Pool.

Use of the LRC Results in the FS

Comment 04-0287-016 states that EPA used the LRC as the basis for erroneously concluding that buried PCB mass contributes to water column loading and therefore must be removed from the river to prevent further release. Similarly, Appendix F.1 to GE's comments contends that statements in the FS "lead the reader to believe that the LRC study produced unequivocal evidence leading to the Agency's conclusion that the Upper Hudson River sediments are unstable."

The LRC is *not* the primary basis for determining the need for remediation or for evaluating remedial options. The need for remediation is based on a number of factors, including the fact that risk-based concentrations are not met under current conditions and are not expected to be met for many decades under No Action, based on EPA's fate and transport modeling, (which, in fact, does not depend on the LRC). The comparative evaluation of remedial options is also based in part on the modeling.

In Section 3.5.1 of the FS, the results of the LRC are cited as one among 16 "lines of evidence" in the determination of target area selection criteria. Similarly, the LRC results are only one among many lines of evidence regarding the lack of assured stability for buried PCBs in Hudson River sediments (Response to Master Comment 619). The general conclusions of the LRC are appropriate and have been supported by the peer review on the DEIR and LRC. But, even if the LRC results were dismissed entirely, the many other lines of evidence would still lead to the same identification of target areas.

References

USEPA. 1998. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C-A, Low Resolution Sediment Coring Report. Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Gradient Corporation, and Tetra Tech, Inc. July.

USEPA. 1999. Responsiveness Summary for Volume 2C-A, Low Resolution Sediment Coring Report. Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc. and Tetra Tech, Inc., February.

2.3 Other Geochemistry Issues

Master Comment 575

Commenters stated that EPA needs to make a more thorough effort of examining PCB release mechanisms. Commenters claim that EPA failed to collect data to determine the reason for the declining trend in PCBs that it identified in the Phase 1 report. Commenters also state that the FS does not look beyond the water column in its analysis, and that EPA should conduct a closer examination of the uptake of PCBs by submerged rooted macrophytes and subsequent translocation of PCB concentration and possible diminished summer PCB levels in sediments. Commenters also state that temporal trends are only discussed qualitatively and poor statistical trend analysis had been performed.

Response to Master Comment 575

In the Phase 1 Report, EPA noted that loads and concentrations in the late 1980s were substantially lower than those seen in the mid-1970s. However, the EPA also noted that conditions had not changed much during the late 1980s, roughly from 1985 to 1990. Thus the question at the end of Phase 1 was not "Why were PCB levels declining?" but rather, "What was keeping conditions so constant?"

To address this question, EPA undertook a series of sampling studies to elucidate the current sources of PCBs responsible for maintaining the conditions observed. Since it was unclear at the time of the Phase 1 Report (1991) where PCBs originated, it would have been inappropriate to begin a study of mechanisms for PCB release. A study of mechanisms rather than sources might have easily yielded much data about unimportant processes without ever identifying the important sources. Thus the Phase 2 efforts focused on loads and sources. This is not to say that EPA did not examine historical records. In fact, EPA collected a series of dated sediment cores to study and confirm the general lack of recovery in the system to that point in time. Only by understanding the sources and confirming the observed trends could the EPA hope to estimate future conditions.

To this end, EPA's studies, along with the federally mandated monitoring conducted by GE, clearly documented the importance of the sediments to the PCB budget. Despite the occurrence of the Allen Mill event, both the EPA and GE data show the sediments to be the major source of PCBs (currently more than 80 percent) to the water column. This information, along with the various ecological studies which link the sediment and biota PCB contamination, form an important component in the EPA's decision to remove the contaminated sediments.

Detailed discussions on PCB trends in fish tissue, the water column, and surface sediments are provided in Section 2.6 (Responses to Master Comments 629, 631, and 633 respectively), and a general discussion of PCB trends is also provided in Section 2.6 (Response to Master Comment 635).

The initial decline in PCB loads and concentrations in the Upper Hudson may be attributable to several different coincident occurrences of the late 1970s. Among them are:

- A decline in the erosion of the remnant deposits resulting from almost continuous erosion after the dam was removed.
- Cessation of PCB discharges at the GE plant sites.
- Cessation of navigational dredging activities in 1979.

In every case, the mixture of PCBs involved would be very similar. Thus, no PCB fingerprint could tease out one effect from another. EPA attempted to evaluate historical transport through high resolution cores and evaluation of historical data, but these were insufficient to distinguish which of the above-mentioned occurrences were responsible for the historical declines. More to the point, there was little need for such elucidation since it was clear at the start of the Reassessment that the decline seen in the late 1970s and early 1980s was no longer occurring (Responses to Master Comments 629, 631, 633, and 635, Section 2.6). Rather, as discussed above, the EPA focused on identifying the current sources responsible for the extensive PCB contamination still present in the Upper Hudson and impacting the region downstream.

In this regard, the EPA has conducted an extensive series of statistical analyses on the water column, sediments, and biota of the Upper Hudson. These analyses were neither simple nor statistically inadequate. These analyses included linear regression, test of means, ANOVA, MANOVA, kriging, and principal components analysis, among others. In every report, the EPA makes use of statistical analyses to support its assertions.

This is not to say that the EPA has not examined the PCB release mechanisms involved. EPA's HUDTOX and DOSM models have extensively examined PCB release processes throughout the Upper Hudson. To this end, the models explicitly represent resuspension, porewater diffusion, dissolution, and other geochemical mechanisms. These models rely on the long series of historical records of PCB levels in the Upper Hudson to establish the importance of the mechanisms they represent. The HUDTOX model in particular represents many complicated mechanisms governing PCB transport. In fact, the simulations from the HUDTOX model document the importance of the unknown summertime sediment release process, since the model is unable to achieve a mass balance without it. Further discussion on the evidence and possible processes for this mechanism as well as its importance to PCB loads in the Upper Hudson can be

found in Section 2.1, Responses to Master Comments 621 and 623, as well as in Section 2.3, Response to Master Comment 637.

Commenters suggest one potential mechanism in particular, the release of PCB from the sediments via large aquatic plants or macrophytes, as warranting further exploration. The roots of these plants exist largely within the contaminated sediments of the Upper Hudson and may represent an important pathway for PCB release. Given that the main PCB loads from the sediments occur during the warmest periods of the year (May through October), such a mechanism would be temporally consistent with the observations. Evidence for such release for nutrients was found by Templer *et al.*, 1997.

With regard to subsequent study of release mechanisms such as a plant root pathway, the EPA does not feel that further study, with the associated delay, is warranted or necessary in order to achieve the desired reduction in PCB levels in fish, water, and sediment. The data set is sufficient to identify the sediments of the Upper Hudson as the major source of PCBs to the water column and the biota, with the fine-grained (cohesive) sediments as the most important areas for the biota. The modeling analyses clearly identify the occurrence of such a release. Whether the mechanism is plant roots or benthic invertebrate activities, it is clearly the near-shore sediments that are responsible (FS, Appendix D1). Concentrations in surface sediments in many locations are clearly too high to have been deposited anytime in the last five years and possibly the last 15 years in some cases, thus eliminating the process of deposition and burial as a rapid means of isolating PCB from the environment. While further study can always improve the understanding, the current understanding is sufficient to warrant implementation of the selected remedy.

Reference

Templer, P., S. Findlay and C. Wigand. 1997. Sediment Nutrient Chemistry Associated with Native and Non-native Emergent Macrophytes of a Hudson River Marsh Ecosystem. Institute of Ecosystem Studies, Millbrook, NY.

Master Comment 253430

Commenters state that naturally occurring bacteria from the Hudson could destroy lightly chlorinated PCBs. Commenters also state that the dechlorinated PCBs are less toxic and less bioaccumulative.

Response to Master Comment 253430

The EPA is aware of the scientific literature that documents the degradation of selected PCB congeners under aerobic conditions in laboratory settings or in the environment (for example, see Williams and May, 1997 and Mohn *et al.*, 1997). In general, these congeners tend to be the less-chlorinated PCBs produced under anaerobic dechlorination. Alternatively, these processes tend to be very slow and do not represent a significant rate of loss. As part of the Phase 2 investigation, EPA considered the importance of aerobic degradation in two separate reports. The

Revised Baseline Modeling Report discusses aerobic degradation but does not include it in the model simulation because of its apparent small scale relative to other processes.

EPA also directly examined the degree of aerobic degradation occurring within the water column of the Upper Hudson during the transport of PCBs from the TI Pool to Waterford (USEPA, 2000). In this analysis, EPA examined transport and gas exchange and found evidence for the loss of only two of the lightest congeners (BZ#1 and BZ#8). The vast majority of the congeners saw no change in water column inventory beyond that expected from gas exchange. Thus, aerobic degradation was not a significant loss process for the PCB congeners during the study intervals. This is not to say that aerobic degradation was not occurring, but simply that it was small in relation to advection and gas exchange. On the basis of this analysis EPA concluded that the vast majority of the PCBs found in the water column were transmitted to the Lower Hudson or released via gas exchange. Since the sediments of the Upper Hudson are largely anaerobic, the water column represents the main aerobic environment for PCB fate. Given the absence of substantive degradation within the water column, aerobic degradation does not appear to be an important process for PCB destruction in the Upper Hudson in general.

It is EPA's position that these less chlorinated congeners are still toxic and that toxicity is reflected in the cancer slope factors and reference doses. This is further discussed in Responses to Master Comments 541 and 571 (Chapter 3).

References

Mohn, W. W., K. Westerberg, W. R. Cullen, K. J. Reimer. 1997. Aerobic Biodegradation of Biphenyl and Polychlorinated Biphenyls by Arctic Soil Microorganisms. Applied and Environmental Microbiology, pp 3378 - 3384.

Williams, W.A. and R.J. May. 1997. Low-Temperature Microbial Aerobic Degradation of PCB in Sediment. Environmental Science & Technology, Vol. 31, No. 12.

USEPA. 2000. Response to Peer Review Comments on the Data Evaluation and Interpretation Report (DEIR) and the Low Resolution Sediment Coring Report (LRC), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc. and Tetra Tech, Inc., November.

Master Comment 253424

Commenters state that EPA is convinced that buried sediments control the PCB release processes, and that EPA does not consider the importance of sediment/water interface geochemical processes such as dissolution, suspension, adsorption, diffusion, emulsion formation, etc. in arriving at its decision to remediate the “buried” PCBs. Thus, commenters state that EPA has targeted PCB mass, and not PCB concentrations, in its selection of target areas.

Response to Master Comment 253424

EPA agrees that a variety of complex geochemical phenomena control PCB exchange at the sediment-water interface. Over the short term, these phenomena may well describe loading of PCBs into the water column by abiotic processes, although the data do not exist to adequately quantify the mechanisms responsible for these processes in the Hudson River. Two facts are important to note:

- Exchange of PCBs from the sediment to the water column appears to be driven to a large extent by biological processes, including bioturbation and excretion of fecal pellets by benthic organisms, as described in Response to Master Comment 621 (Section 2.1). These processes do not depend solely on rate-transfer kinetics at the sediment-water interface, and may operate to depths of 10 cm or more (Response to Master Comment 637, Section 2.3).
- The net results of the processes cited in the comment are well documented in observational data (Response to Master Comment 623, Section 2.1). It is neither necessary nor appropriate to derive a dynamic, kinetic model of short-time-frame kinetic exchange processes at the sediment-water interface. Over the long time horizons addressed in the HUDTOX modeling, the net effect of the mechanisms of exchange are well summarized by an empirical exchange coefficient, as was done in the RBMR (USEPA, 2000). GE handled such exchange in a similar manner in its model.

EPA has never stated or inferred that PCBs in sediments well below the surface are responsible for the contamination of the water column and biota, although PCBs buried in sediment up to depths of 10 cm or more may contribute to this contamination (Response to Master Comment 637). Further, as discussed at length in Response to Master Comment 607 in Chapter 4 of this document, as well as in the DEIR (USEPA, 1997), the current levels of PCBs within the surface sediments could not have been achieved within the last 10 to 15 years solely as a result of the upstream source. Thus, historical deposited PCBs remain at the sediment surface, unsequestered by burial in many locations. The commenter incorrectly equates historical deposits to buried deposits.

Recognizing that the sediment/water interface in a river is not a stagnant boundary where the net sediment movement is always downward, EPA cannot assume that deeper PCB contamination will always remain buried. Response to Master Comment 619 in Section 2.1 contains additional discussion of this issue. Intrinsic in the nature of a river is the constant reworking of its bed. Thus, sediments at depth, while not active today, may be made available at some later date. EPA, in selecting its target areas, recognized the potential for deeper PCBs to be unearthed and placed at the sediment/water interface.

As noted in Response to Master Comment 597 in Chapter 4 of this document, the EPA used several different criteria in its selection of target areas. As can be seen in Figures 597-1 through 597-5, surface PCB concentrations and sediment PCB mass (as MPA) are correlated. Thus, the areas identified by surface concentration are similar to those identified by MPA. More to the point, the targeting criteria used by EPA more efficiently captured high surface concentrations than high MPA values. This is a direct impact of EPA's recognition of the importance of surface

sediments in controlling current PCB release and exposure. By also recognizing the importance of in-place inventories through the use of MPA, EPA recognizes the dynamic and temporary nature of the PCB storage within the riverbed.

References

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C – Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., The Cadmus Group, Inc., and Gradient Corporation. February.

USEPA. 2000. Phase 2 Report, Further Site Characterization and Analysis. Volume 2D – Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc., January.

Master Comment 637

Some commenters suggested that sediment cores demonstrate that the "vast bulk" of historically deposited PCBs are sequestered and not bioavailable, because they are buried too deeply. It was also suggested that EPA use sediment profile imaging to estimate bioturbation depth.

Response to Master Comment 637

Detectable PCB contamination occurs across a wide range of sediment depths in the Hudson River. It is not only those PCBs that lie at the sediment surface that are directly available to the food chain. Organisms that bury and feed in the sediments can access PCBs buried below the surface, and can play a significant role in transporting hydrophobic contaminants into the water column and the food chain (Reible *et al.*, 1996; Menzie, 1980; Robbins, 1982). Feeding activities of organisms such as tubificid oligochaetes have been shown to efficiently rework and mix freshwater sediments to depths of 6 to 9 cm or more (Fisher and Lick, 1980; Karickhoff and Morris, 1985). By feeding at depth and excreting fecal pellets at the surface, these organisms create a "conveyor belt" that transports contaminants to the surface where it is also available to non-burrowing organisms.

It is true that a portion of the PCBs stored in the sediments of the Upper Hudson River currently may lie at a greater depth than is readily available to benthic organisms. This fact is largely irrelevant, however, to the assessment of risks in the Hudson, given that the PCB mass that does lie within the bioavailable zone is sufficient to result in unacceptable concentrations of PCBs in benthic organisms and fish. Further, the fact that PCBs are buried now does not necessarily mean that they will always remain deeply buried. Response to Master Comment 619 in Section 2.1 contains further details on the stability of buried PCB sources.

Defining the exact fraction of the sediment PCB mass that is bioavailable under current conditions is difficult because bioavailability depends on the depth of benthic biological activity,

which varies at a fine spatial scale according to characteristics of the sediment and the types of benthic organisms present.

Modeling conducted in support of the FS assumed that it is predominantly the PCBs present in the top 5 cm of the sediment that influence the food chain in the upper Hudson River; however, a portion of the PCBs in biota may also derive from greater depths. EPA's model represents this by calculating sediment-based bioaccumulation from the top two sediment layers (approximately 5 cm), while specifying a cohesive sediment mixed layer depth of 10 cm. As a result, while only PCBs in the top 5 cm are directly bioavailable in the EPA models, PCBs in the top 10 cm (in cohesive sediments) can influence the food chain by mixing with and replenishing PCBs in the top layers.

Little direct evidence on bioturbation mixing depths in the Upper Hudson is available at this time, but the assumption that the most important contribution is from the 0-5-cm active zone is consistent with observations from lakes indicating maximum tubificid activity at depths from 2 to 9 cm and maximum oligochaete activity at depths from 1 to 3 cm (Fisher and Lick, 1980; Milbrink, 1973; Krezoski *et al.*, 1978). However, there is also evidence for benthic activity to much greater depths. Millbrink (1973) noted tubificid penetration in lake muds up to 15 cm. *Chironomus*, which is abundant in the Hudson River, can burrow as deep as 50 cm (Charbonneau and Hare, 1998). *Hexagenia limbata* is reported as routinely burrowing to depths of 10 cm and can excavate 52 cm^3 per m^2 per day (Charbonneau and Hare, 1998). A number of megadrile oligochaetes are routinely reported at depths of 10 cm, while certain tubificids have been collected at depths greater than 1 m (personal communication from Ken Fritz, Aquatic Ecology Laboratory, Department of Biological Sciences, Auburn University, Auburn, AL to Ken Cerretto, Menzie-Cura & Associates, 2001).

It is therefore appropriate to assume that the most bioavailable PCBs in sediments are those lying at a depth up to 5 cm, but that a reduced level of bioavailability extends much deeper. Fine-scale cores collected by GE in 1998 and segmented at 1 cm intervals over the top 5 cm generally show little trend in concentration from 0 to 5 cm, consistent with efficient bioturbation of this zone. Mixing of sediments by benthic organisms is likely to occur up to at least 10 cm, and some mixing may occur to much greater depths under favorable conditions. EPA believes that the representation used in the model (direct bioavailability to benthic organisms to a depth of about 5 cm, with mixing down to 10 cm) is an appropriate average representation of typical conditions in the contaminated cohesive sediment areas of the TI Pool.

NOAA comments suggested the use of sediment profile imaging to obtain measurements of average bioturbation depth, and noted that bioturbation depth might increase as conditions at the Site improve. EPA appreciates this suggestion, and will consider the use of this technique in the monitoring program. There are concerns, however, as to the accuracy of reach-scale estimates that could be obtained in the highly heterogeneous sediment of the Upper Hudson.

Finally, it should be remembered that PCBs that are buried below the bioavailable zone are not sequestered from the environment, even if they lie in thoroughly stable sediment deposits. Movement of porewater is driven by diffusion, benthic invertebrate activity (*e.g.*, burrowing), desorption, groundwater movement through sediments, bioturbation, and processes in the rhizosphere (*e.g.*, uptake of water by plant roots, which causes cracks in the sediment) (Weiner,

2000; DePinto *et al*., 1994). This movement will gradually transport dissolved and colloid-sorbed PCBs from deeper to shallower sediment zones and, over time, will replenish PCBs in the bioavailable zone unless active remediation is undertaken.

References

Charbonneau, P. and L. Hare. 1998. Burrowing behavior and biogenetic structures of mud-dwelling insects. *J. N. Am. Benthol. Soc*., 17(2): 239-249.

DePinto, J.V., W. Lick, and J.F. Paul. eds. 1994. Transport and Transformation of Contaminants near the Sediment-water Interface. Lewis Publishers, Boca Raton, Florida.

Fisher, J.B. and W.L. Lick. 1980. Vertical mixing of lake sediments by tubificid oligochaetes. *J. Geophysical Res*., 85(C7): 3997-4006.

Karickhoff, S.W. and K.R. Morris. 1985. Impact of tubificid oligochaetes on pollutant transport in bottom sediments. *Environ. Sci. Technol*., 19: 51-56.

Krezoski, J.R., S.C. Mozley, and J.A. Robbins. 1978. Influence of benthic macroinvertebrates on mixing of profundal sediments in southeastern Lake Huron. *Limnol. Oceanogr.*, 23: 1011-1016.

Menzie, C.A. 1980. Potential significance of insects in the removal of contaminants from aquatic systems. *Water, Air, and Soil Pollution*, 13: 473-479.

Millbrink, G. 1973. On the Vertical Distribution of Oligochaetes in Lakes Sediments. Report No. 53. Institute of Freshwater Research, Fishery Board of Sweden.

Reible, D.D., V. Popov, K.T. Valsaraj, L.J. Thibodeaux, F. Lin, M. Dikshit, M.A. Todaro, and J.W. Fleeger. 1996. Contaminant fluxes from sediment due to tubificid oligochaete bioturbation. *Wat. Res.*, 30(3): 704-714.

Robbins, J.A. 1982. Stratigraphic and dynamic effects of sediment reworking by Great Lakes zoobenthos. *Hydrobiologia*, 92: 611-622.

Weiner, E.R. 2000. Applications of Environmental Chemistry: A Practical Guide for Environmental Professionals. Lewis Publishers, Boca Raton, Florida.

Master Comment 639

Commenters observed that research by EPA, GE, and others demonstrates that anaerobic dechlorination of certain PCB congeners occurs in sediments of the Hudson under the proper conditions. One comment asked why EPA "does not fully examine how rapidly and to what extent natural decay would care for the residual contamination in the river south of Fort Edward." Differing viewpoints were presented as to whether this process is or is not reducing the mass of PCBs and the exposure to PCBs in the Hudson.

Response to Master Comment 639

EPA has examined the extent of PCB dechlorination in both of its geochemical reports (USEPA, 1997, USEPA, 1998). As discussed in these reports, the extent of dechlorination varies with initial PCB concentration such that the most contaminated sediments typically exhibit the greatest degree of dechlorination. Within the Upper Hudson, many sediments exhibit high degrees of dechlorination. However, these sediments still contain significant fractions of their original mixture, thus they still exhibit much of their original toxicity.

This issue raised relative to natural decay and residual contamination is addressed at length in Section 4.3.2 of the DEIR (USEPA 1997). EPA established that:

(1) Anaerobic dechlorination does not result in the destruction of PCBs; rather, it results in the selective removal of chlorine atoms from individual PCB congeners.

(2) Significant dechlorination in Hudson River sediments appears to occur only above an initial concentration of about 30 ppm total PCBs.

(3) The potential extent of natural anaerobic dechlorination in the Hudson River is limited to a mass loss of 23 percent for Aroclor 1242, the mass represented by meta- and para-chlorines. (In practice, some of the dechlorination products are not reported in the Phase 2 database, so the apparent limit of dechlorination in the Phase 2 data is 26.1 percent). No molar loss of PCBs occurs as a result of this dechlorination.

(4) Most dechlorination in Hudson River sediments occurs rapidly after deposition, followed by only limited subsequent dechlorination.

These points from the DEIR (USEPA, 1997) are also supported by experimental work (*e.g.*, Liu *et al.*, 1996). As a result, EPA concludes that essentially all the dechlorination of historically deposited PCBs in the Upper Hudson that will occur has already occurred, and any further anaerobic dechlorination that does occur will not reduce the molar concentration of total PCBs in the sediments. Therefore, natural decay will not remedy the residual contamination in the river, nor is it likely to result in significant reductions in future exposure concentrations.

Additional comments addressed potential changes in toxicity of the PCB mixture following anaerobic dechlorination. These issues are addressed in Responses to Master Comments 541 and 571 in Chapter 3. The potential for aerobic destruction of PCBs is addressed in Response to Master Comment 253430 in this section.

References

Liu, X., R.C. Sokol, O.-S. Kwon, C,M, Bethoney, and G.-Y. Rhee. 1996. An investigation of factors limiting the reductive dechlorination of polychlorinated biphenyls. *Environ. Toxicol. Chem.*, 15(10): 1738-1744.

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C – Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., The Cadmus Group, Inc., and Gradient Corporation. February.

USEPA. 1998. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C-A, Low Resolution Sediment Coring Report. Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Gradient Corporation, and Tetra Tech, Inc. July 1998.

2.4 Baseline Modeling Assumptions

Master Comment 363193

A commenter observed that bed load transport is mentioned in the FS, but not in earlier documents. The commenter asked how much transport is expected by this mechanism and whether it is accounted for in EPA's model.

Response to Master Comment 363193

Bed load represents the transport of solids that roll or saltate along the river bottom without being brought into suspension in the water column. Bed load can be an important part of the overall mass transport of coarser-grained solids in many rivers. In the Hudson, its importance is lessened because the river is controlled by a series of low-head dams. These dams will effectively trap bed load. As a result, bed load is a mechanism that can move some sediment within reaches defined by dams in the Hudson, but is not a significant component of long-range transport through the Upper Hudson.

Bed load transport is expected primarily for coarser-grained, non-cohesive sediments. The HUDTOX model does not explicitly simulate bed load as a separate component of solids transport, and no site-specific monitoring data are available with which to develop and calibrate a bed load model.

The issue of bed load transport was addressed in detail in Response 3d to the RBMR Peer Review (USEPA, 2000a). Past model simulation efforts for the Hudson that included a bed load component (Tofflemire and Quinn, 1979) demonstrated that bed load in the TI Pool area accounts for less than one percent of the total solids load at a flow of 10,000 cfs and about four percent at 100,000 cfs. It was therefore concluded that it was not necessary to include an explicit representation of bed load transport in the HUDTOX transport and fate model to answer the principal Reassessment questions.

While HUDTOX does not contain a bed load component, it does, however, implicitly represent bed load transport:

- First, the representation of erosion from non-cohesive areas is based on shear stress using the Borah formulation applied to site-specific particle size distribution data (see USEPA, 2000b, Section 4.3.3). This relationship represents the scour or removal of sediment, and does not specify whether this scoured sediment goes into suspension or bed load transport.

- Second, the primary calibration targets for solids mass transport in HUDTOX are water column solids loads and water column solids concentrations at the TI Dam, Schuylerville, Stillwater, and Waterford. Each of these sampling points is at or near a dam. The calibration samples are thus from locations where bed load is not a significant part of solids transport.

As the scour portion of the model includes sediment liberated to both suspension and bed load, while the transport portion is calibrated to suspended load only, mass balance closure is achieved by setting non-cohesive sediment deposition rates in a manner that accounts for both deposition of suspended load and trapping of bed load.

In sum, the HUDTOX model implicitly represents both the erosion of solids into bed load and the deposition of bed load. This approach is expected to provide an accurate representation at the reach-averaged scale of the model. Neither EPA's nor GE's PCB models are able to represent the sub-reach movement of bed load.

At the sub-reach scale, bed load transport may represent an important mechanism for the mixing and redistribution of non-cohesive sediments. In addition, significant amounts of non-cohesive sediment are scoured and redeposited within a single model reach. These solids may pick up additional PCBs in the water column if water column concentrations are high. Over the long term, this process results in the mixing of PCBs released from cohesive sediment *hot spots* into the surficial non-cohesive sediments of the river.

References

Tofflemire, T.J. and S.O. Quinn. 1979. PCB in the Upper Hudson River: Mapping and Sediment Relationships. NYSDEC Technical Paper No. 56. March 1979. NYSDEC, Albany, New York.

USEPA. 2000a. Response to Peer Review Comments on the Revised Baseline Modeling Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc., November.

USEPA. 2000b. Phase 2 Report, Further Site Characterization and Analysis. Volume 2D – Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc., January 2000.

2.4.1 HUDTOX

Master Comment 833

One commenter questioned why, in the EPA transport and fate model, were lower sediment mixing depths and slower sediment mixing rates chosen for non-cohesive sediments with increasing distance downstream in the Upper Hudson River. Another commenter asserted that the model does not include PCBs from sediment depths greater than 5 cm that are mobilized into the food chain because the GE surficial sediment data did not extend below 5 cm.

Response to Master Comment 833

Sediment particle mixing in HUDTOX, the EPA fate and transport model, was determined on the basis of observed sediment core depth profiles, judgments on spatial distributions of biological activity, and model calibration to long-term Tri+ PCB concentration trajectories in the surface sediments. Sediment organic carbon was used as a surrogate for biological activity. In turn, sediment mixed depth and particle-mixing rates were assumed to be proportional to biological activity.

Particle-mixing depths in the model calibration were 10 cm in all cohesive sediment areas, both in TI Pool and in downstream reaches. This was consistent with inspection of sediment core depth profiles (USEPA 1997; QEA 1999) and with reported results for a large number of sites worldwide (Boudreau 1998). For non-cohesive sediment areas, particle-mixing depths were 6 cm in TI Pool and 4 cm in downstream reaches. There is more uncertainty in mixing depths in downstream reaches than in TI Pool. Some downstream reaches achieved calibration constraints better with a 4-cm depth of mixing, while other areas were better at 6 cm of mixing. To avoid use of different parameters for individual reaches downstream of TI Pool, without supporting data or a clear scientific justification, 4 cm was used for all downstream reaches (USEPA, 2000).

Lower sediment-mixing depths and slower sediment-mixing rates were used for non-cohesive sediments in downstream reaches for two reasons. First, sediment organic-carbon concentrations (and, hence, levels of biological activity) tended to be lower in downstream reaches than in TI Pool, and second, overall model calibration results were judged to be better with lower values for these parameters in downstream reaches.

Based on results from sensitivity analyses conducted with the calibrated HUDTOX model, a mixing depth of 6 cm for non-cohesive sediments in all downstream reaches appears reasonable and may represent an alternate choice for the historical calibration. The extent to which this alternate calibration would have any significant impact on forecasted levels of PCBs in fish is limited because the EPA bioaccumulation model (FISHRAND) includes sediment exposures from both cohesive and non-cohesive sediment areas. The cohesive sediment areas are more highly contaminated and represent the primary sediment-exposure route, especially at localized spatial scales and in the vicinity of hot spots.

The model includes all PCBs to a depth of 26 cm in the Upper Hudson River (Figures 7-17 through 7-19, RBMR, USEPA, 2000). As discussed in the foregoing text, the surface mixed

layer is 10 cm deep in all cohesive sediment areas and between 4-6 cm deep in noncohesive sediment areas. Furthermore, deeper sediment layers may become "active" if overlying material is removed due to erosion. With respect to the food chain, PCBs to a depth of approximately 5 cm are directly bioavailable and PCBs in the top 10 cm in cohesive sediment areas can influence the food chain by mixing with and replenishing PCBs in the top layer. Response to Master Comment 637, Chapter 2 contains more information on depth of bioavailable PCBs in the sediments and how this depth was represented in the EPA models.

References

Boudreau, B.P. 1998. Mean mixed depth of sediments: The wherefore and the why. Limnology and Oceanography. 43(3):624-526.

Quantitative Environmental Analysis (QEA). 1999. PCBs in the Upper Hudson River: Volume 2, A Model of PCB Fate, Transport and Bioaccumulation. Prepared for General Electric, Albany, New York.

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C – Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., the Cadmus Group, Inc., and Gradient Corporation. February.

USEPA. 2000. Phase2 Report, Further Site Characterization and Analysis. Volume 2D – Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, Inc., and Tetra-Tech, Inc. January.

2.4.2 FISHRAND

Master Comment 779

Some commenters say that the FISHRAND model contains several errors or incorrect parameterizations leading it to predict greater (or lesser) declines in surface sediment associated aquatic organisms (such as brown bullhead) than should have been predicted, including:

- Total organic carbon values used in FISHRAND as compared to the values used in the HUDTOX model.
- Growth rates for fish that are higher than observed (particularly for brown bullhead).
- Exposure zones for only small portions of sediments in each pool.
- Specific values for Log K_{ow}.

Other commenters note that the parameterization of FISHRAND minimizes the differences between any remedy and No Action because perhaps predicted fish body burdens (and surface sediment concentrations) decline too quickly in the No Action model runs.

Response to Master Comment 779

EPA disagrees with comments implying that the FISHRAND model contains significant errors and/or incorrect parameterizations. Each of the issues raised by commenters is described individually below.

Total organic carbon in sediment: TOC

Total organic carbon (TOC) is specified by reach-specific distributions in the FISHRAND model. In developing these distributions, EPA relied primarily on TOC data from the EPA Phase 2 ecological sampling program. Those data best reflect the TOC experienced by benthic invertebrates and the food web generally, as these sediment samples were taken at the same time and place as the benthic invertebrate samples that form the base of the food web. It has been found that organic carbon is one of the most important factors (and more important than grain size) in determining field distributions of benthic invertebrates, because organic matter is a prominent source of food for deposit feeders (Sims, 1996).

TOC is a measure of bioavailability of PCBs and need not necessarily be the same between the physical and biological models. In fact, differences are expected. Figure 779-1 provides a histogram of the TOC data from the EPA Phase 2 dataset for n=27 in the TI Pool. The distribution for TOC in the TI Pool used in the FISHRAND model is specified as triangular with parameters minimum, mode, and maximum (0.5, 4.7, 10.0). As can be seen in Figure 779-1, the values in the calibrated FISHRAND model correspond very closely to the observed values.

For the area below the TI Pool and above the Federal Dam, there are nine data points for TOC from the Phase 2 biological sampling program. Four data points are from RM 169.5 (3.4, 3.6, 4.9, 4.2) and five are from RM 159 (1.1, 1.5, 1.6, 1.8, 1.9). These nine data points were combined to represent the area below the TI Pool, and taken together, are consistent with the larger General Electric (GE) TOC dataset.

An example of the way in which TOC is a measure of bioavailability of PCBs in sediment is given by the following exercise. Individual measured brown bullhead concentrations (mg/kg lipid normalized) were divided by the mean organic carbon normalized sediment concentrations predicted by the HUDTOX model (Table 4-8 of the RBMR, USEPA, 2000), yielding the following results:

Brown Bullhead: Sediment Accumulation Factors

Parameter	River Mile 189	River Mile 168
Average	0.7	1.7
Standard Deviation	0.7	1.4
Minimum	0.2	0.1
Maximum	4.9	15.2

These results are presented as a histogram in Figure 779-2. There is a much greater range and the mean accumulation factor at RM 168 is actually higher than at RM 189 (TI Pool), suggesting a

different relationship between brown bullhead body burdens and sediment concentrations. The brown bullhead is an opportunistic feeding fish (assumed in FISHRAND to be primarily a bottom feeder), with approximately 90 percent of its diet derived from sediment sources.

Note that TOC is specified as a point estimate (mean) in the HUDTOX model while it is specified as a distribution in the FISHRAND model. The distribution assigns a probability of each TOC value, including the mean value used in the HUDTOX model. Also note that although HUDTOX and FISHRAND both used available data to specify TOC on a reach-specific basis, there is not a one-to-one correspondence between HUDTOX sediment segments and the sediment segments used to specify sediment exposure concentrations to FISHRAND. Only selected HUDTOX sediment segments were used to specify sediment exposure concentrations, and these selections were based on known distributions of benthic invertebrates and on spatial distributions of TOC.

Finally, it is important to note that the linkages between the GE model components and the EPA model components differ significantly, which impacts the choice of TOC. The EPA models were linked via selected groups of HUDTOX sediment segments in both cohesive and non-cohesive sediment areas. The GE models were linked via all sediment segments in cohesive areas and no segments in non-cohesive areas. The incorporation of both cohesive and non-cohesive sediment segments influences the choice of TOC. Response to Master Comment 847 in Chapter 6 provides additional information on the ability of the models to determine the relative impact of remediation at the scale of individual sediment deposits.

Growth Rate

First, the model used as a starting point the growth rates reported in Burkhard (1998) rather than the growth rates originally reported in the development of the Gobas model. However, there are differences between individual growth rates (such as are obtained from length-weight-age field observations) and the "population" growth rate as it used in the FISHRAND model. Individual growth rates are not directly comparable to the growth rate as it is implemented in the FISHRAND model. The "population" growth rate shows larger seasonal variation due to active seasons of fish spawning and breeding (that is, the population growth rate takes into account not only changes in individual growth rates during warm periods, but also variations in fish numbers in the population as a whole). Individual field-based growth rate observations are not in the form required for the model. This is true for all species, including the brown bullhead.

Growth rate is a temperature-dependent parameter, and individual-based field observations do not provide this temperature dependency, introducing further uncertainty. In addition, measurements are not available for all fish types and the data that are available are not sufficient to describe growth rate as a distribution for each species. In particular, the tails of these distributions would be inaccurately specified which (in a probabilistic model) could affect the predicted central tendency. Finally, the growth rate is independent of all other parameters in the model, making it a good choice for the Bayesian updating procedure followed in the calibration.

The population growth rate in FISHRAND can be represented by:

$$1/N*dM/dt$$

where N is the size of the whole fish population, and M is the collective mass of the population.

The growth of the population mass has two components:

- The growth of each individual fish – DM1.
- The difference in biomass between fish mortality and birth of fish – DM2.

Thus, the equation becomes: $1/N*(DM1/DT + DM2/DT)$.

The model assumes that the average fish population is stable, expressed as $\langle DM2/DT \rangle = 0$ where $\langle\rangle$ is time averaging. But the model does not assume that DM2=0 in any given month. Biologically, we expect that DM2 is greater than 0 in spring due to spawning, and DM2 is less than 0 during over-wintering. Consequently, in principle it is possible that DM2 makes an even larger contribution to dM/dt than DM1.

Exposure Zones

The sediment exposure regime within each pool used to drive the FISHRAND model was selected so as to achieve a correspondence with the sampling locations for the available fish monitoring data. This information, together with knowledge of the biology of the fish species and physical attributes of the river (*e.g.*, presence of dams and locks, etc.), guided the segmentation of the HUDTOX model and subsequent correspondence to exposure zones in the FISHRAND model. In the TI Pool, the HUDTOX model is gridded to include nearshore and channel areas and it was the nearshore segments that were selected to represent exposure to fish in the FISHRAND model. The HUDTOX model is not as finely gridded below the TI Pool, but the lateral gradient in sediment and water PCB concentrations observed in the pool is less downstream of the pool, as discussed in Section 6.3.1.1 of the RBMR (USEPA, 2000).

For the FS, the RM 189 (TI Pool) and RM 154 (Waterford) segments were maintained to be consistent with the RBMR and to be able to compare the impact of alternatives across a consistent set of assumptions. In addition, instead of modeling the Stillwater reach (RM 168), the FS includes results for the reach just above Northumberland Dam, or RM 184. This area, although not a historical fish monitoring location, is more highly contaminated than the Schuylerville sampling location. Modeling this location for the FS more appropriately reflects the impact and potential risk reduction that would occur as a result of remediation.

The GE model uses only cohesive sediments to obtain exposure concentrations for fish. In River Section 3, the Waterford reach, this corresponds to a very small area representing only two percent of the sediments. The biology and foraging strategies of the modeled fish species show that these fish integrate exposure over spatial scales on the order of a mile or more, and given that sediments in River Section 3 are predominantly non-cohesive, it is inappropriate to assume such localized exposure.

Responses to Master Comments 843 and 847 in Chapter 6 provide additional information on differences between the GE and EPA models in terms of exposure averaging and the ability of the models to determine the relative impact of remediation at the scale of individual sediment deposits. Additional information relating to bioavailability of sediments is discussed in the Response to Master Comment 637 (Section 2.3), and in Response to Master Comment 619 and 621 (both in Section 2.1).

Octanol-Water Partition Coefficient: Log K_{ow}

The distributions used for K_{ow} in the FISHRAND model are appropriate and should be specified separately for each reach of the river.

- First, Appendix K of the Ecological Risk Assessment as well as NOAA (1997) found that the mix of individual congeners in the Tri+ mixture shifts moving downriver. Since each individual congener contributes to the apparent K_{ow} of the entire mixture, it follows that if the contribution of each individual congener changes, so does the partitioning behavior of the mixture as a whole.

- Second, the partitioning behavior of individual PCB congeners within the Tri+ mixture is a temperature dependent process, as shown in the DEIR (USEPA, 1997). Changes in temperature between segments may amplify the differences in K_{ow} attributable to changes in the congener mixture.

- Third, since Tri+ is modeled as a mixture, the effective K_{ow} of the mixture is not known, except for the limited locations and times where congener-specific analyses are available.

Log K_{ow} was chosen as a calibration parameter within constraints because K_{ow} represents a particularly important and sensitive parameter in the model, and plays a role in several different rate constants simultaneously. The purpose of the Bayesian Updating calibration procedure is to focus on highly uncertain variables; the true K_{ow} of the Tri+ mixture is highly uncertain given the change in individual congener contribution to the overall mixture as well as the effect of changes in temperature. Finally, only the mode of the triangular distribution of K_{ow} is varied between segments, 6.47 as compared to 6.6 (the minimum and maximum are identical).

Note also that in response to peer review comments, congener-specific modeling in FISHRAND was done using a fixed K_{ow}. These results are found in USEPA, 2000, under the response to comment 10 starting on page 28.

Rate of Decline

Some commenters suggested that fish show too fast a rate of decline and that this underestimates the effects of No Action, while other commenters suggested that the fast rate of decline overestimates the benefits of dredging. The rate of response to changes in sediment and water exposures is not concentration dependent; that is, the mechanisms responsible for PCB uptake and depuration are consistent across all alternatives. This means that even if the predicted rate of

decline in exposure concentrations were more gradual, the comparison across alternatives would show the same results as currently.

Fish respond most to changes in sediment and water exposure concentrations. That is, the long-term rate of decline is primarily driven by changes in exposure concentrations, while the short-term rate of decline is controlled primarily by fish physiology, such as the depuration rate. A comparison of declines in predicted fish body burdens show they are commensurate with declines in predicted sediment and water exposure concentrations. The short-term rate of decline of predicted body burdens in fish is closely related to the depuration rate in the model. There is evidence that the FISHRAND model captures overall depuration rates. The following table provides the average depuration half-times for the Tri+ PCB mixture as calculated from the model:

Average Depuration Half-Times for Tri+ PCB

Fish	**Average Half-Time**
RM189 Modeled	
Yellow Perch	$T^{1/2}$ = 103 days
Brown Bullhead	$T^{1/2}$ = 117 days
Largemouth Bass	$T^{1/2}$ = 129 days
RM168 Modeled	
Yellow Perch	$T^{1/2}$ = 105 days
Brown Bullhead	$T^{1/2}$ = 82 days
Largemouth Bass	$T^{1/2}$ = 122 days

These values are comparable to results obtained in a laboratory study (Fisk *et al.*, 1998). This study exposed rainbow trout to spiked food for 30 days, followed by 160 days of depuration. The authors found that depuration half-times for individual Tri+ congeners ranged from 24 days for PCB 18 to 224 days for PCB 153. Differences were shown depending on the food concentration used in the experiment. For example, at a food concentration of 22 ng/g wet weight, the depuration half-time for PCB 153 was 224 days ($\pm$ 75 days), while at a food concentration of 124 ng/g, the depuration half-time was 69 days ($\pm$ 7 days). The individual congener that has been shown to behave most like the Tri+ mixture, PCB 28, showed a depuration half-time of 44 and 46 days ($\pm$ 5.5 and 6.1) at food concentrations of 16 and 108 ng/g wet weight, respectively. The average depuration half-time across all congeners was 69 days ($\pm$ 11 days).

Although the fish used in the study were much smaller and likely had physiological differences from the adult fish modeled in FISHRAND, the modeled depuration rates from FISHRAND are also higher than the ones in the study. Thus, this comparison suggests that the FISHRAND model is estimating appropriate depuration rates.

The rate of decline of predicted fish tissue concentrations and the rate of decline observed in the data are discussed in White Paper – Trends in PCB Concentrations in Fish in the Upper Hudson River and in Response to Master Comment 627 (Section 2.6). Additionally, the rate of decline in water concentrations is discussed in the Response to Master Comment 631 (Section 2.6), and in sediment concentrations in the Response to Master Comment 633 (Section 2.6).

References

Burkhard, L.P. 1998. Comparison of two models for predicting bioaccumulation of hydrophobic organic chemicals in a Great Lakes food web. *Environ. Toxicol. Chem*. 17: 383-393.

Fisk, A.T., Norstrom, R.J., Cymbalisty, C.D., and D.C.G. Muir. 1998. Dietary accumulation and depuration of hydrophobic organochlorines: bioaccumulation parameters and their relationship with the octanol/water partition coefficient. *Env. Toxicol. Chem*. 17(6):951-961.

National Oceanographic and Atmospheric Administration (NOAA). 1997. Hudson River Congener-specific Analysis, Data Summary and Analysis Report. Prepared by EVS Environmental Consultants. July.

Sims, J.G. 1996. Grain size and total organic carbon effects on benthic organisms. US Army Corps of Engineers, Waterways Experiment Station, Environmental Effects of Dredging Technical Notes, EEDP-01-37, March.

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C – Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., the Cadmus Group, Inc., and Gradient Corporation. February.

US Environmental Protection Agency. 2000. Response to Peer Review Comments on the Revised Baseline Modeling Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Limno-Tech, Menzie-Cura & Associates, and TetraTech, November.

2.4.3 Farley Model

Master Comment 313787

The commenter noted that there is a strong correlation between PCB levels in the water column and in fish tissue, and it is possible that a claimed 40- to 60-percent reduction of PCBs in the water column of the Lower Hudson will result in reductions of the same order in fish tissue over the forecast period. However, the commenter noted that there are no comparisons of remedial alternatives for the Lower Hudson River.

Response to Master Comment 313787

In response to this comment, an estimation of water column and sediment concentrations of the Lower Hudson River was performed using the model developed by Farley *et al.*, (1999) for the No Action (NA), Monitored Natural Attenuation (MNA), REM-3/10/S, CAP-3/10/S, and REM-0/0/3 Alternatives. The Farley model takes the flux of PCBs over the Federal Dam computed by the EPA's Upper Hudson River fate and transport model of (HUDTOX) (USEPA, 1999), as an external input.

The water and sediment concentrations from the Farley fate-and-transport model are used as input for the USEPA bioaccumulation model (FISHRAND) to generate the PCB body burdens for all fish species examined in the Lower Hudson. The Farley bioaccumulation model was also applied to yield PCB concentrations in white perch.

In summary, this analysis predicted that the selected remedy would reduce the concentrations of PCBs in the water column by about 70 percent compared to the No Action Alternative in 2029. In comparison to MNA, the selected remedy is predicted to reduce the water column concentrations by about 30 percent (see Table 313787-1). By 2029, the CAP-3/10/S Alternative was predicted to result in a 69 percent water column concentration reduction compared to the No Action Alternative and a 27 percent reduction compared to the MNA Alternative. Reductions of the water column concentrations for the REM-0/0/3 alternative were projected at 74 percent and 38 percent in 2029 compared to the No Action and MNA Alternatives, respectively.

The strong correlation between the PCB levels in the water column and in the fish tissue can be seen from the Farley model and FISHRAND results. Farley model results for the selected remedy indicate that in 2029, the selected remedy reduced the white perch body burden by 70 percent compared to the No Action Alternative and by 30 percent compared to the MNA Alternative (Figure 313787-1). The Farley model predicted that the CAP-3/10/S Alternative results in the white perch body burden reduction of 69 percent compared to the No Action Alternative, and reduction of 28 percent compared to the MNA Alternative. For the REM-0/0/3 Alternative, the Farley models predicted a reduction of 74 percent compared to the No Action Alternative and a reduction of 39 percent compared to the MNA Alternative. Similarly, FISHRAND results predicted about the same amount of reductions in white perch body burdens (Figure 313787-2) and in other fishes (Figures 313787-3 through 313787-5).

References

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

USEPA. 1999. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E – Baseline Ecological Risk Assessment, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA, Region 2 and USACE, Kansas City District by TAMS/MCA. August.

2.5 PCB Transport to the Lower Hudson River

Master Comment 423847

A commenter requested the EPA to consider an additional model for determining the solute dynamics for the Lower Hudson.

Response to Master Comment 423847

The EPA used the most appropriate model for the Lower Hudson River known to be available at the time the work was done. This is the model of Farley *et al.* (1999), developed for the Hudson River Foundation. In response to comments, EPA has expanded and revised the lower river simulation using the Farley model (Response to Master Comment 313787, this section). EPA does not feel that it is necessary to construct an additional model for simulation of the lower Hudson.

It should be noted that the Lower Hudson model was not a key factor in the remedy selection process, as the remedy is focused on the Upper Hudson River sediments. The model was used to provide information on PCB fate and transport in order to calculate risks from consumption of fish to the Lower Hudson River communities. Therefore, the development of another model would not enhance the attainment of this objective.

References

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

2.6 Long-Term Trends in PCB Concentrations

Master Comment 629

Commenters contended that EPA's interpretation of trends in fish tissue PCB concentrations contradicts the sediment and water column trends, uses too short a period of data, and should have used different time intervals for the analysis. Commenters also stated that apparent increasing trends in recent years in some species reported by EPA are unreliable. A detailed reanalysis of trends presented by GE (including year 2000 data that were not available at the time the FS was completed) contends that PCB levels in TI Pool fish are declining at a rate between 7 and 16 percent per year, and that this conclusion is consistent with the NAS analysis of natural recovery.

Other commenters noted that PCB levels in upper Hudson River fish are no longer declining; despite initial late-1970s declines, PCB concentrations in fish have leveled off and remain unacceptably high. Commenters further stated that, given the high levels of PCBs in Hudson River fish, reported PCB annual rates of decrease of three or four percent in the upper and lower Hudson would still equate to many generations for fish to reach more acceptable levels.

Response to Master Comment 629

In the FS, EPA noted that fish tissue PCB concentrations in certain species and at certain locations did not show evidence of a decreasing trend in the latter half of the 1990s, after the leakage of unweathered PCB oil from the vicinity of the GE Hudson Falls facility had largely been controlled. This evidence is important, because EPA's reach-scale model suggests that

tissue concentrations in all fish species should be decreasing along a family of exponential decay curves.

Evidence from NYSDEC fish monitoring data suggests that EPA's models present too optimistic a picture for natural attenuation or that events at the spatial scales of fish foraging areas associated with specific sample locations may deviate from the reach-average trend predicted by the model, or both.

EPA believes that the fate and transport model captures reach-averaged trends, but recovery of fish species at specific historic sampling locations, particularly those whose food chain pathways are closely associated with the sediment, may occur at rates slower than the reach average. This in turn suggested that it was appropriate to consider an upper bound calculation, including modeled water column concentrations and more slowly decreasing sediment concentrations, to evaluate the range of possible responses of target fish at specific locations.

The analyses presented in Appendix D.1 of the FS used data available at the time of writing. These included complete NYSDEC data through 1998 and preliminary 1999 results. Since that section was written, NYSDEC has released an update of their database, including final 1999 and 2000 sample results. In addition, most of the brown bullhead and largemouth bass samples collected in 1998 through 2000 at RM 189 and at RM 176 were split between NYSDEC and GE, with GE's samples being subjected to capillary column GC at North Eastern Analytical (NEA) with homologue/congener identification. Because NYSDEC switched contract laboratories for the 1999 data, and because there are unanswered questions remaining regarding the consistent interpretation of earlier NYSDEC Aroclor-based packed column GC analyses, it is prudent to rely on the NEA results for Tri+ in the 1998-2000 results for brown bullhead and largemouth bass in the TI Pool at Griffin Island (RM 189) and at Stillwater/Coveville (RM 176) to provide a consistent basis for comparison to earlier results converted to a consistent Tri+ basis.

It should be noted that the change of laboratories by NYSDEC in 1999 came only after a long, careful process of inter-laboratory comparisons and performance evaluations, and that even with the switch in laboratories the NYSDEC results are consistent with earlier data in terms of total PCBs and Aroclor quantitations. Conclusions drawn on the 25 years of NYSDEC data do not change because of the shift in analytical techniques.

An update to Section 2.1 of Appendix D.1 of the FS, incorporating the 2000 data, is provided as White Paper – Trends in PCB Concentrations in Fish in the Upper Hudson River. Examination of the 2000 data on a lipid basis yields results that are lower than the 1999 data for both largemouth bass and brown bullhead at both Griffin Island and Stillwater/Coveville. On the other hand, the 1999 data were elevated relative to the previous few years, and year 2000 results were generally similar to 1998. (Note: As in the FS and many supporting analyses, it is most informative to examine trends in PCB concentration in fish on a lipid basis. This is because PCBs preferentially accumulate in fatty [lipid] tissue, and the wet-weight concentration of PCBs in fish is thus subject to variability due to changes in the lipid content of the fish sampled. Risks to consumers of fish [human or animal], however, are based on the wet-weight concentration.)

As to the question of whether inclusion of the 2000 data changes the analysis presented in Appendix D.1, the answer, in general, is no. For 1995-2000, largemouth bass at Griffin Island

show a slowly decreasing trend with a half-life of 11.6 years, still much slower than the model-predicted rate of 3.6 years. For largemouth bass at Stillwater and brown bullhead at Griffin Island, inclusion of the 2000 data actually increases estimated half-lives. The case of brown bullhead is particularly important, as this species feeding habits tie it closely to the surface sediment. For the period of 1995-2000, Tri+ PCB concentrations in brown bullhead at Griffin Island exhibit a half-life of 578 years, while at Stillwater the trend in brown bullhead remains one of general increase.

Thus, inclusion of the 2000 data in no way changes the observations noted in Appendix D.1 of the FS. Rather, the longer period of data further supports the observation that fish tissue concentrations at the specific locations of NYSDEC sampling appear to be decreasing at substantially slower rates than is predicted by the model. The brown bullhead results, including year 2000 data, are summarized in Figure 629-1, Concentration Trends in Brown Bullhead, Including 2000 Data. For complete details, see White Paper – Trends in PCB Concentrations in Fish in the Upper Hudson River.

GE's comments (GE, Appendix H) contain a detailed, alternative analysis of concentration trends in fish, with results more favorable to natural attenuation as a remedial option. This analysis is based on a selective reading and interpretation of the data, and does not invalidate EPA's analysis. A full review of GE's alternative analysis is provided in White Paper – Trends in PCB Concentrations in Fish in the Upper Hudson River.

Specific Comments

GE contested EPA's interpretation that consistent decreases in fish tissue concentrations are not seen in the last five years, and stated that EPA's interpretation is "spurious" for four reasons. Each of these objections can be directly refuted:

1. *GE noted that EPA documented apparent interruptions to trends in fish tissue concentration in 1989 in pumpkinseed and in 1990/91 for largemouth bass, "yet included these data in the evaluation of trends prior to the Allen Mill event."*

This objection has no bearing on the analysis of trends after the upstream source was controlled. There may have been "interruptions" in the declining trends in fish tissue prior to 1991, or individual samples may be anomalous. This is relevant to the variability in fish response from year to year, but is irrelevant to the analysis of later trends.

2. *GE commented that EPA's analysis of the post-Allen Mill period consisted of only a four-year period, and may be influenced by a 1998 event due to sediment and debris removal in the vicinity of the Hudson Falls pump house.*

In fact, EPA's analysis in the FS included data through 1999. With the availability of new data for 2000, this objection is lessened. Only data from 1995 on are relevant to analysis of conditions after primary control of the upstream source, so the estimate that is provided is the best that is available at this time. It should also be noted that there was little increase in PCB load past Rogers Island during the GE Hudson Falls pump house interim remedial measure.

3. GE stated that the trend reported for brown bullhead in the 1980s "is contradictory to the trends reported for largemouth bass and pumpkinseed."

The time course of observed trends in brown bullhead in the 1980s does appear to differ somewhat from trends observed for largemouth bass and pumpkinseed (they are smoother, with less year to year variability). EPA believes that this does not represent a contradiction. Rather, it reflects the fact that tissue concentrations in brown bullhead are closely tied to surface sediment concentrations, whereas concentrations in pumpkinseed and largemouth bass are more strongly driven by both water column and surface sediment concentrations, with the water column concentration exhibiting greater year-to-year variability (USEPA, 2000).

4. GE states that the change in brown bullhead trends between the 1980s and 1990s requires some unexplained change in underlying mechanisms.

EPA disagrees that there is a qualitative change in trends in brown bullhead between the 1980s and 1990s. Rather, the sampling results reflect a situation in which the bullhead are closely tied to surface sediment concentrations. During the 1980s these concentrations declined relatively rapidly, as erodable contaminated sediment deposits upstream washed out.

During the later 1990s, the decline in bullhead tissue concentrations appears to have stopped, presumably because the concentrations now seen reflect food chain contributions from contaminated sediment areas that are not being buried or otherwise naturally remediated.

GE also stated that trends in fish tissue concentration should be evaluated over the period 1994-2000, rather than 1995-1998. As noted above, EPA has now extended the end date for evaluation of trends to 2000 with the availability of new data. This does not change the conclusions presented in the FS.

As to the choice of a starting period for the trend analysis, it is true that 1994 fish results in the TI Pool (but not Stillwater) were much higher in 1994 than in 1995, thus beginning the analysis in 1994 provides a much greater rate of decline for fish concentrations in the TI Pool. EPA's position is that it is inappropriate to start the analysis in 1994, as most fish samples were collected in the spring, and samples collected in the spring of 1994 (particularly largemouth bass) are likely to reflect the effects of the high upstream loads released by the GE Hudson Falls facility during 1993. If the drop in TI Pool fish concentrations between spring 1993 and spring 1994 was a valid predictor of the subsequent trend, a similar rate of decline would be expected to continue in subsequent years, which it does not.

GE cites the recent National Academy of Sciences (NAP, 2001) study observation of long-term rates of decrease in Hudson River fish tissue concentrations over the period 1983-1998, and states that "this finding contradicts EPA's conclusion." GE's synopsis is incorrect, as there is no contradiction. As noted above, strong declines are evident over the period of record, but most of these declines occurred during the early 1980s. The NAS finding of long-term decline since 1983 has little bearing on rates of decline in fish tissue concentrations from 1995 onward.

Another commenter also mentions the NAS report, but notes "that over the past 5 to 6 years, PCB levels in upper Hudson River fish are no longer declining," citing a personal communication from Dr. Ron Sloan at NYSDEC.

References

National Academy Press. 2001. A Risk Management Strategy for PCB-Contaminated Sediments. Committee on Remediation of PCB-Contaminated Sediments, Board on Environmental Studies and Toxicology, National Research Council. 452 pages.

USEPA. 2000. Phase 2 Report, Further Site Characterization and Analysis. Volume 2D – Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc., January.

Master Comment 633

Some commenters opined that EPA examined only a small subset of the available sediment data in evaluating trends in sediment PCB concentrations. Commenters suggested that additional sediment cores with finer-scaled vertical segmentation should be collected from multiple locations, without compositing. Commenters contended that EPA relied on the small number of samples collected in 1994 for the low resolution coring study, plus a few high resolution cores to evaluate trends, and that this subset of the data is an inadequate basis for examining trends. Some contend that EPA's conclusion that surface sediment PCB levels have shown little decline in the 1990s is not valid and conflicts with the evidence provided by larger data sets. One comment further states that the 1976-78, 1991, and 1998 sediment sampling results for the top 5 cm "provide a basis to examine trends."

Response to Master Comment 633

The implication that EPA ignored portions of the available sediment data is unfounded. In fact, all sediment data available were used to the maximum extent possible in both the modeling and data analysis. For instance, the 1976-78, 1991, and 1998 data all provided important constraints in the development of the fate and transport model (USEPA, 2000). It was not possible to include the limited 1998 GE sampling results in those reports, such as the DEIR and LRC Report, which were released before the 1998 data became available.

EPA admits that the availability of data to assess trends in surface sediment concentration is limited. The largest sediment data set, collected by NYSDEC in 1984, generally used a coarse vertical scale that is not sufficient to resolve concentrations in the top few centimeters. Many samples from 1976-78 do include shallow samples, but there is considerable uncertainty regarding the interpretation of the analytical methods, as the packed column GC quantitation methodology used for this study was non-standard and is not well documented.

GE sampling in 1991 (prior to the Allen Mill gate failure) did include 0-5 cm sections and covered a large portion of the Upper Hudson River. The results of this sampling are obscured,

however, by the fact that almost all samples were analyzed as composites of many individual samples (O'Brien & Gere, 1993), and these composites were formed across broad spatial scales. Furthermore, the compositing appears to have often mixed samples from highly contaminated and less-contaminated areas. The 1998 GE sampling was limited in scope, and many of these samples were also composites, but the composites were not designed to match the composites obtained in 1991. In contrast, EPA's LRC sampling was designed to match sample locations occupied in 1984, thus providing a clearer basis for examining trends over time.

EPA agrees with NOAA comments that the limited amount of sediment data at fine vertical scales is a source of uncertainty in the modeling, and that it would be desirable to have additional individual sediment cores with finer-scaled vertical segmentation, without compositing. EPA also believes, however, that the existing data are sufficient to enable an evaluation of trends in surface sediment concentration and to develop input for the HUDTOX model.

Despite uncertainties regarding the interpretation of the 1976-78 results, it is clear that surface sediment concentrations declined markedly between this period and 1998. EPA's data analysis, observations of water column and fish tissue concentrations, and modeling are all in agreement on this point. Indeed, this result is not surprising, as the 1976-78 samples were taken soon after the massive remobilization of contaminated sediments following the removal of the Fort Edward Dam.

EPA's fate and transport model suggests that average cohesive sediment surface Tri+ PCB concentrations in the TI Pool declined from 103 to 13 ppm (87 percent) between 1977 and 1998, while average non-cohesive sediment surface concentrations declined from 33 to 6 ppm (81 percent). More than half of this decline, however, occurred prior to 1984. EPA anticipates that the decline in average surface concentrations will continue at a slow rate.

Note that the fate and transport modeling results apply to reach-averaged concentrations. It is important to realize that the average is not necessarily representative of what happens at specific locations.

Direct comparison of the GE 1991 and 1998 sediment sampling results is fraught with difficulties, due to the differing compositing techniques and differing spatial coverage between the two sampling campaigns. In addition, there is a possibility that the Allen Mill event may have reset surface sediment concentrations shortly after the 1991 sampling, although such an effect is not clearly visible in high-resolution cores. A direct comparison of the results (without correction for different sample support) reveals little change between the two dates. For the near surface sediments (all samples from 0 to 5 cm), the geometric mean concentration in the TI Pool in 1991 was 15.9 mg/kg, while in the 1998 samples the geometric mean concentration was 11.8 mg/kg Tri+ PCBs. An examination of the cumulative frequency distributions, however, reveals that most of the change occurred in the lower 60 percent of the distribution (Figure 633-1, Cumulative Frequency Distribution of Total PCB Concentration in Surface Sediments in the TI Pool, 1991 and 1998 GE Data). In other words, the surface concentrations have remained high in many of the more-contaminated areas. At the same time, the molar dechlorination product ratio (MDPR) appears to have experienced a small increase across the entire distribution (Figure 633-2, Cumulative Frequency Distribution of MDPR in Surface Sediments in the TI Pool, 1991 and 1998 GE Data). This is consistent with either some continuing dechlorination or the mixing of

lighter congener dechlorination products toward the surface; it is not consistent with extensive replenishment of the sediment by unweathered Aroclor 1242 from the upstream source.

As noted above, the average rate of change in surface sediment concentrations is not necessarily representative of what happens at specific locations. The data collected by both EPA and GE indicate that PCB concentrations near the sediment surface remain highly elevated in certain areas, such as *hot spots* 8, 10, and 14 (Response to Master Comment 619, Section 2.1).

To test rates of change in surface sediment concentrations in specific locations it is necessary to match the location of sediment samples over time. This was first done in the LRC Report (USEPA, 1998), in which samples taken by EPA in 1994 were matched to samples collected by NYSDEC in 1984 and 1976-78. These sampling campaigns do not generally provide a fine enough vertical resolution to assess concentration trends in sediment samples in the top few centimeters. The data most appropriate for this task are the GE samples collected in 1991 and 1998. Appendix D.1 of the FS presents a comparison of matched samples between 1991 and 1998.

Although there is considerable uncertainty inherent in the matching, due to the method of compositing used by GE in 1991, 11 approximately co-located sample groups were identified. Within the TI Pool, observed changes in surface sediment Tri+ PCB concentration ranged from -61.6 percent to +82.0 percent with a median of -33 percent. As described in FS Appendix D.1, the data suggest that a statistically significant decline in average surface cohesive sediment concentration did occur between 1991 and 1998; however, there was also a significant amount of local variability, including some locations where concentrations apparently increased. For example, Tri+ PCB concentrations in fine sediment below Lock 6 appear to have increased from 26.3 to 26.6 mg/kg, while concentrations at *Hot Spot* 14 (the most contaminated area sampled by GE) declined by less than 10 percent, from 40.7 to 36.9 mg/kg (see Table 5 in Appendix D.1 of the FS).

The spatial variability in response is important: It means that reducing the *average* surface sediment concentration in a reach does not guarantee a reduction in *all* surface sediment exposure concentrations. As a result, biota that accumulate PCBs from food chain pathways tied to the sediment may reflect conditions in the sampling location that differ from reach-average predictions.

In sum, EPA has used all available data to evaluate changes in sediment PCB concentrations over time. These data are sufficient to conclude that surface sediment PCB concentrations in the Upper Hudson do not exhibit a comprehensive and significant decline. Instead, some areas appear to show slow declines in concentration in the 1990's, while other locations, including some of the most contaminated areas of the TI Pool, show little decline or increases.

References

O'Brien & Gere. 1993. Data Summary Report, Hudson River Project, Sampling and Analysis Program, 1991 Sediment Sampling and Analysis Program. Report to General Electric Company, Albany, NY. O'Brien & Gere Engineers, Inc., Syracuse, NY, May 1993.

USEPA. 1998. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C-A, Low Resolution Sediment Coring Report. Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Gradient Corporation, and Tetra Tech, Inc. July 1998.

USEPA. 2000. Phase 2 Report, Further Site Characterization and Analysis. Volume 2 – Revised Baseline Modeling Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc. January 2000.

Master Comment 635

Numerous commenters felt that since 1984, conditions in the river have improved dramatically, and that the Hudson is healthier than it has been in decades. Fish and wildlife were noted as abundant. PCB levels in fish, sediment, and water continue to decline, they say, whereas EPA claims that the data do not show continuing declines in PCB levels. It was said that EPA's analysis of trends conflicts with mass-balance modeling results, and that the models provide the best tools for evaluating historic trends.

Other commenters say that temporal trends are discussed qualitatively in the Feasibility Study and proper statistical analysis should be applied. Some comments noted that fish concentrations show little evidence of decline since 1995.

Response to Master Comment 635

This response is one of four addressing the analysis of recent trends in PCB concentrations in the Hudson River, and covers the subject of trend analysis in general. Further details on trends in fish, sediment, and water are provided in Responses to Master Comments 629, 631, and 633, respectively, all in Section 2.6.

A number of comments expressed a general position that PCB levels in the environment had declined dramatically over time, and that the river was therefore cleaning itself. The trends derived from the environmental time series are, however, very much dependent on which time interval is examined.

This point is well illustrated through an examination of annual average water-column concentrations. USGS monitoring at Stillwater and Waterford constitutes two of the longer-running data series, collected at consistent locations and analyzed by known methods, that are available for the Upper Hudson. These data are available for 1977 through 1997. Figure 635-1 (Annual Average PCB Tri+ Concentrations from USGS Monitoring at Waterford and Stillwater) displays the annual average water-column concentrations. These concentrations were obtained from the whole of the data with a minimum of processing other than conversion of individual data points to a consistent PCB Tri+ concentration to account for changes in analytical methods over time, as described in the RBMR (USEPA, 2000).

The figure shows a series of events in the history of PCB contamination. In the 1970s, concentrations were very high, reflecting the rapid redistribution of the unstable PCB-contaminated deposits left behind when the Fort Edward Dam was removed, due to high flows in subsequent years and navigational dredging. The water column Tri+ PCB concentrations generally declined through 1988, with an interruption due to the high-flow event of spring 1983. Concentrations increased in the early 1990s, reflecting increased loads from the Hudson Falls plant. In 1994, the upstream seeps were largely controlled, and concentrations dropped back to levels similar to those seen in 1988 and 1989. For 1994 through 1997 the trend is essentially flat.

One can interpret this graph in various ways. On the one hand, one could say that the 1997 concentration at Stillwater is only four percent of the 1977 concentration. Or, as per GE comments, one could observe that PCB levels in the water column now are lower than those in 1984. Finally, one could note that the 1997 concentration is greater than the 1989 concentration.

It is clear that environmental concentrations of PCBs in the Hudson River have declined markedly since the disastrous conditions of the late 1970s, as is fully acknowledged and documented by EPA (USEPA, 1997). Conditions were still improving in 1984, when EPA issued its original interim No Action decision. However, only slight improvement has been seen after 1984, which is one reason why it is now appropriate to revisit the interim No Action determination.

In sum, EPA agrees with comments that point out that there has been a massive reduction in environmental exposure concentrations of PCBs since the 1970s, but notes that almost all of this reduction occurred prior to 1987, with little improvement since. Similar conclusions can be drawn regarding PCB concentrations in fish tissue, water-column loads, and PCB concentrations in surface sediment. These are addressed in greater detail in Responses to Master Comments 629, 631, and 633, respectively, all in Section 2.6.

GE also claimed that the data-based trend analyses produced inconsistent results between different media, and, therefore, recommended that the GE and EPA models provided the best tools for evaluating trends.

EPA disagrees with this comment. First, the data-based analyses are not inconsistent with one another, but rather represent different spatial and temporal scales. Second, if the data and models differ, the data should not be rejected out of hand in favor of the models without strong supporting evidence.

It is of the utmost importance to examine the data directly, independent of the models. EPA believes that its model represents the best available summary of conditions and trends in the Hudson River at broad spatial and temporal scales. However, potential inaccuracies in the model as well as conditions that occur at localized spatial scales not captured by the model must be taken into consideration in the selection of a remedy. These issues are discussed at length in Appendix D.1 of the FS.

Comments received from NOAA on the discussion of trends in the main text (FS, pp. 1-39 to 1-40) question the qualitative presentation of temporal trends. EPA provided both a qualitative and a quantitative presentation in the FS. A qualitative presentation was provided in the main text for

reasons of simplicity and readability. A quantitative, statistical evaluation of the data on temporal trends is provided in Appendix D.1 of the FS.

Additional information on the analysis of trends may be found in Responses to Master Comments 629, 631, and 633 in Section 2.6. In particular, Response to Master Comment 629 documents that fish tissue concentrations have not exhibited a consistent decline in recent years. Response to Master Comment 633 shows that surface sediment concentrations have declined in some areas, but not in others. Finally, Response to Master Comment 631 shows that the summer water column concentrations in the TI Pool have remained approximately constant over the last five years.

Various public comments offered qualitative observations that fish and wildlife populations were more numerous now than in previous decades. These observations are not directly relevant to the assessment of risks posed by PCBs in the Hudson River. First, fish generally exhibit lower sensitivity to environmental concentrations of PCBs compared to humans and piscivorous avian and mammalian wildlife. The ecological and human health risks posed by PCBs in the Hudson are driven by fish tissue concentrations of PCBs, rather than by direct impacts on the fish population itself (Response to Master Comment 313320, Chapter 11). In addition, the current status of fish populations integrates many different factors. Both reductions in discharges of conventional pollutants and limitations on fishing in the Hudson are believed to have improved the status of many fish species. As discussed further in Response to Master Comment 819, Chapter 3, available population level data are not sufficient to confirm or reject a link between PCB exposure and population abundance in the Hudson River.

EPA agrees that conditions in the upper Hudson River have improved dramatically since the 1970s and 1980s. However, the rate of improvement in PCB concentrations in the environment and in biota has leveled off in recent years, and substantial further improvement by natural attenuation cannot be guaranteed (Response to Master Comment 405926, Chapter 4). For this reason, EPA believes that active remediation is needed to restore the Hudson River.

References

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C – Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., the Cadmus Group, Inc., and Gradient Corporation. February.

USEPA. 2000. Phase 2 Report, Further Site Characterization and Analysis. Volume 2 – Revised Baseline Modeling Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc. January.

Master Comment 631

Some commenters say that PCB concentrations in water are declining at rates faster than stated by EPA. Some contend that EPA's analysis of trends in water is based on an incorrect

hypothesis: water column PCB concentrations in the TI Pool during summer low flow achieve a maximum concentration that is in steady-state with PCB levels in the sediments, and that recent load reductions reflect low flows in recent years. Comments also state that EPA's analysis relies on data from the TID-West station, which is biased. It was suggested that trends should be evaluated from the "unbiased" Schuylerville station, which shows a 40 percent reduction in load from 1991 to 2000.

Response to Master Comment 631

Recent Water Column PCB Concentration Trends

Water column concentrations of PCBs declined significantly from late 1991 to 1995. However, the concentrations in late 1991 were elevated over those seen in the 1980s due to increased releases in the vicinity of the GE Hudson Falls plant, and a major part of the decline from 1991 to 1995 is attributable to the partial control of that Hudson Falls source. Concentrations in the water column in the late 1990s are similar to those seen in 1989. Over the same 1991-1995 time period, the load gain from the TI Pool sediments appears to have been nearly constant (Response to Master Comment 621, Section 2.1). Analysis of congener signatures links this load gain to sub-surface sediments in *hot spot* areas (Response to Master Comment 623, Section 2.1).

Recent monitoring data received from GE (running through 5/9/01) show little change in summer water column total PCB concentrations at the TID-West station near the TI Dam over the past five years. Table below shows the average water column concentrations at the TI Dam for June to August from 1996 to 2000, as well as the estimated total PCB load gain between Rogers Island and TI Dam (without correction for potential sampling station bias, which is discussed below). The summer average concentrations have remained relatively constant, between 100 and 165 ng/L total PCBs. The 1999 summer average concentrations were higher than 1996, but load was low due to low flows in this year. These data do <u>not</u> provide a basis for concluding that summer PCB concentrations in water continue to exhibit a steady decline.

Recent Summer Water Column Total PCB Concentrations and Loads in the Thompson Island Pool

Year	June-August Total PCB Concentration (ng/L)	June-August Total PCB Load Gain across TI Pool (kg)
1996	139.4	128.0
1997	164.8	102.5
1998	101.9	95.7
1999	157.8	55.5
2000	124.2	143.5

A discussion of mechanisms of release of PCBs from the sediments of the TI Pool, as well as a response to comments regarding summer "steady state" concentrations is found in Response to Master Comment 621 in Section 2.1.

GE questions EPA's "hypothesis that water column PCB concentrations in the TI Pool during summer low-flow achieve a maximum concentration that is in steady-state with the sediment PCB levels."

As described in Response to Master Comment 621 (Section 2.1), this statement misrepresents EPA's position. Recent monitoring data provide a strong indication that apparent load reductions in the later 1990s were in large part due to reduced flows, with little change in concentration.

Potential Bias in TID-West Monitoring Data

Several comments addressed the use of the TID-West sampling station to evaluate PCB concentrations leaving the TI Pool. In 1997, GE determined that the nearshore observations taken near the TI Dam at TID-West may be biased high relative to center channel observations (Rhea, 1997), and might therefore overestimate load leaving the TI Pool. GE collected a number of concurrent samples at TID-West, the center channel above the dam (TID-Center), and downstream of the dam (TIDPRW) between 1996 and 1998.

Water column concentrations near shore often appear to be higher relative to center channel concentrations in the lower TI Pool. A lateral concentration gradient occurs primarily during summer low flow conditions when mixing is reduced, and reflects the important role of releases from historically deposited sediments in causing elevated exposure concentrations in the nearshore environment. Although samples from this station may at times be higher than the average concentration leaving the TI Pool, they still provide information that is essential to interpretation of the cycling of PCBs in the Upper Hudson River.

EPA's analysis of the concurrent GE samples suggests that a bias between the nearshore and center channel stations exists primarily at low flow conditions when lateral mixing is minimized and when upstream concentrations are low.

Figure 631-1 (Ratio of Tri+ at Center Channel to TID-West, Plotted against Upstream Flow and Concentration) plots the ratio between TID-Center samples (or TIDPRW samples when TID-Center is not available) and TID-West samples for Tri+ PCBs. Part of the scatter is likely due to analytical inaccuracies, coupled with short-period temporal variation. It does appear, however, that the tendency towards a low bias is consistent only at low flows and at low upstream concentrations. This is consistent with a situation in which quiescent nearshore waters have established a quasi-equilibrium with local contaminated sediment deposits.

EPA developed empirical bias correction factors to help adjust the TID-West samples toward the estimated center channel concentration. While individual concentration estimates may still be inaccurate, EPA believes this procedure results in representative estimates of longer-term average trends, and, in particular, provides unbiased estimates of loading patterns.

For Tri+ PCBs, the average of the ratio between TID-Center and TID-West/TIDPRW samples is significantly different from 1 only for flows less than 4,000 cfs. For these low flows, the ratio has an average of 0.69 for upstream concentrations less than 15 ng/L, and 0.88 for upstream concentrations greater than 15 ng/L. Application of these factors as corrections yields an estimate of concentrations leaving the TI Pool, and was used in EPA's model calibration effort. Note that no correction factor is needed for flows greater than 4,000 cfs, which account for much of the mass transport of PCB load. A similar analysis was conducted for total PCBs.

Interpretation of Schuylerville Monitoring Data

GE contends that the data from the TID-West station should not be used to analyze trends in water column PCB concentration or load. After dismissing the TID-West station, GE claims that only the Schuylerville station (Rt. 29) provides valid data for assessing trends in the 1990s. GE states that the summer load at this station declined 40 percent from 1991 conditions to 1998-2000 conditions. Unfortunately, GE did not sample the Schuylerville station from July 1992 through September 1997.

An examination of the load series at the Schuylerville (Rt. 29) station and at Fort Edward (Rt. 197) shows that the statement made by GE about a 40 percent decline is uninformative and incorrect (Figure 631-2, Monthly Total PCB Loads at Rt. 197 (Fort Edward) and Rt. 29 (Schuylerville) Estimated from GE Data). That is, loads at the Schuylerville station did decline, but by a small amount, while the upstream loads at Fort Edward declined much more dramatically. Thus, most of the reduction of the load at Schuylerville noted by GE is attributable to differences in the upstream load between 1991 and recent conditions.

EPA also recomputed summer loads at the Fort Edward and Schuylerville stations using the averaging estimator approach described in the DEIR (USEPA, 1997) and defining summer as June through August only. The September 1991 monthly averaging results cannot be used in the comparison as they are inflated by the failure of the Allen Mill gate structure; September is also omitted from the 1998-2000 results for consistency of comparison.

During this period, the total PCB summer loads at Schuylerville did decline, but only by 4 percent, from 0.91 kg/d in 1991 to 0.87 kg/d total PCBs in 1998-2000. Meanwhile, the upstream load at Fort Edward (Rt. 197) declined by 66 percent, from 0.38 to 0.13 kg/d total PCBs. The difference in load between Fort Edward and Schuylerville (load gain) actually increased, from 0.53 kg/d in 1991 to 0.75 kg/d total PCBs in 1998-2000.

Over all months for which PCB monitoring is available at both Fort Edward and Schuylerville, as well as USGS provisional flows, the estimated load gain between Fort Edward and Schuylerville is approximately 0.97 kg/day (2.13 lb/d) total PCBs. For these periods of concurrent monitoring (April 1991 through June 1992, October 1997 through November 2000) the sediments appear to have contributed 64 percent of the total PCB load passing Schuylerville. For the October 1997 to November 2000 period, the Hudson River sediments contributed 84 percent of the total PCB load passing Schuylerville.

References

Rhea, J. 1997. Memorandum Re: TIP Time of Travel Surveys to J. Haggard, GE, October 6, 1997. HydroQual, Inc.

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C – Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., The Cadmus Group, Inc. and Gradient Corporation. February.

2.7 Adequacy of RI Data Collection to Support the FS

Master Comment 627

A set of comments questioned the adequacy of the data collection effort undertaken by EPA to support the Reassessment RI/FS. Commenters stated that little or no data were collected by EPA itself on most lower trophic level aquatic organisms, subaquatic vegetation, and fish, and that most of the data on water column and sediment PCB concentrations were collected by organizations other than EPA. Specifically, comments stated that EPA

- Collected no data or inadequate data on primary aquatic biota in the Hudson River food chain and on submerged aquatic vegetation, but GE did (GE comment 11-0101-022).
- Collected fish data only in 1993, whereas NYSDEC has collected data since the 1970s "with significant funding from GE" (GE comment 11-0101-026).
- Collected water column data only in 1993, whereas GE has conducted routine water column sampling since 1991 (GE comment 11-0101-027).

It was suggested that much of EPA's work did not follow the scientific method and did not rigorously evaluate and test hypotheses.

Response to Master Comment 627

Characterization of the Phase 2 Sampling Effort

Throughout the Phase 2 and Phase 3 efforts, EPA has relied on all available, quality-assured sources of data, including data collected by GE, NYSDEC, USGS, NOAA, and others, in addition to the data collected by EPA itself. All parties have frequently exchanged data, and analyzed and commented upon other parties' sampling plans and data quality assurance procedures.

The data set on which the Hudson River PCBs Reassessment RI/FS is based is the sum total of the data collected by all parties. For this reason, the official database for the project (USEPA, 2000a; USEPA, 1995) includes data from GE, NYSDEC, USGS, NOAA, and NYSDOH, as well as data collected by USEPA.

In fact, the EPA Phase 2 sampling effort was never designed to be a stand-alone effort. The Phase 2 sampling plan (USEPA, 1992) recognizes this, and devotes a section (4.1) to the acquisition and processing of data being collected by GE, USGS, NYSDEC, and others. At the time the Phase 2 effort was planned, GE had already begun its remnant deposit monitoring program and its temporal water column-monitoring program. The remnant deposit monitoring program was being conducted pursuant to the Consent Decree between EPA and GE for capping of the remnant deposits. EPA was aware that these data would also be valuable to the reassessment of the interim No-Action alternative for the PCB-contaminated sediments in the Upper Hudson.

In general, EPA's Phase 2 data collection effort was designed to answer a number of specific questions regarding PCB fate and transport in the river; to provide a higher-resolution analysis of PCB congeners in water, sediment, and fish than was being provided by the GE, USGS, and NYSDEC analytical programs; and to provide a quality/usability check on data collected and submitted by GE. Because GE's analytical data were found to be generally of adequate quality, as acknowledged in USEPA, 1997, it was not necessary for EPA to replicate efforts such as, for example, GE's water column monitoring required by the Consent Decree for the remnant deposit capping, except insofar as needed to determine comparability of results.

In sum, the data available for the Hudson River PCBs Site should be viewed as a whole, and are more than adequate to support the Feasibility Study. As GE points out in their comments, data collected by other parties has served to fill in many gaps in EPA's Phase 2 sampling effort.

Use of Phase 2 versus GE Data

EPA has made full use of data collected by its own contractors, by GE, by NYSDEC, by NOAA, and by other parties in completing the DEIR (USEPA, 1997), the Revised Model Calibration Report (USEPA, 2000b), the Feasibility Study, and other project documents.

In general, all the data sources complement one another to form a consistent picture of the history and dynamics of PCBs in the Hudson River. In the few cases where conflicting analytical evidence is available from different sources, EPA has preferred data generated by the Phase 2 program, as these data were collected and analyzed under Quality Assurance/Quality Control procedures that were more rigorous and better documented than those for any of the other sources of data.

GE implies that EPA reached various "broad conclusions" in the DEIR (USEPA, 1997) "on the basis of its water column data" alone. This is incorrect. First, EPA used multiple lines of evidence from monitoring in the water column, sediment, and biota to evaluate PCBs in the Hudson River. The DEIR makes full use of water column data collected by EPA, GE, and USGS. However, only the EPA water column data provide certain types of information, including "transect" sampling designed to follow a parcel of water through the entire length of the upper river from Fort Edward to Waterford, flow-averaged sampling designed to evaluate cumulative PCB loads over time, and full separation of PCB analyses into dissolved and particulate components.

In contrast, most of the GE water column monitoring has involved analysis for total PCBs (as measured by peak-specific PCB analysis) at fixed sites and at fixed intervals, except for some special studies in the reaches between Bakers Falls and the TI Dam. In addition, EPA used a larger sampling volume and achieved lower detection limits and resolution of more individual congeners than did GE. As a result, the Phase 2 results contain important information that is not available from GE monitoring. Nonetheless, obtaining a complete picture of PCBs in the Upper Hudson has required combination of both EPA and GE monitoring results.

GE claims (in part) that EPA's analysis was based primarily on 1993 Phase 2 data, and that "[d]ata for the previous 15 years were ignored, [and] a single statement about trends was made on the basis of a few years of recent data."

As stated repeatedly above, EPA has thoroughly evaluated data collected by other sources, such as GE, NYSDEC, USGS, NOAA, NYSDOH, and others. These data are included in EPA's database. EPA does believe that data collected since 1991 and analyzed to the congener level by capillary column GC (by both EPA and GE) are of greater reliability than data analyzed by packed column GC against Aroclor standards. However, the entire span of available data has been used by EPA in the analyses presented in the DEIR (USEPA, 1997), the RBMR (USEPA, 2000b), and the Feasibility Study. The DEIR (USEPA, 1997) contains a detailed analysis of trends in water column concentrations and loads since the earliest data from the 1970s, and also re-examines the 1984 sediment data and historic sediment cores. The entire period of available biotic PCB data is examined in detail, including trend analysis, in the RBMR (USEPA, 2000b) and again in the Feasibility Study.

Finally, EPA's modeling effort (USEPA, 2000b) makes full use of all the data available from the 1970s, 1980s, and 1990s to derive a model that provides a best representation of the history and causal factors of PCB contamination in the Hudson River.

The Scientific Method

GE states, "The Scientific Method was not consistently applied or used...EPA's Phase 2 work plan...did not evaluate specific hypotheses. As a result, EPA failed to collect the data necessary... This led to a reliance on an inadequate data set and untested hypotheses to determine the need for and benefits of sediment remediation."

EPA disagrees with this comment. The series of technical reports produced by EPA was subjected to a rigorous, independent peer review process that generally validated the scientific approach used by EPA. Where significant shortcomings were identified by the peer review, these were subsequently addressed. Response to Master Comment 467 in Chapter 1 contains a more detailed discussion of the peer review process.

In contrast to the description provided by GE, the Phase 2 sampling effort was carefully designed to test specific hypotheses reflecting the state of understanding of the problem at the end of Phase 1. These included the following eight hypotheses:

> 1. PCB load in the Upper Hudson is a combination of load derived from historically emplaced sediments and a (then) unknown source upstream of Rogers Island. This hypothesis arose directly from the Phase 1 analysis, at which time the existence of the massive PCB seeps around the GE Hudson Falls facility was unknown.
>
> 2. PCB loads in the Upper Hudson are primarily due to releases from the GE facilities. Sampling upstream of GE and in tributaries to the Upper Hudson should reveal minimal PCB contributions.
>
> 3. PCB loads derived from historically emplaced sediments can be distinguished from unweathered PCB loads by a careful analysis of the congeners present in the

environment. In addition, congener analysis can resolve different Aroclor contributions as sources.

4. Extensive PCB contamination of the Upper Hudson began with GE's capacitor manufacturing operation. Loads peaked with the spring floods following the removal of the Fort Edward Dam. The signature of this loading history should be discernible in dateable sediment cores from consistently depositional areas.

5. The PCB loads in the water column at Stillwater and Waterford are essentially the same PCB load that leaves the TI Pool (as represented in early GE sampling and USGS sampling at Fort Miller). This hypothesis should be answerable through tracking of a parcel of water at multiple stations throughout the Upper Hudson.

6. PCB concentrations in biota likely represent an integration of water and sediment exposure pathways, which are not necessarily in equilibrium. Identification of congener signatures in fish, water, and sediment should help resolve the factors that control PCB body burden in fish and enable calibration of a predictive model to guide remediation efforts.

7. The majority of the PCB loads to the freshwater portion of the Lower Hudson are due to GE loads. Loads in the saline portion of the Lower Hudson represent a combination of upstream GE loads and loads derived from the New York metropolitan area. Confirmation of this hypothesis should be available through analysis of datable sediment cores.

8. Massive stores of PCBs remain buried within the sediments of the TI Pool. The bulk of these PCBs remains there (as of 1991) but is at risk of being remobilized by a large flood event.

EPA believes that the Phase 2 sampling effort, when combined with the known ongoing monitoring efforts by GE, NYSDEC, and USGS, was well designed to test these hypotheses.

In fact, the sampling effort and subsequent analyses, as reported in DEIR (USEPA, 1997) and RBMR (USEPA, 2000b), have conclusively confirmed the first seven hypotheses that guided the Phase 2 sampling effort. The eighth hypothesis (imminent risk) was rejected based on data analysis and modeling (USEPA, 2000b). Further investigation of flood remobilization of buried PCB contamination, based on revised information on potential 100-year flood magnitudes provided by NYSDEC, was also conducted (Response to Master Comment 364582, Chapter 6).

Of course, when conducting environmental investigations, many unanticipated conditions arise. In this way, investigations of environmental problems differ markedly from controlled laboratory experiments to test hypotheses.

In the Hudson River, the major unanticipated factor was the massive release of unaltered PCBs from the GE Hudson Falls site between 1991 and 1994. This circumstance could not be foreseen in the planning for the Phase 2 sampling effort. As a result, EPA's data, collected in 1993, were

used to examine a variety of questions that were not anticipated in the sampling plan. Similarly, GE conducted a variety of new, previously unplanned analyses during the 1990s. All these data were incorporated into EPA's analyses leading to the Feasibility Study.

EPA believes that its conclusions in the FS are well founded in a massive data set (collected by EPA, GE, and others) that is more extensive and detailed than that available for almost any other CERCLA site.

Specific Comments

GE claims that EPA's characterization of submerged aquatic vegetation and benthic macroinvertebrates is inadequate. This topic is discussed in further detail in Response to Master Comment 815 in Chapter 3.

GE claims that EPA "failed to collect data to determine the reason for the declining trends in PCBs that it identified in the Phase 1 Report," specifically referring to the evaluation of data. Although PCB levels declined over the time period from the late-1970s to 1989, data from the last 10 to 15 years show that PCB levels have remained essentially unchanged, except for the perturbations introduced by releases from the GE Hudson Falls facility. It is not possible to go back and collect more data from past decades. In any case, the question is moot; whatever the mechanisms may have been for the rapid declines seen in previous decades, the fact is that those mechanisms no longer exist under the current conditions in the Hudson River.

A second problem for investigating earlier conditions in the river was caused by the failure of the Allen Mill gate structure at GE's Hudson Falls Plant in September 1991. This event released large quantities of unweathered PCBs into the river and made difficult any examination of the factors controlling PCB distribution prior to 1991.

One source of new data that does provide a historical record is dated sediment cores. EPA invested considerable effort in locating and analyzing high-resolution sediment cores with datable radionuclide chronologies (USEPA, 1997). These cores, coupled with results from cores collected earlier by other researchers, provided considerable insight into historical trends in PCB contamination in the Hudson River.

NOAA pointed out that additional PCB surface sediment data from the early 1990s collected by NOAA NS&T, EPA EMAP, and EPA R-EMAP are available in NOAA's Newark Bay watershed database at http://response.restoration.noaa.gov/cpr/watershed/watershedtools.html. However, as they concern New York Harbor sediment concentrations they are primarily relevant to the discussion of current PCB concentrations in the Lower Hudson, and do not have a direct bearing on the selection of a remedial action for the Upper Hudson.

References

USEPA. 1992. Final Phase 2 Work Plan and Sampling Plan, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 by TAMS Consultants, Inc. and Gradient Corporation. September.

USEPA. 1995. Phase 2 Report, Further Site Characterization and Analysis. Database Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 by TAMS Consultants, Inc. and Gradient Corporation. October.

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C – Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., The Cadmus Group, Inc. and Gradient Corporation. February.

USEPA. 2000a. Database for the Hudson River PCBs Reassessment RI/FS, Release 5.0. Compact Disk. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc. October.

USEPA. 2000b. Phase 2 Report, Further Site Characterization and Analysis. Volume 2D – Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc., January.

Master Comment 313799

Some commenters contended that EPA's data collection, analysis, and risk evaluation in the FS was deficient and inadequate for EPA to select a remedy**.** In a similar vein, several commenters suggested that more study should be conducted, or that there should be a moratorium on remediation while the status and trends in the river were monitored.

Response to Master Comment 313799

EPA strongly disagrees. In addition to a significant sampling event conducted by USEPA and its contractors, EPA also reviewed and utilized data from many agencies and others including USGS, NYSDEC, NOAA, and GE, ultimately developing a database spanning approximately 25 years and including over one million records. EPA has revised and updated risk assessments, both ecological and human health, since the initial preliminary risk assessments presented in the Phase 1 Report. These risk assessments have been peer reviewed as well as made available for public comment. In addition, EPA has also engaged specialized technical consultants to assist in fate and transport modeling and other technical aspects of the FS that were the basis for the proposed remedy.

Therefore, EPA does not agree that the risk assessments or the data or its evaluation are insufficient. Rather, the database developed for this project is comprehensive in terms of the time span covered, the area covered, and the types and amount of data generated and utilized in the analysis and evaluation. Therefore, the information provided in the Reassessment RI/FS is sufficient to support an appropriate risk management decision in accordance with 40 CFR 300.430(e)(9) and the 1988 USEPA RI/FS guidance (USEPA, 1988).

Specific issues raised by commenters regarding the analysis, evaluation, and interpretation of the data are discussed in greater detail in subsequent chapters of this responsiveness summary.

Specifically, comments regarding the adequacy of the human health and ecological risk assessment are addressed as follows:

- Chapter 3 – the baseline conditions.
- Chapter 7 – risk estimates used to evaluate specific alternatives and use and interpretation of the various models.
- Chapter 11 – use of the FS results in the detailed analysis of remedial alternatives, the step immediately preceding the identification of the selected remedy (*i.e.*, the risk management decision).

Finally, EPA disagrees with the suggestion that additional study be conducted, or that the remediation should be delayed. As noted above, the selected remedy was identified following an extensive reassessment RI/FS program that took 10 years to complete and included the analysis of data spanning a 25-year period. The reader is also referred to the Response to Master Comment 485 in Chapter 11 of this Responsiveness Summary in which EPA states that the administrative record supports its decision, and to Response to Master Comment 377, Chapter 1, in which EPA summarizes the rationale for its determination that the 1984 Interim No Action decision is no longer appropriate.

Reference

USEPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (OSWER Directive 9355.3-01 [1988]).

3. BASELINE RISK ASSESSMENTS AND PRGS

3.1 Baseline Human Health Risk Assessment

3.1.1 PCB Toxicity

3.1.1.1 PCB Toxicity – Cancer

Master Comment 571

Several comments stated that EPA estimated PCB carcinogenicity based on animal bioassays that substantially overstate the toxicity of PCBs to humans based on the cancer slope factor. These comments also state that a formal weight of evidence review of the human epidemiological studies shows that there is no credible evidence that PCBs cause cancer in humans. Other comments suggest that cancer risks may be underpredicted because effects from dioxin-like congeners were not fully considered. Several comments were received indicating that dechlorination of PCBs in the environment would alter the carcinogenicity of the dechlorinated PCB mixture.

Other comments state that EPA's guidance prohibits EPA from applying the toxicity values in the Agency's Integrated Risk Information System (IRIS) database without first carefully considering the evidence of lower toxicity values submitted by GE. One comment provided calculations of the PCB body burdens based on EPA's Proposed Plan, suggesting that the potential body burdens are below those found in the worker population. Some comments stated that EPA has not performed research on PCBs.

Other comments agree with EPA's classification of PCBs as a probable human carcinogen. These comments highlight the exposures of the population to a combination of chemicals each day, stating that it is not possible in most cases to definitively conclude that a specific chemical has caused a specific cancer. A comment also quoted conclusions from the Toxicological Profile for Polychlorinated Biphenyls (Update), developed by the Agency for Toxic Substances and Disease Registry (ATSDR) and subsequently externally peer reviewed, as additional support for the conclusions that PCBs are probable human carcinogens (ATSDR, 2000 and Johnson *et al.*, 1999). Another comment reviewed the study by Kimbrough *et al.* (1999a), recommending that "the data from Kimbrough require that PCBs be reclassified as a known human carcinogen."

Response to Master Comment 571

Overview

EPA received numerous comments relating to the carcinogenicity of PCBs (*i.e.*, the ability of PCBs to cause cancer) and their cancer potencies (the numerical estimates of dose-response, which are quantified as cancer slope factors).

The following response presents an overview of the Agency's process for assessing PCB carcinogenicity and cancer potencies, a review of recent human epidemiological studies, a discussion of some of the uncertainties related to PCB carcinogenicity, and a discussion of the

cancer slope factors used in the Revised HHRA (USEPA, 2000a). White Paper – PCB Carcinogenicity discusses all of these issues in more detail and provides a more complete reference list.

EPA has conducted significant research on the mechanisms of action of PCBs and has worked with other federal agencies (*i.e.*, National Institutes of Environmental Health Sciences [NIEHS] of the National Institutes of Health [NIH] and others) to further support EPA's PCB research effort. The National Academy of Science's report on PCB-contaminated sediments (NAP, 2001) also concluded that PCBs may pose long-term health effects to humans, including cancer. At this time, studies of the mechanisms of action of PCBs are areas of ongoing research.

EPA Process for Assessing Carcinogens

EPA's process for evaluating human epidemiological and animal evidence to determine the carcinogenicity and cancer potencies of chemicals, including PCBs, is set forth in Agency guidelines (USEPA, 1976, 1984, 1986, 1994, 1996a). The guidelines were developed within the Agency, published in the *Federal Register* for external comment, and peer reviewed by a panel of expert scientists in the fields of carcinogenesis, toxicity, exposure, and related scientific disciplines from universities, environmental groups, industry, labor, and other governmental agencies. EPA responded to comments on the draft guidelines and made changes based on a review of the comments submitted by these groups and individuals. The guidelines were also submitted for review to EPA's Science Advisory Board, an external scientific review panel. Agency guidelines for assessing carcinogens are consistent with the scientific approaches that are used by national and international agencies (*e.g.*, the National Toxicology Program [NTP, 1984] and the International Agency for Research on Cancer [IARC, 1987]) for evaluating the carcinogenicity of chemicals.

Carcinogenicity Weight of Evidence

EPA classified PCBs as probable human carcinogens in 1988 (USEPA, 1988) and reaffirmed this classification in 1996 (USEPA, 1996b). EPA's classification is based on a formal weight-of-evidence approach described in the 1986 Carcinogen Guidelines (USEPA, 1986) and the proposed 1996 Carcinogen Guidelines (USEPA, 1996a).

Using the formal weight-of-evidence approach, EPA evaluated human epidemiological evidence, animal bioassay data, and other supporting studies (*e.g.*, mutagenicity tests and metabolism data) (USEPA, 1996b). EPA concluded that there was sufficient evidence of carcinogenicity from animal studies to document PCBs as known animal carcinogens. EPA also concluded that there was "limited to inadequate evidence" of carcinogenicity from human epidemiological studies, resulting in an overall classification of PCBs as probable human carcinogens. The results of this analysis were externally peer reviewed and this information was made available through IRIS and supporting documents. The external peer reviewers supported EPA's conclusions (USEPA, 1996c).

Other national and international agencies have reached similar conclusions independently regarding the carcinogenicity of PCBs, also using a weight-of-evidence approach. Such agencies include IARC, part of the World Health Organization; the NTP, part of the National Institutes of

Environmental Health Sciences of the National Institutes of Health; and the National Institute of Occupational Safety and Health (NIOSH); part of the Centers for Disease Control and Prevention (CDC).

One comment suggested that EPA conduct a cancer epidemiological study of residents living near the Site using data from the Glens Falls Hospital to evaluate the potential carcinogenicity of PCBs. EPA does not conduct epidemiological studies of residents living in the vicinity of Superfund sites for use in HHRAs. Rather, EPA relies on nationally developed toxicity values and weight of evidence classifications for chemicals, as discussed. EPA used the information from the 1996 PCB Cancer Reassessment in developing the HHRA for the Hudson River. The use of data from IRIS was evaluated by the external peer reviewers for the HHRA, who agreed with EPA's use of this data with some updates in the HHRA (ERG, 2000). The HHRA evaluates both current and future cancer risks and non-cancer health hazards under baseline conditions, *i.e.*, in the absence of remedial action and institutional controls, consistent with Agency guidance, policies, and guidelines.

Cancer Slope Factors

In 1996, EPA revised the cancer slope factors (CSFs) for PCBs (USEPA, 1996b) that were developed in 1988 (USEPA, 1988) consistent with the Agency's carcinogen guidelines (USEPA, 1986 and 1996a) based on human epidemiological evidence and animal bioassay data. These data included the GE-funded rat carcinogenicity study (Brunner *et al.*, 1996 later published as Mayes *et al.*, 1998) and other reports submitted to EPA. EPA developed separate CSFs for inhalation, ingestion, and provided a recommendation for dermal assessments. The current CSFs are based on studies using a number of different Aroclor mixtures (*i.e.*, the commercial formulation of PCBs including Aroclor 1016, 1242, 1254, and 1260), which together span the range of congeners most frequently found in environmental mixtures (USEPA, 1996b). To the extent that a congener is present in the Aroclor mixture tested in the animal studies that serve as the basis of the CSF, it was evaluated in the PCB carcinogenicity assessment in the HHRA. Therefore, even though EPA used Tri+ PCBs in the HHRA because they were the best indicator of total PCB concentrations in fish tissues, the adverse effects of mono- and dichlorobiphenyl congeners were not overlooked in the assessment because these congeners were present in the Aroclor mixtures upon which the CSFs were based. The PCB CSFs were revised downward from those developed in 1988 (USEPA, 1988) based on the reevaluation of rat liver tumor data, use of a new cross-species scaling factor (USEPA, 1992), and not using a time-weighted average dose. The results from several animal studies in both males and females, using a variety of dose levels including doses below the maximum tolerated dose, were considered in deriving the CSFs (Norback and Weltman, 1985 and Brunner *et al.*, 1996). Based on the GE-funded rat carcinogenicity bioassay study, the dose-response curve was quite shallow, suggesting that cancer risks do not fall off rapidly at the lowest dose tested (USEPA, 1996b).

Consistent with EPA's Carcinogen Guidelines (USEPA, 1986, 1996a), benign and malignant tumors were evaluated and determined to be related to PCB exposures, based on the fact that benign tumors progressed to malignant tumors in multiple studies using different strains of rats, varying dose levels, and less-than-lifetime exposures (USEPA, 1996b).

The external peer reviewers for EPA's 1996 PCB cancer reassessment (USEPA, 1996c) supported EPA's derivation of the revised CSF values. Although in general EPA favors dose-response assessments based on human epidemiological studies, both EPA and the external peer reviewers for EPA's 1996 PCB reassessment concluded that due to the inadequacies and limitations of the human epidemiological data (*e.g.*, limited exposure information, differences in occupational and environmental exposures), they could not be used as the basis for deriving quantitative toxicity values for PCBs. In fact, the external peer reviewers concluded that the current methodologies used in the reported epidemiological studies were inadequate to show associations between exposure to PCBs and development of cancer in populations, and recommended another epidemiological study design to evaluate these associations (USEPA, 1996c).

New Epidemiological and Toxicological Information Published Following the Completion of the Integrated Risk Information System (IRIS) File

Consistent with the procedures set forth in USEPA's 1993 guidance (USEPA, 1993), prior to issuance of the HHRA, EPA evaluated the latest cancer toxicity data for PCBs in coordination with its National Center for Environmental Assessment in the Office of Research and Development, which is responsible for IRIS. The Revised HHRA summarized recent epidemiological and toxicological information published since 1996 and concluded that this new information does not change either the carcinogenicity classification or the current CSFs for PCBs. The development of site-specific CSFs for PCBs is not appropriate because cancer toxicity is an inherent property of a chemical and does not change on a site-specific basis.

The peer reviewers of the HHRA recommended that EPA revise the toxicity section of the report to more fully discuss the recently published human epidemiological studies (ERG, 2000). In response, EPA updated the list of human epidemiological studies in Appendix D of the Revised HHRA (USEPA, 2000b). EPA identified a number of limitations with these newer human epidemiological studies, including:

- Lack of sufficient exposure information.
- Failure to adequately account for co-exposures to other chemical compounds.
- Questions about the appropriateness of the control populations.
- The influence of timing of exposure, especially at critical periods during a lifetime.
- Questions about whether blood PCB levels were measured at the appropriate time to represent critical periods of exposure (*i.e.*, puberty for breast cancer in women).
- Inconsistency between study results.

One study that was identified in the comments is a study of workers at two capacitor plants in New York State published by Dr. Kimbrough and colleagues (Kimbrough *et al.*, 1999a). EPA evaluated this study and concluded that it does not change the Agency's weight-of-evidence classification for PCBs and cannot be used to develop a CSF for PCBs. EPA is not alone in identifying the limitations of the Kimbrough *et al.* (1999a) study for assessing PCB carcinogenicity, as indicated by two letters to the editor of the *Journal of Occupational and Environmental Medicine* (Bove *et al.*, 1999 and Frumkin and Orris, 1999). In addition, ATSDR's Toxicological Profile for PCBs (ATSDR, 2000), which was also externally peer reviewed in 1999, reached similar conclusions regarding the limitations of the Kimbrough *et al.* (1999a)

study. Dr. Kimbrough and colleagues responded to the letters to the editors (Kimbrough *et al.*, 1999b), and the response was reviewed by EPA. Other human epidemiological studies (*e.g.*, Hardell *et al.*, 1996, Hoyer *et al.*, 1998) have similar limitations for the purpose of assessing the carcinogenicity of PCBs.

Cancer Slope Factors Used in the Revised HHRA

EPA places its carcinogenicity information, including the CSFs, into IRIS, the Agency's consensus database for toxicity values (USEPA, 1999). EPA periodically updates IRIS with important new scientific information that significantly changes the existing conclusions regarding the toxicity of a chemical. IRIS chemical files undergo an external peer review, followed by an internal Agency consensus review, before files are loaded onto the website (www.epa.gov/iris) (USEPA, 1996b, 1999). Consistent with EPA guidance and policy, the cancer slope factors in IRIS are the preferred toxicity values for Superfund risk assessments unless revised by the Agency based on new toxicological studies (USEPA, 1989 and 1993).

The PCB cancer slope factors in IRIS were used in the Revised HHRA. The CSFs used in the HHRA were selected based on exposure pathways (USEPA, 1996b). The inhalation CSF was used for exposure to volatilized PCBs in air. A specific oral CSF was used for ingestion of fish. Appropriate dermal adsorption factors associated with CSFs were used for direct contact with sediment and water.

EPA recognizes that environmental processes can alter the congener composition of a PCB mixture (*e.g.*, dechlorination, bioaccumulation). IRIS provides for using a lower CSF for risk calculations when congener analysis demonstrates a predominance of the lower chlorinated congeners (*i.e.*, when congener or isomer analysis verifies that congeners with more than four chlorine atoms comprise less than 0.5 percent of the total PCBs). This lower CSF was not used in the HHRA based on congener analysis of Hudson River fish, which showed a predominance of Tri+ PCBs. The peer reviewers of the HHRA agreed with EPA's use of toxicity information from IRIS (ERG, 2000).

Dioxin-Like PCBs

Following EPA guidance and procedures (USEPA, 1996b), EPA evaluated cancer risks from exposure to dioxin-like PCBs using the latest scientific consensus on toxicity equivalence factors (TEFs) for dioxin-like PCBs (USEPA, 1996b) as an additional consideration for the risk manager. Risks from dioxin-like PCBs were not combined with non-dioxin-like PCBs; EPA is currently working to develop a method for combining these risks.

Blood PCB Levels

Research has shown that PCBs are probable human carcinogens and may cause non-cancer health effects. The fact that blood PCB levels in capacitor workers were elevated in the past and may be declining now is not relevant to the assessment of cancer risks and non-cancer health hazards for individuals consuming fish from the Hudson River. Capacitor workers were primarily exposed to PCB congeners by dermal contact and inhalation, while people eating fish are exposed to different PCB congeners by ingestion. In addition, sensitive populations (*i.e.*,

infants, young children, the elderly, and people with pre-existing medical conditions) may have a reduced ability to metabolize and eliminate PCBs compared to healthy worker populations. The fact that the blood PCB levels of health workers may decline with time does not address the potential current and future risks from PCB exposure associated with ingestion of fish that were evaluated in the baseline risk assessment. EPA's goal is to remediate the contaminated sediments so that future exposures to PCBs through fish ingestion are prevented or minimized.

Conclusion

EPA followed appropriate guidance, policies, and guidelines in performing a weight of evidence evaluation of the carcinogenicity of PCBs, concluding that PCBs are probable human carcinogens. Other national and international agencies agree with EPA's conclusion (*i.e.*, IARC, NTP, and NIOSH). The cancer slope factors used in calculating risks in the HHRA reflect the application of EPA's 1986 Carcinogen Guidelines and the proposed 1996 Guidelines, and the evaluation of an extensive animal bioassay that included the range of congeners found in the environment (*i.e.*, Brunner *et al.*, 1996 later published as Mayes *et al.*, 1998). EPA's evaluation of the more recent studies of human epidemiological carcinogenicity (*i.e.*, Kimbrough *et al.*, 1999a) and other studies indicates that many of the limitations identified in EPA's earlier evaluations of human epidemiological studies still exist. Based on these limitations, EPA does not change its conclusion that PCBs are probable human carcinogens. Based on this evaluation, EPA used the consensus values presented in IRIS that were also externally peer reviewed, published in a peer-reviewed journal, and presented to Congress. Following EPA's evaluation of PCB carcinogenicity, the risks from exposure to dioxin-like PCBs were also evaluated in the HHRA to provide additional information for consideration by the risk manager. Information on blood PCB levels presented in comments does not change EPA's conclusions regarding the baseline cancer risks from consumption of PCB-contaminated fish under current and future exposures, as detailed in the HHRA.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2000. Toxicological Profile for Polychlorinated Biphenyls. Agency for Toxic Substances and Disease Registry, Atlanta, Georgia. November 2000.

Bove, F.J., B.A. Slade, and R.A. Canady. 1999. Evidence of excess cancer mortality in a cohort of workers exposed to polychlorinated biphenyls. *J. Occup. Environ. Med*. 41(9):739-740.

Brunner, M.J., T.M. Sullivan, N.W. Singer, M.J. Ryan, J.D. Toft, II, R.S. Menton, S.W. Graves, and A.C. Peters. 1996. An Assessment of the Chronic Toxicity and Oncogenicity of Aroclor 1016, Aroclor 1242, Aroclors 1254, and Aroclor 1260 Administered in Diet to Rats. Columbus, Ohio. Battelle Study #SC920192. Chronic toxicity and oncogenicity report.

Eastern Research Group, Inc. (ERG). 2000. Report on the Peer Review of the Hudson River PCBs Human Health Risk Assessment. Prepared for U. S. Environmental Protection Agency, Region 2. September. Final Report.

Frumkin, H. and P. Orris. 1999. Evidence of excess cancer mortality in a cohort of workers exposed to polychlorinated biphenyls. *J. Occup. Environ. Med.* 41(9):739-745.

Hardell, L., B. Van Bavel, G. Lindstrom. 1996. Higher concentrations of specific polychlorinated biphenyl congeners in adipose tissue from non-Hodgkin's lymphoma patients compared with controls without a malignant disease. *Int. J. Oncol.* 9(4):603-608.

Hoyer, A.P., P. Grandjean, T., Jorgensen, J.W., Brock, and H. B. Hartvig. 1998. Organochlorine exposure and risk of breast cancer. *Lancet* 352:1816-1820.

International Agency for Research on Cancer (IARC, 1987). "IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Supplement 7, Overall Evaluations of Carcinogenicity: An Updating of IARC Monographs Volumes 1-42." Lyon, France.

Johnson, B.L. Hicks, H.E., Cibulas, W., Faroon, O., Ashizawa, A.E., DeRosa, C.T., Cogliano, V.J., and Clark, M. 1999. Public Health Implications of Exposure to Polychlorinated Biphenyls (PCBs). Agency for Toxic Substances and Disease Registry. Online at: http://www.atsdr.cdc.gov/DT/pcb007.html.

Kimbrough, R.D., M. LO. Doemland, and M. E. LeVois. 1999a. Mortality in male and female capacitor workers exposed to polychlorinated biphenyls. *J. Occup. Environ. Medic*. 41(3):161-171.

Kimbrough, R.D., Doemland, M.L., and LeVois, M.E. 1999b. The authors reply. J. Occup. Environ. Medic. 41(3):742-745.

Mayes, B.A., E.E. McConnell, B.H. Neal, M.J. Brunner, S.B. Hamilton, T.M. Sullivan, A.C. Peters, M.J. Ryan, J.D. Toft, A.W. Singer, J.F. Brown Jr., R.G. Menton, and J.A. Moore. 1998. Comparative carcinogenicity in Sprague-Dawley rats of the polychlorinated biphenyl mixtures Aroclors 1016, 1242, 1254, and 1260. *Toxicol. Sci.* 41(1):62-76. January.

National Academy Press (NAP). 2001. A Risk Management Strategy for PCB-Contaminated Sediments. Committee on Remediation of PCB-Contaminated Sediments, Board on Environmental Studies and Toxicology, National Research Council. 452 pages.

National Toxicology Program (NTP). 1981. "Second Annual Report on Carcinogens: Summary 1981." Research Triangle Park, NC: US Department of Health and Human Service, Public Health Service, National Toxicology Program.

NTP. 1984. Report of the Ad Hoc Panel on Chemical Carcinogenesis Testing and Evaluation of the National Toxicology Program, Board of Scientific Counselors. Available from: US Government Printing Office, Washington, D.C. 1984-421-132:4726.

Norback, D.H. and R.H. Weltman. 1985. Polychlorinated biphenyl induction of hepatocellular carcinoma in the Sprague-Dawley rat. *Environ. Health Perspect*. 60:97-105.

US Environmental Protection Agency (USEPA). 1976. Interim procedures and guidelines for health risk and economic impact assessments of suspected carcinogens. *Federal Register* 41:21402-21405.

USEPA. 1984. Proposed guidelines for carcinogen risk assessment. *Federal Register* 49:46294. November 23.

USEPA. 1986. Guidelines for carcinogen risk assessment. *Federal Register* 51:33992-34003.

USEPA. 1988. "Drinking Water Criteria Document for Polychlorinated Biphenyls (PCBs)." Environmental Criteria and Assessment Office, Office of Research and Development, Cincinnati, Ohio. ECAO-CIN-414.

USEPA. 1989. Risk Assessment Guidance for Superfund (RAGS), Volume I. Human Health Evaluation Manual (Part A). USEPA, Office of Emergency and Remedial Response, Washington, D.C. USEPA/540/I-89/002, December.

USEPA. 1992. "Draft Report. A Cross-Species Scaling Factor for Carcinogen Risk Assessment Based on Equivalence of $mg/kg^{3/4}$-day. Notice." *Federal Registry* 57(109):24152-24173.

USEPA. 1993. Memorandum from William H. Farland, Director of the Office of Health and Environmental Assessment and Henry L. Longest, II, Director of the Office of Emergency and Remedial Response to: Directors of the Waste Management Divisions, Emergency and Remedial Response Divisions, Hazardous Waste Management Division and Hazards Waste Division. Subject: Use of IRIS Values in Superfund Risk Assessment. OSWER Directive #9285.7-16. December 21.

USEPA. 1994. "Report on the Workshop on Cancer Risk Assessment Guidelines Issues." Office of Research and Development, Risk Assessment Forum, Washington, D.C. EPA/630/R-94/005a.

USEPA. 1996a. Proposed guidelines for carcinogen risk assessment. *Federal Register* 61 (79) 17960-18011. April 23.

USEPA. 1996b. "PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures." National Center for Environmental Assessment, Washington, D.C. USEPA/600/P-96/001F. September.

USEPA. 1996c. "Report on Peer-Review Workshop on PCBs: Cancer-Dose Response Assessment and Application to Environmental Mixtures." National Center for Environmental Assessment, Office of Research and Development, Washington, D.C.

USEPA. 1999. Integrated Risk Information System (IRIS) Chemical File for PCBs. National Center for Environmental Assessment, Office of Research and Development, Cincinnati, Ohio.

USEPA. 2000a. Further Site Characterization and Analysis, Revised Human Health Risk Assessment (HHRA) Volume 2F, Hudson River PCBs Reassessment RI/FS. Prepared for the

USEPA Region 2 and USACE by TAMS Consultants, Inc. and Gradient Corporation. November 2000.

USEPA. 2000b. Response to Peer Review Comments on the Human Health Risk Assessment, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the US Army Corps of Engineers (USACE) by TAMS Consultants, Inc. and Gradient Corporation. November.

3.1.1.2 PCB Toxicity – Non-Cancer

Master Comment 541

Several comments indicate that EPA has overestimated the reference dose (RfD) for non-cancer health hazards. In part, this contention is based on EPA's use of monkey studies (*i.e.*, rhesus monkeys) as the critical study and the conclusion that monkeys are more sensitive to the effects of PCBs than humans. Other comments indicate that EPA has used excessive uncertainty factors (*i.e.*, factors of 3 rather than 1) for both extrapolating from animals to humans and extrapolating from subchronic exposure to chronic exposures. The comments suggest that EPA should use a new RfD of 2 x 10E-4 mg/kg-day, which is 10 times higher than EPA's current RfD for Aroclor 1254 of 2 x 10E-5 mg/kg-day, and that this new value should be used in the HHRA.

Other comments suggest that EPA's RfD is not adequately protective of human health based on several neurobehavioral studies conducted in children of mothers who consumed fish and other food products that contained PCBs. These studies evaluated the effects of PCBs on groups of children exposed to varying levels of PCBs over time (*i.e.*, as the children mature). The comments also suggest that EPA has not considered the effects of PCBs on pregnant or nursing mothers, and the health impacts of PCBs on developing fetuses.

Several comments were received indicating that dechlorination of PCBs would alter the toxicity of the dechlorinated PCB mixture. Comments were also received indicating that EPA's use of Tri+ PCBs in the assessment overlooks the adverse effects of mono- and dichlorobiphenyl congeners in the assessment. Other comments indicate that the averaging times used in the calculation of Average Daily Dose may be too long.

Response to Master Comment 541

Overview

This is a general response to the comments listed above with more details provided in White Paper – PCB Non-Cancer Health Effects. As background to understanding this issue, an RfD is defined as "an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime (USEPA, 2000a, p. 63)." This response describes EPA's process for evaluating non-cancer health effects; summarizes RfD development; discusses the RfDs for PCBs; discusses EPA's ongoing reassessment of non-

cancer health effects associated with PCBs; and also discusses use of chemical toxicity information from IRIS, PCB blood levels, and non-cancer hazard calculations.

EPA Process for Assessing Non-Cancer Toxicity

EPA's process for evaluating human epidemiological and animal evidence to determine the non-cancer toxicity of chemicals, including PCBs, is set forth in the Agency's guidelines (USEPA, 1986a-b, 1991, 1992, 1993a, 1996, 1998) and the background document on non-cancer toxicity provided on IRIS (USEPA, 1993b). The guidelines cover a variety of health endpoints, including Developmental Toxicity (USEPA, 1986b, 1991); Reproductive Toxicity (USEPA, 1996); Neurotoxicity (USEPA, 1998); Female Reproductive Risk (USEPA, 1986a); and Male Reproductive Risk (USEPA, 1986a). The guidelines were developed within the Agency, published in the *Federal Register* for external comment, and peer reviewed by a panel of expert scientists from universities, environmental groups, industry, labor, and other governmental agencies working in various fields associated with non-cancer toxicity, including developmental toxicity, neurological toxicity, endocrine effects, etc. EPA responded to comments on the draft guidelines and made changes based on a review of the comments submitted by these groups or individuals. The guidelines were also submitted for review to EPA's Science Advisory Board, an external scientific review panel.

On September 14 and 15, 1992, EPA convened a Risk Assessment Forum (RAF) Colloquium to evaluate the developmental neurotoxic effects of PCB exposure (USEPA, 1993a). The workshop papers discuss the principles and methods for evaluating data from animal and human studies. The report concluded that the currently available data are sufficient for risk assessment, stating:

> "The sense of the meeting seemed to be that, at least in qualitative terms, the available data are sufficient. In other words, based on an evaluation of the strengths and weaknesses in the data and on the consistency of effects seen in all species tested, including humans, there is sufficient information to indicate that PCBs cause developmental neurotoxicity. Interestingly, the data suggest that prenatal exposure to PCBs may be more detrimental than postnatal exposure, even though the level of exposure via breast milk is much greater than that occurring via placental transfer."

On May 24 and 25, 1994, EPA convened an RAF Workshop to assess whether the RfD for Aroclor 1016 (USEPA, 1994) represents a full consideration of the available scientific data and whether that analysis is clearly articulated in the RfD entry on IRIS. The results from this workshop were used in finalizing the RfD for Aroclor 1016 (USEPA, 1999a) currently listed on IRIS. The IRIS chemical files for both Aroclor 1016 (USEPA, 1999a) and Aroclor 1254 (USEPA, 1999b) represent the consensus of the Reference Dose/Reference Concentration Workgroup, responsible for reaching consensus on non-cancer toxicity values, that was in existence when the files were completed.

EPA is not alone in its concern regarding the non-cancer toxicity of PCBs. The National Academy of Science (NAP, 2001) concluded:

> "The Committee's review of recent scientific information supports the conclusion that exposure to PCBs may result in chronic effects (*e.g.*, cancer, immunological,

developmental, reproductive, and neurological effects) in humans and/or wildlife. Therefore, the committee considers that the presence of PCBs in sediments may pose long-term public health and ecosystem risks."

RfD Development and RfDs for PCBs

EPA derives RfDs (USEPA, 1993b) by first identifying the highest dose level that does not cause observable adverse effects (*i.e.*, the non-observed-adverse-effect-level or NOAEL). If a NOAEL is not identified, the lowest-observed-adverse-effect-level, or LOAEL, may be used. The dose level is then divided by uncertainty factors to calculate an RfD. The four standard uncertainty factors that can be used when calculating an RfD range from 1 to 10 and account for:

- Variation in sensitivity among members of the human population.
- Uncertainty involved in extrapolating from animal data to humans.
- Uncertainty involved in extrapolating from less than chronic NOAELs to chronic NOAELs.
- Uncertainty involved in extrapolating from LOAELs to NOAELs.

An additional modifying factor can also be applied to the calculation for the RfD. The modifying factor is an additional uncertainty factor that is greater than zero and less than or equal to 10. The magnitude of the modifying factor depends upon an assessment of the scientific uncertainties of both the study and the database used in deriving the RfD that are not explicitly treated in the uncertainty factors, *e.g.*, completeness of the overall database and number of species tested.

The RfDs for Aroclor 1254 (USEPA, 1999b) and Aroclor 1016 (USEPA, 1999a) were developed following USEPA guidance and policies (see above), considering human epidemiological evidence and animal toxicity information. The RfD for non-cancer health effects of Aroclor 1016, derived in 1993, is based on reduced birth weights in monkey reproductive studies. The RfD for Aroclor 1254, derived in 1994, is based on immunologic and clinical changes in monkeys. Together, Aroclor 1016 and Aroclor 1254 span a range of congeners (including varying percentages of mono- and dichlorobiphenyls), and include the congeners most frequently found in environmental mixtures. To the extent that a congener is present in the Aroclor mixture tested in the animal studies that serve as the basis of the reference dose, it was evaluated in the non-cancer toxicity assessment in the HHRA. Therefore, even though EPA used Tri+ PCBs in the HHRA because they were the best indicator of total PCB concentrations in fish tissues, the adverse effects of mono- and dichlorobiphenyl congeners were not overlooked in the assessment because these congeners were present in the Aroclor mixtures upon which the RfDs were based.

Some of the research papers identified in the comments to support a reduction in the uncertainty factors for interspecies and subchronic to chronic extrapolation from 3 to 1 were evaluated as part of the development of the RfDs for Aroclors 1016 and 1254. At that time, EPA concluded that monkeys are not less sensitive than humans, and therefore the uncertainty factor of 3 applied for extrapolation from monkeys to humans is appropriate (USEPA, 1999a,b). Similar adverse health effects (ocular and dermal effects, neurobehavioral effects, decreased birth weight, etc.) have been found in exposed human populations and monkey studies. The uncertainty factor of 3 applied for extrapolation from subchronic to chronic exposures is appropriate; the exposures in the critical studies continued for approximately 25 percent of the lifespan of the monkeys, and

the immunologic and clinical changes that were observed did not appear to be dependent upon exposure duration. Tilson *et al.* (1990) performed a cross-species analysis of the effect of PCBs and concluded that humans are more sensitive to the effects of PCBs than monkeys. ATSDR used similar uncertainty factors in its development of health protective intermediate and chronic minimal risk levels (MRLs) for non-cancer effects of PCBs (ATSDR, 2000).

In deriving the RfDs for Aroclors 1016 and 1254, EPA concluded that the available human data were useful only in a qualitative manner. The IRIS file makes similar statements for both Aroclor 1016 (USEPA, 1999a) and Aroclor 1254 (USEPA, 1999b). The summary from the Aroclor 1254 (USEPA, 1999b) chemical file states:

> "Human data available for risk assessment of Aroclor 1254 are useful only in a qualitative manner. Studies of the general population who were exposed to PCBs by consumption of contaminated food, particularly neurobehavioral evaluations of infants exposed in utero and/or through lactation, have been reported, but the original PCB mixtures, exposure levels and other details of exposure are not known (Kreiss *et al.*, 1981; Humphrey, 1983; Fein *et al.*, 1984a,b; Jacobson *et al.*, 1984a, 1985, 1990a,b; Rogan *et al.*, 1986; Gladen *et al.*, 1988). Most of the information on health effects of PCB mixtures in humans is available from studies of occupational exposure. Some of these studies examined workers who had some occupational exposure to Aroclor 1254, but sequential or concurrent exposure to other Aroclor mixtures nearly always occurred, exposure involved dermal as well as inhalation routes (relative contribution by each route not known), and monitoring data are lacking or inadequate (Alvares *et al.*, 1977; Brown and Jones, 1981; Colombi *et al.*, 1982; Fischbein *et al.*, 1979, 1982, 1985; Fischbein, 1985; Warshaw *et al.*, 1979; Smith *et al.*, 1982; Taylor *et al.*, 1984; Lawton *et al.*, 1985). Insufficient data are available in these studies to determine possible contributions of Aroclor 1254 alone, extent of direct skin exposure and possible contaminants. However, it is relevant to note that dermal and ocular effects, including skin irritation, chloracne, hyperpigmentation and eyelid and conjunctival irritation, have been observed in humans occupationally exposed to Aroclor 1254 and other Aroclor formulations."

Reassessment of PCB Non-Cancer Effects

EPA updates their IRIS chemical files and other documents to reflect new scientific information, following appropriate procedures for internal and external peer review. EPA's National Center for Environmental Assessment (NCEA) is currently in the process of reassessing PCB non-cancer toxicity. As part of this reassessment, EPA will use a weight-of-evidence approach to critically evaluate all available non-cancer toxicity information (including newly published human epidemiological studies, neurobehavioral studies in monkeys, other animal studies, metabolism data, and mechanistic data) to develop a new RfD or reaffirm the current RfD. EPA will also evaluate any newly available toxicity studies on particular PCB congener groups (*e.g.*, mono- and dichlorobiphenyl PCBs) as part of the non-cancer toxicity reassessment.

EPA is aware that a number of recent human epidemiological studies, updated studies of the cohorts originally described in 1993/1994 IRIS chemical files, and laboratory studies in infant and young monkeys have been published since the RfDs for Aroclors 1016 and 1254 were developed. Neurobehavioral alterations have been reported following exposure to PCBs in both

the human studies and the rat and monkey studies. As mentioned above, the results of many of the new studies are described in Appendix D of the Revised HHRA (USEPA, 2000b). These newer studies are being considered as part of EPA's on-going reassessment of PCB non-cancer toxicity. The data from these studies may aid in understanding the mechanisms of action of PCBs on the central nervous system. However, at this point, it is premature to determine whether the results from these newly published human epidemiological or animal studies will result in revisions to EPA's RfDs for PCBs, and if so, in which direction.

As a point of comparison, ATSDR has developed intermediate and chronic PCB MRLs. The intermediate MRL (ATSDR, 2000) is based on several recent neurobehavioral studies in monkeys (Rice, 1997, 1998, 1999; Rice and Hayward, 1997, 1999). The chronic MRL is based on studies by Tryphonas *et al.* (1989, 1991a) that were also the basis for EPA's RfD for Aroclor 1254 (ATSDR, 2000). ATSDR's calculated intermediate MRL is slightly higher than the chronic MRL (*i.e.*, 0.00003 mg/kg-day vs. 0.00002 mg/kg-day). The chronic oral MRL for PCBs was the same as EPA's chronic oral RfD for Aroclor 1254 (0.00002 mg/kg-day). These results indicate that the neurobehavioral effects used in the development of ATSDR's toxicity value occur at a slightly higher LOAEL dose level (0.0075 mg/kg/day) than the LOAEL based on immunotoxicity endpoints (0.005 mg/kg-day) used in development of EPA's chronic RfD and ATSDR's chronic MRL.

Use of IRIS Values in the HHRA

At the time they were developed, the IRIS values were evaluated by the RfD/RfC Workgroup, and the RfD for Aroclor 1016 was externally peer reviewed through the Risk Assessment Forum (USEPA, 1994). A colloquia on developmental neurotoxic effects of PCBs was also held (USEPA, 1993a). Based on this information, these RfDs are the preferred toxicity values for use in risk assessments, as indicated in EPA's risk assessment guidance (USEPA, 1989). Consistent with this USEPA guidance and CERCLA and NCP policies, the information on PCB non-cancer health effects and the RfDs (described above) presented in USEPA's IRIS system was used in the HHRA.

The use of IRIS data in the evaluation of chemical toxicity at Superfund sites addresses EPA's goal of using consistent toxicity information at Superfund sites across the country. In addition, many of the studies presented in the comments were previously evaluated as part of the development of the RfDs for Aroclors 1016 and 1254 as described above. EPA's 1993 memo (USEPA, 1993c) on the use and updating of IRIS toxicity values indicates that it is not necessary for EPA to re-evaluate information previously considered in the development of EPA's toxicity values.

In the HHRA, EPA used the RfD for Aroclor 1016 for water and sediment exposure and the RfD for Aroclor 1254 for the fish ingestion pathway. The RfDs were selected based on congener-specific analyses, and therefore address the extent to which dechlorinated PCBs are present in water, sediment, and fish in the Hudson River.

EPA specifically charged the external peer reviewers of the HHRA for the Hudson River to evaluate whether use of the IRIS values was appropriate (USEPA, 2000c). The peer reviewers for the HHRA agreed with EPA's use of non-cancer toxicity information from IRIS, but

recommended that EPA also provide a discussion of the more recently published studies on non-cancer endpoints to determine what effect these studies might have on risk estimates. In response, EPA made the appropriate changes to the document and summarized a number of newly published human epidemiological studies on the non-cancer effects of PCBs identified in the IRIS files for Aroclors 1016 and 1254, including updates of the neurodevelopmental studies in cohorts of children and adults. This information is in Appendix D of the HHRA (USEPA, 2000a). Based on an evaluation of this data, EPA concludes that the toxicity values in IRIS are still appropriate for the HHRA.

Blood PCB Levels

The fact that blood PCB levels in capacitor workers were elevated in the past and may be declining now is not necessarily relevant to individuals consuming fish from the Hudson River, since workers were exposed to different PCB congeners through different routes of exposure (dermal and inhalation as opposed to ingestion). Also, sensitive groups (*i.e.*, children, adolescents, those with pre-existing conditions, etc.) may have a reduced ability to metabolize and eliminate PCBs compared to healthy worker populations. Thus, the rate of decline of blood PCB levels in fish-eating populations may be slower than that for workers.

Hovinga *et al.* (1992) found that the blood PCB levels of individuals exposed to PCBs through fish decreased slightly from 1977 to 1985 (approximately 1.5 ppb). However, this time period showed the largest declines in PCB concentrations in fish, and fish tissue concentrations have not exhibited a consistent decline in recent years (Response to Master Comment 629, Chapter 2). EPA evaluates non-cancer health hazards based on current and future exposures to PCBs under the baseline risk assessment, and thus consideration of past exposure to higher or lower concentrations of contaminants is not appropriate under this paradigm (USEPA, 1989).

Non-Cancer Hazard Calculations

The non-cancer assessment in the HHRA used an averaging time that is equivalent to the exposure duration x 365 days/year, consistent with EPA risk assessment guidance (USEPA, 1989). The peer reviewers agreed that EPA's selection of averaging times was appropriate, with a caveat to evaluate the effects of PCBs to pregnant and nursing women using a shorter exposure duration (USEPA, 2000c). The non-cancer hazards to the fetus and infant were addressed qualitatively in the Revised HHRA, based on the lack of an approved methodology for modeling the effects of PCBs on the fetus and for calculating the PCB levels in breast milk based on the mother's body burden.

Conclusions

The RfDs for Aroclors 1016 and 1254 are appropriate for use in the HHRA and are protective of sensitive populations. Many of the studies identified in the comments were previously evaluated in the development of the RfDs and newer studies, such as those summarized in the HHRA (Appendix D). Based on this prior review, it is not appropriate to modify the uncertainty factors used in calculating the RfD. EPA will evaluate the new data presented in the comments as part of the non-cancer RfD reassessment for PCBs. The reassessment will be made available for public review, after which there will be an external peer-review and an internal IRIS consensus review.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2000. Toxicological Profile for Polychlorinated Biphenyls. Agency for Toxic Substances and Disease Registry, Atlanta, Georgia. November 2000.

Alvares, A.P., A. Fischbein, K.E. Anderson. 1977. Alterations in drug metabolism in workers exposed to polychlorinated biphenyls. Clin. Pharmacol. Ther. 22(2): 140-146.

Arnold, D.L., F. Bryce, R. Stapley. 1993a. Toxicological consequences of Aroclor 1254 ingestion by female Rhesus (Macaca mulatta) monkeys, Part 1A: Prebreeding phase - clinical health findings. Food Chem. Toxicol. 31: 799-810.

Arnold, D.L., F. Bryce, K. Karpinski. 1993b. Toxicological consequences of Aroclor 1254 ingestion by female Rhesus (Macaca mulatta) monkeys, Part 1B: Prebreeding phase -clinical and analytical laboratory findings. Food Chem. Toxicol. 31: 811-824.

Barsotti, D.A. and J.P. van Miller. 1984. Accumulation of a commercial polychlorinated biphenyl mixture (Aroclor 1016) in adult rhesus monkeys and their nursing infants. Toxicology. 30: 31-44.

Brown, D.P. and M. Jones. 1981. Mortality and industrial hygiene study of workers exposed to polychlorinated biphenyls. Arch. Environ. Health. 36(3):120-129.

Colombi, A., M. Maroni, A. Ferioli. 1982. Increase in urinary porphyrin excretion in workers exposed to polychlorinated biphenyls. J. Appl. Toxicol. 2(3): 117-121

Fein, G.G., J.L. Jacobson, S.W. Jacobson. 1984a. Intrauterine exposure of humans to PCBs: Newborn effects. USEPA, Duluth, MN. EPA 600/53-84-060.

Fein, G.G., J.L. Jacobson, S.W. Jacobson. 1984b. Prenatal exposure to polychlorinated biphenyls: Effects on birth size and gestation age. J. Pediatr. 105: 315-320.

Fischbein, A. 1985. Liver function tests in workers with occupational exposure to polychlorinated biphenyls (PCBs): Comparison with Yusho and Yu-Cheng. Environ. Health Perspect. 60: 145-150.

Fischbein, A., M.S. Wolff, R. Lilis. 1979. Clinical findings among PCB-exposed capacitor manufacturing workers. Ann. NY Acad. Sci. 320: 703-715.

Fischbein, A., M.S. Wolff, J. Bernstein. 1982. Dermatological findings in capacitor manufacturing workers exposed to dielectric fluids containing polychlorinated biphenyls PCBs). Arch. Environ. Health. 37(2): 69-74.

Fischbein, A., J.N. Rizzo, S.J. Solomon. 1985. Oculodermatological findings in workers with occupational exposure to polychlorinated biphenyls (PCBs). Br. J. Ind. Med. 42: 426-430.

Gladen, B.C., W.J. Rogan, P. Hardy. 1988. Development after exposure to polychlorinated biphenyls and dichlorobiphenyl dichloroethene transplacentally and through human milk. J. Pediatr. 113: 991-995.

Hovinga, M.E., Sowers, M., Humphrey, H.E.B. (1992). Historical changes in serum PCB and DDT levels in an environmentally exposed cohort. Arch. Environ. Contam. Toxicol. 27:362-366.

Humphrey, H.E.B. 1983. Population studies of PCBs in Michigan residents. In: PCBs: Human and Environmental Hazards, F.M. D'Itri and M. Kamrin, Ed. Butterworth, Boston, MA. p. 299-310.

Jacobson, J.L., S.W. Jacobson, P.M. Schwartz. 1984a. Prenatal exposure to an environmental toxin: A test of the multiple effects model. Develop. Psychobiol. 20(4): 523-532.

Jacobson, J.L., G.G. Fein, S.W. Jacobson. 1984b. The transfer of polychlorinated biphenyls (PCBs) and polybrominated biphenyls (PBBs) across the human placenta and into maternal milk. J. Public Health. 74(4): 378-379.

Jacobson, S.W., G.G. Fein, J.L. Jacobson. 1985. The effect of intrauterine PCB exposure on visual recognition memory. Child Develop. 56:856-860.

Jacobson, J.L., S.W. Jacobson and H.E.B. Humphrey. 1990a. Effects of in utero exposure to polychlorinated-biphenyls and related contaminants on cognitive-functioning in young children. J. Pediatr. 116: 38-45.

Jacobson, J.L., S.W. Jacobson and H.E.B. Humphrey. 1990b. Effects of exposure to PCBs and related compounds on growth and activity in children. Neurotoxicol. Teratol. 12: 319-326.

Kreiss, K., M.M. Zack, R.D. Kimbrough. 1981. Association of blood pressure and polychlorinated biphenyl levels. J. Am. Med. Assoc. 245(24):2505-2509.

Lawton, R.W., M.R. Ross, J. Feingold. 1985. Effects of PCB exposure on biochemical and hematological findings in capacitor workers. Environ. Health Perspect. 60: 165-184.

Levin, E.D., S.L. Schantz and R.E Bowman. 1988. Delayed spatial alternation deficits resulting from perinatal PCB exposure in monkeys. Arch. Toxicol. 62: 267-273.

National Academy Press (NAP). 2001. A Risk Management Strategy for PCB-Contaminated Sediments. Committee on Remediation of PCB-Contaminated Sediments, Board on Environmental Studies and Toxicology, National Research Council. 452 pages.

Rice, D.C. 1997. Effect of postnatal exposure to a PCB mixture in monkeys on multiple fixed interval-fixed ratio performance. Neurotoxicol. Teratol. 19(6):429-434.

Rice, D.C. 1998. Effects of postnatal exposure of monkeys to PCB mixture on spatial discrimination reversal and DRL performance. Neurotoxicol. Teratol. 20(4):391-400.

Rice, D.C. 1999. Behavioral impairment produced by low-level postnatal PCB exposure in monkeys. Environ. Res. 80:8113-8121.

Rice, D.C. and Hayward, S. 1997. Effects of postnatal exposure to a PCB mixture in monkeys on nonspatial discrimination reversal and delayed alternation performance. Neurotoxiclogoy. 18(2):479-494.

Rice, D.C. Hayward, S. 1999. Effects of postnatal exposure of monkeys to a PCB mixture on concurrent random interval-random interval and progressive ratio performance. Neurotoxicol. Teratol. 21(1):47-58.

Rogan, W.J., B.C. Gladen, J.D. McKinney. 1986. Neonatal effects of transplacental exposure to PCBs and DDE. J. Pediatr. 109: 335-341.

Schantz, S.L., E.D. Levin, R.E. Bowman. 1989. Effects of perinatal PCB exposure on discrimination-reversal learning in monkeys. Neurotoxicol. Teratol. 11: 243-250.

Schantz, S.L., E.D. Levin and R.E. Bowman. 1991. Long-term neurobehavioral effects of prenatal polychlorinated biphenyl (PCB) exposure in monkeys. Environ. Toxicol. Chem. 10: 747-756.

Smith, A.B., J. Schloemer, L.K. Lowry. 1982. Metabolic and health consequences of occupational exposure to polychlorinated biphenyls. Br. J. Ind. Med. 39: 361-369.

Taylor, P.R., C.E. Lawrence, H.L. Hwang. 1984. Polychlorinated biphenyls: Influence on birth weight and gestation. Am. J. Public Health. 74(10): 1153-1154.

Tilson, H., Jacobson, J., and Rogan, W. 1990. Polychlorinated biphenyls and the developing nervous system: cross-species comparisons. Neurotox. Teratol. 12:239-248.

Tryphonas, H., S. Hayward, L. O'Grady. 1989. Immunotoxicity studies of PCB (Aroclor 1254) in the adult rhesus (Macaca mulatta) monkey – preliminary report. Int. J. Immunopharmacol. 11: 199-206.

Tryphonas, H., M.I. Luster, G. Schiffman. 1991a. Effect of chronic exposure of PCB (Aroclor 1254) on specific and nonspecific immune parameters in the Rhesus (Macaca mulatta) monkey. Fund. Appl. Toxicol. 16(4): 773-786.

Tryphonas, H., M.I. Luster, K.L. White. 1991b. Effects of PCB (Aroclor 254) on non-specific immune parameters in Rhesus (Macaca mulatta) monkeys. Int. J. Immunopharmacol. 13: 639-648.

USEPA. 1986a. The Risk Assessment Guidelines for 1986. Office of Health and Environmental Assessment, Washington, D.C. EPA/600/8-89/043, July.

USEPA. 1986b. Guidelines for the Health Assessment of Suspect Developmental Toxicants. Federal Register 51 (185) 34028-34040, 24 September 1986.

USEPA. 1989. Risk Assessment Guidance for Superfund (RAGS), Volume I. Human Health Evaluation Manual (Part A). USEPA, Office of Emergency and Remedial Response, Washington, D.C. USEPA/540/I-89/002, December.

USEPA. 1991. Guidelines for Developmental Toxicity Risk Assessment. Federal Register 56 (234) 63798-63826, 5 December 1991

USEPA. 1992. Guidelines for Exposure Assessment. Federal Register 57 (104) 22888-22938, 29 May 1992

USEPA. 1993a. Workshop Report on Developmental Neurotoxic Effects Associated with Exposure to PCBs. U. S. EPA, Risk Assessment Forum, Office of Research and Development, Washington, D.C. EPA/630/R-92/004, May, 1993.

USEPA. 1993b. Reference Dose (RfD): Description and Use in Health Risk Assessments. Background Document 1A. USEPA, National Center for Environmental Assessment (NCEA), Office of Research and Development, Washington, D.C. March 15, 1993.

USEPA. 1993c. Memorandum from William H. Farland, Director of the Office of Health and Environmental Assessment and Henry L. Longest, II, Director of the Office of Emergency and Remedial Response to: Directors of the Waste Management Divisions, Emergency and Remedial Response Divisions, Hazardous Waste Management Division and Hazards Waste Division. Subject: Use of IRIS Values in Superfund Risk Assessment. OSWER Directive #9285.7-16. December 21.

USEPA. 1994. Report on the Technical Review Workshop on the Reference Dose for Aroclor 1016. USEPA, Risk Assessment Forum, Office of Research and Development, Washington, D.C. EPA/630/R-94/006, November.

USEPA. 1996. Guidelines for Reproductive Toxicity Risk Assessment. Federal Register 61 (212) 56274-56322, 31 October 1996

USEPA. 1998. Guidelines for Neurotoxicity Risk Assessment. Federal Register 63 (93) 26926-26954, 14 May 1998.

USEPA. 1999a. Integrated Risk Information System Chemical File for Aroclor 1016. USEPA, National Center for Environmental Assessment, Office of Research and Development, Cincinnati, Ohio.

USEPA. 1999b. Integrated Risk Information System Chemical File for Aroclor 1254. USEPA, National Center for Environmental Assessment, Office of Research and Development, Cincinnati, Ohio.

USEPA. 2000a. Phase 2 Report, Further Site Characterization and Analysis. Volume 2F-Human Health Risk Assessment (HHRA), Hudson River PCB Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS Consultants, Inc. and Gradient Corporation. November.

USEPA. 2000b. Further Site Characterization and Analysis, Revised Human Health Risk Assessment (Revised HHRA) Volume 2F, Hudson River PCBs Reassessment RI/FS. Prepared for the USEPA Region 2 and USACE by TAMS Consultants, Inc. and Gradient Corporation. November 2000.

USEPA. 2000c. Peer Review Responsiveness Summary for Volume 2F - Human Health Risk Assessment, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS Consultants, Inc. and Gradient Corporation. March.

Warshaw, R., A. Fischbein, J. Thornton. 1979. Decrease in vital capacity in PCB-exposed workers in a capacitor manufacturing facility. Ann. NY Acad. Sci. 320: 277-283.

3.1.2 Fish Consumption (Rate and Species Mix)

Master Comment 569

Some comments stated that EPA's fish ingestion rates are too high, which results in overestimated cancer risks and non-cancer health hazards due to fish consumption. Comments stated that EPA should have conducted a study of Upper Hudson anglers to determine site-specific fish ingestion rates. Comments stated that the 1991 New York Angler survey should not have been used as the basis for EPA's estimate of fish ingestion rates because it is not representative of actual anglers in the Upper Hudson region. Comments stated that the fish consumption rates used for the Hudson River are too high because most anglers fish in more than one location (*i.e.*, in areas other than Hudson River and in different areas within the Hudson). One commenter (GE, Appendix J) used the 1992 Lake Ontario angler survey (Connelly *et al.*, 1996) in a "micro-exposure" Monte Carlo analysis to derive fish ingestion rates that are three to five times lower than the rates used by EPA.

Other comments stated that EPA's fish ingestion rates for the Site are too low, which underestimates of the cancer risks and non-cancer health hazards from eating PCB-contaminated fish. Comments stated that EPA's fish ingestion rates should be higher to include subsistence anglers. Comments suggested that EPA should evaluate fish consumed by non-anglers, especially women and children who may receive fish from anglers and who are sensitive subpopulations.

A third group of comments expressed support for the fish ingestion rates used by EPA stating that the fish ingestion rates are reasonable point estimates for adults.

Response to Master Comment 569

With respect to the comments that EPA's fish ingestion rates are too high, in the HHRA EPA reviewed the major angler surveys published in the scientific literature and fish ingestion data in EPA's Exposure Factors Handbook (USEPA, 1997). EPA selected the 1991 New York State Angler survey for use in deriving the fish ingestion rates for the point estimate calculations because, among other reasons, it was conducted in New York State, it provided the opportunity to compare species specific ingestion rates for similar water bodies without fish advisories, and it included a large sample size. The demographics of the 1991 New York Angler survey are reasonably similar overall to the demographics of the Upper Hudson angler population as reported in the 1996 Survey of Hudson River Anglers (NYSDOH, 1999). Although there are some differences in household income and age distribution, the two survey populations had very similar general and racial compositions (HHRA, p. 43). EPA's rationale for using the 1991 New York Angler survey as the basis for its point estimate fish ingestion rate and for the base case of the Monte Carlo analysis is presented in the HHRA (pp. 41-44).

GE identified the 1992 Lake Ontario Diary Study (Connelly *et al.*, 1996) as its preferred survey. EPA did not use the 1992 Lake Ontario Diary Study to develop the fish ingestion rates for the point estimate calculations in part because the survey showed that the fish consumption advisories in place at the time of the survey reduced fish consumption by the participants (HHRA, p. 39-40). This means that fish ingestion rates derived from the 1992 Lake Ontario Diary Study would not be representative of the baseline conditions of the HHRA for the reasonably maximally exposed individual and would not be representative of the No Action Alternative (absence of fishing restrictions and fish consumption advisories). Similarly, EPA did not collect Site-specific information on fish consumption due to the fish consumption advisories that have been in place for the Hudson River since 1975 (refer also to GE Appendix J, p. 29). The HHRA peer reviewers agreed that Site-specific data regarding fish consumption would be difficult to interpret in light of the fish consumption advisories and the fishing restrictions in the Upper Hudson. It is important to note that the cancer risks and non-cancer hazards calculated by GE using the 1992 Lake Ontario Diary Study are still above acceptable levels.

EPA quantitatively assessed the effect of selecting the 1991 New York Angler survey in its Monte Carlo calculations, which considered the 1991 New York Angler survey (base case) and three other independent surveys as a sensitivity analysis. Those three surveys are the 1992 Maine Angler Survey (Ebert *et al.*, 1993), the 1992 Lake Ontario Diary Study (Connelly *et al.*, 1996), and the 1989 Michigan Sport Angler Survey (West *et al.*, 1989) (HHRA, p. 44-45 and Table 3-2). EPA's sensitivity analysis of fish ingestion rates showed that even using the survey that provided the lowest fish ingestion rates (*i.e.*, the 1992 Maine Angler Survey), cancer risks and non-cancer health hazards are above acceptable levels.

EPA's assumption that all fish consumed by anglers are caught in the Hudson River is protective of human health and is reasonable in light of the large geographic area encompassed by the Site (HHRA, p. 22 and 80). The assumption is also supported by the fact that 56.5 percent of the respondents in the 1991 New York Angler survey reported that they fished in only one or two locations (35.5 percent in one location, 21 percent in two locations).

As for fishing along different sections of the Hudson River, in the HHRA EPA did not assume fish were caught in the same location year after year. For the point estimate calculations and the base case Monte Carlo analysis, EPA evaluated consumption of fish caught from the entire Upper Hudson River (*i.e.*, average of three locations within 40-mile Upper Hudson, see HHRA, pp. 14 and 59). As a sensitivity analysis in the Monte Carlo calculations, EPA considered the effects of catching fish in the upstream end of the Upper Hudson only (the Thompson Island Pool) and in the downstream end of the Upper Hudson (the Waterford/Federal Dam area). This analysis showed that the cancer risks and non-cancer health hazards for the specific reaches of the Hudson River were unacceptable for each area (HHRA, p. 81).

Further, the Monte Carlo analysis did not assume that fish species were always caught and consumed in the same proportions by all anglers. Rather, a range of fish species consumption fractions among different anglers were selected randomly from a distribution based on the 1991 New York Angler survey responses (HHRA, p. 49 and HHRA Table 3.1).

Microexposure Event Analysis

EPA reviewed the "microexposure" Monte Carlo analysis presented in Appendix J of GE's comments. The table below provides a comparison of the cancer risks and non-cancer health hazards from fish ingestion calculated by GE's "microexposure" analysis and by EPA's Monte Carlo analysis. GE's "microexposure" analysis yielded cancer risks and non-cancer health hazards that range from three to five times lower than EPA's estimates. Most of the difference is due to GE's use of the Lake Ontario Diary Study to derive fish ingestion rates that are on average four-fold lower than those used by EPA in its base case Monte Carlo analysis. To a much lesser extent, the difference is due to GE's later starting date of 2004, compared to the 1999 start date used in EPA's HHRA.

EPA prefers its Monte Carlo analysis to GE's "microexposure" analysis. As discussed above in this response, EPA believes its peer-reviewed fish ingestion rates derived from the 1991 New York Angler survey are more appropriate for this Site than the fish ingestion rates derived by GE from the 1992 Lake Ontario Diary Study. In addition, GE limited the uncertainty analysis in its "microexposure" analysis to the uncertainty associated with a single angler survey, and did not evaluate uncertainty using several angler surveys, thereby ignoring published studies indicating higher rates of fish consumption compared to those in the 1992 Lake Ontario survey (Connelly *et al.*, 1996). In contrast, EPA conducted a sensitivity analysis of fish ingestion rates, using the results of four independent angler surveys. Moreover, EPA's review of the "microexposure" analysis was hampered by insufficient disclosure of the information used to generate many of the exposure factor distributions (*e.g.*, procedures for selecting and excluding data, range of estimates, and distribution fitting procedures). Nonetheless, the different methods used by GE and EPA yield very similar results, and both show that cancer risks and non-cancer health hazards from eating fish are above acceptable levels.

Comparison of USEPA Baseline HHRA and GE "No Action" Microexposure Analysis

40-Mile Upper Hudson River				
Source of Estimate	**Cancer Risk**		**Non-Cancer Hazards**	
	CT	**RME**	**CT**	**RME**
EPA HHRA – Point Estimate	2.9×10^{-5}	1.4×10^{-3}	12	104
EPA HHRA – Base Case Monte Carlo (MCA)	6.4×10^{-5}	8.7×10^{-4}	11	51
GE Microexposure Analysis	2.6×10^{-5}	2.1×10^{-4}	2.9	17.6
Ratio (HHRA MCA/GE)	**2.5**	**4.1**	**3.8**	**2.9**
CT = Central Tendency, RME = Reasonable Maximum Exposure				

Fish Ingestion by Subsistence Anglers, Non-anglers, Women, and Children

EPA disagrees with comments that EPA's fish ingestion rates should be higher to include subsistence fishing. The fish ingestion rate distribution used in the HHRA Monte Carlo analysis included a range of up to 1,000 meals per year, based on the 1991 New York Angler survey. For the reasonably maximally exposed adult individual, the fish ingestion rate used in the point estimate calculations and the base case Monte Carlo analysis is 31.9 grams per day, or about a one-half pound fish meal a week. EPA's review of the limited literature available on subsistence anglers in New York State (Wendt, 1986) or highly exposed Native American anglers (Fitzgerald *et al.*, 1995) supports the assumption that highly exposed subsistence anglers in the Upper Hudson area are likely to be adequately represented in the total distribution of fish ingestion rates developed for the Upper Hudson (HHRA, p. 46). Thus, EPA believes it has adequately captured cancer risks and non-cancer health hazards to subsistence anglers within the analysis for the RME individual.

Non-anglers consuming Upper and Lower Hudson River fish caught by a friend or family member (*i.e.*, gift fish) were considered qualitatively but there is little or no information available to quantify non-angler fish ingestion rates. Despite this lack of information, the cancer risks and non-cancer hazards for non-anglers consuming sport fish are expected to be lower than for anglers, based on expected lower fish consumption rates.

Consumption of fish by children anglers was evaluated in the HHRA. Fish consumption by women anglers was included implicitly to the same extent that they are represented in the 1991 New York Angler survey. The IRIS toxicity values for PCBs that were used in the HHRA are considered by EPA to be protective of sensitive populations such as women and children (see USEPA, 1999).

Conclusion

EPA disagrees with comments stating that its fish consumption rates are too high or too low and do not reflect consumption patterns by a reasonably maximally exposed individual. Cancer risks and non-cancer health hazards calculated by GE using lower fish ingestion rates still results in cancer risk and non-cancer health hazards that are above acceptable levels. EPA acknowledges

comments stating its peer-reviewed fish consumption rates are appropriate. These same ingestion rates were used in the development of the preliminary remediation goals (PRGs) in the Feasibility Study and the remediation goals (RGs) in the ROD.

References

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

Connelly, N.A., B.A. Knuth, and T. Brown. 1996. Sportfish consumption patterns of Lake Ontario anglers and the relationship to health advisories. *N. Am. J. Fisheries Management* 16:90.

Ebert, E.S., N.W. Harrington, K.J. Boyle, J.W. Knight, and R.E. Keenan. 1993. Estimating consumption of freshwater fish among Maine Anglers. *North American Journal of Fisheries Management* 13:737-745.

Fitzgerald, E.F., S.A. Hwang, K.A. Brix, B. Bush, K. Cook, and P. Worswick. 1995. Fish PCB concentrations and consumption patterns among Mohawk women at Akwesasne. *J Exposure Anal Environ Epidem* 5(1):1-19.

New York State Department of Health (NYSDOH). 1999. Health Consultation: 1996 Survey of Hudson River Anglers, Hudson Falls to Tappan Zee Bridge at Tarrytown, New York. February. (Raw survey data received electronically from Edward Horn of NYSDOH in June, 1998.)

USEPA. 1997. Exposure Factors Handbook, Volume I-III. Office of Research and Development, USEPA/600/P-95/002Fa, August.

USEPA. 1999. "Integrated Risk Information System Chemical File for Polychlorinated Biphenyls." National Center for Environmental Assessment, Cincinnati, Ohio.

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

Wendt, M.E. 1986. Low income families' consumption of freshwater fish caught from New York State waters. Thesus. Cornell University, August.

West, P.C., M.J. Fly, R. Marans, and F. Larkin. 1989. "Michigan Sport Anglers Fish Consumption Survey. A Report to the Michigan Toxic Substance Control Commission." Michigan Department of Management and Budget Contract No. 87-20141.

3.1.3 Exposed Population

Master Comment 543

Comments stated that the fish consumption advisories (along with source control/natural attenuation) are sufficient to protect public health. The ban on the consumption of fish is widely known and obeyed by anglers in the Upper Hudson. A recent survey (NYSDOH, 1999) showed that anglers never ate the fish they caught from the Hudson River. The existence of fishing advisories and the absence of a commercial fishery should be factored into the EPA analysis of risk. Given the existence of alternative fishing locations (other than the Upper Hudson River) in New York and the growing popularity of catch and release fishing, EPA overstated the risks of fish ingestion from the Upper Hudson River. EPA should have collected data to characterize the size of the potentially impacted angler population.

Other comments stated that the fish consumption advisories are insufficient to protect public health. Reports show that anglers and their families continue to consume fish from the Hudson River despite the fish consumption advisories. New Yorkers have a long-standing common law right to fish, grounded in public trust, which implicitly includes the right to eat the fish one catches. Another comment asked why EPA focused on Upper and Mid-Hudson anglers and did not include those who fish in the Lower Hudson.

Response to Master Comment 543

EPA disagrees with comments suggesting that the fish consumption advisories alone are sufficient to protect public health. Neither does EPA agree that the effect of the current institutional controls such as fish consumption advisories and fishing restrictions (*e.g.*, catch and release only in Upper Hudson, ban on commercial fishing of all but three fish species in the Lower Hudson) on the consumption of fish from the Site should have been factored into its baseline risk analysis. Consistent with EPA policy and guidance (USEPA 1989, 1990, 1992a, 1992b, 1995), the HHRA is a baseline risk assessment and thus evaluates current and future cancer risks and non-cancer health hazards to the reasonably maximally exposed individual and the central tendency (*i.e.*, average) individual based on the assumption of no remediation or institutional controls, such as the fish consumption advisories currently in place (see, for example, HHRA [USEPA, 2000], pp. ES-1, 1 and 41).

As stated in the NCP preamble,

> "The baseline risk assessment is essentially an evaluation of the no-action alternative. Institutional controls, while not actively cleaning up the contamination at the Site, can control exposure and, therefore, are considered to be limited action alternatives. The effectiveness of the institutional controls in controlling risk may appropriately be considered in evaluating the effectiveness of a particular remedial alternative, but not as part of the baseline risk assessment." (USEPA, 1990, p. 8711).

The baseline cancer risks and non-cancer health hazards were properly presented in the HHRA and FS No Action Alternative without consideration of the existing institutional controls. The MNA, capping, and removal alternatives evaluated in detail in the FS include the institutional controls to reduce the cancer risks and non-cancer health hazards associated with consumption of fish from the Site. The No Action Alternative is not protective of human health because the baseline cancer risks and non-cancer health hazards are above acceptable levels. The MNA Alternative is not sufficiently protective of human health and the environment because, among other things, it relies more heavily on institutional controls than the active remedial alternatives. This is a result of the significantly longer time required to achieve target PCB concentrations in fish under MNA. Institutional controls do not completely eliminate human exposure to the PCB-contaminated fish and do not address risks to ecological receptors.

According to the 1991-1992 and 1996 survey data summarized in NYSDOH (1999), most Upper Hudson respondents (almost 92 percent) never eat their catch and most (88 percent) are aware of the official health warnings against eating fish. Looked at another way, however, these surveys show that approximately 8 percent of Upper Hudson respondents do eat their catch and some 12 percent are unaware of the fish consumption advisories. The 1991-1992 survey (Barclay, 1993) found the same number of anglers unaware of the advisories as aware. Both the 1991-1992 and the 1996 surveys found that anglers eat and share their catch with others, whether or not they are aware of the advisories. These surveys also showed that none of the survey respondents reported knowledge of the "eat none" advisory for women of childbearing age and children under the age of 15 years. The raw survey data from the state-wide 1991 New York Angler survey (Connelly, *et al.*, 1992) showed no significant difference in the mean number of freshwater fish meals eaten when comparing New York waterbodies with full, partial, or no advisories, despite the expectation that the fishing advisories would likely suppress fish ingestion rates to some degree (*e.g.*, Lake Ontario). Thus, the available data confirm that fish consumption advisories are not 100 percent effective in preventing or limiting fish consumption.

EPA disagrees with comments suggesting that it has overestimated Site risks given the existence of alternative fishing locations in New York (other than the Upper Hudson River) and the growing popularity of catch and release fishing. As previously discussed in this response, institutional controls are not fully effective in preventing or limiting fish consumption. The suggestion that anglers should avoid the Hudson River and seek alternative fishing locations is simply another way of imposing a restriction on fishing in the Hudson River. An important goal of the selected remedy is to improve conditions in the Hudson River such that PCB levels in fish are reduced to the point where the existing fishing advisories can be relaxed and perhaps ultimately removed (lifted) from the river.

Several comments suggested that EPA should have collected Site-specific data to characterize the size of the potentially impacted angler population information for its HHRA. As was discussed in the HHRA and in Section 3.1.2 (Master Comment 569), in light of the fish consumption advisories that are in place, it would be difficult to assess the size of the potentially impacted angler population from data collected on the Hudson. Consistent with CERCLA policy and guidance, EPA assessed cancer risks and non-cancer health hazards to the reasonably maximally exposed and central tendency (*i.e.*, average) individual and did not conduct a population risk assessment. However, in response to a recommendation of the HHRA peer reviewers, EPA provided perspective on the approximate size of the exposed population in the HHRA (p. 8). For example, the total population of the five counties surrounding the Upper Hudson is about 750,000 (US Census Bureau, 1990), and an estimated 78,628 fishing licenses were issued to anglers in these five counties during the 1998-1999 fishing season (NYSDEC, 2000). This number of fishing licenses, though, does not include children under the age of 15 for whom licenses to fish in the Upper Hudson are not required, or friends and families who eat fish caught by an angler. EPA focused the HHRA on Upper and Mid-Hudson sport anglers and did not include those who fish in the Lower Hudson below RM 64, just south of Poughkeepsie, because concentrations of PCBs in fish generally decrease with river mile. Due to this decrease, cancer risks and non-cancer health hazards for anglers below the Poughkeepsie area are expected to be lower than for Upper and Mid-Hudson anglers.

EPA encourages all anglers to abide by applicable laws and regulations and to follow the fish consumption advisories, regardless of whether they believe there is a long-standing common law right to eat self-caught fish. As has been stated, fish consumption advisories and regulations prohibiting fish harvesting in the Upper Hudson are institutional controls and do not correspond to baseline conditions under CERCLA. A goal of the selected remedy is to reduce levels of PCBs in fish such that the Site-related fish consumption advisories and the regulations against fish harvesting can be reduced and eliminated.

References

Barclay, B. 1993. "Hudson River Angler Survey." Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

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

New York State Department of Environmental Conservation (NYSDEC). 2000. Resident and non-resident hunting, fishing and trapping licenses by type - New York State by county. Licenses year ended September 30, 1999. Sporting License Bureau, February 2, 2000.

New York State Department of Health (NYSDOH). 1999. Health Consultation: 1996 Survey of Hudson River Anglers, Hudson Falls to Tappan Zee Bridge at Tarrytown, New York. February. (Raw survey data received electronically from Edward Horn of NYSDOH in June, 1998.)

United States Census Bureau. 1990. Census summary tape File 3. - Sample count - all socioeconomic and demographic variables. http://venus.census.gov/cdrom/lookup.

USEPA. 1989. Risk Assessment Guidance for Superfund (RAGS), Volume I. Human Health Evaluation Manual (Part A). USEPA, Office of Emergency and Remedial Response, Washington, D.C. USEPA/540/I-89/002, December.

USEPA. 1990. National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule, codified as amended at 40 CFR. Part 300.

USEPA. 1992a. Guidelines for exposure assessment. *Federal Register* 57(104), May 29.

USEPA. 1992b. "Guidance on Risk Characterization for Risk Managers and Risk Assessors." Memorandum from F. Henry Habicht, III Deputy Administrator to Assistant Administrators and Regional Administrators. USEPA, Office of the Administrator, Washington, DC.

USEPA. 1995. "USEPA Risk Characterization Program." Memorandum from Administrator Carol M. Browner to Assistant Administrators, Associate Administrators, Regional Administrators, General Counsel and Inspector General on March 21, 1995, Washington, D.C.

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

3.1.4 Sensitive Populations and Additional Exposure Routes

Master Comment 567

A number of comments suggest that risks associated with the consumption of PCB-contaminated fish from the Hudson River are underestimated because the HHRA did not sufficiently consider risks to certain sub-populations (*e.g.*, subsistence anglers), sensitive populations (*e.g.*, women and children), and Lower Hudson anglers. Other comments indicate that EPA underestimated the non-cancer health hazards for inhalation of PCBs because there is no Reference Concentration (RfC) for PCBs that permits quantification of this hazard. Other comments indicate that recently released data show high levels of PCBs in the floodplains of the Upper Hudson, which could imply greater risk to the avid recreator. Other comments indicate EPA underestimated both cancer risks and non-cancer hazards through ingestion of surface water while swimming, since these risks were not quantified in the HHRA.

Response to Master Comment 567

Cancer risks and non-cancer health hazards were not specifically quantified for subsistence anglers, unlicensed anglers, or other subpopulations of anglers who may be highly exposed. Although no distinct highly exposed subpopulations have been identified, the question exists as to whether these subpopulations have been adequately addressed in the Revised HHRA (USEPA, 2000a). However, based on consideration of fish ingestion rates among low income families (Wendt, 1986), fish ingestion rates reported for licensed and non-licensed anglers from the Hudson River angler surveys (Barclay, 1993; NYSDOH, 1999), and fish ingestion rates for angler populations in other areas of the country (see Table 3-2 in the Revised HHRA), it appears likely that any highly exposed subpopulations are represented within the upper percentiles of the fish ingestion rate distribution used in the Monte Carlo analysis, as discussed in Section 3.2.1.4 of the Revised HHRA

The issue regarding effects to pregnant and lactating women is discussed in the Revised HHRA (Section 4.5.2). For reasons discussed there, no generally accepted method exists to quantify PCB effects specifically for pregnant women, in utero exposures, or exposures to nursing infants. Cancer risks and non-cancer hazards to women and young children were quantitatively assessed in the Revised HHRA. The toxicity values in IRIS that were used in the HHRA (USEPA, 2000b) are considered to be protective of sensitive populations such as women and children (USEPA, 1999). The approach used in the Revised HHRA is consistent with the external peer reviewers comments that suggested this analysis be evaluated either quantitatively or qualitatively.

The inhalation route of exposure for non-cancer effects could not be evaluated due to the lack of a reference concentration (RfC) for PCBs in IRIS. Cancer risks associated with exposure to PCBs through inhalation are considered low (*i.e.*, 1 in 1,000,000 to the RME resident, based on exposure for 350 days/year for 40 years). This risk includes young children, adolescent, and adult life stages. Given this low risk, it is unlikely that the non-cancer hazards from this exposure would exceed a HI of 1, as indicated in EPA's response to comments (page 36, Response to HS-1.15) (USEPA, 2000c). A preliminary screening level calculation using a route-to-route extrapolation from the oral RfD for PCBs to an inhalation RfC indicates that the estimated non-cancer hazard index would be 0.02 for the RME adult individual (page 36, Response to HS-1.15). While some commenters have noted that this may cause the overall non-cancer hazards to be underestimated, it must be kept in perspective that cancer risks and non-cancer hazards associated with the ingestion of fish far outweigh risks from all other pathways: the HI for adult ingestion of fish is 65, compared to an HI of 0.2 through inhalation.

The cancer risks due to inhalation of PCBs in air were evaluated based on historical measurements of PCBs in air as well as modeled concentrations of PCBs volatilized from river water into air (Revised HHRA, pp. 16-21 and Appendix B). PCB-contaminated sediments and floodplain soil also potentially contribute to PCBs in air. EPA did not quantify the contribution of PCBs in air from contaminated sediment and floodplain soil because:

a) The contribution is expected to be minor compared to the concentration of PCBs in air that were used in the HHRA, which were obtained during periods of high activity (*i.e.*, during the Remnant Deposit remediation).

b) The calculated cancer risks from inhalation of volatilized PCBs were *de minimus* (*i.e.*, the risk to the RME individual was 1 in 1,000,000, which is not considered significant).

c) Consistent with the scope of the Reassessment RI/FS, the HHRA addresses the cancer risks and non-cancer hazards from PCBs in Hudson River water and sediments, not floodplain soils. The uncertainty associated with concentrations of PCBs in air from all sources, which could include river sediments periodically exposed to air, is acknowledged in the HHRA.

Incidental ingestion of river water while swimming was not quantitatively evaluated because the river water meets federal drinking water standards for PCBs established under the Safe Drinking Water Act (SWDA). The SDWA standards are based on an ingestion of 2 liters/day of water, and it is anticipated that while swimming, an individual will ingest only 50 ml/hour, or approximately 2.5 percent of the amount assumed under the SDWA. Therefore, the cancer risks and non-cancer health hazards are less than EPA's risk range (*i.e.*, less than 1 in 1,000,000 for cancer and less than a HI of 1 for non-cancer).

In addition, as discussed in the baseline HHRA, dermal contact while swimming does not pose a health threat to recreators; the risk is within acceptable range. Finally, as discussed in the Feasibility Study and Responsiveness Summary, releases of PCBs during remediation are not expected to elevate PCB concentrations in the river.

References

Barclay, B. 1993. "Hudson River Angler Survey." Hudson River Sloop Clearwater, Inc., Poughkeepsie, New York.

New York State Department of Health (NYSDOH). 1999. Health Consultation: 1996 Survey of Hudson River Anglers, Hudson Falls to Tappan Zee Bridge at Tarrytown, New York. February. (Raw survey data received electronically from Edward Horn of NYSDOH in June, 1998.)

USEPA. 1999. "Integrated Risk Information System Chemical File for Polychlorinated Biphenyls." National Center for Environmental Assessment, Cincinnati, Ohio.

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

USEPA. 2000b. Phase 2 Report, Further Site Characterization and Analysis. Volume 2F-Human Health Risk Assessment (HHRA), Hudson River PCB Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS Consultants, Inc. and Gradient Corporation. November.

USEPA. 2000c. Responsiveness Summary for Volume 2F. Human Health Risk Assessment, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS Consultants, Inc. and Gradient Corporation. March.

Wendt, M.E. 1986. Low Income Families' Consumption of Freshwater Fish Caught from New York State Waters. Thesis, Cornell University. August.

3.2 Baseline Ecological Risk Assessment

Master Comment 811

A number of comments were received on the Revised Baseline Ecological Risk Assessment (RBERA) (USEPA, 2000a). Opposing viewpoints were received as to whether the RBERA did or did not fulfill baseline risk assessment requirements. It was suggested that EPA did not revise the risk assessment in accordance with the peer reviewers' evaluation, or did so incorrectly, and that EPA produced only a "flawed screening level assessment" of ecological risk using conservative assumptions. Other commenters maintained that the RBERA used solid science to show significant risks to Hudson River receptors from exposure to PCBs; some believe that risks may in fact have been underestimated in the BERA.

Response to Master Comment 811

EPA prepared the Response to Peer Review Comments on the Baseline Ecological Risk Assessment (USEPA, 2000b) and issued the Revised Baseline Ecological Risk Assessment (RBERA) (USEPA, 2000a). specifically in response to the peer reviewers' comments on the original Baseline Ecological Risk Assessment (BERA) (USEPA, 1999). The methodology followed in the RBERA is not a screening level approach. Extensive Site-specific information was obtained with regard to exposure factors, and species-specific information was preferentially used in developing toxicity reference values (TRVs). A joint probability analysis, which provides information on the potential for population-level effects, was conducted to complement the toxicity quotient (TQ) approach.

There is additional evidence since the publication of the RBERA that shows that the results of the TQ approach are valid. The recently published National Academy of Sciences (NAP, 2001) report provides data from semi-field investigations, and also provides recommended TRVs for total PCBs in otter liver on a NOAEL basis of 170 ng/g wet weight or 4 ug/g lipid normalized, and on a LOAEL basis of 460 ng/g wet weight or 11 ug/g lipid normalized. A comparison of the recently released NYSDEC data shows that otter captured within five miles of the Hudson River exceed these values (Table 811-1). Two of these animals exceed the TRVs 20 to 40 times, and these high concentrations are observed in animals that were caught on land, closest to the river rather than to a tributary.

Although the NAS report does not recommend a particular TRV for concentrations in mink liver, they reference Kannan *et al.* (2000) as an authoritative source. Kannan *et al.* (2000) recommend TRVs for total PCBs in mink liver on a NOAEL basis of 0.10 ug/g wet weight or 2.03 ug/g lipid normalized, and on a LOAEL basis of 2.22 ug/g wet weight or 44.4 ug/g lipid normalized. Table

811-1 shows a comparison of these TRVs to measured PCB concentrations in mink liver from animals trapped within five miles of the Hudson River. Measured concentrations consistently exceed the NOAEL, and two of the animals exceed the LOAEL as well. The Responses to Master Comments 815 and 819 in Section 3.2.2 provide additional detail on wildlife data collected from the area surrounding the Hudson River.

Additional specific comments related to TRVs are addressed in the Response to Master Comment 813 in Section 3.2.1. Specific comments related to the area use factors are provided in Response to Master Comment 793 in Section 3.2.3. The remainder of this response addresses the issue of population-level risks. One commenter states "in light of the fact that EPA failed to demonstrate any population-level risks, any removal of sediments would most likely have far greater adverse effects on fish and wildlife than the contaminants."

EPA disagrees with this statement because the joint probability analysis showed that populations of ecological receptors, particularly otter and mink, are significantly at risk now and into the future under current conditions. However, one commenter raises several issues related to the joint probability analyses that are addressed next.

One commenter was able to successfully reproduce the cumulative density functions of exposure, but was unable to reproduce the dose-response functions as reported by Moore *et al.* (1999). For the analysis presented in the RBERA, USEPA obtained discrete values directly from Dr. Moore for ED01 through ED99. These were combined with the exposure-concentration functions to obtain the final response curves. However, in a validation exercise, the probit model presented in Moore *et al.* (1999) was programmed in Visual Basic as a Microsoft Excel add-in and found to reproduce the results exactly. Note that Moore *et al.* (1999) state that the toxicity data for both the mammalian and avian receptors represent mean responses rather than individual responses.

As one commenter pointed out, it is important to distinguish sources of uncertainty (Thompson and Graham, 1996; Vorhees *et al.*, 1998). Typically two sources of uncertainty are quantitatively identified: uncertainty that arises from lack of knowledge (*e.g.*, uncertainty in the true mean exposure concentration) and uncertainty that arises from variability, or population heterogeneity. Variability cannot be reduced, only better understood, because it refers to the heterogeneity of values in the population. For example, body weight is predominantly described by variability. In the analysis presented in the RBERA, all distributions were specified as variable, when in fact the environmental concentrations (*e.g.*, fish, sediment, benthic invertebrates, and water) are properly described as uncertain. All other exposure parameters (*e.g.*, body weight, ingestion rate, proportion of dietary items, and area use factor) are properly described as variable (von Stackelberg *et al.*, 2001; Kelly and Campbell, 2000).

The joint probability analysis was rerun using exactly the same exposure distributions as in the RBERA with one addition: the area use factor (or temporal habitat factor in the exposure tables) was specified as a triangular distribution with parameters, minimum, mode, and maximum (0.5, 0.75, 1.0). The justification for all the parameters is provided in the exposure concentration tables (Tables 3-69 to 3-70 in the RBERA). Typically, triangular distributions are appropriate for situations in which there are limited data with which to characterize a more refined distribution shape. The final column for these tables provides ranges for the exposure variables. These were

specified as triangular with the point estimate specified as the mode. This was done because there was not enough information available to more precisely define the distribution shape. The uncertain distributions in the joint probability analysis (sediment, water, fish, and benthic invertebrate predicted concentrations) were described as lognormal. Data for the Hudson River in these four media based on the Phase 2 dataset show that these concentrations are typically lognormally distributed in the environment, and other studies have conducted this kind of analysis in a similar manner (Cohen *et al.*, 1996; Moore *et al.*, 1999). Moreover, a lognormal specification is appropriate for variables bounded by zero and with skewed right tails. An uncertainty evaluation conducted as part of the Revised Baseline Modeling Report showed that model predictions are typically within a factor of two across the modeling results. This factor of two was used to construct the distributions shown in Table 3-103 of the RBERA and presented here as Table 811-2. Mean predicted environmental media concentrations were obtained from the HUDTOX and FISHRAND modeling results.

Results

Figures 811-1 through 811-3 present the results of the revised joint probability analysis for bald eagle, mink, and river otter, respectively. These graphs show that including a distribution for area use factor and separating uncertain and variable parameters still results in the potential for significant population-level effects. The graphs include three curves for each year and river mile, the lower confidence limit or 5th percentile (5 percent LCL), the best estimate, and the 95th percentile or upper confidence limit (95 percent UCL).

Figure 811-1 presents the results for the bald eagle. At RM 189 (Thompson Island Pool, TIP), the results for 1993 show that there is virtually a 100 percent probability of 80 to 100 percent reduction in fecundity. By 2015, there is a 50 percent probability of a 50 to 75 percent reduction in fecundity, and an 80 percent probability of a 40 to 65 percent reduction in fecundity. At RM 168 (Stillwater), the results for 1993 show an 80 percent probability of a reduction in fecundity ranging from 72 to 90 percent. This range decreases by 2015 to from 20 to 35 percent. At RM 154 (Waterford), there is a 50 percent probability in 1993 of a reduction in fecundity ranging from 43 to 63 percent. By 2015, there is an 80 percent probability of a reduction on the order of 10 to 15 percent.

Figure 811-2 presents the results for the mink. At RM 189 (TIP), the results for 1993 show that there is virtually a 100 percent probability of 80 to 100 percent reduction in fecundity. By 2015, there is a 50 percent probability of a 50 to 75 percent reduction in fecundity, and an 80 percent probability of a 40 to 65 percent reduction in fecundity. At RM 168 (Stillwater), the results for 1993 show an 80 percent probability of a reduction in fecundity ranging from 72 to 90 percent. This range decreases by 2015 to from 20 to 35 percent. At RM 154 (Waterford), there is a 50 percent probability in 1993 of a reduction in fecundity ranging from 43 to 63 percent. By 2015, there is an 80 percent probability of a reduction on the order of 10 to 15 percent.

Figure 811-3 presents the results for the river otter. At RM 189 (TIP), the results for 1993 show that there is virtually a 100 percent probability of 80 to 100 percent reduction in fecundity. By 2015, there is still an 80 percent probability of an 85 to 97 percent reduction in fecundity. At RM 168 (Stillwater), the results for 1993 show virtually a 100 percent probability of an 80 to 95 percent reduction in fecundity. In 2015, there is still a 50 percent probability of a reduction in

fecundity ranging from 56 to 75 percent. At RM 154 (Waterford), there is an 80 percent probability in 1993 of a reduction in fecundity ranging from 75 to 92 percent. By 2015, there is a 50 percent probability of a reduction on the order of 25 to 43 percent and a 20 percent probability of a reduction in fecundity ranging from 35 to 55 percent.

These results show that under the baseline No Action Alternative, significant population-level risks exist for the piscivorous birds and mammals.

Implications for Feasibility Study Results

The most optimistic result (5 percent LCL) from the No Action Alternative showed a 90 percent probability of at least an 80 percent reduction in fecundity in 2015 at RM 189. The highest predicted risk, or 95 percent UCL, shows a 90 percent probability of a 40 percent reduction in fecundity in 2021. Although 2021 is just a few years later than 2015, the smallest possible difference between No Action and the selected remedy is still 40 percent.

The FS presents results for the joint probability analyses conducted for the different alternatives in Figures 7-9 to 7-11. The results shown in those figures correspond approximately to the 95 percent UCL in the current analysis. The modeling results across all alternatives, including No Action, show that the ratio between the 5 percent LCL and the 95 percent UCL is approximately 0.5. The modeling results for the alternatives presented in the FS can thus be multiplied by 0.5 to obtain lower confidence limits across all alternatives.

Conclusions

The RBERA, which was prepared in response to peer review comments, is not a screening level document. Consistent with USEPA guidance, the approach taken in the risk assessment is an appropriate method for evaluating potential future risks for which data are obviously unavailable. In addition, the risk assessment is used to compare risk reductions among remedial alternatives. The risk assessment represents a well-established and robust framework for evaluating potential future risks as compared to current risks, as well as for comparing the expected effects of remedial alternatives under a consistent set of modeling assumptions.

References

Cohen, J.T., Lampson, M.A., and T.S. Bowers. 1996. The Use of Two-stage Monte Carlo Simulation Techniques to Characterize Variability and Uncertainty in Risk Analysis, *Human and Ecological Risk Assessment* 2:939-971.

Kannan, K., A.L. Blankenship, P.D. Jones, and J.P. Giesy. 2000. Toxicity reference values for the toxic effects of polychlorinated biphenyls to aquatic mammals *Human and Ecological Risk Assessment* 6(1):181-201.

Kelly, E.J. and K. Campbell. 2000. Separating Variability and Uncertainty in an Environmental Risk Assessment. Making Choices. *Human Ecol. Risk Assess*. 6:1-13.

Moore, D.R.J., Sample, B.E., Suter, G.W., Parkhurst, B.R. and R.S. Teed. 1999. A probabilistic risk assessment of the effects of methylmercury and PCBs on mink and kingfishers along East Fork Poplar Creek, Oak Ridge, Tennessee, USA. *Environ. Tox. Chem*. 18(12):2941-2953.

National Academy Press (NAP). 2001. A Risk-Management Strategy for PCB-Contaminated Sediments. Committee on Remediation of PCB-Contaminated Sediments, Board on Environmental Studies and Toxicology, National Research Council. 452 pages.

von Stackelberg, K., Burmistrov, D., Vorhees, D.J., Bridges, T.S. and I. Linkov. 2001. Importance of uncertainty and variability to predicted risks from trophic transfer of PCBs in dredged sediments. Submitted to *Risk Analysis*.

Thompson, K.M. and J.D. Graham. 1996. Going Beyond the Single Number: Using Probabilistic Risk Assessment to Improve Risk Management, *Human and Ecological Risk Assessment* 2:1008-1034.

USEPA. 1999. Further Site Characterization and Analysis, Volume 2E - Baseline Ecological Risk Assessment (BERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc. and Menzie-Cura & Associates, Inc. August 1999.

USEPA. 2000a. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E-Revised Baseline Ecological Risk Assessment (RBERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. November 2000.

USEPA. 2000b. Response to Peer Review Comments on the Baseline Ecological Risk Assessment, Hudson River PCBs Reassessment RI/FS. Prepared for the USEPA Region 2 and USACE by TAMS Consultants, Inc. and Menzie-Cura & Associates, Inc. November 2000.

Vorhees, D.J., Kane Driscoll, S.B., von Stackelberg, K., and T.S. Bridges. 1998. Improving Dredged Material Management Decisions with Uncertainty Analysis, Dredging Operations and Environmental Research Program, Technical Report DOER-3.

Master Comment 801

Commenters stated that dredging of PCBs will protect resources in the upper river and downstream. One commenter noted that the federal trustees for natural resources, the US Department of the Interior (DOI) and the National Oceanic and Atmospheric Administration (NOAA), (together, "the Trustees") are in the process of investigating natural resource injuries caused by PCBs. The Trustees have recently determined that the Hudson River fishery has suffered "injury," as authorized by Section 107(f) of CERCLA. The Trustees have further concluded that this injury will continue into the future unless PCB contamination in fish is reduced. Dredging will protect not just the upper river, but lower river resources as well. Curtailing the flow of PCBs over the Troy Dam will protect Hudson River resources for the 150-mile stretch to the Battery and will also protect New York Harbor's resources. Ultimately, a

comprehensive approach will prevent the gradual dissipation and redistribution of these PCBs to the Atlantic Ocean and beyond.

Response to Master Comment 801

EPA concurs that dredging will protect ecological resources (and also human health) in the upper and lower river by reducing PCB concentrations in fish. Therefore, a dredging remedy (REM-3/10/S - now the selected remedy) was chosen to reduce concentrations of this bioaccumulative contaminant. Long-term natural resource and human health benefits are considered to outweigh short-term impacts.

3.2.1 Ecological Toxicity of PCBs

Master Comment 813

Comments stated that overly conservative TRVs were used in the Revised Baseline Ecological Risk Assessment (mammals and fish) (USEPA, 2000a), and that the study used to develop mink and otter TRVs is inappropriate. Under alternative assumptions, risks are lower using source control in the lower two sections (34 of 40 miles) of the upper river (GE, Appendix N).

Response to Master Comment 813

Toxicity Reference Values (TRVs) for Mammals

As described in the following text, EPA changed the field study used to develop the TRV for the mink and river otter in the 2000 Revised Baseline Ecological Risk Assessment (RBERA) (USEPA, 2000a) in response to peer reviewer's comments that EPA's methodology for deriving TRVs was too conservative. The rationale for this change is described below.

The methodology, described on page 80 of Section 4.2.1 of the 1999 Baseline Ecological Risk Assessment (BERA) (USEPA, 1999), states that the lowest appropriate NOAEL and corresponding LOAEL were selected for the development of TRVs. The peer reviewers pointed out that the lowest appropriate LOAEL in the dataset, rather than the lowest appropriate NOAEL, is a more appropriate basis upon which to develop a TRV. EPA concurred that the study that reported the lowest appropriate LOAEL, the study that reported the lowest dose or body burden at which significant adverse effects on growth, reproduction, or mortality were observed, should be selected for development of the TRV. This revised methodology is described on page 99 of Section 4.2.1 of the 2000 RBERA.

Consequently, the mink TRV for the 1999 BERA, which was based on the lowest appropriate NOAEL in the dataset (NOAEL=0.004 mg/kg bw/day from Heaton *et al.*, 1995), was replaced in the 2000 RBERA with the study that reported the lowest appropriate LOAEL in the dataset (LOAEL= 0.04 mg/kg bw/day from Restum *et al.* 1998).

As noted in Appendix N of the GE comments, the reported LOAEL for the Restum *et al.* (1998) study is three times lower than the LOAEL reported in the Heaton et al (1995) study. However, it

is not unexpected that Restum *et al.* (1998) would report effects at a lower dose, since mink in this study were exposed over a longer period of time and effects were examined over multiple generations. Therefore, the Restum *et al.* (1998) study is not believed to represent, as stated in Appendix N, "a more conservative and inappropriate LOAEL TRV." EPA used the Restum *et al.* study (1998) to develop TRVs because it represents a technically sound study that examines a sensitive endpoint, reduced rate of growth (15 percent lower than control mink at 6 weeks of age) in offspring of females exposed to PCBs in the diet.

Use of field studies to derive TRVs has both advantages and limitations. As noted in Appendix N, because of the presence of co-occurring contaminants in field exposures, especially chlorinated organics with dioxin-like activity, observed effects may not be attributable solely to the presence of PCBs. The Saginaw Bay fish fed to minks in the Restum *et al.* (1998) study contained PCBs and other chlorinated organics with dioxin-like activity, all of which contributed to observed effects in mink. The question as to whether or not the contribution of PCBs to observed effects is similar between Saginaw Bay fish and Hudson River fish is an area of uncertainty. To address this uncertainty, TRVs were also developed on the basis of total dioxin-like equivalents.

To assess the contribution of PCBs between the Hudson River and Saginaw Bay studies, EPA evaluated the Hudson River database from NYSDEC to determine if there were samples for which there were both PCB congener and dioxin-furan congener results. Six samples were identified. The results for the individual congeners were multiplied them by the appropriate TEF for mammals (Van Den Berg *et al.*, 1998). The proportion of each contributing to the total mass was assessed, following the method presented in Giesy *et al.*, 1997. This was done to be able to compare the proportion in Hudson River fish samples relative to the proportions in the Saginaw Bay, which provided the data for the derivation of the toxicity reference values for mammals.

Percentage of Dioxin, Furan, and PCB Congeners in Hudson River Samples

Species	Sample Date	River Mile	%PCDD	%PCDF	%PCB	%PCDD with ½ DL	%PCDF with ½ DL	%PCB with ½ DL
LMB	19910514	189.1	0	2	98	6	3	91
BB	19910514	189.1	2	3	95	2	3	95
PKSD	19910514	189.1	0	1	99	2	1	97
LMB	19910530	157.6	0	2	98	4	3	93
BB	19910530	157.6	0	0	100	39	39	21
PKSD	19910530	157.6	23	1	77	67	21	13
Note: final three columns use data with values set to 1/2 the detection limit								

These results show that because there were numerous nondetect values for the dioxin-furan congeners, setting the nondetect values equal to zero results in the greatest proportion of the mixture attributable to PCB congeners. However, when half the detection limit is used (following the methodology in Giesy *et al.*, 1997), the proportions span a wider range.

The proportions reported in Giesy *et al.*, 1997 for fish tissue are given below:

Species	%PCDD	%PCDF	%PCB
YOY walleye	29.9	45.5	25.6
Yearling walleye	23.9	41.6	34.5
Small walleye	20.5	40.2	39.3
Medium walleye	17.1	59	23.9
Large walleye 1	28.5	46.5	25
Large walleye 2	4.9	68.7	26.5
Large alewife	23.8	26.3	50.1
YOY gizzard shad	14.8	67.6	17.6
Yellow perch	19	48.5	32.5
Common carp	38.2	50.1	11.7
Mean (with carp)	20.3 (7.6)	49.3 (13.7)	30.6 (9.8)
Mean (without carp)	22 (9.1)	49.4 (12.9)	28.7 (11)
Note: Standard deviation given in parentheses			

These results show that the proportion of PCBs contributing to the overall mixture is much higher in the Hudson River samples than in the Saginaw Bay samples. This supports the use of the TRVs developed for total PCBs in the RBERA for mink and otter, and, if anything, suggests that TRVs based on data from the Saginaw Bay may understate the true effect of PCBs.

The advantage to using field studies over laboratory studies is that due to weathering (*e.g.*, evaporation of lighter congeners) and metabolism, the mixture of PCB congeners in field-collected samples is typically much different than that of the commercial mixture. Because Hudson River fish metabolize PCBs, the mixture of congeners to which the mink is exposed in the field is different and of unknown toxicity relative to the unaltered Aroclor mixture administered in laboratory studies. Because of these concerns, the peer reviewers of the 1999 BERA stated that field studies are important in estimation of toxic effects and should be used in the development of TRVs. Thus, in response to comments from peer reviewers, EPA used field studies to develop final TRVs for the 2000 RBERA.

Mink in laboratory studies tabulated by Leonards *et al.* (1995) were fed Aroclor mixtures, rather than a mixture from a field-collected sample. Therefore, it is not surprising that effects were observed at higher concentrations of PCBs than were observed in field studies. In addition, the studies reviewed by Leonards *et al.* (1995) examined effects on litter size and kit survival, endpoints that are expected to be less sensitive that the effects on kit growth rate that were documented in the Restum *et al.* (1998) study. The dose that results in the death of kits is expected to be higher than the dose that results in wasting or reduced weight gain in kits.

Appendix N notes that the sensitivity of river otters to PCBs has not been extensively studied and they "could" be less sensitive than mink to the effects of PCBs. However, since river otter belong to the same taxonomic family as mink (Mustelidae), and closely related species often show similar sensitivity to PCBs, river otter could also be just as sensitive as mink. Kannan *et al.* (2000) state that "Otters are sensitive to the toxic effects of PCBs and other organochlorine chemicals" (p. 187). Further, these authors state that "Although several explanations such as habitat destruction, drowning in fishing nets, traffic accidents, eutrophication, acidification and

toxic chemicals have been suggested for the otter population decline, PCB pollution is considered to be one of the major factors in this decline" (ibid.).

The mink TRV of 0.04 mg/kg bw-day corresponds to a 25 percent effect level in the dose-response function from Moore *et al.*, 1999. A TRV of 0.13 mg/kg bw-day corresponds to a 50 percent effect level in the same dose-response function. The interpretation is that 50 percent of the mink population experienced adverse reproductive effects at a concentration of 0.13 mg/kg bw-day. Kannan *et al.* recommend a dietary dose NOAEL for mink of 0.004 mg/kg bw-day and a LOAEL of 0.13 mg/kg bw-day based on reproductive effects. This study is further cited in the NAS report (NAP, 2001).

Also, note that while reproductive effects generally resulted in the most sensitive endpoint relative to the survival and growth endpoints examined, other endpoints not evaluated in the BERA might serve as more sensitive endpoints to organisms exposed to PCBs. Such endpoints include immunological effects or effects on enzyme levels. This would have the effect of lowering the TRVs from their current levels.

TRVs for Fish

The observation in Appendix N of the GE comments that interspecies uncertainty factors were not used to develop final TRVs for the 2000 RBERA is correct. Although the use of uncertainty factors is common practice when deriving TRVs (*e.g.*, NAP, 2001, pp. 171 and 386), they were not used to derive the RBERA TRVs, because peer reviewers felt that their use was overly conservative. However, the suggestion in Appendix N of GE's comments that EPA attempted to offset the removal of uncertainty factors by developing new and lower TRVs for certain species is incorrect. As described in the Responsiveness Summary for Volume 2E-Baseline Ecological Risk Assessment (USEPA, 2000b, pp. 66-67), the study by Hansen *et al.* (1974) that was used in the 2000 RBERA to develop fish TRVs was not originally identified in the literature search that was conducted for the BERA, presumably because the paper was published in a journal with a limited distribution. This paper was provided to EPA by NOAA in their comments on the 1999 BERA as a more appropriate study upon which to base the development of TRVs. Upon review, EPA concurred that the Hansen *et al.* (1974) study was the more appropriate study for the development of a fish TRV for total PCBs. The rationale for this finding is discussed in the following text.

Bengtsson (1980), the study that was used in the 1999 BERA, reported that exposure to Clophen A50 resulted in significantly reduced hatchability at 170 mg PCBs/kg body weight, but not at 15 mg PCBs/kg body weight. Significantly reduced hatching times were observed at 15 mg PCBs/kg body weight, but not at 1.6 mg PCB/kg body weight. (Note that units are mg PCBs/kg body wt, not mg PCB/kg-body wt/day as reported in GE, Appendix N, page 10. Reported units represent measured concentrations of PCBs in tissue, not daily dietary doses, which are reported in mg/kg-body wt/day.) Reduced hatching time was reported to result in premature death of the fry, although statistics were not reported for fry survival. The 1999 BERA did not use the reduced hatching time endpoint for development of TRVs because the association with the endpoints of concern (growth, reproduction, and mortality) is uncertain. Premature death of fry, which was reported to be associated with premature hatching, was not used because no statistics were provided for this endpoint.

The Hansen et al (1974) study reported significantly reduced survival of fry at concentrations of 9.3 mg PCBs/kg body weight, but not at 1.9 mg PCBs/kg body weight. Note that these concentrations are very similar to concentrations that resulted in significantly reduced hatching time and associated reduced fry survival in the Bengtsson study (LOAEL = 15 mg PCBs/kg bw, NOAEL = 1.6 mg PCBs/kg bw).

In conclusion, EPA selected the study by Hansen *et al.* (1974) because it reported significant adverse effects on an ecologically important endpoint, fry survival. The revised TRVs were not developed to offset the removal of uncertainty factors.

References

Bengtsson, B.E. 1980. Long-term effects of PCB (Clophen A50) on growth, reproduction and swimming performance in the minnow, *Phoxinus phoxinus*. *Water Research*, Vol. 1, pp. 681-687.

Giesy, J.P., D.J. Jude, D.E. Tillitt, R.W. Gale, J.C. Meadows, J.L. Zajieck, P.H. Peterman, D.A. Verbrugge, J.T. Sanderon, T.R. Schwartz, and M.L. Tuchman. 1997. Polychlorinated dibenzo-p-dioxins, dibenzofurans, biphenyls and 2,3,7,8- tetrachlorodibenzo-p-dioxin equivalents in fishes from Saginaw Bay, Michigan. *Environ. Tox. Chem.* 16(4):713-724.

Hansen, D.J., Parrish, P.R., and Forester, J. 1974. Aroclor 1016: toxicity to and uptake by estuarine animals. *Environmental Research*, Vol. 7, pp 363-373.

Heaton, S.N., S.J. Bursian, J.P. Giesy, D.E. Tillitt, J.A. Render, P.D. Jones, D.A. Verbrugge, T.J. Kubiak, and R.J. Aulerich. 1995. Dietary exposure of mink to carp from Saginaw Bay, Michigan. 1. Effects on reproduction and survival, and the potential risk to wild mink populations. *Archives of Environmental Contamination and Toxicology*. 28:334-343.

Kannan, K., A.L. Blankenship, P.D. Jones, and J.P. Giesy. 2000. Toxicity reference values for the toxic effects of polychlorinated biphenyls to aquatic mammals *Human and Ecological Risk Assessment* 6(1):181-201.

Leonards, P.*E.G.*, .H. de Vries, W. Minnaard, S. Stuijfzand, P. de Voogt, W.P. Cofino, N.M. van Straalen, and B. van Hattum. 1995. Assessment of experimental data on PCB-induced reproduction inhibition in mink, based on an isomer-and congener-specific approach using 2,3,7,8-tetrachlorodibenzo-*p*-dioxin toxic equivalency. *Environ. Toxicol. Chem.* 14(4):639-652.

Moore, D.R.J., Sample, B.E., Suter, G.W., Parkhurst, B.R. and R.S. Teed. 1999. A probabilistic risk assessment of the effects of methylmercury and PCBs on mink and kingfishers along East Fork Poplar Creek, Oak Ridge, Tennessee, USA. *Environ. Tox. Chem*. 18(12):2941-2953.

National Academy Press (NAP). 2001. A Risk Management Strategy for PCB-Contaminated Sediments. Committee on Remediation of PCB-Contaminated Sediments, Board on Environmental Studies and Toxicology, National Research Council. 452 pages.

Restum, J.C., S.J. Bursian, J.P. Giesy, J.A. Render, W.G. Helferich, E.B. Shipp, and D.A. Verbrugge. 1998. Multigenerational study of the effects of consumption of PCB-contaminated carp from Saginaw Bay, Lake Huron, on mink. 1. Effects on mink reproduction, kit growth and survival, and selected biological parameters. *Journal of Toxicology and Environmental Health*, Part A, 54:343-375.

USEPA. 1999. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E - Baseline Ecological Risk Assessment (BERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. August 1999.

USEPA. 2000a. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E-Revised Baseline Ecological Risk Assessment (RBERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. November 2000.

USEPA. 2000b. Responsiveness Summary for Volume 2E – Baseline Ecological Risk Assessment. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS Consultants, Inc. and Menzie-Cura Associates, Inc. March 2000.

Van den Berg, M., L. Birnbaum, A.T.C. Bosveld, B. Brunstrom, P. Cook, M. Feeley, J.P. Giesy, A. Hanberg, R. Hasegawa, S.W. Kennedy, T. Kubiak, J. C. Larsen, F.X. Rolaf van Leeuwen, A.K. Jjien Liem, C. Nolt, R.E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tyslind, M. Younges, F. Waern, and T. Zacharewski. 1998. Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. *Environmental Health Perspectives*. Vol. 106 (12):775-792.

Master Comment 359281

Commenters pointed out that field and laboratory animal studies support the conclusion that exposure to PCBs can adversely affect wildlife and humans. Other commenters felt that there was not conclusive evidence showing that PCBs are harmful to living creatures.

Response to Master Comment 359281

As discussed in Chapter 4 of the Revised Baseline Ecological Risk Assessment (RBERA) (USEPA, 2000a), the toxicity of PCBs has been shown to manifest itself in many different ways among various species of animals. Typical responses to PCB exposure in animals include wasting syndrome, hepatotoxicity, immunotoxicity, neurotoxicity, reproductive and developmental effects, gastrointestinal effects, respiratory effects, dermal toxicity, and mutagenic and carcinogenic effects. Some of these effects are manifested through endocrine disruption. Table 4-1 of the RBERA provides a summary of the common effects documented to occur in animals as a result of PCB exposure.

Ecological exposure to PCBs is primarily an issue of bioaccumulation resulting in chronic effects rather than direct toxicity (NAP, 2001). PCBs bioaccumulate directly by bioconcentration and

biomagnification, thereby posing the greatest risk to animals at the top of the food chain. Reproductive effects tend to be the most sensitive endpoint for animals exposed to PCBs. Toxicity studies in vertebrates indicate a relationship between PCB exposure and functions such as reproductive success that are mediated by the endocrine system.

The link between PCBs and adverse effects in humans was described in Chapter 4 of the Revised Human Health Risk Assessment (Revised HHRA) (USEPA, 2000b), and is further addressed in the Responses to Master Comments 541 (Section 3.1.1.2) and 571 (Section 3.1.1.1), in White Paper – PCB Non-Cancer Health Effects, and in White Paper – PCB Carcinogenicity.

The collective body of evidence that PCBs can adversely affect wildlife and humans is strong enough to merit the inclusion of PCBs in the Stockholm Convention on Persistent Organic Pollutants (POPs), which was signed by the USA on May 24, 2001. This international agreement restricts the use of 12 dangerous POPs. As President Bush stated in his remarks on April 19, 2001, "Concerns over the hazards of PCBs, DDT and the other toxic chemicals covered by the agreement are based on solid scientific information. These pollutants are linked to developmental defects of cancer and other grave problems in humans and animals. The risks are great and the need for action is clear: We must work to eliminate or at least to severely restrict the release of these toxins without delay."

References

National Academy Press (NAP). 2001. A Risk Management Strategy for PCB-Contaminated Sediments. Committee on Remediation of PCB-Contaminated Sediments, Board on Environmental Studies and Toxicology, National Research Council. 452 pages.

USEPA. 2000a. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E-Revised Baseline Ecological Risk Assessment (RBERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. November.

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

3.2.2 Field Studies

Master Comment 815

Some commenters contended that EPA collected no data and did no analysis of the location or abundance of the primary aquatic biota in the Hudson River food chain that would allow one to characterize the present state of the Upper Hudson or to evaluate the effect of remedial alternatives. No data were collected on subaquatic vegetation, wetlands, insects, or fish.

Response to Master Comment 815

The general vegetation and biota of the Upper Hudson River have been characterized in several studies: the Baseline Ecological Risk Assessment (BERA) (USEPA, 1999 Appendices A, C, D, E, F, G, and H) and Revised Baseline Ecological Risk Assessment (RBERA) (USEPA, 2000a pp. 15-27 and Tables 2-1 to 2-9), NYSDEC studies and data collection (Hudson River Database, USEPA, 2000b); NYSDOH (NYSDOH, 1974); and other studies (*e.g.*, Saratoga National Historic Park [SNHP], 1981, 2000); as well as studies commissioned by GE (Exponent, 1998a, 1998b,). Throughout the Reassessment RI/FS, EPA has considered and used, as appropriate, all available quality-assured sources of data, including data collected by EPA, NYSDEC, USGS, NOAA, GE, and others, as described in the Response to Master Comment 627 (Chapter 2). All parties have frequently exchanged data and metadata, and have analyzed and commented upon other parties' sampling plans and data quality assurance procedures.

Submerged aquatic vegetation (SAV) has not been mapped to date, as it was not a critical component of the RBERA. However, SAV will be characterized during the remedial design, as described in the Response to Master Comment 507 (Chapter 9). NYSDEC and federal National Wetland Inventory (NWI) wetlands have been mapped (see RBERA Plate 1, sheets 1-17), and it is recognized that field verification and further delineation are needed prior to the start of remediation.

Aquatic insects were characterized in EPA's benthic invertebrate study (BERA, Appendix H). The benthic macroinvertebrate study was designed and conducted scientifically. EPA disagrees with the suggestion that its benthic macroinvertebrate study was "conducted in an inept manner." In the BERA Responsiveness Summary (USEPA, 2000c), EPA noted that effects of environmental variables such as site depth, grain size, total organic carbon (TOC), and other potential toxic chemicals could not be clearly separated. Therefore benthic community structure was one of three lines of evidence used to evaluate the benthic community measurement endpoint (USEPA, 2000c, p. 74). The inability to separate the effects of a large number of variables is a reality of much of today's science.

NYSDEC has studied fish in the Hudson River extensively for over 20 years and provided its data to EPA for use in the Hudson River PCBs Reassessment RI/FS. In addition, EPA provided some funds to NYSDEC and NOAA for congener-specific PCB analyses in fish in 1993. NOAA and NYSDEC also conducted congener-specific analyses in 1995. Both sets of data were used in the Reassessment RI/FS.

The effect of the remedial alternatives on wildlife was evaluated using alternative-specific ecological toxicity modeling for the mink and river otter (Response to Master Comment 819 in this section). The federal Trustees (FWS and NOAA) concur that adverse impacts of the selected remedy on river habitat will be temporary, and that this temporary loss will be greatly offset by the accelerated recovery of the entire Hudson River. In fact, the Trustees support implementing a more comprehensive remedy than the one selected.

There is a large amount of Site-specific data available regarding the Hudson River, and because that is so, the present state of the river can be generally characterized. This level of characterization is appropriate for the conceptual design contained in the FS. This baseline

characterization of ecological resources will assist in evaluating effects of remedial actions on specific contaminated areas selected for cleanup. As stated previously, a detailed characterization of submerged aquatic vegetation, wetlands, and associated biota will be performed prior to the initiation of any remedial work.

References

Exponent. 1998a. Data Documentation and Interpretation Report: Submerged Aquatic Vegetation and Fish Community Analysis. Prepared for General Electric Company.

Exponent. 1998b. Data report: Macroinvertebrate communities and diets of selected fish species in the Upper Hudson River, Volumes I and II. Prepared for General Electric Company.

General Electric (GE). 1999. Comments of the General Electric Company on Volume 2E-Baseline Ecological Risk Assessment Hudson River PCBs Reassessment RI/FS. Prepared by LWB Environmental Services, Inc. and Quantitative Environmental Analysis, Inc. September 7, 1999.

New York State Department of Health (NYSDOH). 1974. Macroinvertebrate Survey of the Upper Hudson River New York - 1972. Environmental Health Report No. 2. By K. Simpson, T.B. Lyons, and S.P. Allen. October 1974.

Saratoga National Historic Park (SNHP). 1981. Vegetation Map for Saratoga National Park. US Department of the Interior, National Park Service.

SNHP. 2000. Mammalian, Avian, and Herpetological Species Lists for Saratoga National Historic Park. US Department of the Interior, National Park Service.

USEPA. 1999. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E- Baseline Ecological Risk Assessment (BERA). Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. August.

USEPA. 2000a. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E-Revised Baseline Ecological Risk Assessment (RBERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. November.

USEPA. 2000b. Database for the Hudson River PCBs Reassessment RI/FS. Release 5.0 (Compact Disk). Prepared for USEPA, Region 2 and the USACE, Kansas City District by TAMS Consultants, Inc. October.

USEPA. 2000c. Responsiveness Summary for Volume 2E - Baseline Ecological Risk Assessment, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. March.

Master Comment 819

Some commenters stated that EPA collected no usable data on wildlife populations in or near the Hudson River. Some said that available field data were disregarded by EPA, including the tree swallow study, fish species abundance data in the Lower Hudson River, and the bald eagle work. Further, it was said that apart from work in 1993, EPA has not collected data on PCB concentrations in fish in the Hudson, which has been done routinely by NYSDEC since the 1970s. Other commenters stated that EPA did use available field data to support its conclusions, and that recent data (NYSDEC, 2001) confirm that PCBs pose a risk to wildlife, especially to piscivorous species.

Response to Master Comment 819

EPA used observed concentrations of PCBs in benthic invertebrates and fish in the Hudson River and field studies of birds and mammals in and along the Hudson to characterize risks to ecological receptors in the Revised Baseline Risk Assessment (RBERA, Sections 3.4.1 [benthic invertebrates], 3.5.1 [fish], 3.6.1 [birds], 3.7.1 [mammals], and 5.0 Risk Characterization) (USEPA, 2000a). Throughout the Phase 2 and Phase 3 efforts, EPA has relied on all available quality-assured sources of data, including data collected by GE, NYSDEC, USGS, NOAA, and others in addition to the data collected by EPA itself. All parties have frequently exchanged data and analyzed and commented upon other parties' sampling plans and data quality assurance procedures.

Studies conducted by NYSDEC, NOAA, and USFWS have generally found elevated concentrations of PCBs in wildlife and indications of behavioral or reproductive effects, confirming the ecological modeling results contained in the RBERA, as noted by several commenters. This includes the USFWS tree swallow work (Response to Master Comment 253462). Recent tissue, blood, egg, and prey samples taken from Hudson River avian receptors (*i.e.*, tree swallow, great blue heron, and bald eagle) by NYSDEC and USFWS show considerable concentrations of PCBs in samples taken in the upper and lower river (Table 3-20a of RBERA). Bald eagle blood serum taken from individuals in the lower river showed concentrations as high as 14,240 ng/g, and eagles wintering in the upper river may have even higher concentrations of PCBs, due to higher concentrations in prey.

Recent NYSDEC mink and otter data show that most mink and all river otter captured near the Hudson River had tissue concentrations above the NOAEL (Table 811-1 of this RS). Some individuals also had PCB levels above the LOAEL.

The limitations of the extensive observational data for fish in the Lower Hudson were discussed in the Responsiveness Summary for the BERA (pg. 81) (USEPA, 2000b). As noted therein, population level data are only available for the Lower Hudson River, not the Upper Hudson River, and these were collected specifically to evaluate the impact of power plant discharges on fish population parameters. These data are not directly relevant to the BERA, which assesses ecological risks posed by PCBs in the river, because they do not establish a link between PCB exposure and population abundance. In addition, biological changes may not respond to an outside factor in a linear or consistently predictable manner, as discussed in the Response to Master Comment 253462 in this chapter. Retrospective evaluations of population abundance

prior to the occurrence of PCBs for each of the receptors of concern cannot be performed for obvious reasons.

References

New York State Department of State (NYSDOS). 1987. Hudson River Significant Habitats, Habitat documentation. November 15, 1987.

USEPA. 1999. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E- Baseline Ecological Risk Assessment (BERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. August.

USEPA. 2000a. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E- Revised Baseline Ecological Risk Assessment (RBERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. November.

USEPA. 2000b. Responsiveness Summary for Volume 2E - Baseline Ecological Risk Assessment. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. March.

Master Comment 253462

GE's analysis of the USFWS tree swallow data (GE, Appendix O) found no indication of adverse effects to tree swallows along the Hudson River on any endpoint evaluated, including reproductive, plumage development, behavioral, or genetic endpoints.

Response to Master Comment 253462

EPA, after its review of GE's analysis and in consultation with the study authors (Secord, 2001), disagrees with the findings of GE's analysis of the tree swallow data.

Summary and Study Design

1) GE's analysis (Appendix O) does not fully and accurately summarize the conclusions of the Hudson River Tree Swallow project. GE incorrectly suggests that the project concluded that PCBs *caused* the patterns reported. The McCarty and Secord papers published in the peer reviewed literature explicitly state that the study authors have not established a causal link between PCBs and any of the anomalies described in Hudson River tree swallows. They clearly state that the design and goals of their study "make it impossible for us to unequivocally assign PCBs a causal role in any of the patterns observed here." (McCarty and Secord, 1999b, p. 1438).

2) GE's analysis accurately summarized the shortcomings of the Lock 9 (Champlain) reference site in 1994, as reported in the McCarty and Secord publications. EPA finds it reasonable that sample sites in a field investigation cannot all have identical conditions (*e.g.*, topography, slope, soils, vegetation, and size). GE's analysis fails to point out that the study authors did not use

reproductive success data from the Lock 9 (Champlain) site in their peer-reviewed publications. (Similarly, GE refers to data from the Saratoga Inland site without noting that data from this location were not used in any of the McCarty and Secord peer reviewed publications.) Further, GE's analysis mentions that eggs at the Champlain site had higher than expected concentrations of PCBs, but does not reflect that these data support a hypothesis that adults nesting at the Lock 9 sites *arrived* with high PCB body burdens that were transferred to eggs. These high body burdens in adults may have been accumulated during migration up the Hudson River.

3) GE's analysis of the Ithaca site states that "very limited information" is available about this site (Appendix O, p. 3). In fact, the Ithaca site is described in McCarty (1995) and in numerous papers published in the scientific literature. Moreover, GE's analysis does not reflect data presented in McCarty and Secord (1999b, p. 1434) that show elevated levels of PCBs in Ithaca tree swallow eggs (103 ng/g) and nestlings (6 ng/g). Further, although GE's analysis criticizes comparisons between tree swallows from Ithaca, New York, and the Hudson River, GE uses tree swallow data collected at sites as distant as British Columbia and as long ago as 1932 (Appendix A of GE's Appendix O).

4) GE's analysis comments on expected concentration-response relationships, without recognizing that biological changes may not respond to an outside factor in a linear or consistently predictable manner. Such comments are unsupported, given that the dose-response relationship for PCBs vs. reproductive success in tree swallows has not been characterized, and the shape of any dose-response curve (and where on any hypothetical curve the Hudson River study population may lie) is unknown (see also discussion of Type II statistical errors noted below).

Effects on Reproduction

GE's analysis presents a compilation of published and unpublished data on tree swallow reproduction across the species range. However, there is insufficient information presented to thoroughly evaluate GE's analysis. For example, Appendix A (of Appendix O) does not provide complete references for the majority of studies cited in the comparison to the Hudson River data, so the sources of these data are not always clear. In addition, the rationale for the criteria used to select studies, as well as the application of the criteria, are not clear. For example, the biological basis for including a study site located 1.9 km from a wetland but excluding one 2.1 km from the ocean is unclear. It is unclear why a sewage lagoon is listed as the nearest body of water for Hussell and Quinney in 1985 (Appendix A of Appendix O). It is also unclear how GE determined that reference sites were "not located on an industrially polluted waterway." Some would consider Lake Erie polluted and many of the northern lakes (such as those around Sudbury) have elevated levels of mercury.

GE's approach seems to be based on comparing the mean values of reproductive parameters from Hudson River sites to the distribution of mean values from a variety of years and populations studied elsewhere. GE's analysis is problematic. It appears that in many instances GE included means for different years from the same study site (*e.g.*, 17 yearly means for Chapman's study at Princeton). These observations may not be independent, and thus all 17 means probably should not be included in analyses as independent observations. Moreover, GE's analysis asks a subtly different question than that asked by the FWS Hudson River project. GE's

approach of examining the distributions of means of reproductive parameters for populations addresses how *population* averages vary. In contrast, McCarty and Secord use reproductive success data from other populations (*e.g.*, McCarty and Secord 1999b, Table 2) to address the distribution of variation among *individuals*. While GE's approach may be valid for the question of variability among populations, it is unable to evaluate the variability among individuals, which seems to drive some of the patterns seen in Hudson River birds.

GE's evaluation focuses primarily on mean clutch size, number of chicks hatched per nest, and number of chicks fledged per nest (Appendix O, p. 8). Earlier work published in the scientific literature also found that these variables are similar between Hudson River birds and tree swallows breeding elsewhere (*e.g.*, McCarty and Secord 1999b, page 1,435). However, it is inappropriate to conclude, as GE has, that the lack of a relationship between PCB concentration and reproductive success is the same as evidence of no relationship. GE’s conclusion is further weakened by the small sample size and low statistical power available for an analysis. Mainstream ecologists have become increasingly aware of "type II" errors in making these comparisons, that is, failure to detect a relationship that in fact exists. A variety of measures of statistical power are widely available and could have been applied by GE.

McCarty and Secord (1999b) specifically noted that there was a high incidence of unexplained nest abandonment and egg burial among Hudson River tree swallows studied. This is an important point given the pattern established in the literature between chlorinated hydrocarbons and aberrant reproductive behavior in a variety of bird species. The fact that this aberrant behavior did not always affect overall reproductive success was also noted in that publication.

Effects on Plumage Development

The evaluation of the patterns of plumage color in female tree swallows focuses solely on the pilot data from 1994 presented in Secord and McCarty (1997). GE failed to analyze the full data set presented in McCarty and Secord (2000) that supercedes the discussion of female plumage in Secord and McCarty (1997), although that data set is referenced. Since GE's analysis of the 1994 data is no longer relevant, that part of their report was not critiqued. Without consideration of McCarty and Secord (2000) and the data within it, GE’s arguments are incomplete.

Some of the general criticisms of the plumage color work presented by GE are addressed in McCarty and Secord (2000) and are not repeated here (*e.g.*, the irrelevance of the age of the females). GE focuses extensively on the question of female age, but fails to note that the question of whether second-year Hudson River females have advanced plumage or whether older females have retarded plumage development is secondary. The suggestion that "skull pneumatization [sic]" should have been used to measure female age is misleading. Skull pneumaticization is a useful technique for determining the ages of passerines at certain times of year. However, careful reading of the standard reference book by Pyle (1997), which updates and corrects Pyle *et al.*, 1987, cited by GE) reveals that this would not, in fact, lead to reliable aging of females in the breeding season. Pyle (1997) clearly states that skull pneumaticization in tree swallows may be complete in individuals as young as six months or may not be complete even into the third year.

GE’s discussion of Control of Plumage Development suggests that they accept that the pattern of plumage color is abnormal in Hudson River females, but that they question the mechanism

behind this change. The McCarty and Secord (2000) discussion of these patterns states that "The hormonal basis for subadult plumage in tree swallows has not been studied, but sex-specific differences in plumage generally are under hormonal control" (page 993) based on studies of other species that almost always involve the endocrine system.

The discussion of the mechanisms guiding plumage development in birds presented by GE has the following basic flaws:

- First, the focus of GE on estrogen misses the basic fact that the endocrine system produces numerous biologically active compounds, and chemical such as PCBs interfere with the normal functioning of the endocrine system. Thus, any number of hormonal pathways could be abnormal in the Hudson River birds.

- Second, it appears that GE has misinterpreted the categories of plumage dimorphism presented in Owens and Short (1995). Owen and Short do review some of the evidence for mechanisms that produce plumage dimorphism in birds; however, their attempt to categorize different species is directed primarily at understanding differences between male and female plumage, not delayed plumage maturation, nor the unusual case of delayed female plumage maturation seen in tree swallows. GE states that: "it has already been established that tree swallows fit in [Owens and Short's] category #2" [page 29], but this conclusion is simply not defensible. GE concludes that plumage color in tree swallows is not in any way influenced by hormones, but is the result of the "difference in chromosomal balance between the homogametic male and the heterogametic female, rather than hormone production" [page 29], despite the lack of empirical evidence.

- Third, GE's conclusion that the subadult plumage of female tree swallows is completely under genetic control raises some interesting questions. Assuming that GE is proposing a mechanism where there are sets of genes on the female sex chromosomes under control of a clock that causes them to produce brown plumage the first time a female molts and blue-green plumage during subsequent molts, why does such a high percentage of Hudson River females have plumage intermediate between the two types? Perhaps GE is suggesting that something special in the Hudson River valley is producing a high incidence of a very specific mutation in the genes for female plumage color.

- Finally, GE also raises a question about Secord and McCarty's 1997 assumption "that tree swallows breeding along the Hudson River are contaminated with PCBs" [page 30]. While it is true that Secord and McCarty do not have data on PCB body burdens for the females used in the plumage study, it is reasonable to assume based on their other published work showing PCB body burdens in Hudson River tree swallows that these individuals are exposed to PCBs along the river.

Effects on Parental Behavior

GE's discussion of the tree swallow project's paper on nest quality (McCarty and Secord 1999a) appears to accept that behavior of adult swallows on the Hudson River is abnormal, and

discusses whether measuring behavior via one endpoint (amount of nest material) or another (time-activity budgets) is more appropriate (page 36). Most of their critique focuses on implications of the behavioral differences for reproductive success (*e.g.*, whether the abnormal nests built by Hudson River tree swallows are actually of lower "quality"). However, there are a number of errors in their critique (detailed below) that together affect their analysis.

> *Page 31, paragraph 2:* GE seems to suggest that there is not a direct relationship between nest volume and nest mass. This would be of concern if the materials used to construct nests varied widely in density (*i.e.*, across orders of magnitude), but since grass is used as the primary material for almost all tree swallow nests, Lombardo's (1994) results are indeed relevant to the Hudson River study.
>
> *Page 32, paragraph 3:* The study conducted by Winkler (1993) was not performed at the same site as used in McCarty and Secord (1999a), but at a larger site approximately two km away. David Winkler did provide the nest quality data for the Ithaca site used in both McCarty and Secord 1999a and 1999b.
>
> *Page 33 bottom to top of page 34:* GE questions using an experimental approach (*e.g.*, Winkler, 1993 and Lombardo *et al.*, 1995) to determine the effect of feathers on reproductive success. The experimental approach is consistent with the majority of mainstream ecologists. GE also states that "it is reasonable to expect that the experimental adults would not be able to feed their nestlings as much as control birds if they are spending time searching for replacement feathers." Winkler considered this idea in his paper; his data indicate that adults do not search for feathers when they have nestlings to feed.
>
> *Page 35, paragraph 1 and page 36, paragraph 2:* GE notes that McCarty and Secord (1999b) did not quantify feathers at their sites and suggests that the mechanism behind the lower numbers of feathers in the nests of tree swallows at more contaminated sites may be that less availability of feathers these sites. The hypothesis that high levels of PCBs in the environment near the GE plants may result in lower numbers of birds and, hence, fewer feathers available to tree swallows is plausible, especially since many species of birds are much more sensitive to PCBs than swallows and may not be able to survive in the conditions created along the Upper Hudson River. However, GE did not consider the strength of the data in Austin and Low (1932) and Schaeffer (1971), which indicate that it is more likely that the lower number of feathers in tree swallow nests at contaminated sites are a function of altered behavior.
>
> *Page 35, paragraph 2:* The implication that thermoregulation is only important during the nestling phase is not correct. Feathers may provide important insulation both to the incubating female and to eggs left unattended earlier in the breeding cycle.

PCB Bioaccumulation in Hudson River Tree Swallows

GE notes that PCBs accumulated in nestlings even at sites that are not adjacent to commonly recognized deposition zones. Insects emerging from the Hudson River at these sites also had high levels of PCBs. GE's observation emphasizes that PCBs released from GE's plants are at

high concentrations over a much wider area than is generally discussed. This is especially evident at the remnant site where adult insects were collected after they emerged from the river, but prior to their first flights.

Secord and McCarty (1997) observed tree swallows foraging in large numbers over the Hudson River adjacent to the Remnant 4 site. Based on a food habit study, they determined that 98 percent of the insects eaten by tree swallows from this site were of aquatic origin, and the Hudson River was the only aquatic habitat within two km of the study colony. It can therefore be concluded with a high degree of certainty that the Hudson River is a significant source of food for the Remnant 4 site tree swallows. It seems reasonable that sediments in the vicinity of the Remnant 4 site are highly contaminated with PCBs.

GE maintains that it is speculative to extrapolate measured TEQ concentrations in swallows to other bird species. However, it is scientifically appropriate and defensible to use existing data in the literature to estimate PCB uptake by species that are not directly studied. For example, a study was conducted at Green Bay to evaluate PCB uptake by closely located tree swallows, red-winged blackbirds, common terns, and Forster's terns (Ankley *et al.*, 1993). Although the PCB congener patterns differ between the Hudson River and Green Bay, PCB uptake relationships demonstrated in this study can be used to estimate PCB uptake by fish-eating birds along the Hudson River, combined with data on tree swallow PCB accumulation. As with all modeling efforts, there is acknowledged uncertainty associated with these estimates.

It is not surprising that other studies have failed to show a relationship between PCB concentrations and biological effects in tree swallows, since the Hudson River tree swallows are more highly contaminated than those from most other studies.

During the Hudson River tree swallow studies, Secord and McCarty did detect some deformities that have not been reported in the literature. These include one cross-billed adult female in 1995, and in 1998, two nestlings with deformed legs, one nestling with small eyes, and one nestling with a crossed bill. They also detected obvious abdominal edema in two nestlings in 1998, and there may have been more subtle manifestations of edema in other nestlings in all years of their study.

References

Ankley, G.T., G.J. Niemi, K.B. Lodge, H.J. Harris, D.C. Beaver, D.E. Tillett, T.R. Schwartz, J.P. Giesy, P.D. Jones, and C. Hagley. 1993. Uptake of planar polychlorinated biphenyls and 2,3,7,8-substituted polychlorinated dibenzofurans and dibenzo-p-dioxins by birds nesting in lower Fox River and Green Bay, WI, USA. *Arch. Environ. Contam. Toxicol. 24:332-344.*

Austin, Jr., O.L., and S.H. Low. 1932. Notes on the breeding of the tree swallow. *Bird Banding* 3:39-44.

General Electric. 2001. Evaluation of the US Fish and Wildlife Service Tree Swallow Studies along the Hudson River. Appendix O of Comments of General Electric Company on the Feasibility Study and Proposed Plan for the Hudson River PCBs Superfund Site (December 2000). General Electric Company, Albany, NY. April 17, 2001.

Lombardo, M.P. 1994. Nest architecture and reproductive performance in tree swallows (*Tachycineta bicolor*). *Auk* 111(4):814-824.

Lombardo, M.P, R.M. Bosman, C.A. Faro, S.G. Houtteman, and T.S. Kluisza. 1995. Effect of feathers as nest insulation on incubation behavior and reproductive performance of tree swallows (*Tachycineta bicolor*). *Auk* 112(4):973¨C981.

McCarty, J.P. 1995. Effects of short-term changes in environmental conditions on the foraging ecology and reproductive success of tree swallows, *Tachycineta bicolor*. Dissertation presented to Graduate School of Cornell University, Ithaca NY.

McCarty, J. P. and A. L. Secord. 1999a. Nest building behavior in PCB contaminated Tree Swallows (*Tachycineta bicolor*). *Auk* 116:55-63.

McCarty, J. P. and A. L. Secord. 1999b. Reproductive ecology of Tree Swallows (*Tachycineta bicolor*) with high levels of PCB contamination. *Environmental Toxicology and Chemistry* 18:1433-1439.

McCarty, J. P. and A. L. Secord. 2000. Female plumage color, PCB contamination, and reproductive success in Hudson River Tree Swallows (*Tachycineta bicolor*). *Auk 117:987-995*.

Owens, I.P.F., and R.V. Short. 1995. Hormonal Basis of Sexual Dimorphism in Birds: Implications for New Theories of Sexual Selection. TREE 10(1):44–47.

Pyle, P. 1997. Identification Guide to North American Birds. Part 1. Slate Creek Press, Bolinas CA.

Pyle, P., S.N.G. Howell, R.P. Yunick, and D.F. DeSante. 1987. Identification Guide to North American Passerines. Slate Creek Press, Bolinas CA.

Schaeffer, F.S. 1971. Tree swallow breeding biology at a coastal and inland area. *EBBA News* 34:216-222.

Secord, A. L., J. P. McCarty. 1997. Polychlorinated biphenyl contamination of tree swallows in the Upper Hudson River Valley, New York. US Fish and Wildlife Service, Cortland, NY.

Secord, A. L., J. P. McCarty, K. R. Echols, J. C. Meadows, R. W. Gale, and D. E. Tillitt. 1999. Polychlorinated Biphenyls and 2,3,7,8-Tetrachlorodibenzo-p-dioxin Equivalents in Tree Swallows from the Upper Hudson River, New York State, USA. *Environmental Toxicology and Chemistry* 18:2519-2525.

Secord, A.L., 2001. E-mail to H. Chernoff, TAMS Consultants, Inc. June 11, 2001.

Winkler, D.W. 1993. Use and importance of feathers as nest lining in tree swallows (*Tachycineta bicolor*). *Auk* 110(1):29-36.

Master Comment 809

Some commenters assert that contamination of the floodplain of the Upper Hudson River was not addressed, and that floodplain exposure pathways should have been evaluated for ecological receptors. This is especially true, according to the comments, since recent data show high levels of PCBs in soils, shrews, mink, and otter along the Upper Hudson floodplain. In addition, other commenters questioned why remediation of the floodplain had not been considered.

Response to Master Comment 809

The Baseline Ecological Risk Assessment (BERA) (USEPA, 1999a) and Revised Baseline Ecological Risk Assessment (RBERA) (USEPA, 2000a) did not quantify risks to terrestrial receptors on the floodplain. This is because these documents are limited to risks associated with PCBs in the sediment, water, and biota in the Hudson River, which is consistent with the focus of the Reassessment RI/FS. In addition there were insufficient data available to characterize the nature and extent of PCBs in floodplain soils (Responsiveness Summary for BERA p. 20 [USEPA, 2000b]; BERA, p. 14; Responsiveness Summary for BERA Scope of Work, p. 21 [USEPA, 1999b]). To address concerns regarding this issue, EPA qualitatively addressed ecological risks associated with exposure to PCBs in floodplain soils as a source of uncertainty (RBERA, p. 193 and BERA, p. 156).

The lack of quantification of risks to floodplain receptors does not indicate a lack of risk. However, risks are expected to be highest for receptors (*e.g.*, aquatic or piscivorous animals) that derive the bulk of their exposure to PCBs from Hudson River sources.

NYSDEC, in association with the NOAA and the USFWS, has analyzed soil and short-tailed shrews for PCBs as part of a Natural Resource Damages Assessment (NRDA) for PCB contamination of the Hudson River. They detected PCBs in floodplain soils from 11 locations in the Upper Hudson River Valley between Stillwater in Saratoga County and Fort Edward in Washington County. PCB levels detected ranged from 0.018 ppm to 360 ppm, with levels generally highest in low-lying areas adjacent to the river and in areas closer to Fort Edward (NYSDEC, 2001).

Oak Ridge National Laboratory (ORNL) has developed a soil screening level of 40 ppm for total PCBs based on effects on terrestrial plants (Efroymson *et al.*, 1997). Out of the 143 NYSDEC soil samples, 11 showed concentrations higher than this screening level. EPA (1999c) provides recommended soil screening levels of 10 ppm based on effects in soybean shoots, and 2.5 ppm based on an acute LC50 (the lethal concentration that kills 50 percent of the organisms) for earthworms. These values are exceeded 30 and 54 times, respectively.

An analysis of short-tailed shrews living on the floodplain showed PCB levels ranging from 0.05 ppm to 38 ppm. Shrews feed on earthworms and other animals and serve as prey for raptors, owls, and other wildlife.

The recent NYSDEC data for mink and otter are discussed in Response to Master Comment 811 in Section 3.2 (Table 811-1). Many of these animals had PCB tissue concentrations above TRVs and were caught within several miles of the Hudson River (*e.g.*, within the floodplain). However,

mink and otter are more likely to derive exposure to PCB from aquatic sources rather than the floodplain, as these animals preferentially feed on fish and aquatic invertebrates living in or near river sediment.

EPA's Reassessment focused on PCB contamination of the river sediments, water, and fish, which resulted in the "eat none" fish consumption advisory in place in the Upper Hudson River since 1976. While the Reassessment investigations were ongoing, EPA undertook cleanup actions at Rogers Island in the Upper Hudson River to address human health concerns regarding levels of PCBs in the floodplain soils there. EPA will continue to review new data collected on floodplain soils and will take action as necessary to protect human health and the environment. Response to Master Comment 821 in Chapter 6 further discusses the issue of floodplain soils as a potential source of PCB loading to the Upper Hudson River in developing the fate and transport models used in the Reassessment.

References

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory.

NYSDEC. 2001. Press Release DEC: Mammals, Soil Near Hudson River Have Elevated PCB Levels. Monday April 2, 2001. http://www.dec.state.ny.website/press/pressrel/2001-52.html

USEPA. 1999a. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E-Baseline Ecological Risk Assessment (BERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. August.

USEPA. 1999b. Responsiveness Summary for Phase 2 - Ecological Risk Assessment Scope of Work. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. April.

USEPA, 1999c. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, Appendix E: Toxicity Reference Values. Peer Review Draft. EPA530-D-99-001C, Office of Solid Waste and Emergency Response. August.

USEPA. 2000a. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E-Revised Baseline Ecological Risk Assessment (RBERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. November.

USEPA. 2000b. Responsiveness Summary for Volume 2E - Baseline Ecological Risk Assessment. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. March.

3.2.3 Ecological Risk Assumptions

Master Comment 793

Some comments said that area use assumptions used for the mink and otter are not appropriate. It was suggested that conservative area use factors (AUFs) were used in the Revised Baseline Ecological Risk Assessment (RBERA) (USEPA, 2000a), and that "more appropriate" AUFs show no significant differences in ecological risk reduction between source control and dredging.

Response to Master Comment 793

The AUF is an adjustment to the dose of a contaminant that an ecological receptor receives through its diet. The AUF addresses the proportion of the receptor's diet that is assumed to consist of prey (*e.g.*, fish) from the contaminated area and considers the size of the receptor's home range compared to the size of the Site (USEPA, 1998).

In the point estimate calculations in the Revised Baseline Ecological Risk Assessment (RBERA) (USEPA, 2000a), EPA retained AUFs of one (*i.e.*, continuous spatial exposure duration) for the mink and river otter (Response to Peer Review Comments on the BERA, p. 9 [USEPA, 2000b]), because it is reasonable that a receptor could use and forage entirely within the large size of the Site. The home ranges of these receptors are less than the size of the 200-mile long Hudson River PCBs Site, so these receptors would be expected to use and forage entirely within the Site (Tables 3-69 and 3-70 of the RBERA).

While the foraging territories for all ecological receptors are well within the spatial scale modeled for the Upper Hudson River, EPA also evaluated the possibility that an individual may forage in nearby tributaries (assumed to be uncontaminated) as well as in the Hudson River. In the probabilistic risk calculations, EPA used AUFs between 0.5 and 1.0 (Master Comment 811 and Table 811-1, in this chapter). The results of the probabilistic analysis confirm that Upper Hudson River otter and mink may experience adverse effects from PCB exposure (Figures 811-1, 811-2, and 811-3) using an AUF less than one, contrary to the results calculated by the commenter.

As discussed in White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River, predicted fish concentrations under the MNA Alternative are significantly higher than predicted fish concentrations under the selected remedy (including using different assumptions as to timing of remediation and remobilization of sediments). Assuming that the same AUF is applied to the modeling results from both scenarios, the difference between the MNA Alternative and the selected remedy would still be the same regardless of the AUF that is used.

References

USEPA. 1998. Guidelines for Ecological Risk Assessment. Federal Register 63(93):26846-26924. May 14, 1998.

USEPA. 2000a. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E-Revised Baseline Ecological Risk Assessment (RBERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. November.

USEPA. 2000b. Responsiveness Summary for Volume 2E - Baseline Ecological Risk Assessment. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. March.

3.3 Preliminary Remediation Goals (PRGs)/Fish Concentration Targets

Master Comment 545

Comments indicate that the fish concentration Preliminary Remediation Goals (PRGs) may underestimate risks because their underlying assumptions are less than fully protective of public health. More specifically, commenters said that PRGs were based on adult exposures and underlying assumptions did not consider sensitive populations (*e.g.*, women, children, infants, and fetuses). Other commenters felt that more protective PRGs were required because the current ones do not consider background body burdens, and because some anglers return to the same fishing spot along the Hudson year after year and catch and consume the contaminated fish. Some comments indicated that the target should be a PCB level of 0.01 ppm in fish.

Some commenters suggested that the PRG is less than fully protective of public health, because the PRG represents a cancer risk of over one per hundred thousand and a hazard index of just over one, rather than being based on a one per million cancer risk and hazard index of one or less. Many comments were received supporting EPA's protective target level of 0.05 ppm, with intermediate targets of 0.2 ppm and 0.4 ppm PCBs in fish fillets.

Other comments indicate that there was no basis for setting the PRG at 0.05 ppm PCBs; the PRG should be fourfold higher than calculated by EPA, based on a higher fish consumption rate (Master Comment 569, Section 3.1.2) Other comments indicated that the 2.0 ppm tolerance standard established for fish by the Food and Drug Administration (FDA) should be used.

Response to Master Comment 545

The risk-based PRG of 0.05 ppm PCBs in fish fillet was calculated based on the reasonable maximum exposure (RME) for adults, assuming the same exposure factors used in the Revised Human Health Risk Assessment (HHRA), *e.g.*, a fish consumption rate of one half-pound meal per week (USEPA, 2000). EPA chose the PRG of 0.05 ppm PCBs in fish fillets as a reasonable goal, one that falls within EPA's acceptable cancer risk range. Also, calculations indicate that non-cancer hazards associated with that PRG would be essentially equivalent to a hazard index (HI) of 1, which is EPA’s goal for protection. Other target concentrations are 0.2 ppm and 0.4 ppm PCBs in fish fillet, which are protective at a fish consumption rate of one half-pound meal per month and one half-pound meal every two months, respectively. These target concentrations could aid in the relaxation of fish advisories along the Hudson, following review by NYSDEC.

Although EPA did not include the target populations of developing fetuses and infants in setting the PRG, the Agency did evaluate exposures to developing fetuses and infants in a qualitative manner (Master Comment 541, in this chapter). However, due to uncertainty and method limitations, they were not factored into the PRG quantitatively. With regard to consideration of subpopulations, these groups are incorporated into the PRG calculation to the extent that they are represented in the 1991 New York Angler survey (Connelly *et al.*, 1992) (Master Comment 567, in this chapter).

Background body burdens were not considered in defining the PRG because the risk assessment under baseline conditions addresses risks under current and future conditions, rather than prior conditions. This procedure is also consistent with the recommendations of the external HHRA peer review panel (ERG, 2000). Specifically, the expert panel that reviewed the current PCB cancer slope factors did not support adjusting for internal dose to reflect previous PCB exposure and current body burdens because the data were not available to determine the appropriate dosimetric for PCB carcinogenicity based on existing PCB body burdens. Therefore, EPA did not increase the average daily dose in the HHRA to account for existing body burdens of PCBs.

In addition, although some anglers return to the same fishing spot along the Hudson year after year and catch and consume contaminated fish, EPA does not feel that a much lower target fish concentration (*e.g.*, 0.01 ppm) is appropriate. While it is likely that different anglers may fish in different locations of the Upper Hudson River, there is little information available to quantify these differences, and the presence of current fishing restrictions preclude gathering such information. Nonetheless, an analysis of the risks associated with a possible population of anglers who fish predominantly in particular stretches in the Upper Hudson River is presented in the HHRA (Section 5.3.1). As the comparison shows, the cancer risks and non-cancer health hazards are highest at the furthest point upstream (Thompson Island Pool), approximately twofold higher than the central tendency and RME scenarios presented in the HHRA, and they decrease downstream with river mile.

The less stringent FDA tolerance level of 2.0 ppm PCB proposed by some commenters as a PRG is not an Applicable or Relevant and Appropriate Requirement (ARAR) with respect to the Hudson River PCBs Site, because the FDA tolerance level is not a standard, requirement, criterion, or limitation promulgated under a federal environmental law, or a more stringent state environmental or facility siting law. See also the Response to Master Comment 447 in this section. In addition, this FDA tolerance level is based on a "market basket" approach, in which consumers purchase a variety of fish from a variety of sources and the average concentration is less than 2 ppm. Therefore, this approach is *not* protective of recreational anglers or subsistence fishers who frequently consume fish from one single source, such as the Hudson River.

EPA does not agree with the suggestions that fish ingestion rates are too high by fourfold, and therefore the PRG for the average angler should be fourfold higher (*i.e.*, 1.6 ppm instead of 0.4 ppm). For reasons discussed in Master Comment 569 in this chapter, EPA believes the fish ingestion rates used to develop the PRGs are based on appropriate and sound fish ingestion rate studies, and therefore no changes to the PRG are required.

References

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

Eastern Research Group (ERG). 2000. Report on the Peer Review of the Hudson River Human Health Risk Assessment. Prepared for the US Environmental Protection Agency, Region 2. September 2000.

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

Master Comment 447

Some commenters felt that the ARARs/health risk PRG are too stringent; they claim that it is absurd to allow restaurants to serve fish at the FDA standard of 2 ppm but require a lower standard for the Hudson River. In addition, a commenter noted that PCB concentrations in fish in some monitored lakes in New York exceed PRGs.

Response to Master Comment 447

The ARARs, which are applicable or relevant and appropriate federal environmental laws and regulations, and also include State environmental and facility siting laws and regulations that are more stringent than the federal requirements, are not established by the FS. Rather, in the FS process, the universe of potentially applicable State and federal requirements is reviewed and compiled. CERCLA remedies must comply with ARARs unless a waiver is justified.

The human health-based PRGs are also developed to reflect risk-based considerations, in this case, the Human Health Risk Assessment (HHRA). The risk-based PRGs for fish are based on reasonable maximum exposure assumptions developed in the HHRA, not worst-case assumptions. The HHRA was peer reviewed. The fact that PCB concentrations in fish in some lakes in New York exceed PRGs is not an appropriate reason for setting the PRGs for Hudson River fish at higher concentrations.

The FDA "standard" is not a "standard" per se, and is not an ARAR. Rather, it is a criterion set by the FDA for commercially caught fish. This distinction is important because implicit in the FDA's criterion is that when brought to market, fish with 2 ppm PCBs will be 'mixed' with fish from non-contaminated sources and therefore the consumer exposure will be to fish with *average* PCB concentrations substantially below the 2 ppm criterion. This FDA assumption reflects a completely different exposure pattern (exposure scenario) than that on which the HHRA is

based; *i.e.*, that recreational anglers will consume fish caught in the Hudson on a regular basis (also see Master Comment 545 in this chapter).

References

USEPA. 2000a. Phase 2 Report, Further Site Characterization and Analysis. Volume 2F-Human Health Risk Assessment (HHRA), Hudson River PCB Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS Consultants, Inc. and Gradient Corporation. November.

USEPA. 2000b. Response to Peer Review Comments on the Human Health Risk Assessment, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the US Army Corps of Engineers (USACE) by TAMS Consultants, Inc. and Gradient Corporation. November.

USEPA. 2000c. Further Site Characterization and Analysis, Revised Human Health Risk Assessment (Revised HHRA) Volume 2F, Hudson River PCBs Reassessment RI/FS. Prepared for the USEPA Region 2 and USACE by TAMS Consultants, Inc. and Gradient Corporation. November 2000.

Master Comment 313300

Commenters suggested that the effectiveness criterion discussed in Section 6.1.1 of the FS, *i.e.*, the effectiveness of a remedial alternative to protect human health and the environment, should also compare PCB fish concentrations to risk-based PRGs for ecological receptors.

Response to Master Comment 313300

Risks to ecological receptors are discussed in detail in Section 7 of the FS, including a discussion of the time to reach ecological-based fish target levels (FS, Section 7.3 and Table 7-8). EPA has compared future PCB concentrations in largemouth bass fillet to the risk-based PRGs for ecological receptors (0.3 to 0.03 ppm PCBs in whole body fish equivalent to 0.12 to 0.012 ppm PCBs in fish fillet). These PRGs are based on the river otter, which is the receptor found to be at greatest risk at the Site. The comparison is presented in the ROD.

Master Comment 362555

Some commenters felt that given the serious threat to human health and the environment, REM-0/0/3 or additional targeted dredging are the best alternatives for achieving PRGs.

Response to Master Comment 362555

Although REM-0/0/3 achieves the fish target concentrations of 0.4 and 0.2 ppm PCBs in the shortest time frames, EPA has determined that the selected remedy is more cost-effective (Master Comment 397, Chapter 1). EPA does not believe that the incremental improvement in risk reduction obtained under REM-0/0/3 justifies the additional $110 million cost of that

alternative. Areas targeted for remediation will be refined during the design phase to obtain the appropriate PCB removal consistent with the selected remedy.

Master Comment 313297

A number of specific comments were made on the fish/biological monitoring program. These comments are addressed individually in the response below.

Response to Master Comment 313297

Comments on the Fish/Biological Monitoring Program:

Main FS Text

Page 5-45: Does the third bullet signify that only striped bass will be collected for PCB analysis in the Lower Hudson? If so, the Lower River sampling should be expanded beyond striped bass collections since health advisories below Federal Dam are not limited to striped bass. The current NYSDOH advisory recommends no consumption of numerous species in the estuary, some of which are more contaminated than striped bass.

Response: As noted in the FS text, the fish monitoring program proposed under MNA is based on the sampling program assembled by NYSDEC in 1997 (included in Appendix G, Part E). This program includes striped bass among other fish for PCB monitoring in the Lower Hudson River (Table 1 of Appendix G, Part E). One of the principal objectives of the NYSDEC program is "to ascertain PCB concentrations in the striped bass recreational and commercial fisheries for purpose of providing health advice through the New York State Department of Health and for regulating commercial fisheries when PCB levels exceed the accepted US Food and Drug Administration tolerance of 2 ppm." The other main objective of the NYSDEC fish monitoring program that necessitates the sampling of other species deals with the assessment of spatial and temporal trends of PCB contamination. All fish data are evaluated by the NYSDOH for establishing and maintaining consumption advisories.

Due to their migratory nature, striped bass usually cannot be considered a good indicator of local PCB contamination, but through use of relatively large sample sizes to counteract significant data variability, striped bass may be an indicator of relatively large scale spatial and temporal patterns of PCB contamination. However, the main focus of the striped bass analysis has been to provide information for the proper regulation of the commercial fisheries. Future monitoring of striped bass will continue to provide this information.

Page 5-46 to 5-52: Additional monitoring tasks that would strengthen the investigation include the collection of samples from the exposure pathways of non-piscivorous avian and terrestrial receptors, such as tree swallows and floodplain soil and biota.

Response: EPA notes that recent USFWS and NOAA data have confirmed the presence of PCBs in floodplain soil and biota. However, the focus of the EPA Hudson River PCBs Reassessment has been on the river itself, as described in the Response to Master Comment 809 in this chapter;

therefore, additional monitoring of non-piscivorous avian and terrestrial receptors is not currently included in the monitoring plan. EPA will, however, work with the NYSDEC on a floodplain sampling program.

Page 5-51, Paragraph 1: Post-construction monitoring is scheduled for 10 years for the sediment removal alternatives and 25 years for the capping alternatives. Model results suggest that the time to achieve target concentrations in fish averaged over the entire Upper Hudson River is 20 to more than 67 years for the REM- or CAP-3/10/Select scenario. This time period is reduced for REM-0/0/3, but the approximate number of years to achieve target levels remains greater than the 10 years of monitoring for fish concentrations of 0.05 and 0.2 ppm PCBs.

Response: As noted in paragraphs 3 and 4 of page 5-51 (Section 5.2.7.4) and Appendix G of the FS (Section G.5.2), fish body burdens are not predicted to meet PRGs over the model forecast period, even under the most extensive remedial alternatives. Therefore, the fish monitoring program may be required indefinitely. Costs for the fish monitoring program were estimated for a 25-year period. In addition to the regular fish monitoring described above, caged fish may also be deployed and collected in the post-construction period to monitor the impacts of water-column exposures to fish after construction. These data would provide a basis for establishing the impact of the upstream dredging efforts on downstream fish exposure.

Page 6-8, Top: *"Monitoring includes measurements of...the migration or harvesting of contaminated organisms."* Monitoring should include measurements of fish and piscivorous wildlife to assess whether fish PRGs are being approached or achieved, and whether adverse effects are detected in piscivorous organisms.

Response: Monitoring will include measurement of fish, as described in Appendix G of the FS (Part A). The ecological PRGs will be used as a guide to determine whether adverse effects are likely to occur in piscivorous wildlife, although it is recognized that testing of piscivorous wildlife directly would provide another monitoring endpoint.

Page 8-22, Top; and elsewhere: Target fish species collected for tissue analysis should, at a minimum, include those evaluated in the ERA (pumpkinseed, yellow perch, white perch, spottail shiner, striped bass, brown bullhead, largemouth bass).

Response: The resident target fish species (note that the striped bass is covered under migratory fish) monitored historically by NYSDEC are the largemouth bass, brown bullhead, white perch, and goldfish/carp, in addition to yearling pumpkinseed. These species have remained relatively available and their data supplement and substantiate the yearling pumpkinseed data. Although a larger number of fish species was evaluated in the Baseline Ecological Risk Assessment, these four species together are considered to provide a good indication of PCB contamination in the river.

Appendix G

Table G-1b: Resident species should include at least three species per location below Catskill.

Response: As noted in the response to the previous comment, resident fish monitoring includes largemouth bass, brown bullhead, and white perch plus goldfish/carp, in addition to yearling pumpkinseed. However, not all species are collected at each sampling station. At the present time, only two species are planned for collection at the Poughkeepsie and Tappan Zee stations; the need for a third resident species will be re-examined during the preparation of a final sampling plan.

Page 5, Paragraph 3: Striped bass are the only species identified for PCB analysis in the Lower Hudson. Additional species should be analyzed at less frequent intervals, including those affected by an existing NYSDOH fish consumption advisory. Targeted species should include American eel, blue crab, white perch, largemouth bass, and white catfish.

Response: Resident fish will be collected in addition to striped bass, although the species (*i.e.*, largemouth bass, brown bullhead, and white perch, and goldfish/carp, in addition to yearling pumpkinseed) were not individually listed in this paragraph. As described in NYSDEC's sampling program, locations principally targeting white perch, white catfish, and American eel were added in 1997 to better correlate with the striped bass locations and their sampling locations (Appendix G, Part E). Addition of these species - white perch, white catfish, and American eel - to the monitoring program is dependent on the availability of species and the results of current sampling. The blue crab has not been historically sampled as part of the NYSDEC Hudson River fish sampling program, and was therefore not added to the list of species sampled. In 1999 and 2000, NYSDEC implemented a supplemental sampling project to gather data on over three dozen fish species from five locations. Much of that data were included in the update to the Hudson River database.

Page 8, Fish Monitoring: The caged fish study should be extended throughout the freshwater Hudson (Albany, Catskill, Poughkeepsie), at least during one season, to coincide with the water column float survey.

Response: Comment is acknowledged and will be considered during final design of the monitoring program.

References

USEPA. 1999. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E- Baseline Ecological Risk Assessment (BERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. August.

USEPA. 2000. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E- Revised Baseline Ecological Risk Assessment (RBERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. November.

Master Comment 795

Commenters suggested that the Proposed Plan would not meet consensus guidelines (*i.e.*, sediment effect concentrations). Adverse effects to sediment and biota occur at PCB concentrations below that which will be achieved by EPA's proposed remedy based on consensus-based guidelines.

Response to Master Comment 795

Consensus-based sediment effect concentrations (SECs) for PCBs in the Hudson River Basin were developed to support an assessment to sediment-dwelling organisms (NOAA, 1999). These NOAA Damage Assessment Center SECs have been subsequently published in peer-reviewed literature (MacDonald *et al.*, 2000).

The consensus-based SECs provide a unifying synthesis of existing sediment quality guidance (SQG); reflect causal rather than correlative effect; and account for the effects of PCB mixtures. The Hudson River PCB threshold effect concentration (TEC) of 0.04 mg/kg dry weight is intended to identify the concentration of total PCBs below which adverse population-level effects (*e.g.*, mortality, decreased growth, and reproductive failure) on sediment-dwelling organisms are unlikely to be observed (NOAA, 1999). The mid-range effect concentration (MEC) of 0.4 mg/kg dry weight represents the concentration of total PCBs above which adverse effects on sediment-dwelling organisms are expected to be frequently observed. Adverse effects are expected to be usually or always observed at PCB concentrations exceeding the extreme effect concentration (EEC) of 1.7 mg/kg dry weight.

The FS does not contain a Remedial Action Objective (RAO) based on specific sediment concentrations. The results of the Revised Human Health Risk Assessment (HHRA) (USEPA, 2000) were used to calculate risk-based concentrations (RBCs) of PCBs corresponding to various cancer risks and non-cancer health hazards. The results of the RBERA were used to calculate toxicity quotients (TQs) for ecological receptors, based on NOAELs and LOAELs (summarized in Section 1.5 of the FS).

PRGs (ARARs and RBCs that are protective of human health and the environment) were then developed to meet RAOs. Numerical PRGs were developed for fish and water concentrations. Two general RAOs were developed pertaining directly to sediments: reduce the inventory (mass) of PCBs in sediment that are or may be bioavailable, and minimize the long-term downstream transport of PCBs in the river.

These RAOs resulted in the selection of two mass per unit area criteria (3 g/m^2 and 10 g/m^2) for the selection of remedial areas. These criteria do not allow for direct comparison with the SECs, but it is acknowledged that the TEC of 0.04 mg/kg dry weight would not be met under the selected remedy. The decrease in the mass per unit area of PCBs will result in a decrease of PCB concentrations in the sediment, and SECs will come closer to being attained by the selected remedy, as opposed to the MNA Alternative.

References

MacDonald, D.D., L.M. DiPinto, J. Field, C.G. Ingersoll, E.R. Long, and R.C. Swartz. 2000. Development and Evaluation of Consensus-Based Sediment Effect Concentrations for Polychlorinated Biphenyls. Environ. Toxicol. Chem. 19(5): 1403-1413.

National Oceanic and Atmospheric Administration (NOAA). 1999. Development and Evaluation of Consensus-Based Sediment Effect Concentrations for PCBs in the Hudson River. Prepared for NOAA Damage Assessment Center, Silver Spring, MD. Prepared through Industrial Economics by MacDonald Environmental Sciences Ltd. March 1999.

USEPA. 2000. Further Site Characterization and Analysis, Revised Human Health Risk Assessment (Revised HHRA) Volume 2F, Hudson River PCBs Reassessment RI/FS. Prepared for the USEPA Region 2 and USACE by TAMS Consultants, Inc. and Gradient Corporation. November 2000.

4. REMEDIAL ACTION OBJECTIVES AND SELECTION OF TARGET AREAS

4.1 Attainment of RAOs

Master Comment 853

Commenters asked when EPA expects the FDA 2 ppm limit to be achieved under the MNA and REM-3/10/Select Alternatives.

Response to Master Comment 853

EPA's model, FISHRAND, predicts that it will take about 10 years longer to achieve 2 mg/kg under the MNA alternative than under the REM-3/10/Select Alternative (i.e., the selected remedy). Because PCB concentrations vary by location and fish species, the year in which the FDA tolerance level is expected to be met depends on the specific species and location considered. FISHRAND forecasts that, under the selected remedy, largemouth bass will achieve 2.0 mg/kg in approximately 2006 at RM 189 and in 2008 at RM 184. At RM 154, concentrations in largemouth bass are already approximately 2 mg/kg. Brown bullhead is forecast to achieve 2.0 mg/kg in approximately 2007 at RM 189 and in 2009 at RM 184 under the selected remedy. At RM 154, brown bullhead concentrations are already 2.0 mg/kg. Note that the FDA tolerance level is not protective of human health at the Site (see, for example, Response to Comment 375, Chapter 1).

The benefits from implementation of the selected remedy compared to the MNA Alternative are likely to be greater than estimated from FISHRAND results. Based on a trend analysis of recent fish data, EPA expects that PCB concentrations in fish under the MNA Alternative would decline more slowly than predicted by FISHRAND, as a result of localized exposure conditions. Because the selected remedy removes sediments (which serve as an additional ongoing source of PCBs to the system and create the localized exposure conditions) and leaves a relatively homogeneous river bottom with respect to PCB concentrations, there is less uncertainty in the predicted rate of decline for the active remedial alternatives. The forecasts for the selected remedy include resuspension effects and a six-year implementation schedule. The forecasts for both the selected remedy and MNA alternative assume additional source control near the GE Hudson Falls plant in approximately 2006.

4.2 Determination of Target Areas and Volumes

Master Comment 605

A comment contended that there is a bias in the selection of remedial areas due to limited sediment data. Further, the comment suggested that the areas that have the greatest amount of data are those most likely to be selected for remediation.

Response to Master Comment 605

The selection process for target area identification under EPA's selected remedy considered the full suite of available data for each section of the river. EPA recognizes that more data is available for some areas relative to others, but this reflects to a large degree the relative levels of PCB contamination of those areas. As a general rule, the fine-grained sediment areas of the river have more samples than the neighboring coarse-grained sediment. The fine-grained areas are also more likely to be targeted for remediation. There is a bias in sampling toward areas known or suspected to have a tendency toward greater contamination for scientifically valid reasons. Sample locations were not randomly selected.

In a similar manner, the extent of targeted area and the number of samples decrease from upstream to downstream. This again reflects the recognition by both the samplers and the remediation planners that sediment contamination generally decreases downstream. In the selection of target areas, this trend is also supported by the fact that most of the water column load originates within the upper sections of the remedial area. Thus, it is not surprising that both sampling and remediation have focused on the same areas.

However, it is important to remember that EPA has used the existing historical data set only as a general guide to help in the identification of sediments for remediation and to estimate the nature and volume of material to be treated. As outlined in Appendix G of the FS, it is EPA's intention to conduct an extensive round of sampling for the purposes of the remedial design. As part of this data collection effort, EPA will evaluate and refine its remedial target areas. This sampling will cover both target areas as well as the areas outside the current target area boundaries. In this manner, EPA will produce a current contamination map of the Site on which to finalize its target area selection.

Master Comment 313219

Calculations performed by a commenter resulted in an estimate of the total removal volume that was 387,900 cy less than the amount calculated in the FS. It was suggested that the bathymetric data used below Lock 5 could limit the accuracy of volume estimates. Commenters also argued that below the TI Pool, equal areas were created for each sample location and grouped together. Concern was expressed that since the groups were assigned a common depth, the volume to be removed will be overestimated because sediments below the removal criterion will also be removed.

Response to Master Comment 313219

The total volume estimation calculations (Appendix B in the FS) involved two different methods based on the bathymetry information available for the sediment volume above and the sediment volume below Lock 5. Above Lock 5, where detailed bathymetry information was available, sediment volumes were calculated based on a dredging surface specified as an absolute elevation, not by a depth of sediment. This calculation was intended to represent the sediment volume for the likely form of the dredging specification.

The engineering requirements of dredging suggest that a dredge operation for the removal of contaminated sediment will be performed to a specified elevation. That is, sediments will be removed to a pre-specified elevation and not a water depth or sediment thickness. Thus the volume of sediments to be removed was estimated as the difference between the river bottom surface and a deeper surface derived as described below.

The river bottom topography was developed using the GIS software 3D Analyst™ (ESRI, 1999). In 3D Analyst™, a triangulated irregular network (TIN) was created from the original elevation contour lines derived from the Phase 2 geophysical survey. Only these lines were used (*i.e.*, no spot elevation data were used) in order to recreate a similar surface as represented by the contour lines on the original "River Bottom Geometry" map. The original TIN (from which the contour lines were extracted) had been created using a different software package and the elevation contour lines generated were then modified using routines specific to the software. This surface formed the river bottom.

The dredge surface was defined by subtracting the proposed depth of removal at each location from the river bottom surface. However, unlike the river bottom whose depth varies continuously, the "dredge-to" surface was only allowed discrete values in terms of feet above barge canal datum. This was done to conservatively reflect the outcome of a dredging specification to discrete depths. The difference between these surfaces at each contour interval forms a cross-sectional trapezoid of sediments to be removed. The trapezoid is defined from the existing sediment surface topography by subtracting the depth of removal from the deeper contour (*i.e.*, lower elevation) and defining a horizontal surface towards the shore, until it passes beneath the next elevation contour (Figure 313219-1). This removal surface, defined by the bottom edge of the trapezoidal shape, was converted to a grid cover with a 1 x 1 ft. cell size. This approach was used for all dredge volume estimates above Lock 5.

Below Lock 5 (*i.e.*, River Section 3), the only elevation or bathymetric data available consisted of approximate locations of 6-foot and 12-foot bathymetric contours with no elevation information. In this section, the best estimate of the volume was calculated using the proposed depth of removal multiplied by the area to be removed. Thus, bathymetry was not included in the calculations for River Section 3. This limits these calculations to some degree, making them less accurate then those for River Sections 1 and 2. Overall, however, the lack of good bathymetric data for defining the dredging volume in Section 3 does not represent a large source of uncertainty since less than 20 percent of the removal volume under the selected remedy is located below Lock 5.

The volume calculations yielded a volume estimate of 2,651,700 cy for the selected remedy. This number is about fourteen percent higher than a volume estimate based on depth of contamination and removal area alone. This value (2,651,700cy) represents a conservative estimate of the removal volume.

It is important to note that the term "equal areas" used by a commenter refers to the assumption that all cores in an area below the TI Dam are equally representative of the contamination in that area. Thus, the dredging area is not literally divided into polygons of equal areas; rather it is assumed that each core represents an equal area for the *hot spot* in which it is located. Essentially, each core contained within a *hot spot* is considered equally representative of that *hot*

spot and used in the calculation of the mean value. This calculation process is the same as the one used in the Low Resolution Sediment Coring Report (USEPA, 1998). EPA recognizes that this approach will tend to overestimate the volume for removal; however, this approach will generate a conservative estimate for engineering purposes as well as ensure that the residual PCB concentration goal is achieved.

References

Environmental Systems Research Institute, Inc. (ESRI), 1999. Arcview 3D Analyst™ for Arcview GIS 3.2a.

USEPA, 1998. Further Site Characterization and Analysis. Volume 2C-A Low Resolution Sediment Coring Report (LRC), Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Gradient Corporation, and TetraTech, Inc. July.

Master Comment 313280

Commenters asked about distribution of material that would require handling under the Toxic Substances Control Act (TSCA). A larger portion of the sediment removed below the Thompson Island Dam (TI Dam) requires special handling under TSCA than the sediments to be removed above the dam. For the 10 g/m^2 removal scenario, approximately 77 percent of the removed sediment below the dam would be classified as TSCA material. Under the same removal scenario only 37 percent of the sediment from the Thompson Island Pool (TI Pool) is estimated to require TSCA handling. This distribution of TSCA material seems contrary to the perception of contaminant distribution in the Upper Hudson.

Response to Master Comment 313280

Sediments that exceed a PCB threshold of 50 mg/kg are regulated under TSCA. TSCA regulations address, among other things, the handling and disposal of such sediments. There are two basic reasons for the large difference between River Sections 1 and 2 in the fraction of TSCA-classified material. The first and main reason arises from the different data sets used in each region and the nature of the calculation process. The second reason results from the difference in contaminant distribution in each section. These are further discussed below.

The original estimate for TSCA and non-TSCA material has been updated for this Responsiveness Summary, as described in White Paper – Estimate of Dredged Material Exceeding TSCA Criteria. Nonetheless, the commenter's observations still apply. The TSCA fraction estimated for the TI Pool is still much smaller than that estimated for downstream sections for the same threshold of removal. (It should be noted that the analyses in the FS and presented below were performed for the purpose of estimating costs, and not to specify dredging sequences or procedures.)

The original estimate for TSCA and non-TSCA material in the TI Pool, as presented in the FS, was based on the sum of Aroclors as reported by NYSDEC for the 1984 survey (Brown *et al.*,

1988). The original calculation did not account for any overcut, nor did it include the channel area. Neither did it account for the unmeasured monochloro and dichloro homologue fractions believed present in the sediments. The use of the sum of Aroclors results without correcting for the unmeasured monochloro and dichloro homologue fractions and the exclusion of the volume of overcut material in the estimation process represented a simplified basis to estimate the TSCA fraction. These assumptions work in opposite directions with respect to the TSCA estimate. It was anticipated that the exclusion of the overcut material would have a greater effect on the estimate than the failure to represent the monochloro and dichloro homologue fractions. Thus excluding them both was expected to yield an estimate that was conservative but not overly so. As it turned out the effects were of similar magnitude, resulting in a one-third decrease in the estimated fraction of TSCA material for Section 1 when these issues were explicitly included in the calculation (White Paper – Estimate of Dredged Material Exceeding TSCA Criteria).

By comparison, for those areas downstream, the sediment classifications were based on total PCBs as measured by EPA in Phase 2 of the Reassessment. Thus the entire spectrum of PCBs was represented in the concentrations. However, like the River Section 1 estimate, the Section 2 estimate did not include the overcut material in estimating the fraction of TSCA material. Thus Section 1 had two important simplifying assumptions that tended to counteract each other, while Section 2 estimates included only one major assumption that tended to drive the estimate to higher values.

The importance of these assumptions becomes clearer when the calculations explicitly correct for the issue. In Section 1, the overcut serves to increase the dredged volume nearly threefold. Mathematically blending the overcut with the overlying contaminated sediments and reexamining the distribution of PCB concentrations yields a decrease in the fraction of the TSCA-listed materials to one third of the original estimate. Conversely, inclusion of the mass of monochloro and dichloro homologues in the concentration data for River Section1 without correcting for the overcut increased the fraction of TSCA-listed waste from 28 percent to 52 percent. Combining the two factors reduces the original estimate of 28 percent TSCA-listed waste in the selected remedy (*i.e.*, the 3 g/m^2 scenario for Section 1) to 20 percent. This number represents a best estimate of this fraction in the material to be removed from the TI Pool during dredging under the selected remedy.

In the original estimates for River Section 2 (*i.e.*, the 3 g/m^2 and the 10 g/m^2 scenarios), the calculations had only one of the two limitations described above, that is, the impact of overcut had not been included in the estimates. There was no concern over the quantitation of total PCBs since the values used were derived from the Phase 2 data set. Thus only one assumption impacted this calculation. In fact, this issue still remains since there is no means to estimate the PCB distribution in the sediments after the overcut. This is a result of the more limited data set for the lower sections, which was deemed insufficient to create a polygonal declustering coverage (statistical analysis). Such a coverage is needed to best represent the distribution of PCBs after incorporating the overcut materials in the TSCA estimation process. Even after the refinement presented in White Paper – Estimate of Dredged Material Exceeding TSCA Criteria, there is still no means to accomplish this directly. Thus the value given in the white paper is quite similar to that of the FS at 77 percent TSCA-listed waste. Unlike the estimate for River Section 1, however, this value represents an upper bound and not a best estimate. This upper bound was used in estimating the costs of the remediation to provide conservatism. For both the

original estimate of TSCA material and the current one, therefore, the River Section 1 estimate was a lower value and a better estimate than the River Section 2 estimate. Similar limitations for the data for River Section 3 restrict the reported TSCA fraction for the section to an upper bound estimate as well.

Using the estimates derived in the TI Pool, it is possible to derive a "better" estimate for the lower sections based on TI Pool relationships observed. Specifically, the inclusion of the overcut materials for River Section 2 would serve to increase the volume of sediments to be removed by 2.4-fold (similar to the threefold increase estimated for River Section 1). In River Section 1, the threefold increase in volume yielded a similar level of reduction in the TSCA fraction. Applying this relationship to River Section 2 reduces the estimated TSCA fraction of 77 percent by 2.4-fold to 32 percent TSCA-listed materials, much closer to that predicted for River Section 1. Note that these estimates apply to different thresholds (*i.e.*, 10 g/m^2 in River Section 2 and 3 g/m^2 in River Section 1), so an exact match would be unexpected.

The foregoing discussion reflects the impact of the available data sets and the analyses they support on the estimation process. A second factor is believed to have influenced the estimate of the fraction of TSCA-listed material as well. This is the distribution of contamination itself. In particular, *Hot Spot* 28 located in River Section 2 represents the single greatest area of PCB concentration found to date. It contains both high concentrations as well as thick layers of PCB-contaminated sediment. Its presence in River Section 2 is expected to contribute to a disproportionate fraction of TSCA-listed material in this section.

For the areas below TI Dam, the length of each core was used to calculate the percentage of TSCA and non-TSCA sediments, by using the following equation:

$$\text{Percentage of sediments greater than 32 mg/kg} = \frac{\text{Sum of the length in cores with a concentration greater than 32 mg/kg}}{\text{Total Length (for all concentrations)}}$$

This approach provides an upper-bound estimate of TSCA and non-TSCA material. Further discussion can be found in White Paper – Estimate of Dredged Material Exceeding TSCA Criteria.

Reference

Brown, M.P., M.B. Werner, C.R. Carusone and M. Klein. 1988. Distribution of PCBs in the Thompson Island Pool of the Hudson River: Final Report of the Hudson River PCB Reclamation Demonstration Project Sediment Survey. Prepared for NYSDEC. Albany, NY

Master Comment 369451

Commenters assert that removal of 40 to 50 percent of the PCB inventory of the Upper Hudson is not sufficient to significantly change the river condition and reduce PCB-related health risks to people and wildlife in this region. Some argue that the percentage is too small and as a result the

project will be ineffectual and should be abandoned. Others argue that further remediation should be done to bring the total mass of PCB removed closer to 100 percent. In some cases, commenters argue that EPA's proposed plan will not remove a sufficient mass of PCB given the disruption it will cause.

Response to Master Comment 369451

In the Phase 2 analyses and the FS, the 1984 NYSDEC survey (Brown *et al.*, 1988) formed the basis for the estimates of PCB inventory in the TI Pool. This data set was considered to be a good representation of the Tri+ inventory in the sediments, but could only provide a lower bound estimate of the Total PCB inventory in this river section. Using the various sediment data sets obtained by EPA and GE during the Phase 2 investigation, it has been possible to develop an estimate of the Total PCB inventory of the TI Pool by combining the recent data with the original 1984 NYSDEC survey. This calculation is described in White Paper – Sediment PCB Inventory Estimates. This calculation basically corrected for the monochloro and dichloro homologues that were largely under-represented in the quantitation techniques that NYSDEC used. This calculation yielded an estimate for Total PCBs in the TI Pool that was three times greater than the Tri+ inventory. Based on this revision, the estimate for the percentage of Total PCBs removed by the selected remedy (REM-3/10/Select) was increased to about 65 percent of the Total PCB contamination in the Upper Hudson.

Examining the implications of this revision more closely within the main source areas above Schuylerville (River Sections 1 and 2), about 82 percent of the Total PCB inventory will be removed by the selected remedy. Thus, in the areas of greatest PCB concentration, the selected remedy will greatly reduce the PCB inventory as well. The main reason for a lower overall removal percentage when including River Section 3 is that PCB concentrations are generally much lower and distributed over a large area (2900 acres) in River Section 3. Only a few areas meet the target criteria for concentration and inventory, and therefore, only five percent of the area in River Section 3 is selected for remediation.

Also, as described in the FS and in Response to Master Comment 597, Section 4.3, the targeted areas under the selected remedy include more than 85 percent of the areas with PCB concentrations greater than 10 mg/kg and more than 75 percent of the areas greater than 3.2 mg/kg. These percentages are not higher due to the difficulty of sediment removal in the remaining areas. Access limitations, shallow underlying bedrock, and small, isolated locations of contamination were some of the primary reasons these areas were excluded. As a result, many of these areas cannot be added without a disproportionate increase in cost and an increased risk of higher sediment resuspension.

EPA concurs that dredging will protect ecological resources (and also human health) in the upper and lower river by reducing PCB concentrations in fish. Based on the FS analyses and those presented in White Papers – Resuspension of PCBs during Dredging, Model Forecasts for Additional Simulations in the Upper Hudson River, and Trends in PCB Concentrations in Fish in the Upper Hudson River, it appears unlikely that the removal of sediments associated with the selected remedy will yield substantively higher PCB concentrations in the Upper Hudson during dredging. Similarly, temporary effects of implementation of the selected remedy on PCB body burdens in fish tissue will be insignificant (see White Paper – Human Health and Ecological Risk

Reduction under Phased Implementation). Rather, model forecasts show that increases in fish PCB body burdens will occur only during the years of the most intense dredging, and will not rise above current levels. Following the completion of the dredging operations, concentrations of PCBs in the water column and fish tissue will rapidly decline and show significant improvement relative to the No Action and MNA Alternatives. Risks to humans posed by consumption of PCB-contaminated fish will be reduced far more rapidly under the selected remedy than under the No Action and MNA Alternatives.

Modeling results show that the Hudson River will see significant benefits associated with the selected remedy. Human health cancer risks and non-cancer health hazards, as well as risks to ecological receptors, will be significantly reduced as a result of remedial dredging. Because the selected remedy is targeting higher concentration areas in general, the vast majority of the PCB inventory will be removed in the most contaminated areas of the Upper Hudson. This approach serves to greatly reduce risks due to PCB exposure while keeping the areas subjected to remediation to less than half of the total acreage in River Sections 1 and 2. EPA has determined that the incremental risk reduction achieved under the more aggressive alternative, REM-0/0/3, does not justify the additional $110 million present worth cost of that alternative.

Doubling the amount of remedial area in these sections (REM-0/0/3 *vs.* REM-3/10/Select) would be expected to yield no more than an additional 20 percent of the total PCB inventory, based on the revised estimates for the Upper Hudson (see White Paper – Sediment PCB Inventory Estimates). Furthermore, these additional areas tend to be coarse-grained or inaccessible areas with relatively little biological value. Hence their remedial value is expected to be relatively low. For the Upper Hudson as a whole, the model forecasts showed a disproportionately smaller improvement in recovery of the river when compared to the far greater area of disturbance for the REM-0/0/3 Alternative as compared to the selected remedy.

Reference

Brown, M.P., M.B. Werner, C.R. Carusone and M. Klein. 1988. Distribution of PCBs in the Thompson Island Pool of the Hudson River: Final Report of the Hudson River PCB Reclamation Demonstration Project Sediment Survey. Prepared for NYSDEC. Albany, NY.

Master Comment 313391

Commenters expressed concern that if additional data are collected to further delineate removal areas, the locations and associated volumes may change substantially.

Response to Master Comment 313391

Many factors were considered during the process of delineating the target areas presented in the FS. These factors include the inventory of PCBs in the sediment (NYSDEC 1977 and 1984 cores; 1994 Low Resolution sediment cores collected by USEPA; and 1991 and 1998 GE data) as well as surface sediment concentrations, sediment texture (from the side-scan sonar analysis), bathymetry, and deposition (whether or not the PCB contamination is buried by greater than 12

inches of “clean” sediment). The data available was judged to be sufficient to define the nature and extent of PCB contamination.

In particular, the EPA has found that areas of fine-grained sediments are typically much more contaminated than other areas. Additionally, fine-grained sediments (cohesive) are considered to be the major source of PCBs to the water column and biota. EPA’s selection of remedial zones has been developed from both chemical and physical data that define these areas. In particular, the remedial area selection process recognized the importance of these areas and targeted them in general. Although the exact inventories of PCBs in these sediments may be refined during further sampling, the physical description of these areas obtained by side-scan sonar is not expected to change greatly. That is, areas found to be fine-grained now are expected to remain fine-grained in the future. These areas are also expected to be a continued source of PCB contamination in the future. Thus the volume estimates of River Sections 1 and 2, which are tied to the side-scan sonar data, are not expected to change substantively upon further investigation.

These sections contain the majority of remedial zones for the selected remedy. Changes in remedial zones in River Section 3, where side-scan sonar data are lacking, will not greatly affect the size of the program since remediation will be much more limited in this section. During the design support program, a new side-scan sonar survey will be performed to aid in refining the removal boundaries. Although some boundary locations might vary slightly, volume estimates and areas to be remediated are not expected to significantly change.

References

Brown, M.P., M.B. Werner, C.R. Carusone and M. Klein. 1988. Distribution of PCBs in the Thompson Island Pool of the Hudson River: Final Report of the Hudson River PCB Reclamation Demonstration Project Sediment Survey. Prepared for NYSDEC. Albany, NY.

Tofflemire, T.J. and S.O. Quinn. 1979. PCB in the Upper Hudson River: Mapping and Sediment Relationships. NYSDEC Technical Paper No. 56, Albany, NY

USEPA, 1998. Further Site Characterization and Analysis. Volume 2C-A Low Resolution Sediment Coring Report (LRC), Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Gradient Corporation, and TetraTech, Inc. July.

QEA, 2001. General Electric Database Transmittal from Michael Werth (QEA) to Doug Tomchuk (USEPA). June 1, 2001.

Master Comment 313224

A commenter has expressed concerns regarding the excessive dredge cut used in some areas (*i.e.*, eight feet), and questioned the minimum depth of cut defined for each one of the three target areas (*i.e.*, where depth of contamination is less than one foot; a one-foot removal depth is used; expanded hot spot areas have a minimum of two-foot cuts; and hot spot areas have a minimum 2.5-foot cut depths). A comment was also made on the fact that Option 5 should have shown a

"diminishing return" (*i.e.,* a lower yield of PCBs per mass of sediment removed) than the preferred remedy.

Response to Master Comment 313224

The issue of remediation depth was originally described in the FS. The following discussion is intended to further illustrate the approach used by EPA. In defining the remedial areas, EPA has utilized both the vertical and horizontal extent of the data to estimate the volume of sediment to be removed. As described in the FS, Chapter 3, and in Response to Master Comment 597 below, the horizontal extent of remediation was determined based on concentration and total sediment mass, with threshold value criteria (*e.g.,* 10 mg/kg or 3 g/m^2). For the vertical extent of contamination, a depth of remediation was set only after an area was selected for remediation. Thus no areas were selected or rejected on the basis of the depth of contamination. Once an area was selected, the goal for remediation is to remove all of the PCB-contaminated sediment within the target area; the target concentration is zero. It is anticipated that such a goal will leave a mean residual concentration of approximately 1 mg/kg Tri+ PCBs.

In order to set the depth of remediation, the various sediment data sets were examined to establish the depth of PCB contamination. Historical data sets from NYSDEC (1977 and 1984) represent the most spatially extensive data sets and were estimated to have detection limits of around 1 mg/kg as the sum of Aroclors. Using these data, the depth of contamination was estimated for each core location. As discussed below, sampling locations within a remedial area were then examined to estimate the depth of removal for the entire area.

For coring locations, the depth of contamination was assigned as the top of the core segment that first attained a non-detect level or a value less than 1 mg/kg PCB as reported. All reported deeper layers must also be non-detect or less than 1 mg/kg. EPA's 1994 core data as well as the GE core data were also considered in estimating the depth of contamination. These data sets have lower detection limits, thus, instead of non-detect levels, just the 1 mg/kg Total PCB threshold was used. That is, the top of the first core segment to fall below 1 mg/kg was selected as the depth of contamination. The EPA data set formed the main data set for the major cohesive sediment areas below TI Dam. The GE data set provided only limited coverage for this purpose and was used largely as confirmation of the other data.

In order to use all available data, incomplete cores were included in the analysis, with the exception of 1977 incomplete cores. Incomplete cores were defined as those cores whose lowest segment did not fall below 1 mg/kg. To estimate the additional material to be removed at the bottom of an incomplete core in order to attain non-detect PCB levels, existing complete cores were examined and grouped based on maximum PCB concentrations in the core and the distance between the maximum and the depth of contamination in the core. This analysis showed that where the maximum concentration in a core is less than 100 mg/kg, the distance between the depth of the maximum PCB concentration and the bottom of contamination in the core is generally less than one foot; and where the maximum concentration is greater 100 mg/kg, this distance is generally more than one foot. Therefore, to calculate the depth of contamination in an incomplete core, if the concentration at the bottom of an incomplete core ranged from 1-100 mg/kg, then 1 foot was added to the core length as an estimate of the remediation depth. If the concentration was greater than 100 mg/kg, then 1.5 feet were added to the core length.

For grab samples, no information is available on the depth of contamination. For these sites and for shallow cores where the depth of contamination was found to be less than one foot, the depth of contamination at the location was assigned as follows:

- Beginning with the shallow core sites and grab sample locations with MPA greater than 10 g/m^2, a depth of 2.5 feet was assigned to these locations. This was based on the average depth of contamination for cores from similar sites (both complete and "corrected" incomplete cores, as noted in the foregoing text) of 2.2 feet in *hot spot* remediation areas.

- For the shallow core and grab sample sites falling between 3 and 10 g/m^2, a value of 2 feet was assigned based on the average depth of contamination for cores falling between 3 and 10 g/m^2 of 1.6 feet in the three river sections.

- For sites falling below 3 g/m^2, a depth of one foot was assigned. This was selected because it represents the minimum dredging depth achievable by the dredging equipment. It was also selected recognizing the general absence of coring locations in the low MPA areas, which is at least partially indicative of the shallow extent of sediments in these areas (generally non-cohesive).

As applied, the minimum depths reflect the fact that as the MPA values increased from 0 to 3 to 10, so did the average depth of contamination. EPA also notes that for grab samples with high MPA values, the assigned depths of 2 to 2.5 feet are substantially greater that the 1 to 1.25 feet nominally assigned by NYSDEC in Brown *et al.,* 1988. This represents a substantial increase in volume relative to NYSDEC's assigned depth of contamination. However, based on the large data set of cores with similar PCB inventories, this depth assignment is considered to be a conservative best estimate. Since so many of the 1984 samples in the TI Pool are grab samples, this approach adds to the apparent overcut. In reality, it is anticipated that the depth of contaminated sediment as estimated from the grab samples from the NYSDEC survey probably underestimates the actual depth of contamination. The evidence from the core samples is expected to provide a much better estimate of the actual contamination depth, hence its application to determine the minimum depth of removal as well as individual target area dredge depths (see below). This approach also best serves EPA's main goal, which is to achieve less than 1 mg/kg Tri+ residual concentrations in the sediment prior to backfill. This goal is best served by designing some degree of overcut into all remedial dredging depths.

This approach generated a set of data that described a best estimate of the depth of contamination at the historical sampling locations. These data were applied to the estimation of depth of removal on a target area basis, not individually. Specifically, the target areas were defined based on both the extent of contamination in an area and the depth of contamination. Thus individual targets were created from clusters of samples with similar levels and depths of contamination. As noted in the FS, no target area was less than 50,000 sq ft. Within each target area, the core site with the greatest depth of contamination set the depth for the entire area. In this manner, the target areas were designed to minimize unneeded sediment removal while still maximizing the likelihood that the residual PCB concentration in each area would be close to the dredging goal of zero mg/kg. In this manner, areas with at least one core were set by a core-based depth. For

those areas, which consisted exclusively of grab sample sites or shallow cores, the depth of removal was set by the approach described above. Thus while grab sample sites represent a large portion of the available data, EPA has used several approaches to refine the estimation process and minimize their impact on the FS volume estimates.

A further conservative assumption resulted from the dredging specification process. Specifically, by requiring dredging to a specific elevation at each location, the specifications effectively add an additional 0.5 feet, on average, to each target area. This is described in Response to Master Comment 313219, Chapter 4. This represents an average overcut of 10 to 20 percent of what should be clean, pre-1945 sediment, helping to further the goal of a low PCB residual.

In general, relatively short cores, on the order of two to three feet of contamination, were used to determine the depth of removal in most areas. However, 23 percent of all the cores used had depths ranging from two to seven feet. Furthermore, at least 10cores had depths of contamination greater than 4.5 feet, and several of these were incomplete. As explained above, one foot to 1.5 feet was added to the depth of contamination for these cores to be conservative with respect to sediment removal. This is why, on plate 17 (sheet one), there are two deeper areas next to the mouth of the Moses Kill with removal depths of six and eight feet. The six-foot area was assigned based on a 1984 sample (Sample ID: 32848). This core was 56 inches deep and the deepest measurement had a concentration of 5 mg/kg. Therefore, because the core was incomplete (from the criteria cited above), one foot was added to produce a six-foot depth. The area assigned eight feet was based on a 1977 core (Sample ID: 32152) that was incomplete at 84 inches with a concentration of 3 mg/kg, and therefore another foot of depth was added. Areas with six- and eight-foot depth above Northumberland Dam were assigned these depths based on the 1999 Canal Corporation Sweep Data, which indicated such depths were required for navigational purposes.

A commenter has also suggested that the REM-0/0/3 Alternative showed a higher yield of PCBs per cubic yard removed than the selected remedy (REM-3/10/Select). However, TI Pool estimates of the PCB inventories in sediments were revised based on additional data and a subsequent analysis of the relationship between Total PCB and Tri+. These revised numbers as well as the amount of mass removed per cubic yard are presented in the following table.

Estimation of the PCB Recovery Rate for Two Dredging Alternatives

Alternative	Volume (cy) [1]	Mass (kg)[2]	Yield (kg/cy)
REM-3/10/Select (selected remedy)	1,600,000	36,000 [3]	
River Section 1	580,000	24,300	
River Section 2	510,000	9,500	
River Section 3	2,700,000	69,800	**0.026**
Total for Alternative			
REM-0/0/3			
River Section 1	2,000,000	42,600 [3]	
River Section 2	1,100,000	28,000	
River Section 3	690,000	13,500	
Total for Alternative	3,800,000	84,100	**0.022**

Notes: 1. Volume numbers rounded from the FS table 6-3, to reflect the precision of the estimate.
2. Mass values reflect revised estimate for TI Pool and other minor refinements. See White Paper – Sediment PCB Inventory Estimates.
3. Mass in Total PCBs. TI Pool total PCBs based on 1984 data as reported by NYSDEC. For TI Pool, various factors were applied to Tri+ values to obtain Total PCB estimates, based on individual concentrations. (White Paper - Relationship Between Tri+ and Total PCBs). The effective ratio of total PCBs to Tri+ is 3.4 for remediated sediments in the TI Pool.

As shown in the table, the REM-0/0/3 Alternative yields a lower ratio of PCB mass to sediment mass removed. Specifically, the volume of sediments removed is 1.4 times higher under REM-0/0/3 and the mass of PCBs removed is 1.2 times higher. The amount of PCBs removed increases at half the rate in proportion to the volume removed. This reflects that fact that the additional sediments yield only 0.013 kg of Total PCBs per cubic yard, half that of the materials removed under the selected remedy. This difference would be expected to be even greater if the estimate under the selected remedy were not so conservative. Specifically, most additional areas dredged under the REM 0/0/3 alternative are located in the channel and had very shallow depth (grabs) or did not have a significant amount of samples available due to the location in the channel area. Therefore, some samples were upgraded to the minimum cut of one foot set for Full-Section, but the original corrected depth would be fairly close to the minimum cut depth, as the average depth of contamination is already around 1.1 feet. However, in the selected remedy, REM-3/10/Select, in the presence of multiple cores of similar depth, the deepest one was used to set the dredging depth, creating a degree of overcut not often applied for the additional areas dredged under REM-0/0/3.

References

Brown, M.P., M.B. Werner, C.R. Carusone and M. Klein. 1988. Distribution of PCBs in the Thompson Island Pool of the Hudson River: Final Report of the Hudson River PCB Reclamation Demonstration Project Sediment Survey. Prepared for NYSDEC. Albany, NY.

Tofflemire, T.J. and S.O. Quinn. 1979. PCB in the Upper Hudson River: Mapping and Sediment Relationships. NYSDEC Technical Paper No. 56, Albany, NY

Master Comment 607

Commenters claimed that EPA has used the low resolution coring (LRC) study as the basis for erroneously concluding that buried PCB mass participates in, or determines, water column loading to the extent that this mass must be removed to reduce loading. Commenters also stated that the reported loss of 40+ percent of PCBs between 1984 and 1994 in the TI Pool from the LRC Report is unverified.

Response to Master Comment 607

The comment's implication that the LRC study is the sole basis for concluding that buried PCB mass must be removed from the Hudson River is false. The LRC is one among many mutually supporting and consistent lines of evidence that lead to this conclusion. Even without the LRC, EPA believes it would be evident that remediation of sediment PCBs is needed.

Key results of other lines of evidence are presented in the FS and summarized in other comment responses. Among these are the following:

- As noted in Chapter 2 in Responses to Master Comments 577, 621, and 631, the sediments of the TI Pool have continued to release a significant amount of PCBs each year. More than two tons of PCBs have been released from the sediments of the TI Pool alone since GE began monitoring in 1991. Nearly half of that occurred since the Allen Mill leakages were greatly reduced in 1996. Thus, the finding of PCB loss from the fine-grained sediments is not surprising and is in fact expected.

- As also noted in Response to Master Comment 577, the TI Pool has been a net source of PCBs for the entire period of GE monitoring. Thus, the entire two tons of net release from the sediments had to have been deposited in the sediments prior to 1991.

- As summarized in Response to Master Comment 619, also in Chapter 2, data from multiple sources, including GE sediment sampling, demonstrate that the stability of currently buried PCBs in sediment cannot be assured.

Therefore, based on both water column monitoring and sediment studies conducted by both EPA and GE, EPA concludes that the sediments have been and will continue to be a significant source of PCBs to the Upper Hudson. EPA does not agree with the commenters' assertion that the conclusions of the LRC Report are not valid and rejects the implication that the LRC report is the basis for "erroneously concluding" that buried sediments should be remediated.

The findings of the LRC Report have been misinterpreted and incorrectly summarized by several of the commenters. The conclusions are repeated here below as well as in Chapter 2 in Responses to Master Comments 577, 625, and 641. As it pertains to the comment above and reflecting the peer review input, EPA concluded:

- The fine-grained sediment areas of the TI Pool examined as part of the LRC program saw a decline in the Tri+ PCB inventory over the period 1984 to 1994. The degree of

loss varied but the mean loss was 45 percent, with a possible range of 4 to 59 percent. Excluding dechlorination losses, the mean loss was 43 percent.

- In the *hot spots* below the TI Dam, PCB loss was documented in a number of locations although the exact amount of PCB loss is less certain.

- To the extent that these areas are representative of the fine-grained areas as a whole, similar mass losses would be expected in some areas while others will see deposition and possibly burial.

- Burial of PCB-contaminated sediment is not occurring everywhere. Of the areas studied, more areas saw PCB loss than gain, implying that burial was not preventing the re-release of PCBs from the sediments in those areas.

It is also important to note what the EPA did not conclude in the LRC Report:

- The EPA did not conclude that all the sediments of the TI Pool lost 43 percent of their PCB inventory. The LRC Report only examined sediments from the 30 percent of the sediments of the TI Pool that are fine-grained (cohesive).

- The EPA did not conclude that deep sediments participate directly in the control of water column loads and biological exposure. EPA has consistently stated that the biologically active zone is approximately 10 and perhaps as great as 15 cm deep (Response to Master Comment 637, Chapter 2).

However, EPA did conclude that much of the sediment at the *surface* of the TI Pool is *not* recently deposited because the PCB levels they contain could not have been generated by the upstream sources any time in the last 10 to 15 years. (USEPA, 1997, Section 4 and White Paper – Relationship Between PCB Concentrations in Surface Sediments and Upstream Sources). Thus the PCBs controlling the water column and biological exposures are part of historical deposits, probably created in the 1970s, which have remained at or near the surface. These historical PCBs are responsible for the continued high concentrations that are found in surficial sediments of the Upper Hudson. EPA recognizes that there may be higher concentrations at depth in some locations; nonetheless, it is EPA's conclusion that much of the existing surface contamination represents historical material. To put it simply, historical deposits of PCBs remain at the surface in many areas of the Upper Hudson. It is largely these deposits which EPA addresses in the selected remedy.

Finally, EPA agrees that the best estimate of 43 percent mass loss from selected fine-grained sediment areas in the TI Pool is subject to uncertainty. Evaluation of the uncertainty in this estimate is discussed at length in Response to Master Comment 641, Chapter 2. While the exact number cannot be verified from currently available data, EPA concludes that the data do conclusively demonstrate that a mass loss has occurred.

References

USEPA, 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C - Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., The Cadmus Group, Inc., and Gradient Corporation. February.

USEPA, 1998. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C-A - Low Resolution Sediment Coring Report (LRC), Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Gradient Corporation, and TetraTech, Inc. July.

4.2.1 PCB Mass vs. Surface Concentration

Master Comment 313214

Commenters noted that the Proposed Plan lists two different values for the estimated mass of PCBs removed under the REM-0/0/3 Alternative: 63,500 kg (p.25) and 70,150 kg (p.17). The mass difference and percentages calculated use both these numbers relative to the 45,600 kg PCBs estimated to be removed under the REM-3/10/Select Alternative. Resolve the correct value.

Response to Master Comment 313214

EPA's current estimate of PCB mass removed under the REM-0/0/3 is 84,000 kg. The derivation of this value is presented in White Paper – Sediment PCB Inventory Estimates. The original value for the estimated mass of PCBs to be removed under the REM-0/0/3 Alternative was 63,500 kg. The previous value (70,150 kg) was an earlier estimate based on a slightly different set of assumptions and was inadvertently included in the text.

The revised PCB mass estimate reflects an improved understanding of the PCB inventory of the TI Pool sediments. The estimated total PCB mass to be removed from River Section 1 was recalculated integrating the 1984 NYSDEC sediment cores with the new information. Various factors were applied to Tri+ values to obtain total PCB estimates, based on individual concentrations. White Paper – Relationship Between Tri+ and Total PCBs contains a further explanation. The value for River Section 1 under the REM-0/0/3 Alternative is now 42,600 kg.

The total PCB mass for the remedial target areas in River Section 2 was determined from the Phase 2 1994 low-resolution cores (USEPA, 1998). A revised estimate for the unremediated areas that yields a minor change in the inventory for this section is given in White Paper – Sediment PCB Inventory Estimates. The revised estimate of PCB mass for Section 2 under REM-0/0/3 was calculated by combining the original mass estimate based on the 1994 data for areas greater than 10 g/m^2 plus the navigational dredging with a mass estimate for the coarse-grained areas of the section derived from the GE 1991 composite samples. This yielded a value of 28,000 kg as a best estimate of the remediated mass of Total PCBs in Section 2 under REM-

0/0/3. This number is presented in Table 363334-3. The Total PCB inventory for the entire river section was estimated at 28,200 kg.

The Total PCB mass for Section 3 was calculated from the low resolution cores for the identified *hot spots* in this area. Thus the mass of total PCBs removed under the 3 g/m^2 threshold is unchanged at 13,500 kg. Therefore, the revised estimate for total PCB mass removed under REM 0/0/3 is now 84,000 kg. To place this revised value in context, the revised estimate of the total PCB mass removed under the selected remedy (REM-3/10/Select) is 69,800 kg.

Reference

USEPA, 1998. Further Site Characterization and Analysis. Volume 2C-A Low Resolution Sediment Coring Report (LRC), Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Gradient Corporation, and TetraTech, Inc. July.

4.2.2 Cohesive vs. Non-Cohesive sediments

Master Comment 313266

Commenters assert that the models indicate that a majority of the PCBs come from the non-cohesive sediment. Commenters contend that EPA's focus on the fine-grained sediments is not because they control PCBs in fish but to push the view that buried PCBs do not, in most cases, stay buried. If PCBs are not being buried and isolated by less contaminated sediments, why is EPA proposing to cover dredged surfaces with fill to isolate PCBs?

Response to Master Comment 313266

EPA agrees that the non-cohesive sediments play an important role in the long-term PCB dynamics of the upper Hudson River. EPA is not unduly focused on the fine-grained sediments. Instead, the information and analyses contained in the FS demonstrate that remediation of both cohesive and non-cohesive sediments will be needed in the Thompson Island Pool. As stated in the FS, “extensive remediation of diffuse contamination is required in River Section 1 to achieve a substantial decline in Tri+ PCB concentrations in water, sediment, and fish.” Indeed, in the selected remedy, approximately half of the sediment area targeted for removal consists of non-cohesive sediment.

The non-cohesive sediments of the TI Pool have, on average, much lower total and Tri+ PCB concentrations than many of the cohesive sediments. Despite this, the non-cohesive sediments play an important role in mediating long-term transport out of the TI Pool. The reasons that they play such an important role in determining the long-term average concentrations leaving the pool are threefold:

- The non-cohesive sediments constitute the majority of the sediment surface area of the pool (Table 5-1 and Figure 5-8 in USEPA, 2000).

- The non-cohesive sediments are generally at greater risk of hydrodynamic scour during high flow than cohesive sediments, and thus more readily release PCBs via scour during flood periods.
- The non-cohesive sediments have lower concentrations of organic carbon, and thus less ability to retain PCBs by sorption.

While the non-cohesive sediments play an important role in releases of PCBs during high flows, the cohesive sediments store the highest concentrations of PCBs and play the greater role in controlling exposure to biota. Specifically:

- The cohesive sediment areas contain the highest near-surface total and Tri+ PCB concentrations, which provide a direct route of exposure to biota.

- The role of non-cohesive sediments in the mass balance is most important during flood events when scour may occur. Such flood events, typically in the spring, may move a large percentage of the annual PCB load. The most important exposure to biota, however, occurs during the summer low-flow period. During this period, the water column exposure concentration in the areas of the TI Pool in which most fish species forage is most affected by releases from high-concentration cohesive-sediment *hot spots* that appear to be driven by biological processes (Response to Master Comment 621, Chapter 2.).

- The cohesive sediments are the areas of greatest biological activity and constitute the primary forage area for many fish species. They are also the areas of greatest benthic macroinvertebrate activity. Thus, exposure to cohesive sediments by biota is amplified relative to their horizontal extent, and it is appropriate to conclude that PCBs in fine-grained sediment are an important control on PCBs in fish in the Thompson Island Pool.

- Cohesive sediments contain the majority of the total and Tri+ PCB mass within the TI Pool sediments. For 1984, 58 percent of the total PCB mass in the TI Pool is estimated to have been in the cohesive sediment areas, based on the revised estimates presented in Appendix B, Table B-2 of USEPA, 1999. The calculations in White Paper – Sediment PCB Inventory Estimates indicate this fraction to be 62 percent (Table 363334-1).

- A portion of the PCBs released from cohesive sediments by biological activity is likely to be temporarily stored in surficial non-cohesive sediments, from whence it may be subsequently released and transported downstream.

As discussed in Response to Master Comment 637 (Chapter 2), PCBs within cohesive sediments to depths of up to approximately 10 cm contribute directly to the food chain. Further, EPA concludes that the stability of more deeply buried PCBs in sediments cannot be reasonably assured (Response to Master Comment 619, Chapter 2). As described in the FS, it will be necessary to remediate both cohesive and non-cohesive sediment areas within River Section 1 to achieve remedial goals.

EPA notes that the statement on p. 5-56 of the FS that "[c]oncentrations of Tri+ PCBs in the water column at the TI Dam are most strongly related to the non-cohesive sediment concentrations" requires clarification. Loading from cohesive sediments appears to control the PCB concentration at the dam during summer low flow conditions with high biological activity, while releases from non-cohesive sediments appear to be more important during the spring flood events that may move a large proportion of the total annual PCB flux across the dam.

EPA's plan to cover dredged areas with fill is not in conflict with EPA's determination of the instability of existing sediment stores. First, natural sedimentation is a heterogeneous and uncontrolled process that provides a less reliable barrier than an engineered placement of backfill. Second, EPA does not contend that backfill will completely isolate any and all residual contamination, although backfill will help reduce the flux of any residual PCBs into the water column. The important point is that the residual concentrations after remediation will be much lower than the current surface sediment concentrations, and will thus contribute less PCBs to the water column, regardless of the efficacy of the backfill in controlling flux.

As described in Section 5.2.6 of the FS, placement of clean backfill serves a number of important purposes in remediation of the riverbed, including isolation of any dredging residuals, mitigation of potential bathymetric changes in shallow areas, and habitat replacement. While isolation of dredging residuals is a principal purpose for the use of backfill, the type of backfill selected is dictated by habitat replacement goals.

References

USEPA, 1999. Responsiveness Summary for Volume 2C-A, Low Resolution Sediment Coring Report. Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc. and Tetra Tech, Inc., February 1999.

USEPA, 2000. Phase 2 Report, Further Site Characterization and Analysis. Volume 2D - Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc., January.

4.2.3 Minimum Target Area for Dredging (50,000 sq ft minimum)

Master Comment 599

Commenters note that neither the Expanded Hot Spot Remediation nor the Hot Spot Remediation will remove all sediments at a mass per unit area (MPA) higher than 3 g/m^2 or 10 g/m^2, respectively. About 15 percent of locations with MPA greater than 3 g/m^2 fall outside the boundaries of the Expanded Hot Spot Remediation area. About 27 percent of locations with MPA greater than 10 g/m^2 fall outside the Hot Spot Remediation area. Commenters question why the preferred alternative is not achieving closer to 100 percent inclusion of areas with an MPA greater than 3 g/m^2. Comments state that the reasons for including or excluding some areas from the removal plan are not explicitly stated (for example not all *hot spots* are targeted for removal).

It appears that the smaller *hot spots* are not being removed because they represent areas less than 1.15 acres (50,000 sq. ft.). Other *hot spots* appear to be excluded because of sediment grain size (in general, the non-cohesive areas are not targeted for removal). These non-cohesive sediments serve as substrate for several species of submerged aquatic vegetation, which serve as important fish feeding, spawning and refuge areas. At a minimum, these highly contaminated areas should be remediated as well as all contaminated fine-grained nearshore sediments, especially those contiguous with known hot spots.

Response to Master Comment 599

Taking into consideration the available data for each river section, criteria were defined for the selection of the remedial target boundaries. Thus both MPA and surface concentrations were considered in defining remediation areas. Both parameters were used to identify remedial areas where elevated levels of PCBs are characteristic of the river sediment. A list of these criteria was provided for each remediation threshold (Full-Section, Expanded Hot Spots [greater than 3 g/m^2] and Hot Spots [greater than 10 g/m^2]). However, as already explained in Chapter 3 of the FS report, these criteria were applied more as guidelines rather than absolute rules. Specifically, it is not appropriate to apply the criteria on a strict basis because of the high degree of variability of the sediment contamination; an isolated high value in the middle of a region of low contamination does not represent an appropriate remediation target. In this instance, the area of high contamination is likely to be "small" both horizontally and vertically since it is uncharacteristic of the area (*i.e.*, it is an isolated high value). Thus the area associated with the isolated high value would not be targeted because of engineering considerations. Ultimately, however, the dredging boundaries will be defined based on the remedial design sampling program and not on the historical data sets. Thus, the boundaries drawn for the FS represent general guides, useful for identifying likely areas for remediation and estimates of sediment mass and volume for the purposes of engineering estimates.

Chapter 3 of the FS report describes the selection criteria for each removal scenario (pages 3-42 to 3-44). The chapter also provides examples (page 3-45 through 3-52) of remediation area selections and describes the approach behind the decision/selection process for each example. EPA did not describe the selection process for each sampling location since such a process is inherently tedious in nature and is not easily summarized except as presented in the FS. In a similar fashion, the EPA did not provide a sample-by-sample discussion of the excluded locations for the same reason, and will not provide one here. There are nearly 3000 historical sampling locations, including NYSDEC, EPA, and GE data, so that such a discussion is not appropriate. More to the point, as mentioned above, the areas identified for the FS serve as general guides and not final boundaries. Thus the selection process used here will not yield the final remediation area boundaries. These final boundaries will be identified during the remedial design.

The issue of sample area requirements is further clarified here. The threshold of 50,000 sq ft. applies only to isolated locations, not clusters or groups of samples. Thus, clusters of locations meeting the criteria were selected even if their individual areas did not represent 50,000 sq ft. each. In this regard, additional information such as sediment type, bathymetry, and proximity to shore were also considered. That is, an individual high value was more likely to have been selected as a target if it was located in an area of fine-grained (cohesive) sediments, located in

shallow water or located close to shore. An isolated high value in the middle of the river in the channel in an area of coarse (non-cohesive) sediment was less likely to have been selected.

This is not to imply that coarse-grained sediments have been ignored. Rather, in these areas, clusters of elevated contamination were identified and selected for remediation as well. As evidence of this, note that under the Expanded Hot Spot threshold, 282 acres of the TI Pool were identified for remediation, including navigational areas. Slightly more than half of this area, 155 acres, were non-cohesive sediments. Of the remainder, 123 acres were cohesive sediments and 4 acres represent mounds and structural areas. This represents 44 percent of the non-cohesive sediment area and 84 percent of the cohesive sediment area of the TI Pool, as identified by side-scan sonar.

The approach applied by EPA serves to yield remediation areas of sufficient size to permit an efficient engineering operation. As can be seen in Figures 597-4 and 597-5, the Expanded Hot Spot threshold captures most (greater than 85 percent) locations meeting the concentration and MPA criteria. At higher concentrations, the capture "efficiency" increases even further. As a direct result of the heterogeneity of the sediment and the consideration of other criteria (such as sediment type), however, many low-level sites are selected for remediation as well (Figures 597-4 and 597-5). The approach used by EPA serves to identify all substantial areas of contaminated sediment for remediation, emphasizing those areas of fine-grained sediment. As noted by the percentages given above, nearly all fine-grained areas of the TI Pool have been slated for remediation. Similarly, areas of elevated PCB contamination have been selected regardless of the sediment type. Isolated sediment contamination or small, isolated areas of fine-grained sediments have been excluded because of the reality of the engineering solutions available for the remediation of Hudson River sediments.

As noted in Response to Master Comment 597 in Section 4.3, the boundaries and estimates provided in the FS serve as a general guide for engineering estimates and subsequent remedial design sampling. The final selection of sediment areas for remediation will be done during the remedial design, incorporating the results of the remedial design sampling as well as any other appropriate data.

4.3 Use of Mass per Unit Area (MPA) as a Criterion

Master Comment 597

Commenters stated that the MPA criterion has no direct relevance to exposure. As a result, the preferred remedy is not extensive enough and should be made more comprehensive in order to better protect natural resources. Comments state that effectively, the MPA approach taken by EPA is based on engineering decisions and does not fully account for the threat to ecological receptors. Many commenters would like an explanation of MPA as an alternative selection criterion.

Response to Master Comment 597

Although the MPA variable was used in the naming of the various remedial alternatives, it was one of up to a dozen different measurements of five principal variables considered for area selection. In the selection process, there were five major criteria that were examined in selecting remedial areas. These criteria were defined in Section 3.5 of the FS and are repeated here in summary form. The overall basis for selection of sediment areas considered geochemical and statistical interpretation of the data, including observations concerning PCB transport as seen in the water column monitoring data, changes in sediment inventory over time (*i.e.*, between sediment surveys), the local density and homogeneity of the sediment PCB distribution both within and among various sediment surveys, and impacts on the biota. The available parameters that best represented these considerations were PCB inventory, PCB concentration, sediment texture (defined by the side-scan sonar survey), proximity to shore, and river bathymetry. The PCB inventory was best characterized by the mass per unit area (MPA) estimate. PCB concentrations were examined in three forms: the surface concentrations, maximum concentrations, and the length-weighted average (LWA) concentrations. Each of these parameters provides a different perspective on the extent of contamination and thus all were useful in the classification of remedial areas. For further detail on the means for selection of remedial areas, see Section 3.5 of the FS, most particularly Section 3.5.4. Figures 3-15 to 3-21 provide detailed examples of the application of the above criteria and the suite of data sets considered in the selection of target areas in the vicinity of six major *hot spots* (*i.e.*, *Hot Spots* 8, 14, 28, 34, 35, and 36).

Five criteria were established for both the Expanded Hot Spot Remediation (the "3" in 3/10/Select), and the Hot Spot Remediation (the "10" in 3/10/Select). Two of the five criteria set values for the MPA and surface concentrations, two more involved the size of target areas, and the fifth was the criterion for the target boundaries based on sediment texture bounds and bathymetry where appropriate.

The MPA was chosen as a target area criterion since it provides a basis to estimate total PCB mass contained in a large area. The MPA is a two-dimensional variable, reducing each core or grab to an area-based measurement by integrating over the depth of the sample. Its application here is in part because of the two dimensional nature of defining the target areas. The process of selecting targets is to specify areas for remediation. Once selected, the goal for the residual concentration in the area is zero, not some depth at which the concentration drops below a threshold. Thus for the purposes of naming the scenarios, the MPA is most reflective of the nature of the remediation. That is, select all areas where the MPA exceeds the threshold (*e.g.*, 3 g/m^2) and then remove all contamination to be found. This measure is most appropriate for a man-made chemical like PCBs where the background concentration in the sediment is truly zero (*i.e.*, pre-1945 sediment).

Setting a strict concentration criterion would imply that dredging would occur to some depth and then stop once concentrations were low enough, that is, when the background concentration is some real value. In this sense then the MPA nomenclature more closely reflects the ideal goal of the remediation, that is, to leave a zero residual.

(It is noted here while it is EPA's goal to remove all PCB-contaminated sediment at a given location [*i.e.*, removal to “zero” PCBs], EPA recognizes that some PCB residual is likely. This residual is estimated to be 1 ppm Tri+ PCBs or less prior to the application of backfill.)

Surface concentrations alone would not be sufficient to select remediation areas, since factors that affect the PCB inventory can affect the MPA and surface concentration in different ways. For example, losses via porewater migration or resuspension will decrease the MPA but will not necessarily affect the surface concentration. Depending on the variation of concentration with depth, the concentration may increase or decrease. Burial by less contaminated sediments would decrease the surface concentration but increase the MPA by adding more PCB mass to the location along with the settling sediments. When both MPA and concentration are considered together, a more extensive understanding of the sediments and their importance as sources is achieved.

For both the 1984 and 1994 data sets, MPA was found to correlate strongly with surface concentration. Therefore, an appropriate MPA criterion would also yield an appropriate surface concentration criterion. The correlation of MPA and surface concentration is exhibited on a Tri+ basis in Figures 3-10 and 3-11 of the FS. These figures are repeated in the Responsiveness Summary as 597-1 and 597-2. The figures represent the relationships among MPA and surface concentration for both cohesive and non-cohesive sediments on a Tri+ basis. As might be expected, the length-weighted average correlates more closely with MPA, since both MPA and the length-weighted average account for all core segments, as well as considering core length. Nonetheless, surface concentration is still correlated with MPA, such that the consideration of both factors for target area selection should identify the worst contamination for both short-term and long-term impacts.

A similar relationship can be seen for the 1991 GE surface sediment composites. This is illustrated in Figure 597-3. Here again, both surface concentration (0-5 cm) and MPA are correlated. These confirm the findings from the 1984 and 1994 data sets; that is, that sites with high MPA also tend to be sites with high surface concentrations. This is consistent with the EPA's finding that elevated surface concentrations are the result of historical contamination still present at the sediment surface. That is, elevated surface concentrations reflect the presence of historical sediment contamination at the surface and the absence of significant burial of sediment PCBs by “cleaner” sediments. Thus the inventory of PCBs at a location and the surface concentration of PCB are found to correlate.

The correlation between MPA and surface concentration is further illustrated in Figures 597-4 and 597-5. In these figures, the “capture efficiency” of the Expanded Hot Spot Remediation is represented for both Tri+ and total PCB for the Thompson Island Pool. The capture efficiency is the percentage of all sampling locations actually selected versus the entire set of samples above a given threshold. Thus, given a set of 100 locations with an MPA greater than 3 g/m^2, a capture efficiency of 85 percent at an MPA 3 g/m^2 would mean that 85 of the 100 locations were contained within the target areas.

The sampling locations considered here are from the NYSDEC 1984 sediment survey, and the remediation areas correspond to the proposed remediation in the TI Pool (Expanded Hot Spot Remediation), which targets a Tri+ MPA of 3 g/m^2 and a Tri+ surface concentration of 10

mg/kg. As further demonstration of EPA's consideration of multiple criteria, note that while the capture efficiencies for both the MPA and the surface concentration criteria are high, the capture efficiency of the proposed remediation is measurably higher for the surface concentration criteria. For Tri+, the capture efficiency for locations with MPAs greater than 3 g/m^2 is 85 percent, while the capture efficiency for locations with Tri+ surface concentrations greater than 10 ppm is 87 percent. When Total PCBs are considered, the capture efficiency for locations with a Total PCB MPA of 3 g/m^2 is 84 percent, and the capture efficiency for locations with total PCB surface concentrations greater than 10 ppm is 86 percent. Thus the targeted areas are more successful at capturing surface sediment locations above the criteria than they are at capturing MPA exceedances. Overall, 76 percent of the sample locations from 1984 are within the proposed remediation areas.

The fact that there are some locations above the criteria that are not targeted is a reflection of the heterogeneity of the sediment contamination. This is expressed as the less-than-100-percent efficiency above the threshold criteria as well as the high percentage removal below the threshold. Note that overall, the targeted areas under the selected remedy will remove 76 percent of all 1984 sampling locations, regardless of concentration (effectively, a 76 percent capture efficiency at the 0 g/m^2 threshold). Limitations of dredging equipment, availability of sediment in and among rocks and rock outcrops, and similar factors guarantee that no operation could remove all contamination. In its selected remedy, EPA recognizes this and strikes a balance between engineering limitations and the desire to achieve the RAOs as quickly as possible.

Notably, the selection of areas for remediation presented in the FS represents only an initial analysis prepared for the purposes of the engineering analysis. Thus the foregoing discussion serves to illustrate how the existing data were applied to the remediation area selection process. These areas provide a general guide as to where the final remediation areas are likely to be found. Ultimately, however, the remediation areas will be refined based on the sediment sampling and side-scan sonar investigations to be conducted during the remedial design. It is expected that some adjustments will be made to the remediation areas described in the FS, but that the total sediment area and volume estimates developed for the FS and this Responsiveness Summary are good approximations of the final values.

4.4 Section-Specific Target Criteria

Master Comment 595

Many commenters felt that the selected remedy is not sufficiently protective of natural resources, nor does it adequately address the threat to ecological receptors from sediment contamination. In particular, comments stated that the mass per unit area (MPA) approach taken by EPA was based on engineering considerations and does not fully account for the threat to ecological receptors from sediment contamination because it does not directly consider risk reduction benefits. Commenters stated that the natural resource benefits that will accrue from additional remediation warrant the incremental costs of achieving a greater degree of protectiveness. Commenters suggested that implementing a more comprehensive remedy, such as the REM-0/0/3 Alternative or the REM-3+ selected areas/3/3 scenario, does not result in any diminishing returns in terms of the benefits of the remedial action. To the contrary, comments suggested that substantial

additional benefits would result from the incremental cost of additional remediation. Commenters wanted clarification on why *Hot Spot* 38 and others are not slated for remediation under EPA's preferred remedy.

Response to Master Comment 595

The EPA recognizes that some additional areas could be targeted at relatively low cost based on the estimated cost per ton of contaminated sediment for the FS. However, there were several criteria that EPA had to balance in developing the selected remedy, not just the incremental cost of dredging.

Besides the additional dredging costs, EPA had to consider the following issues:

- The incremental increase in water column loading from the sediments decreases as the water moves downstream from the TI Pool. This suggests that there are fewer sediments involved in PCB release in the downstream river sections relative to the TI Pool.

- The model forecasts showed relatively little improvement in recovery of the river for the REM-0/0/3 Alternative as compared to the selected remedy (REM-3/10/Select). This analysis suggests that little benefit comes from the additional dredging. For the REM-3+Select/3/3 scenario, the expected improvement would be even less than the REM-0/0/3 Alternative.

- The model shows little improvement in River Sections 2 and 3 for the REM-3/3/3 scenario as compared to the selected remedy (REM-3/10/Select). Some of this is undoubtedly due to the reduced resolution of the model in this reach, which in turn is related to the reduced amount of available data. Nevertheless, EPA believes that its target area criteria for River Sections 2 and 3 are appropriate because there has been no sediment survey akin to the 1984 survey in this region since 1978. Thus, the degree of uncertainty for both the PCB inventory and the outcome of any dredging in this region is greater. The level of uncertainty increases further into River Section 3. There is little side-scan sonar data for Section 3.

- As described in the FS and in the foregoing Response to Master Comment 597, the targeted areas include more than 85 percent of the areas with PCB concentrations greater than 10 ppm and more than 75 percent of the areas greater than 3.2 ppm. The reason that these percentages are not higher is the difficulty of sediment removal in the remaining areas. Access limitations, shallow underlying bedrock, and small areas (less than 50,000 sq ft) were some of the primary reasons these areas were excluded. As a result, many of these areas cannot be added without a disproportionate increase in cost. Special provisions and equipment would have to be made to remediate these areas. Thus, the incremental costs to remediate many of the areas suggested by the commenters would not simply be increments of the estimated cost per cubic yard under the selected remedy.

After considering all these issues, EPA selected the REM-3/10/Select Alternative. Note, however, that the final areas and boundaries will be refined during remedial design. This program will resolve many of the uncertainties in River Sections 2 and 3 with regard to sediment concentration and inventory.

In regard to the specific reference to *Hot Spot* 38, EPA's decision not to include it in the selected remedy is based on several considerations. EPA's main goal in this river section was to identify the likely volume of sediment with the potential to release a significant mass of PCB in the future. Unlike Sections 1 and 2, no side-scan sonar data were available to discern fine-grained and coarse-grained areas. EPA also recognizes that the data obtained in the 1976-1978 NYSDEC survey have analytical limitations due to the age of the analyses, among other factors. Additionally, EPA anticipates that many areas originally surveyed have since been modified by natural geochemical and hydrodynamic processes. EPA concluded that one *hot spot* in this area had lost a significant portion of its PCB inventory although the exact magnitude of the change was unclear. In view of these uncertainties, EPA opted to select a subset of the original *hot spots* in the section. The two *hot spots* examined by EPA in Phase 2 (*Hot Spots* 37 and 39) plus 36 were selected to best estimate the likely volume of material to be removed from this River Section. Like River Sections 1 and 2, the final area selected for removal will be decided on the basis of the remedial design sampling.

Master Comment 359303

Commenters expressed concern about not dredging *Hot Spot* 39 in its entirety. Commenters noted that the EPA's Proposed Plan calls for removal of only a portion of *Hot Spot* 39; however, the overall PCB inventory of this *Hot Spot* is documented as 25 percent of the TIP PCB inventory. Commenters feel that the entire *hot spot* should be remediated. Since *Hot Spot* 39 is downgradient from the confluence of the Hudson and Hoosic Rivers, possible high-flow events may redistribute PCB sediment inventories if they are not all removed. Commenters also questioned the amount of sediment deposition occurring in *Hot Spot* 39, as well as the PCB concentrations of these newly deposited sediments.

Response to Master Comment 359303

The selected remedy includes the removal of selected areas of elevated PCB contamination in River Section 3, which is the section that contains *Hot Spot* 39. The selected areas of *Hot Spot* 39 were identified for remediation because of the presence of elevated PCB concentrations (greater than 30 mg/kg) in the upper sediments (0-12 inches) that may be lost to the water column or taken up by biota. Cores from the selected areas were generally considered "complete" or "nearly complete" in that they had decreasing PCB or cesium-137 levels with depth and probably represented the entire thickness of post-1950 contaminated sediment (see Chapter 3 of USEPA, 1998 for further discussion). This condition is typical of many of the areas selected for remediation throughout the Upper Hudson.

The area defined as "the southern portion of *Hot Spot* 39" and included in the selected areas for River Section 3, is primarily located to the south of the NYSDEC boundary for *Hot Spot* 39. Within this area, the central portion has not been identified for remediation based on currently

available data (see Sheet 6 of 7 of Plate 17 in the FS). Additionally, the northern portion of the *hot spot* as originally delineated is not currently identified for remediation. The portions of *Hot Spot* 39 that have not been selected are not characterized by elevated PCB levels in the surface sediments (0-12 in). In the northern portion of *Hot Spot* 39, the four 1994 low resolution cores yielded relatively low values for surface concentrations in this area (1 to 20 mg/kg), below the 30 mg/kg threshold. These cores also had low MPA values as well, with three of the four cores exhibiting little PCB mass below the top core segment. On the basis of these cores, this area of *Hot Spot* 39 was not selected for remediation since both its surface concentration and PCB inventory were below threshold considerations.

The three cores located in the excluded central area show low Total PCB concentrations (about 5 mg/kg) in the 0-12 inch interval. Additionally, and more importantly for this area, these cores show a PCB maximum concentration in the deepest core segment, nominally 24 to 40 inches. These cores were considered to be "incomplete" with higher levels of both PCBs and cesium-137 with depth. These cores are indicative of high rates of deposition, essentially burying the PCB inventory. Locations that have PCB maximum concentrations at depth are atypical of the remedial target areas of the Upper Hudson where elevated concentrations and the majority of the PCB inventory are close to the sediment/water interface. These conditions led to the conclusion that this portion of *Hot Spot* 39 was undergoing rapid burial and could be left in place.

While the 1994 EPA data were the basis for the exclusion of these portions of *Hot Spot* 39, these data were also the basis for including an extensive area of contamination not originally identified by NYSDEC in 1979. Specifically, the southernmost portion of the river shoreline near *Hot Spot* 39 as well as an adjacent cove were included in the selected area for remediation based on the 1994 core samples. These areas represent areas of high surface concentration and high PCB inventory. (These areas are illustrated on Sheet 6 of 7 of Plate 17 of the FS.)

The Total PCB surface concentrations in the excluded portions of *Hot Spot* 39 under the selected remedy are fairly well defined. In the northern portion, the four 1994 cores all yielded values at 20 mg/kg or less. In fact, two of the cores had surface concentrations less than 2 mg/kg. In the excluded area, the reported 1994 PCB concentrations of roughly 5 mg/kg in each of the three cores collected in this area indicate a fairly thick layer of relatively clean material in each location. The fact that all three cores yielded nearly the same value provides further support for the occurrence of extensive burial within that portion of *Hot Spot* 39.

It is not likely that the excluded portions of *Hot Spot* 39 would be subject to a resuspension event such as the one that was observed during the Reassessment Remedial Investigation in sampling Transect 3. *Hot Spot* 39 is considered to be far enough downstream of the confluence with the Hoosic that resuspension due to cross-currents caused by the Hoosic is unlikely. The confluence is located 3.2 miles upstream at RM 167.3. Both the intervening distance and the dam at Lock 3 should serve to minimize any Hoosic River flow impacts. No other major tributaries are located in the area. The resuspension event observed in Transect 3 was most likely associated with sediments further upstream closer to the confluence, such as *Hot Spot* 37. Notably, the deep location of the PCB maxima in these cores suggests there has been little or no erosion by high flows in this area since the highly contaminated material was deposited, probably 20 years prior to EPA's low resolution core collection program.

While the excluded central area of *Hot Spot* 39 would meet the mass-per-unit-area (MPA) criteria for removal used for River Sections 1 and 2 (it has an MPA of greater than 10 g/m^2), EPA has determined that it is not necessary to remediate that portion of *Hot Spot 39* based on the clear evidence for PCB burial in this area. In any event, the majority of the PCB inventory in the vicinity of *Hot Spot* 39 will be removed through the remediation of the other portions of the *hot spot.* EPA will conduct additional sampling in *Hot Spot* 39 (as well as in other portions of the Upper Hudson) during remedial design to better define the areas to be dredged.

Reference

USEPA, 1998. Further Site Characterization and Analysis. Volume 2C-A Low Resolution Sediment Coring Report (LRC), Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Gradient Corporation, and TetraTech, Inc. July.

4.5 Habitat-Based Targeting

Master Comment 453

Commenters suggested that EPA add an additional RAO to reduce risks to non-piscivorous wildlife by directly reducing concentrations of PCBs in sediment and water and indirectly reducing PCBs in their diet.

Response to Master Comment 453

Although ecological risks are not limited to piscivorous receptors, those receptors are at the greatest risk. In addition to piscivorous birds and mammals, future risks were calculated for the benthivorous mallard, omnivorous raccoon, and insectivorous little brown bat. As discussed in the Response to Master Comment 817 (Chapter 7), most risks to ecological receptors are based on a toxic equivalency (TEQ) measure, which quantifies the toxicity of PCB congeners relative to the toxicity of the potent dioxin 2,3,7,8-TCDD (RBERA, Section 3.1.2). Exposures based on Tri+ PCB calculations (which are nearly equal to total PCBs in most Phase 2 biota samples) have greater compatibility with the current knowledge of PCBs in the Hudson River as well as less uncertainty associated with them than the TEQ estimates. The only non-piscivorous receptor with toxicity quotients greater than one (*i.e.*, unacceptable risks) on a Tri+ PCB basis was the little brown bat, whose future risks were less than three on a NOAEL basis. As risks to non-piscivorous wildlife were not uniformly seen, a separate RAO was not included for these receptors.

Reference

USEPA, 2000q. Further Site Characterization and Analysis, Revised Baseline Ecological Risk Assessment (RBERA), Volume 2E. Prepared for USEPA Region 2 by TAMS Consultants, Inc. and Menzie-Cura & Associates, November 2000.

Master Comment 593

Commenters stated that the fine-grained nearshore environment (*i.e.*, within 50 feet of the shoreline) in the Thompson Island Pool was two to three times more contaminated (135-264 ppm) than previously described (66 ppm) in the Phase 1 Report. Some commenters pointed out that these nearshore and vegetated areas are especially important since they can act as a continuing source of contamination and may compromise remedial efforts if excluded from remediation. It was suggested that specific degraded habitats should be targeted for remediation because of the functions they provide or because remobilization of PCBs from these areas can impact important adjacent or downstream areas.

The critical habitat that yields fish with exceptionally high PCB concentrations is replaceable and should be sacrificed to eliminate the residual PCB in sediments that could recontaminate downstream remediated areas. Areas in the TI Pool, near Griffin Island, and in River Sections 2 and 3 that support vegetation and fish habitat are not being fully remediated.

Response to Master Comment 593

Many nearshore and vegetated areas function as important habitats for fish and macroinvertebrates. In turn, fish and macroinvertebrates serve as prey to a variety of wildlife. Because many vegetated (*e.g.*, SAV) areas are depositional, PCBs tend to concentrate in these areas. PCBs bioaccumulated by aquatic organisms can subsequently be transferred to predators living in and near the river and also to predators outside of the immediate vicinity of the river. They can also be transported downriver in sediments and water. EPA recognizes that nearshore areas, in particular vegetated areas, are some of the most productive but most contaminated areas in the river (FS, Chapter 3). In addition, the main PCB flux from the sediments appears to be biologically mediated, originating from the near-shore environment that supports a high density of plants and animals.

EPA concurs with the Federal Trustees for Natural Resources (2001), responsible for the protection of these nearshore areas, who state that "Adverse impacts associated with remediation of these areas will be temporary. The temporary loss will be greatly offset by the accelerated recovery of these areas". Therefore, EPA considers remediation of these "critical" habitat areas necessary.

The selected remedy will remediate 61 percent (63,200 feet of 104,000 feet) of shoreline (*i.e.*, nearshore) area in River Section 1, including island shorelines (*e.g.*, Griffin Island), based on the areas selected in the FS. In River Section 2, 18 percent (15,700 feet of 85,800 ft) of nearshore areas will be remediated, and in River Section 3, 3 percent (11,700 feet of 394,000 feet) will be remediated. Overall, 15 percent (90,600 feet of 585,000 feet) of the nearshore area in the upper river from Fort Edward to the Federal Dam at Troy will be remediated.

As noted in the FS (Section 3.5.3), the anticipated remedial operations are not "surgical" in nature and thus it is not appropriate or productive to attempt to remove all sediments exceeding a specified threshold value. It is important to recognize that the purpose of remediation is not to remove all PCB-contaminated sediments exceeding some specified threshold. Given the importance of the near-shore environment to both ecological exposures and PCB release from

the sediment, the focus of the application of each remediation threshold will be sufficient reduction of PCB mass and concentration to achieve the RAOs, not to target every isolated contaminated area.

Detailed data will be collected prior to remediation (Response to Master Comment 507, Chapter 9), and precise dredging locations will be determined during the preparation of the remedial design.

Reference

Federal Trustees for Natural Resources, 2001. The Federal Trustees for Natural Resources, the United States Department of the Interior (DOI) and the National Oceanic and Atmospheric Administration (NOAA), (together "the Trustees") comment on the Proposed Plan submitted to the USEPA on April 16, 2001.

5. TECHNOLOGY EVALUATION AND REMEDIAL ALTERNATIVE DEVELOPMENT

5.1 Technology Evaluation

5.1.1 Capping/Aquablok™

Master Comment 651

Commenters stated that there was insufficient information to support AquaBlok™'s use on the scale required in the Upper Hudson. They were concerned that there may be potential problems with hydration, potential problems with aquatic revegetation, and root penetration problems. Commenters felt that there were uncertainties concerning the reliability of the CAP scenarios. Commenters questioned (1) why only mechanical dredges were proposed for CAP-3/10/Select while both mechanical and hydraulic equipment was proposed for REM- 3/10/Select and REM-0/0/3; (2) how hydraulic dredges used either alone or with mechanical dredges would alter estimated costs for the capping alternative; and (3) whether the anticipated placement rate of the cap material is correct. It was also suggested that EPA should use a thin-layer cap over contaminated riverbed sediments at selected locations.

Response to Master Comment 651

EPA did not choose CAP-3/10/Select because of concerns about the long-term stability of a cap and the need to monitor and maintain it indefinitely. EPA is also concerned that in the event of a major flood, the cap might be eroded and contaminated sediments would be spread within the sensitive ecosystem. As explained in Chapter 4 of the FS Report, AquaBlok™ is a capping system consisting of gravel particles to which bentonite clay is bonded. Pilot tests of a sufficiently large scale for comparison to the selected remedy for the Upper Hudson River are in progress (*e.g.*, Ottawa River in Ohio and Fort Richardson in Alaska) that do not show problems with proper hydration of the cap material in forming a continuous layer. It should be noted that for CAP-3/10/Select, 12 inches of backfill (consisting of sand, silt, and gravel, as appropriate) will be placed in areas that are dredged but not capped. Areas capped with AquaBlok™ would be backfilled with six inches of sand, silt, and gravel mixture. The main root zone for most aquatic plants is typically within the top six inches. Therefore, revegetation problems would not be expected, since these plants would be primarily established within the backfill materials. It is possible that some of the deeper roots of some aquatic plants could extend up to 15 inches from the surface of the backfill and partially penetrate into the cap materials. The proposed cap is 18 inches thick; therefore even in instances where there is some root penetration, it is expected there would be at least three inches of an impervious AquaBlok™ layer.

It should be noted that mechanical dredges were proposed for CAP-3/10/Select because dredging is only performed in targeted areas between the shoreline and the six-foot navigation contour, and the volume of sediments to be removed for this alternative is relatively small compared to the volume tom be removed for the REM alternatives. The

use of hydraulic dredges for the capping alternative would not be expected to alter the costs significantly.

As explained in Chapter 4 of the FS, EPA evaluated and rejected a number of capping alternatives including thin layer, multi-layer, and active systems. These systems were generally determined to be inapplicable to the Hudson River due either to problems with placement of the cap material in a riverine environment or to the potential for significant erosion of the cap by river hydraulic forces.

Master Comment 423258

Page 8-34, Paragraph 1: "...in River Section about 1,160 acres of PCB-contaminated sediments are capped". Should it read "...in River Section 1 about 160 acres…."?

Response to Master Comment 423258

Yes, the statement on page 8-34, paragraph 1 should read, "...in River Section 1, about 160 acres.…"

5.1.2 Treatment/Vitrification

Master Comment 253189

Commenters cited several proven alternative PCB treatment technologies, including beneficial reuse and bioremediation, which may be applicable to the proposed sediment treatment and disposal. They suggested that these technologies could help reduce transportation costs and the amount of hazardous sediments in need of disposal. Several commenters suggested that these technologies need to be re-evaluated before a final remedy is selected.

Response to Master Comment 253189

EPA has, in fact, as suggested by commenters, reviewed the technologies that were previously considered by EPA in the FS Report as well as other technologies that were identified in submittals from vendors during the public comment period. The findings of EPA's current review are the same as those documented in the FS Report. As indicated in the Chapter 4 of FS, the following publications, databases, and technical reports were reviewed as part of the Agency's thorough search to identify and evaluate remedial technologies for possible use at the Hudson River PCBs Site:

- Superfund Innovative Technology Evaluation (SITE) Program (USEPA, 1999).
- Selecting Remediation Techniques for Contaminated Sediment (USEPA, 1993).
- Assessment and Remediation of Contaminated Sediments (ARCS) Program Remediation Guidance Document (USEPA, 1994).
- USEPA Hazardous Waste Clean-up Information (CLU-IN) website (USEPA, 2000a).

- USEPA Remediation and Characterization Innovative Technologies (USEPA REACH IT) database (USEPA, 2000b).
- Federal Remediation Technologies Roundtable (FRTR, 1999) website.
- Remediation Technologies Network (RTN) Remediation Information Management System (RIMS, 2000) Database.

These resources identified a number of potential remedial technologies or process options available to treat PCBs at the Site. As an initial screening, each of the potentially applicable remedial technologies was evaluated in terms of effectiveness and technical implementability at the Site. Technologies that were retained after the initial screening were evaluated in a second round of the screening process. The evaluation criteria included effectiveness, implementability, and costs.

Technologies that were retained after the second screening were then used to develop remedial alternatives for the Site, as discussed in the FS. For purposes of the detailed analyses in Chapters 8 and 9, certain process options (*i.e.*, hydraulic and mechanical dredging/dewatering/stabilization/beneficial use) were selected for cost analysis/comparison purposes. During the remedial design phase of the project, treatability studies may be conducted to refine the required engineering parameters.

White Paper – Additional Technology Evaluation contains additional information relative to evaluation of the submittals from vendors during the public comment period.

References

Federal Remediation Technologies Roundtable (FRTR) Website. 1999. Information obtained from http://www.frtr.gov.

Remediation Technologies Network Remediation Information Management System (RIMS) Database. 2000. Owned and Operated by the Research Technologies Network, L.L.C. provided on http://www. enviroglobe.com.

USEPA. 1993. Selecting Remediation Techniques for Contaminated Sediment. EPA/823/B93/001. June 1993.

USEPA. 1994. Assessment and Remediation of Contaminated Sediments (ARCS) Program Remediation Guidance Document. Great Lakes National Program Office. EPA-905-B94-003.

USEPA. 1999. The Superfund Innovative Technology Evaluation (SITE) Program: Technology Profiles, Tenth Edition. EPA/540/R-99/500.

USEPA. 2000a. Hazardous Waste Clean-up Information (CLU-IN) Website. Provided at http://www.clu-in.org.

USEPA. 2000b. Remediation and Characterization Innovative Technologies (USEPA REACH IT) Database (includes VISITT; Vendor FACTS; and ITT). Provided at http://www.epareachit.org.

Master Comment 313704

A commenter indicated that dewatering of the mechanically dredged material was not included in Figure 5-1 of the FS. The commenter also asked about the area requirement of the sediment transfer/processing facility.

Response to Master Comment 313704

Assuming that a mechanical dredging technology is selected, hopper and/or deck barges will be used to transport the dredged sediments to the processing/transfer facility. Prior to unloading barges, excess water that would accumulate above the incoming sediments would be pumped off, treated, and discharged back to the river.

Once the dredged material has been off-loaded, it will be discharged into a hopper through a series of racks and screens. The dredged material will then be blended with Portland cement (or other stabilizing agent) in a pug mill. The stabilized sediments will be placed into a temporary staging area prior to being loaded into the trucks by either conveyors or front-end loaders for delivery to the rail car loading area. The conceptual unit processes have been presented in Figure 5.1 of the FS. White Paper – Example Sediment Processing/Transfer Facilities contains a preliminary facility layout for treating the mechanically dredged sediment.

For the mechanically dredged sediment processing facility, the treatment plant and the associated rail transfer facility will require about 10 to 15 acres of land area (Montgomery, 1985). For the hydraulically dredged sediment processing facility, the treatment plant and the rail transfer facility will require about 15 to 20 acres of land area.

Reference

Montgomery, J.M. (1985) Water Treatment Principles and Design, John Wiley & Sons, New York, NY.

Master Comment 313758

A commenter indicated that thermal destruction should be retained as an option for dealing with dredged material.

Response to Master Comment 313758

Thermal destruction is an effective process (Destruction / Removal Efficiency = 99.9999) that uses high temperatures to destroy hazardous contaminants. The technology theoretically could be used at a near-river or off-site location. In accordance with CERCLA Section 121(e)(1), federal, State, and local permits are not required for remedial actions undertaken entirely on site, including incineration, although an on-site incinerator would still need to comply with the substantive requirements of federal and State permitting laws. In any event, numerous on-site

incineration projects have experienced long delays due to local opposition. The use of existing off-site facilities would avoid such issues but would require transportation of the material.

One of the key factors that must be considered in the selection of treatment technologies for PCB-contaminated sediments is what happens to the sediments after treatment is completed. EPA's FS report does retain thermal destruction under the high-value beneficial use option, where manufacture of commercial products is involved (Table 4-13 of the FS). However, EPA's FS report does not retain thermal destruction if the sediments will be disposed of in a landfill after treatment is completed, because such an option would not be cost-effective. That option requires payment of both treatment and disposal costs. Thermal destruction costs in general are moderate to very high compared to other technologies (approximately $560-$900/ton). The high energy requirements and necessary emission controls are the primary contributors to the high costs. For disposal at an off-site incinerator, significant transportation costs may be incurred in addition to treatment costs. Therefore, near-river as well as off-site incineration of PCB-contaminated sediments was not retained for further consideration. A detailed analysis of the treatment options is presented in Chapter 4 of the FS Report.

5.1.3 Dredging Technologies

Master Comment 657

Questions have been raised as to whether or not advances in dredging technologies have occurred over the last 10 years or so. Some of the comments suggest that there have been no recent technological advances, and others suggest that numerous innovations have occurred.

Response to Master Comment 657

Chapter 5 in the Feasibility Study and FS Appendix H summarize the principal changes that have taken place in both mechanical and hydraulic dredging technologies over the last 10 years. In fact, it is reasonable to conclude that attainment of goals specified for the Hudson River remedy, *i.e.*, removal of targeted sediments without causing significant additional impact, are achievable as a result of the technical advances that have taken place over the last decade.

The following paragraphs detail several of the principal changes that have occurred in mechanical and hydraulic dredging systems. The emphasis is on the two variants of mechanical and hydraulic dredging systems that have been identified as preferred for use on the upper Hudson: an excavator fitted with a horizontal profiler-type bucket and an appropriately configured cutterhead suction dredge. There have also been numerous advances in specialty dredging equipment that can be applied to removal work in shallow areas. These systems are discussed in FS Chapter 4 and are not addressed further here.

Mechanical Dredges

Following is a discussion of some of the major innovations in mechanical dredging systems.

Various types of enclosures have been added to clamshell buckets to limit the release of excavated sediments. Examples of systems that employ sophisticated enclosing mechanisms include the Cable Arm bucket (suspended from a barge-mounted crane) and the Horizontal Profiling bucket (attached to a hydraulic excavator). Ten years ago enclosures were, in fact, being added to clamshell buckets to reduce spillage during navigational dredging work. However, those enclosures were essentially retrofits to existing buckets, whereas the Cable Arm and Horizontal Profiling systems are completely new concepts developed specifically to limit contaminated sediment release.

In addition to incorporating enclosures in a new bucket design, the Cable Arm and Profiler have incorporated numerous auxiliary devices that further control sediment release. These auxiliaries include vents or valves that allow water to be released as the bucket closes, gaskets to enhance bucket sealing, and sensors to provide information on bucket closure. Each of these auxiliary features enhances the performance of the mechanical dredging system and either was not available or not being applied 10 years ago.

One of the most significant, and perhaps least appreciated, recent modifications to the clamshell bucket has been to its cutting profile. The ability of the new bucket systems to take wide, flat sediment cuts has enormous advantage for Superfund-type work, where most contamination is in the upper few feet of sediment. First, the flat cut improves efficiency in areas where only two or three feet of sediment are targeted. Additionally, when coupled with electronic positioning capability, the flat cut allows for development of innovative dredging plans that allows removal work to be phased in horizontal and vertical patterns that would not have been considered 10 years ago.

Another major development in the last 10 years has been the application of digital geographic positioning and electronic monitoring technologies to dredging and other earth moving construction equipment. With the use of these digital electronic systems, it has become possible to remove sediments to within several inches of planned targets. Such precise targeting both improves efficiency and allows for real-time tracking of ongoing work by the dredge operator and the construction management team.

The recent coupling of micro-processor-based computer systems with remote sensing information from multi-beam sonar and other technologies has allowed contractors to display, in real time, digital terrain information for the work site. With that information, the contractor is able to know the configuration of the river bottom; the targeted dredging limits in relationship to existing bottom; the quantity and location of material that must be removed to achieve project goals; and the mass that has already been excavated. New developments in these digital materials accounting systems are occurring at a rapid pace and undoubtedly will continue into the future.

Hydraulic Dredges

Numerous new approaches to hydraulic dredge design have also occurred over the last 10 years or so. The most significant of these technological improvements have occurred in instrumentation and dredge positioning capability. Also, improvements in dredging equipment - pumps, pipelines, ancillary equipment, and the materials from which they are constructed - have resulted in marked increases in dredging production and efficiency. A brief description of several notable advances in hydraulic dredging technology follows.

The swinging ladder is an example of the type of innovative thinking that can potentially be applied to the Hudson River. A swinging ladder is not a new piece of equipment, but it is one that is not commonly used, particularly in Superfund work. In the conventional hydraulic dredge, the ladder is fixed laterally to the hull and "swings" as the hull swings. The dredge completes its swing width by moving the entire dredge hull in one direction then in another. In the newer configuration of the swinging ladder, only the ladder swings from side to side. A swinging ladder can be a more stable and flexible platform, especially if the hull is held in place by spuds rather than anchors.

A gooseneck cutterhead dredge is another example of flexible and adaptable technology that has specific applications and is designed to maximize efficiency of the system. On a gooseneck cutterhead dredge, the ladder and cutterhead are angled with respect to the vertical axis of the ladder, so as to keep the cutterhead in a more parallel position with respect to the bed of the river. Different arrangements of the ladder and cutterhead angle might be required as the nominal river depth varies along the river.

The impact of technology is most readily appreciated in the computerization of standard operations. Modern dredges have highly instrumented systems for locating and positioning the dredge, as well as for monitoring and documenting dredge production and dredge efficiency. Examples of this increasing automation include pipeline flow meters, slurry density meters, depth sounders, and ladder position indicators. Global positioning systems (GPS) technology and computerized surveying of the river bottom are also used as part of the overall dredging system.
Dredge operations management based on information obtained from electronic instrumentation systems is also common today. Detailed real-time reports on virtually all aspects of operations are instantly available, including fuel consumption and status, engine horsepower, and electrical motor operational status. New digital control systems are now being developed that integrate electronic information from dredge operations, process instrumentation, and geographic positioning systems to enable both remote monitoring and control of dredging operations.

Finally, considerable knowledge has been gained over the last 10 years with regard to processing sediment slurries generated by hydraulic dredges. Much of this experience comes from sites designated for remediation by EPA under the Superfund program. Since sediments removed from Superfund sites cannot be disposed in an uncontrolled manner, it has proven necessary to develop systems to process these slurries as a first step to either landfilling or treatment. As a result, not only have advances been made in equipment for separating, stabilizing, dewatering, and otherwise improving sediment handling characteristics, but considerable experience has now also been gained in designing entire processing trains that can achieve the level of reliability needed to successfully implement large dredging programs.

Master Comment 364760

A question was posed relative to the text on page 5-11, in paragraph 1: Limitations are imposed on dredging equipment depending on the option categories. For example, Option Categories B and E are selected if mechanical dredging is performed, while Option Categories A and D are selected if hydraulic dredging is performed. Commenters wondered what dredging equipment will be associated with the selection of Option Category H, and whether defining the equipment for a particular option category may ultimately restrict the selection in the design phase.

Response to Master Comment 364760

The commenter has misunderstood the discussion in Section 5.1.2 of the FS. The options listed identify what can potentially happen to the Hudson River sediments after they are dredged, *i.e.* , disposal with or without treatment <u>or</u> manufacture of commercial products after treatment. EPA assumed that the disposal would be performed at an off-site location because of opposition from the local near-river communities (Chapter 4). The treatment can be performed at a near-river location or at an off-site location. As explained in the text, the particular *ex situ* treatment considered in the FS prior to disposal is stabilization in order to improve the transportation and handling characteristics of the dredged sediments. The type of dredging equipment used (mechanical or hydraulic) will dictate the choice of the post-removal option categories and not *vice versa*. Therefore, the FS does not restrict selection of dredging equipment. This selection will be performed during the design phase of the project. Hydraulically dredged does not require stabilization and Option H is one possible post-removal option for the hydraulically dredged sediments. Stabilization (blending with Portland cement or other such additives) may potentially interfere with the manufacturing process for some commercial products that might otherwise present possibilities for beneficial reuse.

Master Comment 366358

Commenters have suggested that dredging is not an effective technology and is not guaranteed to work. They feel the technology is not advanced enough yet and that EPA should wait until a less disruptive/destructive technology is developed. In addition, commenters expressed the opinion that the limitations of dredging technology will prevent the EPA from successfully removing the amount of PCBs necessary to have a beneficial effect on the river system.

Response to Master Comment 366358

Two dredging technologies have been identified (Feasibility Study, Chapter 5) as being applicable to removal of contaminated sediments within the upper Hudson River. These are 1) a mechanical dredging system utilizing a hydraulic excavator fitted with a European-style horizontal profiling bucket and 2) a cutterhead hydraulic dredge outfitted with a cutterhead and ladder configured specifically for work on the Upper Hudson.

As stated in Response to Master Comment 657, there have been numerous advances in mechanical and hydraulic dredging systems over the last fifteen years. These advances allow for better monitoring of operations, more precise control of dredge position, and increases in machine productivity. Overall, as a result of the many advances in dredging technology, it is expected that modern dredging equipment will generate markedly reduced levels of suspended sediment in comparison to equipment available in the 1980s. The enhanced ability of modern dredging equipment to limit resuspension will in turn lead to lower water column levels of trace contaminants and reduced impacts to various water quality parameters (White Paper – Potential Impacts to Water Resources).

EPA has estimated the quantity of sediment that is expected to be resuspended when either hydraulic or mechanical dredges operate on the upper Hudson (White Paper – Resuspension of PCBs during Dredging). The rates of resuspension are generally predicted to be lower than the natural variation in the river's suspended solids load. As part of EPA's selected remedy, an in-river monitoring program will be conducted to confirm the acceptability of releases from dredging operations. Results of that program can also be used to adjust various dredging parameters (operating speed, production rate, etc.) to further limit releases during dredging. Thus, it is expected that much river disruption can be avoided by selecting appropriate dredging equipment at the outset and then monitoring and adjusting its actual performance.

Both the mechanical and hydraulic dredging systems described in the FS have been scaled (sized) to remove the quantity of dredged material necessary to achieve the project's risk reduction targets. Production rates to be achieved by the selected mechanical and hydraulic systems are discussed in White Paper – Dredging Productivity and Schedule. The planned production levels will enable remedial work to be accomplished in six construction seasons from 2005 to 2010. Risk reduction benefits of EPA's selected remedy have been estimated on the basis of a six-year construction period beginning in 2004 and found to be significant.

Before EPA initiates dredging operations, considerable additional data will be collected for purposes of designing an environmentally sound project. That data will be used to select final dredging target areas and to create detailed dredging plans and schedules. In addition, EPA will consider the many public concerns related to dredging and will address those concerns as part of the public process that will accompany the project planning. This will be accomplished, in part, by placing numerous constraints on the dredging work, including limits on sediment resuspension and increases in other water quality parameters. As mentioned above, the contractor's work will be monitored to ascertain compliance with the project's technical specifications.

Thus by taking a measured and systematic approach to accomplishing the selected remedy, EPA expects to conduct the project without the problems raised as concerns by commenters. In addition, EPA has indicated that, as the project proceeds, there will be considerable opportunity for public review and input both to the planning and the work-in-progress. Given the overall approach being taken to implement the selected remedy, it is not likely that significant unplanned disturbance to the river will occur; should a disturbance arise it will be quickly observed and controlled in accordance with strategies adopted at the outset of work.

Master Comment 423845

Some commenters have suggested unique alternatives to dredging contaminated sediments.

Response to Master Comment 423845

EPA has given some consideration to several of these concepts (*e.g.*, dry excavation) as part of a general review of applicable technologies. EPA has selected dredging as the preferred method of removing contaminated sediments from the upper Hudson in light of the numerous environmental and other constraints posed by river conditions. It is EPA's view that dredging the river will enable effective removal of targeted sediments and, thereby, result in significant reductions of health and environmental risks. None of the technologies suggested by commenters appears to offer the same certainty that project goals can be attained.

Master Comment 366262

A number of commenters recommended that hydraulic dredging should be the selected remedy because it will minimize resuspension.

Response to Master Comment 366262

Hydraulic dredging technology has advanced to a point where it can, and does, effectively control resuspension of sediments during dredging. Numerous improvements have also been made to mechanical dredging systems to the point where EPA now views this technology as a potential candidate as well (Response to Master Comment 657). To the extent that commenters' concerns relate to sediment resuspension, reference should be made to Response to Master Comment 583 and White Paper – Resuspension of PCBs during Dredging. While control of resuspension will be a major factor in selecting a final dredging technology, some consideration needs to be given to the overall processing and handling of dredged materials. The two dredging technologies described in the FS present substantially different logistical issues for EPA and, consequently, an entire range of unique riverine and community issues. EPA will consider both the in-river and out-of-river aspects of the selected remedy when choosing a dredging technology. Finally, commenters should note that it may be beneficial to utilize both technologies, but in different river segments, to optimize results in an environmentally protective manner.

Master Comment 423609

A commenter contended that it is unrealistic for EPA to assume, as presented in the FS, that the slurry resulting from hydraulic dredging will be approximately 20 percent solids before dewatering. A better estimate, it was suggested, would be on the order of two to five percent solids before dewatering, and perhaps up to 10 percent with the addition of a coagulating agent during initial gravity thickening operations. As a result [of this unrealistic assumption], the FS underestimated the quantity of wastewater that will be generated and require treatment.

Response to Master Comment 423609

The solids content of hydraulically dredged slurry will vary with time and is a function of suction pipeline inlet velocity, the physical characteristics of the *in situ* material, and the effective operational controls (Souder *et al*., 1978). As cited in the ARCS Remediation Guidance Document (USEPA, 1994), typical dredged material solids content varies between 10 to 20 percent by weight (Herbich and Brahme; 1991; Herbich, 1992). The Feasibility Study (Appendix H - Hydraulic Dredging Report) describes specific aspects, properties and characteristics of the materials anticipated during hydraulic removal of contaminated sediments from the Upper Hudson River. An actual solids content of 12 to 13 percent was assumed for estimating the volume of water that is generated and that will require treatment. This information was obtained from actual sediment samples taken from the targeted areas of similar remediation projects.

References

Herbich, D.F. 1992. Handbook of dredging engineering. First Edition. McGraw-Hill Book Company, New York, NY.

Herbich, J.B., and S.B. Brahme. 1991. Literature review and technical evaluation of sediment resuspension during dredging. Contract Report HL-91-1. Prepared for the US Army Engineer Waterways Experiment Station, Vicksburg, MS. Texas A&M University, College Station, TX.

Souder, P.S., Jr., L. Tobias, J.F. Imperial, and F.C. Mushal. 1978. Dredged material transport systems for inland disposal and/or productive use concepts, June 1978. Dredged Material Research Program Technical Report D-78-28. US Army Engineer Waterways Experiment Station, Vicksburg, MS.

US Environmental Protection Agency (USEPA). 1994. ARCS Remediation Guidance Document, EPA-905-B94-003.

5.2 Remedial Alternative Development

Master Comment 255302

EPA should adopt a more comprehensive remediation alternative than that identified as EPA's selected remedy (3/10/Select) in the Proposed Plan. NRDC and Scenic Hudson have identified an alternative labeled "3+select/3/3" and Hudson River Sloop Clearwater has identified an alternative labeled "3+/0/3+" which they believe will remove more PCBs from the Upper Hudson River and also address EPA's concerns about cost-effectiveness and cost. These parties believe that EPA's selected remedy is too timorous both in terms of PCB mass removed and cost-effectiveness.

Response to Master Comment 255302

EPA acknowledges the desire of some commenters for a more aggressive remedy. EPA considered and modeled a wide range of remedial alternatives during the FS, and these are listed in Section 5.3.1.6 of the FS Report. These model runs included alternatives that can be defined as "REM-0/3/3" and "REM-3/3/3." REM-0/3/3 is clearly more aggressive than the "3+select/3/3" alternative proposed by NRDC and Scenic Hudson, and REM-3/3/3 is somewhat less aggressive than the "3+select/3/3" alternative proposed by NRDC and Scenic Hudson. EPA did not select an alternative more aggressive than REM 3/10/Select for the reasons described below.

As part of the alternatives evaluation process, EPA noted that:

- At the scale of the model segments, long-term predictions of Tri+ PCB concentrations in River Sections 1, 2, and 3 are controlled by assumptions of boundary conditions for upstream Tri+ PCB loads.

- Predictions of non-cohesive sediment Tri+ PCB concentrations are strongly dependent on the target threshold boundaries (degree of remediation); extensive remediation of diffuse contamination in River Section 1 (as was selected in the 3 g/m^2 target areas), as well as tight control of the upstream loads is required to achieve a substantial decline in Tri+ PCB concentrations in these sediments. Downstream of the TI Dam, the concentration of Tri+ PCBs in the water column at the TI Dam is the most important factor controlling water column exposure.
- As was illustrated in Appendix D3, Figures RE-128 through 130 of the FS, there is a relatively minor improvement in fish body burdens between the selected remedy and the most aggressive scenario, REM 0/0/3. Much larger declines in fish body burdens occur in the REM scenarios relative to the MNA with source control. Thus, less aggressive scenarios proposed by the commenters will fall within the relatively narrow difference between the selected remedy and the full section removal.

EPA also noted that based on the model, it was important to perform the most extensive remediation in River Section 1 relative to the other sections, and that it was possible to perform less extensive remediation in River Sections 2 and 3 and still achieve comparable results for reductions in fish tissue PCB concentrations. EPA believes that it is not desirable to choose a remedial scheme like the "3+/0/3+" alternative proposed by Hudson River Sloop Clearwater for all of the reasons outlined.

In the Proposed Plan and FS, EPA has explained the Agency's rationale for selecting the particular degree of remediation for each river section for the selected remedy.

EPA's selected remedy was chosen to reduce to acceptable levels the risks to human health and the environment from the consumption of PCB-contaminated fish. These risk reductions are presented in Chapter 7 of the FS. Chapters 8 and 9 of the FS contain EPA's detailed analysis for all the alternatives that passed the initial screening (for effectiveness, implementability, and cost) using seven of the nine NCP criteria (the two threshold criteria and the five balancing criteria). EPA believes that the selected remedy significantly reduces the mass of bioavailable PCBs and is

cost-effective. As noted in the FS and the ROD, additional data will be collected during the design that will help to refine the areas targeted for remediation.

As part of the comments received from Scenic Hudson, a list of remedial zones was suggested. The following discussion describes EPA's analysis relative to each zone.

River Section 1

- Map ID A - North of Rogers Island. The region is difficult to dredge since the river is fairly shallow and rocky. Also, currents may be strong.
- Map ID B - Area west of Lock 7 and south of the tip of Rogers Island. This region consists largely of isolated data points with no consistent pattern. Some data points have been included already, although the large associated polygons were not included, recognizing the large uncertainty in those areas due to the extrapolation made via the use of Theissen polygons.
- Map ID C - Area north of D3-4 and *Hot Spot* 5. The sampling location was included. Again, the entire polygon associated with the data point was not included, recognizing the large uncertainty associated with the extrapolation made using the Theissen polygons.
- Map ID D - Area north of mile 191 between D3-6 and D3-7 along west shoreline of river. The 1994 data do not indicate substantive contamination (5 samples < 10 ppm) in this area.
- Map ID E - Area north of mile 191 just east of Area E in the channel. The region is non-cohesive, within the channel and has surface concentrations < 10 ppm.
- Map ID F - Area extending east from Griffin Island located just to southwest of removal zone D3-10. This polygon is due to a single data point in a rocky area. The data point is included in EPA's proposed dredged area, but the large associated polygon is not included.
- Map ID G - Area just below Griffin Island in channel. Data points are included within the remediation zone but again, the entire polygons associated with data points not included recognizing the large uncertainty associated with the extrapolation made by the Theissen polygons.
- Map ID H - North of Thompson Island Dam East Channel (northward to D3-11). EPA had made an initial decision not to dredge the land-cut part of the channel since little or no data are available for this area. It will be explored further under remedial design.

River Section 2

- Area D3-14. This area is in a land-locked section, behind rocky areas. This area is expected to have potential accessibility problems. It does not meet the 10 g/m^2 criterion.
- Area D3-16. Area D3-16 is a non-cohesive area. The 1994 data from the area does not indicate high contamination. Thus, it does not meet the 10 g/m^2 criterion.
- Area D3-17. It does not meet the 10 g/m^2 criterion.

- Area D3-18. *Hot spot* 27 does not appear to exist any longer, based on the absence of cohesive material and the presence of rocks or rock outcrops as observed in 1994. It will be further explored under remedial design.
- Area D3-19. It does not meet the 10 g/m^2 criterion.
- Area D3-20. It does not meet the 10 g/m^2 criterion.
- Area D3-21. It does not meet the 10 g/m^2 criterion.
- Area D3-22. It does not meet the 10 g/m^2 criterion.

River Section 3

- Area D3-29. Data uncertainties in this region are great. Additional areas may be included after remedial design sampling.
- Area D3-30. The area was not included in the proposed dredged areas due to the occurrence of deeply buried contamination (greater than two to three feet based on 1994 samples).
- Area D3-26. Data uncertainties in this region are great. Additional areas may be included after remedial design sampling.

Master Comment 313803

A commenter indicated that Option Categories C and F include off-site *ex situ* treatment, rather than the near-river *ex situ* treatment as stated in the FS.

Response to Master Comment 313803

EPA concurs with the reviewer. The post-removal Option Categories C and F for the removed sediment include off-site *ex situ* treatment as stated on page 5-8 of FS.

Master Comment 313983

It was suggested that screening of remedial action alternatives should include REM-0/3/3 and REM-0/0/0. It was also suggested that REM-0/3/3 and REM-0/0/0 be added to the list of removal alternatives retained for detailed analysis.

Response to Master Comment 313983

Alternative REM-0/3/3 was among the large number of alternatives that were modeled by EPA. (FS, Section 5.3.1.6 and Response to Master Comment 255302, Section 5.2).

The selection of sediment target areas for remediation is described in Section 3.5 of the FS Report. This section describes the available data sets and the selection criteria. It also indicates that full-section remediation is not anticipated for River Section 3. The REM-0/0/0 alternative is not consistent with EPA's selection of target areas for remediation. Therefore, EPA does not agree with addition of the REM-0/0/0 alternative to the list of alternatives retained for screening or detailed analysis, as suggested in the comment.

Master Comment 314017

On Page 6-40, for Insert Section 6.4.2.3, a commenter recommended adding REM-0/3/Select as a refined remedial alternative.

Response to Master Comment 314017

REM-0/3/Select is a more aggressive remedy than the selected remedy; EPA acknowledges the desire among numerous commenters for a more aggressive remedy. EPA considered and modeled a large range of remedial alternatives during the FS process; these are listed in Section 5.3.1.6 of the FS Report. These model runs included alternatives that can be defined as REM-0/3/3 and REM-3/3/3. REM-0/3/3 is more aggressive than the REM-0/3/Select alternative proposed in the comment, and REM-3/3/3 is somewhat less aggressive than the REM-0/3/Select alternative proposed in the comment. These alternatives bracket the REM-0/3/Select alternative and, therefore, although EPA did not specifically evaluate the REM-0/3/Select alternative under Detailed Analysis in the FS, the outcome of such an evaluation is bracketed by those performed. Additional explanation of the reasons such an alternative was not selected is described under the Response to Master Comment 255302, above.

Master Comment 405965

Commenters wanted to know why the EPA is not planning to dredge the entire Hudson River.

Response to Master Comment 405965

The Hudson River PCBs Reassessment Feasibility Study, released in December 2000, focused on the Upper Hudson River sediments, since data have shown that these sediments contain a substantial portion of the PCBs released from the GE facilities. Figure 405965-1 illustrates historical PCB concentrations relative to river mile in the entire Hudson River PCBs Site. There is a clear decrease in concentration of PCBs heading down river toward RM 0 at the lower limit of the Hudson River PCBs Site. The 1975 through 1981 data show a decrease in PCB concentrations toward RM 0 of up to three orders of magnitude, relative to Upper Hudson River sediment concentrations. The 1991 and 1992 data show that the Lower Hudson River still has substantially lower PCB concentrations as compared to the Upper Hudson sediments. Addressing the PCB-contaminated sediments above the Federal Dam with the targeted dredging in the selected remedy will bring the greatest benefit in the most cost-effective manner.

The geochemical and physical properties of the tidally influenced Lower Hudson River have thoroughly mixed the PCBs with cleaner sediments from the various tributaries and dispersed them throughout the Lower Hudson River. As a result, the Lower Hudson River is not an environment of focused PCB hot spot concentrations as is the Upper Hudson. While sediment concentrations vary from location to location, the Lower Hudson River sediments consistently show lower PCB concentrations relative to the Upper Hudson River sediments (Figure 405965-1) and they are generally below the target thresholds prescribed for the Upper Hudson. In

addition, there are numerous other active sources of PCBs in the Lower Hudson, so, cleaning up the sediments would not only be very costly and time-consuming, but would also have a limited impact on achieving the fish goal and targets. The selected remedy, which removes the bulk of the historic PCBs in the Upper Hudson sediments, along with source control measures to eliminate the input of fresh PCBs from the two GE facilities, will be beneficial to the Lower Hudson River.

Master Comment 313835

It was suggested that CAP-0/0/0 should be added to the list of Capping with Dredging Alternatives retained for detailed analysis.

Response to Master Comment 313835

The selection of sediment target areas for remediation is described in Section 3.5 of the FS Report. This section describes the available data sets and the selection criteria. It also indicates that full-section remediation is not anticipated for River Section 3. The CAP-0/0/0 alternative is not consistent with EPA's selection of target areas for remediation. Therefore, EPA does not agree with retention of the CAP-0/0/0 alternative for detailed analysis as suggested in the comment.

Master Comment 313459

In FS Section 6.3.2, Evaluation of REM Alternatives, Figures 6-7 through 6-23 were used to compare modeling results for several alternatives. A commenter suggested that the evaluation would benefit from tabular presentation of data gleaned from the figures regarding time required to achieve a PRG and the forecasted concentration if the PRG is not met.

Response to Master Comment 313459

During this screening stage of the FS process for evaluation of alternatives, both figures and tables were used to perform the screening evaluations. Tables 6-1 and 6-2 and Figures 6-7 through 6-23 were used to perform this evaluation. EPA does not believe that the screening level evaluation would gain additional benefit from the tabular representation of when specific PRGs would be achieved. It should be noted that the figures presented in the FS are, in fact, a graphical representation of massive tables covering the entire time period of 67 years that were generated by the modeling effort.

EPA feels that the tabular representation suggested in the comment is better applied to the detailed evaluation of the alternatives that were retained after this screening process. In fact, EPA did use such a tabular representation at that stage of the FS process for evaluating alternatives (Tables 7-4 and 7-8).

5.3 Comparison of MNA vs. Active Sediment Remediation

Master Comment 362912

Commenters said that the cost of dredging demonstrates that it is not the proper remedy because source control alone (MNA) achieves similar results to dredging. It is appropriate to compare the costs of dredging and to consider the cost-effectiveness of the two remedies. Cost is one of the five balancing criteria to be considered in the comparison and selection of remedial alternatives. "Although cost cannot be used to justify the selection of a remedy that is not protective of human health and the environment, it can be considered in selecting from options that are adequately protective." Ohio v. E.P.A., 997 F.2d 1520, 1533 (D.C. Cir. 1993) (rejecting a broad challenge by several states to the NCP that cost should not be considered in determining exposure levels of a remedy). Indeed, "there is nothing in section 121 [of CERCLA] to suggest that selecting permanent remedies is more important than selecting cost-effective remedies." CERCLA, under 42 U.S.C. § 9621(b)(1) "places as much emphasis on the selection of cost effective [sic] remedies as it does on the selection of permanent remedies." Id. at 1532. Dredging does not satisfy the cost-effectiveness criteria under CERCLA or NCP. 40 C.F.R. § 300.430(f)(1)(D) (2000) (providing that the remedy selected "shall be cost-effective, provided that it first satisfies the threshold criteria"). According to the NCP, "costs that are grossly excessive compared to the overall effectiveness of alternatives may be considered as one of several factors used to eliminate alternatives." 40 C.F.R. § 300.430(e)(7)(iii) (2000). Dredging the upper Hudson is projected to cost $460 million, but could cost over $700 million. Source control would cost only $39 million but would achieve nearly identical results. Assessment of the benefits of dredging in the face of its adverse impacts and its marginal improvements in PCB concentration over source control demonstrates that its costs are "grossly excessive compared to [its] overall effectiveness." Id. A balancing of the costs of dredging and monitored natural attenuation therefore favors the latter. Therefore, dredging does not satisfy the cost-effectiveness criteria of CERCLA and the NCP and may not be selected as the remedy.

Response to Master Comment 362912

EPA strongly disagrees with the comment, which incorrectly assumes that MNA is substantially as effective as the selected remedy in protecting human health and the environment. EPA's analyses of data collected by EPA, NYSDEC, and GE during the Reassessment RI/FS unequivocally show that control of the Hudson Falls source alone, without any remediation of the PCB-contaminated sediments (*i.e.*, monitored natural attenuation) is considerably less protective of human health and the environment than remedial alternatives that include remediation of the sediments, including the selected remedy (FS, Section 8.3.2, Section 8.5.2, Section 9.1 and Appendix D).

For example, the fish PCB target concentration of 0.2 mg/kg (1 meal/month) averaged over the entire Upper Hudson River is expected to be achieved at least 25 years more quickly under REM-3/10/Select, than under MNA. (FS Section 9.1.1.1.) EPA's model also predicts that the 0.4 mg/kg PCB target fish concentration averaged over the entire Upper Hudson River is achieved at least 14 years, and possibly more than 47 years, sooner under REM-3/10/Select, the selected

remedy, than under MNA. The shorter time periods required to achieve these fish PCB target levels under the selected remedy represent a significant improvement in protectiveness of human health, given that people continue to eat fish caught in the Upper Hudson River. EPA also determined that remedies involving active remediation of contaminated sediments show greater reductions in risks to piscivorous mammals (river otter and mink) than MNA (FS Section 9.1.2); these environmental receptors are not at all protected by the fish consumption advisories. Further, EPA's modeling indicates that for the first 25 years, as shown in Figures 6-33 through 6-37 of the FS, the water quality for the dredging alternatives is significantly better than that achieved by the MNA (or source control) Alternative. As expected, the greatest improvement in water quality as a result of dredging is seen at the TI Dam. Moreover, as stated in the Feasibility Study (Appendix D), the ROD, and elsewhere in this Responsiveness Summary, EPA's modeling may be overly optimistic with respect to the rate of decline of PCBs in fish predicted for the MNA Alternative, in which case the relative benefits of dredging over MNA are even greater.

In White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River and White Paper – Human Health and Ecological Risk Reduction under Phased Implementation, EPA presents the results of additional model runs that were performed after issuance of the Proposed Plan. These model runs reflect the revised remediation schedule of six years (versus five years in the FS and Proposed Plan) and possible impacts of PCBs being remobilized during dredging. No significant differences in human health or ecological risk reduction were seen between the original five-year and the new extended phasing time frames. The new model runs are consistent with EPA's determination in the FS and the Proposed Plan that active remediation will substantially reduce risks to humans and wildlife, and allow fish target concentrations to be met more quickly, than without active sediment remediation.

EPA also has determined that the selected remedy is cost effective, which means that the overall effectiveness of the remedy is proportional to its cost. In sum, it is abundantly clear that the assertion that source control and dredging achieve similar results is false. The difference in cost between MNA and the selected remedy does not justify the selection of MNA, which is significantly less protective of human health and the environment than REM-3/10/Select.

Master Comment 369325

Commenters suggested that the project is too costly and that the money that would be spent on implementing the selected remedy should be used for other purposes to benefit the Upper Hudson Valley, for example State parks or education programs in the Upper Hudson Valley.

Response to Master Comment 369325

EPA has determined that the selected remedy is necessary to address the unacceptable risks to human health and the environment posed by PCB-contaminated sediments at the Site. EPA also has determined that the selected remedy is cost-effective, which means that the costs of the remedy are proportional to its overall effectiveness. Overall effectiveness of the remedy is determined based on an evaluation of the remedy against the following three criteria: long-term

effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; and short-term effectiveness. 40 CFR § 300.430(f)(1)(ii)(C)(6).

EPA disagrees with the comment because the expenditures suggested by the commenter would not address the unacceptable human health and ecological risks at the Site.

Master Comment 405888

Several public comments state support for "GE's plan" (involving upstream source control alone) as opposed to EPA's Proposed Plan.

Response to Master Comment 405888

The Monitored Natural Attenuation (MNA) Alternative relies on naturally occurring attenuation processes to reduce the toxicity, mobility, or volume of PCBs in the Upper Hudson River sediments, and assumes a separate source control removal action near the GE Hudson Falls plant. Therefore, the MNA alternative and source control are not differentiated in the FS. For a discussion concerning natural attenuation processes, refer to Master Comment 405926, Chapter 11.

Control of PCB loadings from upstream sources is required of GE and will proceed independently of any sediment remediation activities in the Hudson River. GE has discussed an approach with NYSDEC and EPA for terminating PCB releases near the Hudson Falls plant. For purposes of modeling for the FS, EPA has assumed that a source control system will be in place, which will reduce PCB loads originating from the plant site to 0.0256 kg/day by January 1, 2005.

EPA has determined that MNA (with source control alone) would not be sufficient to reduce the current level of PCB exposure to the Hudson River ecosystem and to human consumers of fish from the river. Discussions related specifically to source control occur in other chapters of this RS. The relative benefits of MNA (with source control) versus active remediation are discussed in Response to Master Comment 573 in Chapter 2, which demonstrates the need for active remediation. As explained in Response to Master Comment 405926, Chapter 11, EPA disagrees with commenters' claims that the river is cleaning itself, and that, therefore, active remediation is not needed. As discussed in Response to Master Comment 823 in Chapter 6, EPA disagrees with other comments that the selected remedy would not result in significant improvement relative to MNA, based on modeling work presented by GE. EPA believes that the results presented by GE are based on an arbitrary and inappropriate specification of model inputs and parameters that are designed to minimize the apparent effectiveness of active remediation.

6. MODELING ASSUMPTIONS AND INTERPRETATION

Master Comment 451

One commenter stated that EPA's dismissal of its model is arbitrary and capricious. This comment was made in regard to EPA's discussion of multiple lines of evidence for selection of the remedy, which included the results of modeling as well as other analyses, such as the analysis of recent trends in fish tissue concentrations in NYSDEC sampling.

Response to Master Comment 451

EPA did not dismiss its models when developing the selected remedy for the Site. As stated in the Rationale for Selection of Preferred Alternative section of the December 2000 Proposed Plan, "USEPA's comparison of the relative effectiveness of the [remedial] alternatives is based on the results of modeling each remedial alternative as well as data projections." The models are an important part of EPA's decision-making. However, EPA also considered recent data trends for PCB concentrations in fish, which suggest that the models may be overly optimistic with regard to the rate of PCB decline in fish predicted under the No Action and Monitored Natural Attenuation (MNA) Alternatives (*i.e.*, the models predict that PCB levels in fish decline more rapidly under the MNA and No Action scenarios than is suggested by recent data trends for PCB concentrations in fish), and that the relative benefits of active sediment remediation are likely to be greater than suggested by the models. White Paper – Trends in PCB Concentrations in Fish in the Upper Hudson River contains further details. It is entirely appropriate for the Agency to consider multiple lines of evidence and analyses when making a remedial decision for the Site.

6.1 Fate and Transport Modeling

Master Comment 823

Comments contend that under more realistic assumptions, source control alone will lower PCB levels in fish more quickly in most of the Upper Hudson River and will lower the mass of PCBs entering the Lower Hudson River, as compared to the proposed EPA dredging plan.

Response to Master Comment 823

EPA does not agree that the assumptions used by GE upon which this comment is based are “more realistic.” These assumptions include resuspension and release of 2.5 percent of target PCB mass during dredging, a project implementation period of 10 years, and residual PCB concentrations of 5 ppm in dredged areas that are not backfilled. EPA believes that the assumptions in the Feasibility Study on PCB resuspension during dredging, project implementation period, and residual PCB concentrations are reasonable and technically defensible. Under the FS assumptions, the selected remedy adds significantly to the benefit that can be achieved by source control alone.

As part of the Responsiveness Summary, EPA has provided additional information to support the assumptions and interpretations in the Feasibility Study, and strengthen its position that the GE assumptions are not “more realistic.” Refer to White Paper – Resuspension of PCBs during Dredging for supporting information on PCB resuspension and release during dredging. Refer to White Paper – Dredging Productivity and Schedule for supporting information on project implementation period. Finally, refer to White Paper – Post-Dredging PCB Residuals for supporting information on residual PCB concentrations in dredged areas that are not backfilled.

EPA has performed analyses to assess the impact that higher losses of PCBs during dredging would have on the levels of PCBs in fish in the Upper Hudson River and the loss of PCBs to the Lower River. EPA has also revised the schedule from five to six years to allow additional time for phased implementation of the remedy. Response to Master Comment 423154 in Chapter 1 of this document contains information on the rationale for phasing of the remediation schedule. White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River contains results from model forecast simulations with higher losses of PCBs during dredging and phasing of the remediation schedule. White Paper – Human Health and Ecological Risk Reduction under Phased Implementation contains details on evaluation of risks associated with higher losses of PCBs during dredging and phasing of the remediation schedule.

It should be added that source control and active remediation are not mutually exclusive alternatives. Control of PCB loadings from upstream sources is important to the overall recovery of the river. EPA has determined, however, the control of the upstream source without active remediation of contaminated sediments is not sufficiently protective of human health and the environment.

Master Comment 849

Commenters suggested that the EPA mass balance models will need to be updated and new projection simulations conducted after EPA collects additional sediment data during the design phase of the proposed dredging project.

Response to Master Comment 849

Additional sediment data to be collected during remedial design of the selected remedy are not expected to change the basic calibration of the EPA models to historical data, nor are they expected to change the forecasting ability of the models to such a degree that it will change the outcome of the FS. Refinements to models will, of course, be made if water quality, geochemical, or fish data indicate this is appropriate. The primary purpose of the additional sediment data collection is to provide detailed information necessary to refine estimates of sediment volumes to be removed.

Master Comment 364582

Some commenters expressed concern that deeply-buried PCBs could become "reactivated" in the event of a large flood in the Upper Hudson River, and that the depth of scour analysis conducted

by EPA for a 100-year peak flow did not represent a sufficiently large flood. In particular, the EPA depth of scour analysis was conducted for a 100-year peak flow of 47,330 cfs at Fort Edward. It was asserted that proposed new Sacandaga Reservoir management practices could result in the release of higher flows from the Sacandaga Reservoir during an extreme event that are more than the 8,000 cfs that EPA assumed in its flood frequency analysis. Commenters requested that a higher 100-year peak flow be evaluated due to Sacandaga Reservoir operational changes that may result from the relicensing agreement reached between Orion Power and NYSDEC.

Response to Master Comment 364582

An important question in the Hudson River PCBs Reassessment was whether there are contaminated sediments now buried that are likely to become "reactivated" following a major flood, possibly resulting in contamination of the fish population. To address this question, a depth of scour model (DOSM) was developed to provide estimates of sediment erodibility in response to large floods. In the Revised Baseline Modeling Report (RBMR, USEPA, 2000) the DOSM was applied to a 100-year peak flow estimated to be 47,330 cfs, based on available historical data. To respond to the concerns expressed in this comment, the DOSM was reapplied to a new higher estimate of 61,835 cfs for this 100-year peak flow. This higher flow value is considered to be an upper limit for the peak flow that could occur during a 100-year flood. White Paper – Application of the Depth of Scour Model (DOSM) in the Thompson Island Pool for Alternative Flooding Assumptions contains complete details of this analysis.

Results from reapplication of the DOSM to the new higher estimate for the 100-year peak flow indicate that:

- Average bottom shear stress on cohesive sediments increase by 27 percent for the upper limit flood peak versus the lower flow analyzed in the RBMR (21.3 dynes/cm2 versus 16.8 dynes/cm2).

- Average erosion depth in cohesive sediments is approximately 2.27 times greater for the upper limit flood peak than for the lower flow analyzed in the RBMR (0.719 cm versus 0.317 cm).

- The 95th percentile maximum scour depth for the upper limit 100-year flood peak flow is less than the depth of peak PCB concentrations at the same four of five high-resolution sediment core locations in the TI Pool that were analyzed for the lower flow in the RBMR.

- Using 1991 surficial sediment data representing average PCB concentrations in the top 5 cm of the sediments across the entire TI Pool, a low-end estimate of PCB mass scour can be made. This estimate indicates that an additional 30 kg of Tri+ PCBs would be scoured for the upper limit flood peak flow than for the lower flow analyzed in the RBMR (60 kg versus 30 kg). On a total PCB-basis, the increase in estimated scour for the upper limit flood peak would be 60 kg (120 kg versus 60 kg).

- Using 1984 sediment data representing average PCB concentrations in the top 30 cm of the cohesive sediments in TI Pool, a high-end estimate of PCB mass scour can be made. This high-end estimate indicates that an additional 101 kg of Tri+ PCBs would be scoured for the upper limit flood peak flow than for the lower flow analyzed in the RBMR (190 kg versus 89 kg). On a total PCB-basis, the increase in estimated scour for the upper limit flood peak would be 350 kg (650 kg versus 300 kg).

- The predicted mass of PCBs resuspended on either a Tri+ or total PCB basis for the upper limit peak flow is small, ranging from 0.2 to 3 percent of the mass inventory estimated to reside in the cohesive sediments of the TIP.

In summary, the major RBMR findings related to the assessment of flood-induced sediment PCB resuspension are not significantly altered based on the results from a reapplication of the DOSM to the upper limit estimate of 61,835 cfs for the 100-year peak flood flow. The details of this analysis are presented in White Paper – Application of the Depth of Scour Model (DOSM) in the Thompson Island Pool for Alternative Flooding Assumptions. EPA continues to believe that the 47,330 cfs flood analyzed in the RBMR is the most relevant indicator of risk of PCB resuspension associated with large flood events, although the possibility of a larger flood must also be addressed. As discussed in the RBMR, it does not appear that large flood events are likely to "remobilize" large quantities of PCB mass that are currently buried in cohesive sediments.

This does not, however, mean that these currently buried PCBs are safely sequestered. Rather than catastrophic mobilization during a single flood event (as analyzed in the White Paper – Application of the Depth of Scour Model (DOSM) in the Thompson Island Pool for Alternative Flooding Assumptions), it appears that gradual resuspension of buried PCBs is of greater concern. This gradual resuspension occurs through a number of processes, including the cumulative effect of many smaller flood events, non-hydrodynamic disturbance of sediment (including bioturbation, uprooting of macrophytes, ice scour, and other forms of physical disturbance), and porewater transport. The issue of the ultimate stability of currently buried PCB stores is addressed in greater detail in Response to Master Comment 619 in Chapter 2.

Reference

USEPA. 2000. Phase 2 Report, Further Site Characterization and Analysis. Volume 2D – Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc., January.

6.1.1 External PCB Loads to the Model

Master Comment 821

Commenters cited evidence of PCB contamination of floodplain soils and noted that the EPA modeling effort did not address PCB loading from the floodplain to the river.

Response to Master Comment 821

The objectives of the EPA modeling effort were to focus on evaluations of PCBs in the water, sediments, and fish. The HUDTOX fate and transport model was designed to simulate PCB contamination inside the normal shoreline boundaries of the Upper Hudson River. This is consistent with the overall objective of determining the appropriate course of action to address PCB contamination in the sediments of the Upper Hudson River. PCBs in floodplain soil were not explicitly included in the HUDTOX model because insufficient data were available to characterize the nature and extent of PCBs in floodplain soils, or to determine whether these PCBs constituted significant sources to the river. EPA has assumed that the contributions of floodplain soil to the river are of secondary significance relative to the loads originating from sediment within the river and from the Hudson Falls area. Processes such as PCB deposition in the floodplain and subsequent erosion back into the river are accounted for implicitly in the model to the extent that the water column solids and PCB data used to calibrate the model reflect the impacts of such processes. Also included implicitly are any PCB inputs to the river from floodplain soils that were contaminated prior to 1977, or to new external sources of floodplain soil contamination after 1977. Data are not available to determine the existence or magnitude of these potential additional PCB sources. Response to Master Comment 809 in Chapter 3 of this document contains information on floodplain exposure pathways as they relate to ecological receptors.

Master Comment 825

It was suggested that EPA should have assumed the presence of some PCBs in tributary inflows during its model projections when comparing the benefits of source control to its proposed dredging plan, as opposed to assuming that PCBs will enter the Site only from upstream.

Response to Master Comment 825

EPA assumed the presence of some PCBs in tributary inflows during model calibration, but not during forecast simulations for No Action, MNA, or any of the active remediation scenarios. This was done because the primary interest from a regulatory decision-making perspective was to determine the incremental benefits from remediating the sediments. Omission of PCBs in tributary inflows allowed differences between and among the various scenarios to be more clearly distinguished.

In terms of their magnitudes, tributary loadings of PCBs were relatively small during the model calibration period and it is reasonable to assume that they will continue to decline slowly over time as the atmospheric background decreases (RBMR, Figure 6-51; USEPA, 2000) and readily-transportable PCBs on land are exhausted. In the final calibration year (1997) for the HUDTOX fate and transport model, PCB loadings from all tributaries except the Mohawk River were less than nine percent of the PCB loading across the upstream boundary at Fort Edward. The Mohawk River enters the Upper Hudson River below Waterford and just before Federal Dam at Troy. Consequently, PCB loadings from the Mohawk do not influence PCB concentrations in water, sediments, or fish in most of the upper river.

It is not inconsistent to omit tributary loadings of PCBs, but to include PCB loadings across the upstream boundary at Fort Edward in the model forecast simulations. Tributary PCB loadings are relatively small and are expected to decline slowly over time as atmospheric background concentrations decline. PCB loadings at Fort Edward are controlled primarily by continuing inputs from bedrock seepage under the General Electric Plant at Hudson Falls, not by inputs from atmospheric background. After source control at Hudson Falls, EPA has assumed a continuing upstream load at Rogers Island equivalent to an average concentration of 2 ng/L Tri+ PCBs.

Assumptions on tributary PCB loads will not affect comparisons among different remedial alternatives if the same assumptions are used across all forecast simulations, nor will they affect reductions in risk for any individual alternative relative to No Action. Differences in presence or absence of tributary PCBs will affect time-to-target, loading over Federal Dam, and the ultimate, long-term levels of PCBs in the water, sediments, and fish for any individual alternative.

Reference

USEPA. 2000. Phase 2 Report, Further Site Characterization and Analysis. Volume 2D – Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc., January.

Master Comment 835

Commenters asked, if the PCB load from GE plant sites is negligible, *i.e.*, 0 ng/l, what the estimated PCB load over the Federal Dam would be in the year 2035.

Response to Master Comment 835

This comment refers specifically to the CAP-3/10/Select and REM-3/10/Select (selected remedy) scenarios. The HUDTOX model was run for REM-3/10/Select with an upstream boundary concentration of 0 ng/l, beginning in 2005 (White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River). The estimated Tri+ PCB loads over Federal Dam can be highly variable from year to year due to changes in hydrological inputs among the different years and predicted sediment "spikes" in some downstream areas. For this particular run, the estimated Tri+ PCB load over Federal Dam in 2035 was 12.2 kg and the median load for the eleven-year period from 2030-2040 was 7.6 kg. For comparison, the Tri+ PCB load over Federal Dam for the selected remedy (REM-3/10/Select) was 19.6 kg in 2035 and the median load for the 11-year period from 2030-2040 was 13.9 kg. The HUDTOX model was not run for CAP-3/10/Select with an upstream boundary concentration of 0 ng/l.

It should be noted that even if the Tri+ PCB load from the GE plant sites were negligible (*i.e.*, 0 ng/L), the total upstream boundary load would not be zero because there is a small, ongoing background load from upstream of the GE plants. By the year 2030, however, it is reasonable to assume that this upstream background load will have declined to an insignificant level as

atmospheric background decreases (RBMR, Figure 6-51; USEPA, 2000) and readily transportable PCBs on land are exhausted.

It is inappropriate to consider percent reductions in Tri+ PCB loads over Federal Dam without clearly stating that Tri+ loads from tributaries were assumed to be zero in all of the forecast simulations with the HUDTOX model. Response to Master Comment 825 above contains more information on tributary loadings. It is also inappropriate to consider percent reductions in Tri+ PCB loads over Federal Dam without clearly stating the assumptions used for the upstream boundary. In all of the HUDTOX forecast simulations, Tri+ PCB loads over Federal Dam originate from two sources: the sediments and the upstream boundary. Consequently, changes in Tri+ PCB loads over Federal Dam can be due to changes in the upstream boundary and/or changes in sediments due to active remediation. Differences in Tri+ PCB loads over Federal Dam between any two forecast simulations can only be attributed to active remediation if the upstream boundary conditions were the same for both simulations.

Reference

USEPA. 2000. Phase 2 Report, Further Site Characterization and Analysis. Volume 2D – Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc., January.

6.1.2 Spatial Resolution of Modeling

Master Comment 787

Some commenters say that EPA's methodology for identifying sediment areas for remediation is flawed and inadequate because it fails to consider whether and how different sediment areas contribute to PCB levels in fish. They contend that sedimentation rates, sediment stability, and PCB concentrations in the bioavailable surface sediments influence food chain exposures. Several comments suggest that a smaller dredging project could be just as effective as a larger one. On the other hand, other comments suggest that the preferred remedy does not dredge a large enough area and does not account for sub-reach scale exposures because these cannot be captured in the modeling.

Response to Master Comment 787

Fish integrate exposure over temporal and spatial scales depending on species-specific foraging strategies and ranges, prey availability, substrate requirements, and ecological competitiveness. The foraging ranges and habitat and foraging preferences for each of the modeled fish species was discussed in Appendix A of the RBMR and incorporated into the modeling assumptions. Fish exposure is influenced by both sediment and water column pathways, and, in fact, the water column pathway is significant for both pumpkinseed and spottail shiner (forage fish), which in turn are consumed by largemouth bass. Therefore, it is necessary to achieve a general reduction in water column exposure concentrations in addition to reducing sediment exposure concentrations. To achieve both of these goals, PCB concentrations in both cohesive and non-

cohesive sediments in the TI Pool must be reduced. In addition, there is a continued and significant interaction between sediments at depth below the surface layer and the surface sediments to which the food web is directly exposed. This issue is discussed further in Responses to Master Comments 619, 621, and 637 in Chapter 2.

The sediment exposure regime within each pool used to drive the FISHRAND model was selected during the calibration phase of model development to achieve a correspondence with the sampling locations for the available fish monitoring data. This information, together with knowledge of the biology of the fish species and of the physical attributes of the river (*e.g.*, presence of dams and locks etc.), guided the segmentation of the HUDTOX model and subsequent correspondence to exposure zones in the FISHRAND model. In the TI Pool, the HUDTOX model is gridded to include nearshore and channel areas and it was the nearshore segments that were selected to represent exposure to fish in the FISHRAND model. The HUDTOX model is not as finely gridded below the TI Pool, but the lateral gradient in sediment and water PCB concentrations observed in the TI Pool is less downstream of the pool, as discussed in Section 6.3.1.1 of the RBMR. Further discussion on the exposure zones selected to drive the FISHRAND model is provided in Response to Master Comment 779 in Chapter 2.

Note that it would be very difficult for any model to determine the relative impact of remediation at the scale of individual sediment deposits, and it is not biologically realistic to do so. The available data for solids burial rates, sediment mixing depths, and surface sediment PCB concentrations are spatially limited and are not sufficient to calibrate either the EPA or GE fate and transport models at this level of detail. Additional detail on sedimentation/burial and sediment stability is provided in Response to Master Comments 577 and 619 in Chapter 2. Also in Chapter 2, bioavailable PCB concentrations are discussed in Response to Master Comment 637 and Response to Master Comment 633 discusses trends in surface sediment concentrations. Neither the GE bioaccumulation model nor FISHRAND operates on fine spatial scales, but instead use reach-average PCB exposure concentrations in the water column and sediments to compute PCB body burdens in fish. This is consistent with the life histories of the modeled fish species, which have documented foraging and habitat ranges on the order of a mile or more.

There are numerous criteria by which the selected remedy was chosen. Smaller-scale dredging projects were evaluated but rejected as not sufficiently protective, and this issue is discussed further in Response to Master Comment 601 in Chapter 11.

Master Comment 847

A commenter contended that the GE model has the ability to determine the relative impact of remediation at the scale of individual sediment deposits. It was suggested that EPA could and should have used this model to evaluate sediment remediation at various scales, and to develop a rigorous assessment of the benefits and impacts of a broad range of remedial options.

Response to Master Comment 847

The GE PCB fate and transport model does not have the ability to determine the relative impact of remediation at the scale of individual sediment deposits. The PCB modeling by GE does not

achieve a spatial resolution that is any finer than that provided by the EPA HUDTOX fate and transport model.

The GE hydrodynamic and sediment transport models are specified at finer spatial and temporal scales than the EPA HUDTOX model. However, outputs from these models are not used at these finer scales, but are spatially and temporally collapsed before passing them forward for use in the GE PCB fate and transport model. Calibration of the GE PCB fate and transport model occurred at this coarser spatial scale.

There is additional spatial collapsing when results from the GE fate and transport model are passed forward to the GE bioaccumulation model. The GE fate and transport model computes sediment PCB concentrations for multiple sediment segments within each reach of the river. These results are spatially collapsed into a single reach-average PCB concentration before passing them forward for use in the GE bioaccumulation model. In addition, sediment PCB concentrations in only the cohesive sediment areas are passed forward to the bioaccumulation model. The GE bioaccumulation model assumes that fish are not exposed to PCB concentrations in any of the non-cohesive sediment areas in the Upper Hudson River. Finally, with respect to representation of solids, cohesive and non-cohesive solids components in the GE sediment transport model are lumped into a single solids component in the GE PCB fate and transport model.

Apart from model representations, it is important to note that the available data for solids burial rates, sediment mixed depths, and surface sediment PCB concentrations in the Upper Hudson River are spatially limited and are not sufficient to calibrate either the GE or EPA models at the scale of individual sediment deposits.

EPA raised a number of technical questions about the GE models in the Responsiveness Summary for the Baseline Modeling Report (USEPA, 2000). GE presented modifications to its original model (QEA, 1999) in its comments (Appendix L1); however, these modifications did not address the principal EPA technical concerns. These concerns are:

- The GE fate and transport model fails to account for PCB mass stored in noncohesive sediments at depths below 5 cm.

- The GE bioaccumulation model was calibrated to data reported as PCB Aroclor sums in fish without proper adjustments to account for known changes in analytical methods over time.

- These PCB Aroclor sums are not directly comparable to Tri+ PCB, the calibration target for the GE fate and transport model.

- A significant downward adjustment was necessary to the Tri+ PCB water column concentrations computed by the GE fate and transport model during 1984-1989 to improve the apparent fit of the bioaccumulation model to the fish data.

- The assumed trapping efficiencies used to estimate tributary solids loads appear inconsistent with long-term estimates of solids trapping efficiencies computed by the GE sediment transport model.

In sum, the GE PCB fate and transport and bioaccumulation models have a spatial resolution that is similar to the EPA HUDTOX model, but somewhat less precise because only the cohesive sediment concentrations are ultimately used to predict fish body burden. EPA does not believe that the GE model has the ability to determine the relative impact of remediation at the scale of individual sediment deposits, nor that it is a better tool than the EPA model for developing a rigorous assessment of the benefits and impacts of a broad range of remedial options.

References

Quantitative Environmental Analysis (QEA). 1999. PCBs in the Upper Hudson River, Volume 2 – A Model of PCB Fate, Transport and Bioaccumulation. Prepared for General Electric, Albany, New York. May.

USEPA. 2000. Responsiveness Summary for Volume 2D – Baseline Modeling Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, Inc., and Tetra-Tech, Inc. February.

6.1.3 Post-Remediation Sediment Residuals

Master Comment 837

Commenters suggested that EPA should have provided a summary of sensitivity analyses on residual surface concentrations post-remediation, improper cap placement, and changes in upstream boundary conditions.

Response to Master Comment 837

Sufficient sensitivity analyses were conducted to establish the technical defensibility of the selected remedy. As part of the refined engineering modeling, EPA conducted sensitivity analyses on residual surface concentration after dredging and improper cap placement. These runs are listed in Section 5.3.1.6 of the FS and results are shown in Appendix D. Figures RE85-RE98 of the FS contain results for residual surface concentration. The range of residual surface concentrations in these analyses was between 0 and 5 ppm, and was selected to bound a reasonable range of possibilities. Results for improper cap placement are shown in Figures RE99-RE112 of the FS.

It should be noted that the 1 ppm residual surface concentration in the selected remedy is highly conservative. The targeted fine-grained sediment areas in the Upper Hudson River are generally underlain by older, fine-grained sediments, thus permitting sufficient overcutting to reach relatively pristine sediments. When overlaid with 12 inches of clean backfill material, final residual surface concentrations are expected to be even lower than the target surface

concentration of 1 ppm after dredging. Response to Master Comment 579 in Chapter 10 and White Paper – Post-Dredging PCB Residuals contain additional details.

In response to concerns about assumptions on source control in the selected remedy, sensitivity analyses were conducted for MNA and the selected remedy in which the upstream boundary Tri+ PCB load was reduced to zero upon commencement of dredging activities. Results indicated that elimination of the upstream boundary Tri+ PCB load does not diminish the relative separation between the selected remedy and MNA for Tri+ PCB concentrations in water, surficial sediments, or fish. White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River contains additional information.

Master Comment 407876

Commenters noted that the sediments may contain contaminants other than just PCBs. In particular, commenters mentioned heavy metals, pesticides, and dioxins. Questions were raised regarding the fact that these other contaminants were in the same Upper Hudson sediments, and yet they were not being targeted for remediation. Many commenters suggested that the metals and other contaminants are safely buried and were concerned that the removal of sediments under the preferred remedy would result in residual concentrations of metals that would pose an environmental and human health hazard.

Response to Master Comment 407876

Upper Hudson River sediment collection and analysis have shown that some metals such as cadmium, chromium, mercury, and lead are contained within the same sediments as the PCBs at levels exceeding background concentrations (White Paper – Metals Contamination). However, the data also suggest (Figure 253002-1 in the white paper) that elevated concentrations of heavy metals found in these sediments coincide with those of PCBs.

This co-depositional pattern observed in Figure 253002-1 is based on the coincidence of elevated metal and PCB concentrations from each of the two cores analyzed. Due to this coincidence of the heavy metals and PCBs, the implementation of the selected remedy will effectively remove the heavy metals at the same time the PCB contaminated sediments are removed. Table 253002-12 in White Paper – Metals Contamination illustrates that the residual metal concentrations after the targeted PCB sediments are removed will be near, or in some cases below, background levels. NYSDEC sampled selected metals (*e.g.*, mercury, cadmium, chromium, mercury, nickel, lead, strontium, and vanadium) in fish above (RM 201.3) and adjacent to the Hercules/Ciba-Geigy paint factory (RMs 198.3 and 198.2) to determine concentrations of selected metals in fish (Table 253002-10). In 1988, elevated concentrations of cadmium and chromium were detected in carp liver tissue samples collected near the paint factory. NYSDEC analyzed mercury and cadmium in selected 1997 and 1998 fish samples from RMs 201 and 189 and did not detect any cadmium, although no liver samples were analyzed.

A NYSDEC memo (Sloan, 1999) concluded that other contaminants (*e.g.*, DDT, mercury, PAHs, dioxins, and dibenzofurans) are present in the Hudson River, but do not represent as great a problem as PCBs. Remediation of PCB-contaminated sediments will not only lower the

concentrations of PCBs to which fish are exposed, but will also reduce levels of metals and dioxins, since these co-occurring contaminants will be removed with PCBs. Current fish advisories in the Hudson River are based upon PCB concentrations. Modifications in these advisories will be based upon reductions in PCBs, rather than on other contaminant concentrations.

Dioxins were detected in four samples from the sediment core collected in 1991 at RM 188.6 (White Paper – Dioxin Contamination, Table 860-1), two samples collected in 1983 from RM 188.5 and RM 191.1 (Table 860-2), and in *Hot Spot* 8 from sediment collected in 1987 (Table 860-3). Based on the limited data found in the foregoing referenced tables, the dioxin and furans seem to coincide with the PCBs, similar to the metals. However, additional sediment sampling and analyses need to be implemented during the selected remedy design phase in order to better understand the extent of dioxins and furans within the Upper Hudson River sediments.

NYSDEC fish dioxin/furan data show the presence of dioxins/furans in some upper river fish; however, detection frequencies and concentrations are higher in the lower river, indicating the influence of independent contaminant sources (White Paper – Dioxin Contamination, Table 860-4).

The data available for metals and dioxins/furans indicate that the implementation of the selected remedy will also remediate the bulk of contaminants other than PCBs at the same time that the targeted PCBs are being removed. Residual concentrations for both metals and dioxins/furans are expected to be near background levels and well within acceptable levels after active remediation.

Reference

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

6.1.4 Resuspension

Master Comment 591

It was claimed that EPA uses reduction in the transport of PCBs to the Lower Hudson River to justify dredging, without quantifying actual risk reductions to the Lower Hudson. A commenter contended that evaluation of the model results illustrates that the dredging alternative will provide a 15 percent reduction in the PCB load over the source control alternative, but using "more realistic" dredging assumptions actually shows a 15 percent increase in the PCB load to the Lower Hudson.

Response to Master Comment 591

EPA does not agree that the dredging assumptions on which this comment is based and which lead to conclusions of an increase in PCB load to the Lower Hudson River, relative to source control are "more realistic." These assumptions include resuspension and release of 2.5 percent of target PCB mass during dredging, a project implementation period of 10 years, and residual

concentrations of 5 ppm in dredged areas that are not backfilled. EPA believes that the dredging assumptions in the Feasibility Study are reasonable and technically defensible; under these dredging assumptions, the selected remedy will reduce the PCB load to the Lower Hudson River, relative to source control alone. Nevertheless, as described in Response to Master Comment 823 elsewhere in Section 6.1 of the Responsiveness Summary, EPA has performed sensitivity analyses for PCB loss during dredging.

EPA did quantify the relative human health and ecological risks in the Mid- and Lower Hudson River, respectively, under the various remedial alternatives (Response to Master Comment 413, Chapter 1). In response to comments received on the Feasibility Study, EPA calculated Mid-Hudson human health cancer risks and non-cancer hazard indices and Lower Hudson River ecological toxicity quotients (TQs) for the remedial alternatives in the Feasibility Study (Response to Master Comment 799, Section 6.3). Human health and ecological risks associated with additional selected remedy assumptions are described in White Paper – Relative Reduction of Human Health and Ecological Risks in the Mid- and Lower Hudson River.

Master Comment 363207

Commenters stated that EPA did not include a resuspension flux from dredging in its model forecasts. Resuspension from dredging will yield a significant PCB flux to the river. Inclusion of resuspension in the forecasts will slow the rate of recovery of the river.

Response to Master Comment 363207

Possible impacts of resuspension of PCBs during dredging have been incorporated into model simulations for the revised remedy schedule through inclusion of two different estimated dredging-induced PCB resuspension rates during the proposed dredging season each year. The assumed resuspension rates for these simulations were 0.13 percent (as derived in Appendix E.6 of the FS report and described in the White Paper – Resuspension of PCBs during Dredging) and 2.5 percent sediment mass loss to the water column. However, EPA believes that the 2.5 percent loss rate is unrealistically high and that the 0.13 percent loss rate is a justifiably conservative estimate (FS, Appendix E.6 and White Paper – Resuspension of PCBs during Dredging).

The implications of resuspension PCB flux from dredging the river and a revised schedule for the sediment removal are covered in detail in White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River. The model results demonstrated that while dredging-induced resuspension of sediment will likely increase PCB levels in the water column (as measured by either concentration or load passing a given location) and in fish, the impacts will largely be confined to the years during which the active remedy is implemented, regardless of whether the loss rate applied is 0.13 percent or 2.5 percent. Impacts from dredging-induced resuspension (at either rate) are also predicted to occur in downstream surficial sediments, but the increases in concentration are small relative to existing PCB contamination levels. While the 0.13 percent loss rate shows a negligible increase in predicted fish PCB body burdens for the period of dredging, a loss rate of 2.5 percent shows a notable increase for the period of dredging, but quickly drops following dredging to levels commensurate with the other active remediation modeling scenarios.

The effects of the dredging-induced resuspension of PCB on the fish were modeled using FISHRAND. The FISHRAND model used the averaged sediment and water concentrations from the HUDTOX model for each modeling segment as inputs. A detailed description of the FISHRAND modeling results can be found in White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River, and are summarized as follows. A comparison of the five-year implementation of the selected remedy without dredging-induced PCB resuspension (model simulation run R14S2, presented in the FS) and the selected remedy including the section-specific loss estimate (0.13 percent) for dredging-induced PCB resuspension (model simulation run R14RS) shows that the difference in predicted fish body burdens is no more than approximately 15 percent and typically less than 10 percent for all species and locations in the Upper Hudson River.

A comparison of predicted body burdens under the five-year versus six-year implementation schedule, both assuming the section-specific loss rate (0.13 percent) for dredging-induced PCB resuspension, shows that PCB resuspension has the greatest effect on brown bullhead, with an increase in PCB body burden as high as 100 percent at RM 189 (White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River).

The differences among predicted fish concentrations are typically greater for fish species in which PCB bioaccumulation has a significant component associated with water column exposure pathways than for species in which bioaccumulation is primarily driven by sediment exposure pathways. Thus, greater impacts of dredging-induced resuspension are predicted for largemouth bass and yellow perch, both of which accumulate a portion of their PCB body burdens via food chain pathways that ultimately derive from the water column. In contrast, brown bullhead, which derive a larger proportion of their PCB body burden from sediment-associated food chain pathways, exhibit a smaller response to dredging-induced resuspension.

At RM 189, the predicted differences in brown bullhead body burden from the longer implementation schedule are greater than the predicted differences between the two resuspension assumptions. For largemouth bass and yellow perch, the 2.5 percent resuspension assumption has a greater effect than the difference between the implementation schedules. At RM 154, the effects of resuspension on fish body burden are similar, but last slightly longer than at locations farther upstream.

In summary, resuspension has a limited, temporary effect on fish PCB body burdens. Ecological and human health risk evaluation of the selected remedy with dredging-induced resuspension PCB inclusion is presented in the White Paper – Human Health and Ecological Risk Reduction under Phased Implementation. No major differences in human health or ecological risk were seen among the various alternatives with PCB resuspension inclusion. In general, target concentrations were achieved within a short time frame and risks were similar. Increased resuspension results in approximately a one-year delay in achieving target concentrations.

Master Comment 407907

Commenters expressed concerns about the effects of an earthquake on PCB contamination. They state that the Hudson lies on a fault line.

Response to Master Comment 407907

The Upper Hudson valley is not an area containing major active fault zones. The northeast region of the United States is a passive continental margin whose seismic activity declined greatly more than 100 million years ago. The rifts and faults in the Hudson valley are remnant terranes associated with Mesozoic rifting. Most notable among these are the Hartford rift basin in central Connecticut and central Massachusetts, and the Newark rift basin in the greater New York City area. These fault zones are largely limited to the Lower Hudson and cross the river (*i.e.*, the river is sub-perpendicular to the faults).
Geological features such as these are "scars" of ancient geological episodes throughout New England and adjacent areas; nonetheless, it has been hard to find any unequivocal relationship between these geological features and seismicity in this area. The risk of earthquakes in New England and the Hudson River valley is not zero (over 1,000 earthquakes have hit the Northeast over the last 360 years, according to the USGS, 2001). The bedrock in this area, however, is composed mainly of stable basement rocks such as ancient granites, as well as other igneous intrusives and massive metamorphic rocks and poses little, if any, threat of tectonic activity. The Upper Hudson extends into the Adirondack Mountains, which are over 500 million years old and seismically quite inactive.

Earthquake hazard maps provide an estimate of the level and frequency of expected geologic activity. Hazard maps for New York show a 90-percent likelihood that no earthquake larger than 0.19 G will strike the Hudson Valley in the next 250 years. And it is also ninety percent likely that no earthquake larger than 0.09 G will strike the Hudson Valley in the next 50 years. A 0.19 G earthquake could cause older structures including dams to fail. A 0.09 G earthquake would probably cause only minor damage and old structures, including dams, should remain in place. (Note that the values given here represent an acceleration relative to the earth's gravity [G]. This is not the same scale as the Richter scale values given in the following text.)

The last significant earthquake in the northeastern United States was a magnitude 5.2 on the Richter scale centered in Pymatuning Reservoir, Pennsylvania, in 1998. The last significant earthquake near the Hudson Valley was a magnitude 5.6 centered in Massena, New York in 1944. These represent extreme events in the region. Earthquakes of this size can topple chimneys, but they are insufficient to move large masses of earth. The geologic stability of the eastern North American Plate is not conducive to mudslides or landslides as a result of seismic activity. Notably, the Champlain Canal itself and many of its structures predate the event at Massena, and thereby have withstood the largest recorded earthquake in the region. Therefore, it is judged unlikely that a seismic event would reintroduce previously-removed material containing PCBs to the Hudson River.

References

Lamont-Doherty Cooperative Seismographic Network. 2001. Web page accessed Sept. 24, 2001. http://www.ldeo.columbia.edu/LCSN

Weston Observatory – Boston College. 2001. Web page accessed Sept. 24, 2001 http://www2.bc.edu/~kafka/Why_Quakes/why_quakes.html .

USGS. 2001. Web pages accessed Sept. 24, 2001 http://geology.cr.usgs.gov/pub/i-maps/i-2737/; http://geohazards.cr.usgs.gov/eq/html/genmap.html.

6.2 Bioaccumulation Modeling

Master Comment 785

Commenters state that an unexplained factor in the behavior of the FISHRAND model is the very sudden (almost vertical in some cases) drop in fish PCB concentrations as soon as dredging is completed. Commenters say the sudden decrease is questionable and request EPA to provide more detail on why the EPA model predicts this behavior.

Response to Master Comment 785

Predicted fish body burdens predominantly reflect sediment and water exposure concentrations. Although the model is designed to simulate changes in predicted fish body burdens on monthly time scales, the results are presented as annual averages, which integrates the variation in the month-specific predicted body burdens. In the model calculations, the assumption is that the upstream source is controlled at approximately the same time that dredging is completed; thus, the fish experience the effects of source reduction and remediation simultaneously, accounting for a dramatic decrease in predicted fish concentrations. In addition, the "near vertical drop" is also a function of the scale of the graphs presented in the report. The decrease reflects remediation and source control effects imposed on top of already declining body burden trends.

The depuration rate computed by the FISHRAND model is compared to observed depuration rates from a laboratory study in Response to Master Comment 779 (Chapter 2) and found to be comparable. White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River provides the results and a discussion of predicted fish body burdens across No Action, Monitored Natural Attenuation, and various assumptions under the selected remedy. The rate of decline in predicted fish tissue concentrations relative to the rate of decline observed from the data is discussed in White Paper – Trends in PCB Concentrations in Fish in the Upper Hudson River and in Response to Master Comment 627, Chapter 2. Additionally, Responses to Master Comments 631 and 633, also in Chapter 2, discuss the rate of decline in water concentrations and in sediment concentrations, respectively.

Master Comment 789

Comments were received suggesting that it is not possible to discern differences in projected fish body burdens based on the observed variability from monitoring data. Commenters said that the period of time when one can have confidence that the projected fish concentrations are different is when the 95 percent confidence interval for dredging is not intersected by the 95 percent confidence interval for source control. When this uncertainty is taken into account, it is apparent that for all practical purposes, one cannot distinguish between the results expected from EPA's dredging project and from source control. In fact, commenters say, EPA has seriously overstated the uncertainty associated with the models and the availability of data to test those models.

Response to Master Comment 789

EPA believes that projected fish body burdens of PCBs for the selected remedy are significantly different from those for the MNA Alternative. Comments questioning the existence of significant differences are largely based on Appendix I of GE's comments. This appendix presents a methodology for estimating the expected "variability" in projected fish body burdens presented in the FS. It concludes that "the differences between source control (MNA) and dredging plus source control (REM 3/10/S) will not be significant for most of the model projection time frames." EPA disagrees with this conclusion, and finds that the analysis presented in GE's Appendix I is invalid due to serious conceptual and technical flaws. Reasons for EPA's disagreement are presented below.

Model Projection Basis

Although GE's Appendix I is concerned with estimating the variability in EPA's model projections, the study does not use EPA's model results. Instead, it is based on a rerun of EPA's model projections "using several realistic assumptions" that increase the time required for dredging, the dredging resuspension rate, and the residual surface concentration. EPA believes that these assumptions are not more "realistic," as described in Response to Master Comment 823 in Section 6.1. In any case, it is important to note that GE's Appendix I does not address uncertainty in the EPA model predictions, but rather uncertainty associated with an alternative GE model application.

Sources of Uncertainty

GE's Appendix I notes that the variability in environmental measurements is due to the combination of natural environmental variability and analytical uncertainty. The focus of its analysis, however, is on the analytical uncertainty. That is, GE is not estimating the "variability" associated with the model projections, but rather the variability associated with potential confirmatory samples subject to analytical error as described by two standard errors on the mean. This is not the relevant measure. If two potential actions have different results, EPA would like to choose the better one, regardless of analytical variability. Analytical variability can usually be reduced. It has no bearing on the uncertainty in the population mean; rather, it affects the ability to test and confirm changes in the population mean. The natural environmental variability and the uncertainty in the model itself are the relevant sources of variability for the analysis, but GE does not address these.

Basis for Evaluating Analytical Uncertainty

GE's Appendix I uses the historical NYSDEC fish data to evaluate sample variability. While this is a large and valuable database for estimating the mean PCB concentrations in fish in the Hudson River, it is not an appropriate basis for estimating variability in future samples. The NYSDEC fish data have been analyzed using packed column GC, and quantitated against Aroclor standards using a limited subset of chromatogram peaks. As discussed in the RBMR (USEPA, 2000), this approach can introduce substantial error into the estimation of total PCBs or Tri+ PCBs. Further, NYSDEC's laboratories have changed methods, standards, and reference peaks over time, so that the data over time are not expected to possess constant error characteristics. Modern capillary column GC methods, such as those used by EPA for the Phase 2 sampling effort (Data Evaluation and Interpretation Report [DEIR], USEPA, 1997), substantially reduce the analytical uncertainty.

Wet Weight Basis

The analyses in GE's Appendix I are concerned solely with the variability in samples analyzed on a wet weight basis. As GE itself states in Appendix H of its comments, much of the variability in wet weight PCB concentrations is due to variability in lipid content, and "lipid normalization reduces variability." GE continues to state that "lipid-based values are used to provide a more accurate interpretation of long-term trends than wet weight-based values can provide." EPA agrees with these specific statements made by GE in its Appendix H. The analysis of uncertainty in GE's Appendix I should have been conducted on a lipid basis, with transformation back to wet weight values if necessary. In small samples, the distribution of fish lipid content may not be representative of the population mean. The analysis of model uncertainty based directly on wet weight values is inappropriate and serves to artificially inflate the estimates of variability.

Statistical Approach

GE's Appendix I notes that the standard error of fish samples appears to increase with the mean of total PCBs. It then proposes to evaluate the standard error of future samples based on a linear regression of the standard error on the sample mean. This approach is misguided on several accounts. First, the observation of increasing variance with increasing mean is a common phenomenon in environmental data, known as heteroscedasticity. A variety of statistical tests are available for heteroscedasticity, but none was documented by GE. In many cases, heteroscedasticity can be reduced or eliminated through use of a suitable transformation of the data, such as a logarithmic transformation.

Use of simple linear regression to estimate the standard error from the mean is not valid. Both the standard error (the dependent variable in the regression) and the mean (the supposedly independent variable) are quantities calculated from the observations. Indeed, the standard error can be written in terms of the mean. Clearly, the uncertainty in estimating the standard error is correlated with the mean. The presence of contemporaneous correlation means that the ordinary least squares linear regression estimate is biased, even asymptotically (Kennedy, 1979). In addition, the interpretation of the R2 value is incorrect.

Determination of Overlap

GE's Appendix I uses a graphical method to compare the period "when overlap is expected" between the MNA and REM-3/10/Select Alternatives, stating "that the projected intervals are expected to be different when both upper and lower bounds of MNA are lower than the lower bounds of REM 3/10/S, or when both upper an lower bounds of REM 3/10/S are lower than the lower bound of MNA." The bounds selected by GE are the 95 percent confidence intervals. In other words, GE has constructed a hypothesis test based on the following expression:

$$(M_1 - M_2) \pm z \text{ x } (SE_1 + SE_2)$$

in which

M_1 is the mean of projection 1
M_2 is the mean of series 2
SE_1 and SE_2 are the corresponding standard errors
z is the value of the standard normal distribution at the appropriate confidence level

The null hypothesis that the two means are the same cannot be rejected if the interval estimate covers 0. (Note that GE uses a value of *z* equal to 2, rather than the correct value of 1.96, further inflating the estimate).

GE has not constructed the correct hypothesis test. As shown in Wonnacott and Wonnacott, (1977), the correct hypothesis test for the difference in two means is given by the following expression, with a pooled variance estimator:

$$(M_1 - M_2) \pm z \text{ x } (SE_1^2 + SE_2^2)^{0.5}$$

The sum of the standard errors is not equal to the square root of the sum of the squared standard errors. In fact, the simple sum used by GE will tend to be much larger. For instance, if $SE_1 = 2$ and $SE_2 = 4$, then:

$$(SE_1 + SE_2) = 6$$
$$\text{while } (SE_1^2 + SE_2^2)^{0.5} = 4.472.$$

As a result, GE's Appendix I assigns an overlap between model projections that is much larger than is appropriate for comparison of two means.

Summary

The information presented in GE's Appendix I is based on a faulty premise, that analytical variability in historical NYSDEC fish sampling results is a relevant measure of the uncertainty in model projections, and uses incorrect statistical tests.

In general, the uncertainty in predictions from complex environmental models is difficult to evaluate quantitatively. The major relevant sources of uncertainty are:

- Uncertainty in the future values of external forcing functions, such as flows.
- Uncertainty in the calibrated values of model parameters.
- Any errors in model specification.

Given the complexity of the model and the many sources of uncertainty, the best basis for evaluating net prediction uncertainty is through the use of sensitivity analyses. These are presented in the RBMR (USEPA, 2000), and referenced in the FS. As is acknowledged in the FS, Section 8.1.5.4, "It is important to remember that forecasts are subject to considerable uncertainty. Therefore, the estimate year of target attainment should be considered as a general guide. The estimates serve best as a basis for comparison among alternatives where large differences (5 to 10 years or more) among alternatives in attaining a PRG can be identified."

References

Kennedy, P. 1979. *A Guide to Econometrics*. The MIT Press, Cambridge, MA.

USEPA. 1997. Phase 2 Report, Further Site Characterization and Analysis. Volume 2C – Data Evaluation and Interpretation Report (DEIR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., The Cadmus Group, Inc. and Gradient Corporation. February.

USEPA. 2000. Phase 2 Report, Further Site Characterization and Analysis. Volume 2 – Revised Baseline Modeling Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc. January.

Wonnacott, T.H. and R.J. Wonnacott. 1977. *Introductory Statistics*, Third Edition. John Wiley & Sons, New York.

6.3 Lower Hudson River Modeling

Master Comment 799

Some commenters requested that alternative-specific modeling be performed for the Lower Hudson River for both human health and ecological risks. Some commenters contended that resources downstream in the Lower Hudson will be protected by dredging.

Response to Master Comment 799

In response to comments received, EPA calculated Mid-Hudson human health cancer risks and non-cancer hazard indices and Lower Hudson River ecological TQs for alternatives evaluated in the FS (*i.e.*, No Action, MNA, CAP-3/10/S, the selected remedy [REM-3/10/Select], and REM-0/0/3 Alternatives), using the same assumptions as in the FS. Human health and ecological risks associated with additional selected remedy assumptions are described in White Paper – Relative Reduction of Human Health and Ecological Risks in the Mid- and Lower Hudson River.

Risk Evaluation

The locations modeled in the lower river (below Federal Dam at RM 153.9) are consistent with those modeled in the Revised Human Health Risk Assessment (RHHRA; USEPA, 2000a) and the Revised Baseline Ecological Risk Assessment (RBERA; USEPA, 2000b). The lower river was divided into four segments for evaluating conditions. These segments are located at RM 152 (encompassing RM 153.5 – 123.5); RM 113 (encompassing RM 123.5 – 93.5); RM 90 (encompassing RM 93.5 – 63.5); and RM 50 (encompassing RM 63.5 – 33.5). This covers the Hudson River from below Albany to Ossining, a river length of about 120 miles. The assigned river mile for each segment corresponds to the historical NYSDEC monitoring location in that region.

This comparison uses the same methodology and assumptions that were used in the RHHRA (USEPA, 2000a) and RBERA (USEPA, 2000b). Exposure parameters, toxicity values, and time frames used herein are consistent with those used to model future PCB concentrations in both reports. However, for all alternatives considered here, sediment concentrations were calculated using the 0-2.5 cm layer, as discussed in White Paper – Relative Reduction of Human Health and Ecological Risks in the Mid- and Lower Hudson River.

The start years used to calculate risks are based on the five-year dredging period used in the FS for REM-3/10/S and CAP-3/10/S and a seven-year dredging period for REM-0/0/3. A start date of 2010, the year immediately after the equilibration period following completion of the preferred remedy, was used to calculate human and ecological risk. The REM-0/0/3 Alternative was anticipated to take two years longer for completion; therefore, a start date of 2012 was used. No Action and MNA Alternatives were calculated for both start years, so that comparisons of active alternatives to passive alternatives are made on the same basis. The exposure periods used in the RHHRA and RBERA are used for this analysis, extending up to 2049/2051 for human health risks and to 2034/2036 for ecological risks. As modeling for the lower river was only performed through 2046, the concentrations calculated for 2046 were used to estimate fish concentrations beyond 2046 for the 40-year RME cancer exposure.

The equations and methodology used to calculate risks and risk reduction are described in Chapter 7 of the FS (USEPA, 2000c). Relative reductions in cancer risks, non-cancer health hazards, and ecological TQs are calculated to provide an estimate of risk reduction under the preferred and other alternatives.

Cancer Risks and Non-Cancer Health Hazards and Relative Reductions

Time to Reach Human Health-Based Fish Target Levels

The species-weighted fish fillet average PCB concentrations calculated for each of the three Mid-Hudson River sections (RMs 152, 113, and 90) for the final alternatives examined in the FS are presented in Table 799-1. This table highlights the preliminary remediation goals (PRG of 0.05 ppm PCBs wet weight in fillet with additional target concentrations of 0.2 ppm and 0.4 ppm PCBs wet weight) reached within the modeling time-frame.

At RM 152, the 0.4 ppm target is achieved in 2010 – 2012 for the active alternatives, in 2016 for MNA, and in 2019 for NA (Table 799-2). The 0.2 ppm target concentration is achieved in 2016 –

2018 for the active alternatives, in 2023 for MNA, and beyond 2046 for NA. The target concentration of 0.05 ppm is not reached by 2046 for any alternative. At RM 113, the 0.4 ppm target is reached by all alternatives prior to the completion of remediation between 2007 and 2009, the 0.4 ppm target concentrations is reached by the active alternatives between 2011 and 2012, for MNA in 2016, and for NA in 2022. The 0.05 ppm target is reached only by the REM-0/0/3 Alternative in 2033. At RM 90, the 0.4 ppm target concentration is reached by alternatives in 2006 prior to the completion of remediation. The 0.2 ppm target concentration is achieved by active alternatives between 2011-2012, for MNA in 2014, and for NA in 2019. The 0.05 ppm target is reached only by the REM-0/0/3 Alternative in 2028.

Non-Cancer Health Hazards

Non-cancer No Action Alternative health hazard indices for the central tendency (CT) and reasonable maximum exposure (RME) range from:

- 0.8 – 11 for the Mid-Hudson average.
- 1.4 – 19 at RM 152.
- 0.6 – 8.3 at RM 113.
- 0.5 – 6.5 at RM 90, using start years of 2010 and 2012 (Table 799-3).

MNA hazard indices for the 2010/2012 CT and RME scenarios range between:

- 0.5 – 7.5 for the Mid-Hudson average.
- 0.8 – 12 at RM 152.
- 0.4 – 5.5 at RM 113.
- 0.3 – 4.7 at RM 90.

The CAP-3/10/S hazard quotients for the CT and RME scenarios, respectively, are:

- 0.4 and 5.5 for the Mid-Hudson average.
- 0.7 and 8.6 at RM 152.
- 0.3 and 4.1 at RM 113.
- 0.3 and 3.8 at RM 90.

The selected remedy hazard quotients for the CT and RME scenarios are:

- 0.4 and 5.3 for the Mid-Hudson average.
- 0.6 and 8.2 at RM 152.
- 0.3 and 4.0 at RM 113.
- 0.3 and 3.7 at RM 90.

The REM-0/0/3 Alternative yields hazard quotients of:

- 0.3 and 3.7 for the mid-Hudson average.
- 0.4 and 5.5 at RM 152.
- 0.2 and 2.8 at RM 113.
- 0.2 and 2.7 at RM 90.

Hazard quotients under the central tendency scenario are all below the target level of one, with the exception of the No Action Alternative at RM 152, which has a hazard quotient of about 1.5.

The MNA Alternative shows a 28 to 40 percent reduction in non-cancer hazards as compared to the No Action Alternative, depending on the river section and time frame examined (Table 799-3). CAP-3/10/S achieves a 42 to 54 percent RME hazard index reduction compared to No Action. Comparisons to the CT scenario show slightly higher risk reductions, ranging from 46 to 57 percent. There is a 19 to 31 percent risk reduction when CAP-3/10/S is compared to the MNA Alternative. The selected remedy achieves a 42 to 56 percent RME hazard index reduction compared to No Action. Comparisons to the CT scenario show slightly higher risk reductions, ranging from 47 to 58 percent. There is a 21 to 33 percent risk reduction when the selected remedy is compared to the MNA Alternative. REM-0/0/3 achieves a 55 to 65 percent RME hazard index reduction compared to No Action. Comparisons to the CT scenario show slightly higher risk reductions, ranging from 57 to 67 percent. There is a 32 to 45 percent risk reduction when REM-0/0/3 is compared to the MNA Alternative. The largest reductions in hazards are seen at RM 152, the location closest to the source. Hazard reductions are lower downriver, as transport of PCBs is greatest near the Thompson Island Pool and concentrations of those PCBs that are transported downriver are diluted by the larger volume of water in the lower river.

Cancer Risks

Incremental cancer risks under the No Action Alternative (start year 2010/2012) range from:

- 2.9×10^{-6} - 1.6×10^{-4} for the Mid-Hudson average.
- 4.6×10^{-6} - 2.7×10^{-4} at RM 152.
- 2.1×10^{-6} - 1.2×10^{-4} at RM 113.
- 1.8×10^{-6} - 9.7×10^{-5} at RM 90 (Table 799-4).

Under the MNA Alternative (start year 2010/2012) risks are:

- 1.7×10^{-6} - 8.2×10^{-5} for the Mid-Hudson average.
- 2.8×10^{-6} - 1.2×10^{-4} at RM 152.
- 1.3×10^{-6} - 6.2×10^{-5} at RM 113.
- 1.1×10^{-6} - 5.3×10^{-5} at RM 90.

CAP-3/10/S yields RME and CT risks of:

- 1.5×10^{-6} and 6.4×10^{-5} for the Mid-Hudson average.
- 2.3×10^{-6} and 9.9×10^{-5} at RM 152.
- 1.1×10^{-6} and 4.8×10^{-5} at RM 113.
- 1.1×10^{-6} and 4.4×10^{-5} at RM 90.

The selected remedy yields RME and CT risks of:

- 1.5×10^{-6} and 6.2×10^{-5} for the Mid-Hudson average.
- 2.2×10^{-6} and 9.6×10^{-5} at RM 152.
- 1.1×10^{-6} and 4.7×10^{-5} at RM 113.
- 1.0×10^{-6} and 4.3×10^{-5} at RM 90.

REM-0/0/3 would result in CT and RME risks of:

- $\times 10^{-6}$ and 5.1×10^{-5} for the Mid-Hudson average.
- 1.5×10^{-6} and 7.8×10^{-5} at RM 152.
- 7.9×10^{-7} and 3.9×10^{-5} at RM 113.
- 7.6×10^{-7} and 3.6×10^{-5} at RM 90.

The MNA Alternative shows a 32 to 53 percent reduction in risk as compared to No Action, depending on the river section and time frame examined (Table 799-4). CAP-3/10/S as compared to NA results in a risk reduction of 55 to 64 percent under the RME scenario and 46 to 57 percent under the CT scenario. There is an 18 to 31 percent risk reduction when CAP-3/10/S is compared to the MNA Alternative. The selected remedy achieves a 56 to 65 percent RME incremental cancer risk reduction compared to No Action. Comparisons to the CT scenario show slightly lower risk reductions, ranging from 47 to 58 percent. There is a 20 to 33 percent risk reduction when the selected remedy is compared to the MNA Alternative. REM-0/0/3 achieves a 62 to 70 percent RME reduction as compared to No Action. Comparisons to the CT scenario range from 57 to 67 percent reduction. There is a 28 to 45 percent risk reduction when REM-0/0/3 is compared to the MNA Alternative. The largest reductions in risk are again seen at RM 152, the most upstream location.

Ecological Toxicity Quotients and Relative Reductions

Mink lowest-observed-adverse-effect-level (LOAEL) TQs are below one at all river miles for all alternatives, except No Action at RMs 152 and 113 (Table 799-5). All mink no-observed-adverse-effect-level (NOAEL) TQs are greater than one. Toxicity quotients for the river otter are above one for all alternatives on a NOAEL and LOAEL basis at all river miles (Table 799-5).

Under the CAP-3/10/S Alternative, the percent risk reduction for the mink and river otter is between 43 and 63 percent as compared to No Action, and between 18 and 31 percent as compared to MNA (Table 799-6). Reductions in TQs between the preferred and No Action Alternatives for the mink and river otter range from 43 to 63 percent. When compared to the MNA Alternative, risk reduction ranges from 18 to 31 percent. The REM-0/0/3 Alternative shows reductions of 51 to 70 percent as compared to No Action and reductions ranging from 26

to 44 percent as compared to the MNA Alternative. The highest percent risk reduction for all active alternatives as compared to the NA and MNA Alternatives is seen at RM 152, with progressively less reduction downriver.

Summary

This analysis shows that the Mid- and Lower Hudson River will also benefit from remedial action in the upper river. Human health non-cancer hazards and cancer risks will be reduced, as will risks to ecological receptors.

References

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

USEPA. 2000b. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E - Revised Baseline Ecological Risk Assessment (ERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc. and Menzie-Cura & Associates, November.

USEPA. 2000c. Phase 3 Report, Feasibility Study. Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District, by TAMS Consultants, Inc., December.

6.4 Interpretation and Use of Model Results

Master Comment 589

Several commenters agreed that EPA's model supports the need to remove contaminated sediment from the Hudson River. However, these commenters felt that the model underestimates the risk and recovery time of the non-removal alternatives. The comments expressed concern that this underestimation may lead to a failure to move quickly on the removal program.

Response to Master Comment 589

EPA's combined modeling pair (HUDTOX and FISHRAND) represents one of the most sophisticated model simulations of any Superfund site to date. EPA is satisfied with the forecasts created by the model for the purposes of evaluating alternatives. Nonetheless, the EPA recognizes that any model has its limitations, especially when used as a forecast tool. There are many assumptions, both internal and external to the model, that will influence the forecast. Any deviations from the set of assumptions will result in a different outcome than that predicted by the model. Recognizing these limitations, EPA has performed several sensitivity analyses as presented in the FS and in the RBMR (USEPA, 2000). EPA has also created an upper bound

estimate for localized areas of contamination (FS, Appendix D1). A more detailed discussion of the upper bound estimate can be found in the Response to Master Comment 609 in this chapter.

In its selection of the remedy, EPA has considered the available model forecasts, data trend analyses, geochemical findings, and risk assessments. Each of these components weighs into the decision and no one component overrides the others. It is EPA's intention to move forward quickly in the implementation of the selected remedy.

Reference

USEPA. 2000. Phase 2 Report, Further Site Characterization and Analysis. Volume 2D - Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, Inc., and Tetra-Tech, Inc. January 2000.

6.4.1 Presentation of Model Results

Master Comment 313990

A commenter said that the table on page 6-33 should include the REM-3/10/Select Alternative.

Response to Master Comment 313990

This table does not include alternative REM-3/10/Select because select areas are defined in a later section (Section 6.4.1.1, page 6-36).

6.4.2 Use of Upper Bound Estimates

Master Comment 609

Commenters criticized EPA's presentation of an upper bound estimate of concentration trends in fish, which yielded a PCB half-life of 50 years for brown bullhead in TI Pool. Commenters characterized this calculation as arbitrary and capricious because it was calculated using only a subset of the available data. Commenters also noted that this calculation does not account for resuspension. Finally, a comment asked why the calculation was only done for the No Action and MNA Alternatives, but not for the capping and removal scenarios.

Response to Master Comment 609

EPA does not agree with the commenter's characterization of EPA's use of the bounding calculation. The bounding calculation was designed as a data-based, semi-empirical analysis of PCB trends in fish to address the possibility that the model predictions regarding natural recovery may be overly optimistic.

EPA continues to believe that the HUDTOX/FISHRAND model projections provide the best available tool for evaluating remedial alternatives in the Hudson River. These forecasts, however, are subject to uncertainty, and limitations in the data available for calibration raises the possibility that the model "best estimate" of trends could be overly optimistic for both the No Action and MNA Alternatives. This is particularly likely at localized spatial scales at which fish feed, and may be reflected in the lack of a clear declining trend in recent fish data collected by NYSDEC in the TI Pool and in the Stillwater-Coveville area. It is thus prudent to consider a reasonable upper bound on the rate of natural recovery.

EPA's calculation of an upper bound estimate represents an interpretation of the recent fish body burden data which reflects the recent trends and events in the Upper Hudson. The calculation is based on the data collected annually by the NYSDEC, a long and well-established data set. It is neither arbitrary nor capricious since it uses the available monitoring data, together with model projections of water column and non-cohesive sediment concentrations, and extrapolates the current trends out into the future.

Due to local variability in the rate of decline in bioavailable PCB contamination in cohesive sediments, there are expected to be localized areas where the rate of improvement will significantly lag behind that of the river as a whole. That is, in areas such as the *hot spots*, the rate of recovery is expected to be much slower than for the river section as a whole. The upper bound calculation is directly based on the regular NYSDEC fish monitoring data collected near RM 189 in the TI Pool in the vicinity of Griffin Island and *hot spots* 13, 14, and 15, as well as data collected from the Stillwater-Coveville area.

The upper bound calculation also makes use of recent sediment data collected by GE, which clearly demonstrates that surface sediment PCB concentrations in certain *hot spot* areas of the TI Pool are not declining as fast as the reach-averaged rates of decline predicted by the model (Response to Master Comment 633, Chapter 2). In particular, surface sediment concentrations have remained elevated in the area of *hot spot* 14, near where NYSDEC fish samples are collected in the TI Pool. These elevated sediment exposure concentrations appear to explain the slow rate of decline in fish tissue concentrations at the TI Pool collection point, which is most notable in brown bullhead, the sampled species whose PCB body burdens are expected to be most closely tied to sediment concentrations.

Accordingly, the upper bound calculation is based on the following assumptions:

- The HUDTOX model provides the best available projection of water column and non-cohesive sediment exposure concentrations, as these exposure concentrations are likely to show less local variability than cohesive sediment exposure concentrations.

- Cohesive sediment exposure concentrations at specific localized areas such as *Hot Spot* 14 are likely to decline at rates that are slower than reach-averaged model projections. The rate of decline in these exposure concentrations is assumed to be equal to the rate of decline in PCB tissue concentrations observed in brown bullhead since control of the upstream source.

The calculation of the upper bound estimate was based on all available fish and sediment monitoring data collected since the PCB seeps at the Hudson Falls plant were largely controlled. Examination of earlier data shows an increase in fish body burdens following the Allen Mill event, followed by a sharp decline as the Hudson Falls seeps were controlled. Only those data collected since the effective reduction in the Hudson Falls seep (from about 1995 onward) were used for this extrapolation of trends into the future. Including data from the earlier 1990s would increase the apparent rate of decline in fish tissue concentration, as the data from prior to 1995 show the response of fish to the reduction in the upstream load and water column exposure concentrations, and not the natural rate of attenuation of in-place sediment exposure concentrations. Examining only the post-1995 data and excluding the temporary impact of the Allen Mill event, it is quite clear that the fish PCB levels obtained from NYSDEC's monitoring location in the TI Pool decline only very gradually. These observations provide direct evidence on the rates of decline that occur under conditions of reduced, relatively stable upstream water column concentrations and naturally attenuating sediment exposure concentrations. A detailed discussion of the trends in fish body burdens, including the most recent (year 2000) data from NYSDEC is included in White Paper – Trends in PCB Concentrations in Fish in the Upper Hudson River). Note that the most recent data reaffirm the analysis included in Appendix D1 of the FS.

The upper bound estimate is based on a subset of the data, but not an arbitrary subset. In keeping with the stated purposes of calculating an upper bound, attention is focused on the species (brown bullhead) and location (NYSDEC's TI Pool fish collection site) for which fish tissue concentrations are shown by the data to be declining at rates slower than predicted by the model on a reach-averaged basis. It is quite likely that there are other locations, as well as other biota, that have not been sampled but for which rates of decline under natural attenuation will be even slower. EPA has chosen, however, to rely on the observed data to calculate an upper bound, rather than extrapolate to unmonitored areas.

The calculation of the upper bound estimate is consistent with the observations of sediment concentrations both in surface sediment composites and in high resolution cores. Both data sets show only a gradual decline in the PCB concentrations of surface sediment and recently deposited sediments, respectively. In the high resolution sediment core data, the most recently deposited layers in both the EPA (1992) collection and the GE (1998) collection show little impact of the Allen Mill event. On this basis it appears likely that this event had little impact on the fine-grained sediments of the TI Pool. Further, comparison of GE 1991 sediment samples (obtained before the Allen Mill event) to those collected in 1998 shows that the near-surface, bioavailable PCB concentrations have declined only slowly, if at all, in several of the TI Pool *hot spot* areas. Further discussion on the trends in the sediments can be found in Response to Master Comments 633, Chapter 2, and White Paper – Relationship between PCB Concentrations in Surface Sediments and Upstream Sources.

EPA did not calculate an upper bound for the capping and removal alternatives. As stated in the Proposed Plan (see pg. 18; USEPA, 2000), the over-optimism associated with modeling of the active alternatives is eliminated wherever PCBs are removed or capped, because model-projected sediment concentrations are replaced by specified concentrations (residual levels) in the remediated areas. Therefore, it was not necessary for EPA to calculate an upper bound for the

active remedial scenarios in order to account for the over optimistic declines of surface sediment concentrations. It should be noted, though, that the EPA did examine the sensitivity of the model outcome to the mean residual concentration (FS, Chapter 9). This can be considered an upper bound on the forecast but does not represent localized heterogeneity.

The Agency's comparison of the relative effectiveness of the remedial alternatives in the FS was based on the results of modeling each remedial alternative as well as on data projections (Proposed Plan, section entitled Rationale for Selection of Preferred Alternative, December, 2000). EPA disagrees that it is arbitrary and capricious to consider data trends for PCB concentrations in fish as part of the remedial decision-making process. Comparisons of the model outputs to such recent data trends suggest that the models may be overly optimistic with regard to the rate of PCB decline in fish predicted under the No Action and MNA Alternatives, and that the models may therefore underestimate the benefits of active remediation. It is entirely appropriate for the Agency to consider multiple lines of evidence and analyses when making a remedial decision for the Site.

Reference

USEPA. 2000. Superfund Proposed Plan, Hudson River PCBs Superfund Site. EPA Region 2, New York. December.

6.4.3 Comparison of EPA and GE Models

Master Comment 843

Some commenters noted that predictions from the EPA and GE models are dramatically different. For example, the GE model predicts that fish would meet the present regulatory PCB limit for consumption (*i.e.,* the 2 ppm FDA tolerance level) in a much shorter time span than the EPA model. Also, EPA does not appear to have made any adjustment to its HUDTOX fate and transport model to reflect the fact that model calibration was conducted before GE source control was in effect. Other commenters noted that although there are differences between the EPA and GE models, they use similar approaches and produce fundamentally the same key results: source control is essential to reducing PCB levels in fish; the Upper Hudson River, and particularly the TI Pool, is net depositional; PCBs in the Upper Hudson River are being buried and sequestered by clean sediment; and a 100-year flood will not materially delay continued reduction of PCB levels in fish. Elsewhere it was recommended that a comparison test of the two models be made by an appropriate impartial source to ensure that EPA has applied the best science available before making any decision about remedial alternatives.

Response to Master Comment 843

Predictions from the EPA and GE PCB mass balance and bioaccumulation models are very similar when both sets of models are run using the same sets of assumptions. Predictions from these models are different when different assumptions are used to drive the models.

The EPA fate and transport model results differ from GE predictions when the EPA models are run using the assumptions in the Feasibility Study for PCB resuspension during dredging, project implementation period, and residual concentrations in dredged areas that are not backfilled. In contrast, GE presents a different set of assumptions that include greater PCB resuspension, longer implementation time, and greater residual concentrations, all of which lead to a greater relative benefit for monitored natural attenuation. EPA is confident that the assumptions used to drive the simulations presented in the FS are reasonable and appropriate. Additional information to support these assumptions is provided in Response to Master Comment 823 in Section 6.1.

During both the calibration period (1977-1997) and the validation period (1998-1999), EPA's HUDTOX model included specification of upstream boundary PCB loadings using actual measured data at Fort Edward (USEPA, 2000a). These data included the impacts of whatever GE source controls were in effect during these two periods, to the extent that the available water column data represented these impacts.

Both the GE and EPA bioaccumulation models produce results for PCB concentrations in fish that are in general agreement with each other when the models are similarly parameterized. Specific model parameterizations for the FISHRAND bioaccumulation model are discussed in Response to Master Comment 779 in Chapter 2. A discussion of uncertainty in the modeling and variability in observed fish concentrations is provided in Response to Master Comment 789 in Section 6.2. The results from the EPA and GE models differ primarily due to different assumptions in the fate and transport modeling regarding resuspension, dredging implementation time, and residual concentrations present after dredging (White Paper – Relative Reduction of Human Health and Ecological Risks in the Mid- and Lower Hudson River.

There are some important differences in the technical approaches between the EPA and GE bioaccumulation models. FISHRAND is a probabilistic population model; that is, the objective of the model is to generate population distributions of predicted fish body burdens. Appropriate statistics can be obtained from these distributions, such as the median, or mean. The GE bioaccumulation model simulates bioaccumulation in an individual fish, but the same equation (QEA, 1999, Equation 5-3) is used to describe the average concentration in the fish population. Use of this equation to predict the average concentration in a population of fish is problematic. If this equation is solved for an average fish (*e.g.*, using average weight, lipid content, etc.) and compared to the average of solutions for 100 individual fish (*e.g.*, each with different individual parameters), the results will likely be very different. This is a source of model uncertainty in the GE model that was not evaluated.

Calibration of the FISHRAND model took into account year-to-year fluctuations in lipid content by incorporating a distribution rather than the actual observed lipid content in any given year, as the GE model does. Using the actual observed lipid content in any given year naturally minimizes the difference between predicted and observed body burdens, and creates the impression that the model is very precise. However, in predicting future concentrations, first it is necessary to predict a fish lipid content, and future predictions can vary considerably depending on the value that is selected. The FISHRAND model simply draws from the same distributions that were used for the calibration period, which means that the model incorporates both the mean and variance in lipid content. In contrast, the GE model assumes a constant lipid concentration for future years.

There are also differences in the way in which the bioaccumulation models are linked to the sediment fate and transport models. These are discussed in Response to Master Comment 779 in Chapter 2 and Response to Master Comment 787 in Section 6.1.2. In addition, EPA did not discard any data as outliers during calibration, unlike the calibration procedure followed for the GE model.

In sum, EPA is confident that its bioaccumulation model provides a valid tool for forecasting future PCB concentrations in fish, and corrects a number of deficiencies present in the GE bioaccumulation model.

EPA disagrees with the interpretation of the bioaccumulation model results presented in comments, which suggested that the selected remedy would not result in an appreciable reduction in fish tissue concentrations relative to source control. While source control is important in reducing fish body burdens in the long term, removal of contaminated sediments removes that ongoing source of PCBs to the system as soon as dredging is completed. The FISHRAND model shows that fish body burdens approach asymptotic values driven by the upstream boundary condition (*e.g.*, the ongoing source at the upstream boundary). Under the selected remedy, predicted fish concentrations decrease dramatically following dredging and achieve concentrations on the order of 10 years that would take forty years to achieve under MNA (and source control) alone.

Comments regarding the role of burial in reducing PCB exposure to fish are overstated. Although the Upper Hudson River may be net depositional, this does not mean that sediments below the surface layer are sequestered from the surface layer and the water column. See Response to Master Comment 637 in Chapter 2. EPA does concur that a 100-year flood event will not significantly impact predicted fish body burdens (Response to Master Comment 364582, Section 6.1.

The EPA models have been peer-reviewed by an independent panel of scientists (USEPA, 2000c). This peer review included examination of key variables in the models and model sensitivity. Subsequent to this peer review, the HUDTOX fate and transport model was further tested by successful validation to additional data collected by GE during 1999 (USEPA 2000d, Appendix A).

Finally, EPA has already reviewed the GE model in detail and compared results from the two models (USEPA, 2000b), and thus further comparison tests are not needed. EPA concluded that the GE fate and transport model is more notable for similarities than for differences from the HUDTOX model, and differences in results between the GE and EPA fate and transport model applications are primarily due to differences in data and interpretation.

References

Quantitative Environmental Analysis (QEA). 1999. PCBs in the Upper Hudson River, Volume 2 - A Model of PCB Fate, Transport and Bioaccumulation. Prepared for General Electric, Albany, New York. May 1999.

USEPA. 2000a. Phase 2 Report, Further Site Characterization and Analysis. Volume 2D – Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, Inc., and Tetra-Tech, Inc. January.

USEPA. 2000b. Responsiveness Summary for Volume 2D – Baseline Modeling Report. Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, Inc., and Tetra-Tech, Inc. February.

USEPA. 2000c. Report on the Peer Review of the Revised Baseline Modeling Report for the Hudson River PCBs Superfund Site. Prepared for USEPA Region 2 by Eastern Research Group, Inc. May.

USEPA. 2000d. Response to Peer Review Comments on the Revised Baseline Modeling Report. Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District, by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, Inc., and Tetra-Tech, Inc. November.

7. ALTERNATIVE-SPECIFIC RISK ESTIMATES

7.1 Alternative-Specific HHRA Issues

Master Comment 549

One commenter wanted to know whether the reference to Table 7-3 (Modeled Post-Remediation PCB Concentrations in Fish - Upper Hudson River) at top of page 7-9 in the FS Report should actually be to Table 7-4 (Species-Weighted Fish Fillet Average PCB Concentration). No mention of Table 7-4 was found in the text by the commenter, who also requested clarification of these two tables.

Response to Master Comment 549

Tables 7-3 and 7-4 of the FS Report both contain information on forecasted PCB (Tri+) concentrations in fish fillets. The difference between these two tables is in the time period covered. Table 7-3 presents the annual mean concentrations in fish used to calculate average PCB concentrations in fish over the various multi-year time frames (7, 12, or 40 years) for non-cancer health hazards and cancer risks. As explained in the Revised Human Health Risk Assessment (USEPA, 2000), the point estimate exposure point concentrations in fish were derived using species ingestion fractions from the 1991 New York Angler Survey. Table 7-4 presents the species-weighted exposure point concentrations by year for the duration of the modeling period (1998-2068), and is referred to in Section 7.3.5.1 of the FS, Time to Reach Human Health Target Levels.

Reference

USEPA. 2000. Further Site Characterization and Analysis, Revised Human Health Risk Assessment (Revised HHRA) Volume 2F, Hudson River PCBs Reassessment RI/FS. Prepared for the USEPA Region 2 and USACE by TAMS Consultants, Inc. and Gradient Corporation. November 2000.

Master Comment 547

With reference to a statement on page 15 of the Superfund Proposed Plan, "The model did not show substantial benefits from remediation in River Section 3," it was suggested that the basis for this statement is not clear. According to the table on page 19 of the Superfund Proposed Plan, the time to reach an average fish concentration of 0.4 ppm in the upper river is reduced by almost 50 percent in REM-0/0/3 compared to the preferred remedy.

Response to Master Comment 547

It is true that the model predicts that the REM-0/0/3 alternative accelerates the time to achieve the 0.4 ppm concentration in fish, relative to the selected remedy when evaluated for the Upper Hudson River as a whole. However, when River Section 3 is compared by itself, there is no real difference in the year in which the 0.4 ppm concentration benchmark is reached for the selected

remedy versus REM-0/0/3 (Table 7-4 of the FS). Note that much of the improvement in the Upper Hudson River as a whole from the REM-0/0/3 alternative is due to the more aggressive removal in River Sections 1 and 2, rather than the removal in River Section 3.

Master Comment 561

A commenter cited page 6-11 of the FS, Conclusions: "Risks ...will continue to remain above target concentrations for at least the next 40 to 45 years, and longer for the PRG (0.05 ppm PCB in fish fillet)" and said the statement appears to be incorrect. Risks remain above target concentrations up to more than 67 years at 0.05, 0.2, or 0.4 ppm PCB target concentrations in fish fillet.

Response to Master Comment 561

This comment is in reference to the Monitored Natural Attenuation (MNA) alternative. The conclusion should in fact state that risks will remain above the 0.4 ppm target concentration for 34 to more than 67 years, above the 0.2 ppm target concentration for 60 to more than 67 years, and above the PRG of 0.05 ppm for more than 67 years. Refer to page 19 of Proposed Plan or the table on page 9-2 of the Feasibility Study. Risks remain above target concentrations up to more than 67 years at 0.05, 0.2, or 0.4 ppm PCB target concentrations in fish fillet only for the No Action (NA) alternative.

Master Comment 841

One commenter noted that page 9-6 of the FS Report, paragraph 2 says, "... health hazard reduction under the REM-0/0/3 alternative represents approximately a 10-percentage-point advantage over the REM-3/10/Select alternative." The contention is that the reduction discussed is substantially less than that derived from the table on page 9-5 over the entire Upper Hudson River. Those figures suggest a 30 to 42 percent range in additional reduction in non-cancer health hazards and cancer risks with REM-0/0/3 compared to REM-3/10/Select. The additional risk reduction is in the range of 33 to 47 percent when REM-0/0/3 is compared to CAP-3/10/Select.

Response to Master Comment 841

The comparisons made in paragraph 2 on page 9-6 of the FS were based on reductions in risk between active alternatives and the NA and MNA alternatives. Both non-cancer health hazard and cancer risk reductions for REM-3/10/Select (selected remedy) and REM-0/0/3 alternatives, as compared to NA and MNA alternatives (considering the Upper Hudson as a whole), are within ten percentage points (see Tables 7-6a and 7-7a of the FS). The comparisons in this comment are made between two of the active remedial alternatives, REM-3/10/Select (selected remedy) and REM-0/0/3. Please see Responses to Master Comment 565 in Section 7.1, and Master Comment 397 in Chapter 1 for additional discussion of the relative risk reduction of the selected remedy and REM-0/0/3.

Master Comment 551

With reference to page 9-26 of the FS Report, Section 9.5.4, paragraph 1, third sentence, the following comment was made: "The alternative target concentration of 0.4 ppm PCBs in fish fillets is met in River Sections 1 and 2 in the short term by REM-0/0/3. The 0.4 ppm target level is attained two (for River Section 1) to five years (for River Section 2) after the remedy is completed."

Response to Master Comment 551

For the REM-0/0/3 alternative, the target concentration of 0.4 ppm PCBs in fish fillets is estimated to be met in year 2013 for River Section 1, year 2015 for River Section 2, and year 2010 for River Section 3.

Master Comment 553

Commenters said that EPA's proposed plan would result in increased risk in the short term to human health and the environment due to PCB resuspension. Several contended that the project will not accelerate the date at which fish caught between Troy and the Northumberland Dam can be eaten.

Response to Master Comment 553

Based on the modeling done to estimate long-term effects, a qualitative evaluation of short-term cancer risks and non-cancer health hazards can be made (FS, Section 7.3.1.3). PCB concentrations in fish for the short-term period beginning in 2004 are above all target levels, with the exception of the 0.4 ppm fish concentration target level in River Section 3 for the MNA, CAP-3/10/S, and REM-0/0/3 alternatives, and REM-3/10/Select (selected remedy), (Table 7-4 of the FS). Target levels in fish will be reached first in River Section 3, below the Northumberland Dam. The selected remedy accelerates the time when fish caught between Troy and the Northumberland Dam (i.e., River Section 3) can be consumed at the following rates as compared to the No Action and MNA alternatives (based upon Table 7-4 of the FS):

- One fish meal per week (Remediation Goal of 0.05 ppm) – goal reached more than 17 years before NA and eight years before MNA.
- One fish meal per month (Remediation Goal of 0.2 ppm) –goal reached more than 54 years before NA and six years before MNA.
- One fish meal every two months (Remediation Goal of 0.4 ppm) – goal reached four years before NA and one year before MNA.

White Paper – Human Health and Ecological Risk Reduction under Phased Implementation contains an analysis of expected impacts under various conditions for the selected remedy.

As PCB concentrations are highest in the initial modeling years, it is apparent that most target non-cancer health hazards and cancer risk levels will not be achieved in the short term under any alternative; also, there may be a relatively short-term increase in fish body burdens immediately

after dredging is completed. Overall, however, based on EPA's modeling, remediation is predicted to result in lower, rather than elevated, body burdens in fish, as the removal of PCB-contaminated sediment far outweighs the amount of PCBs that will be resuspended. In the long term, significant reductions in fish body burdens are expected both within the areas that are remediated as well as in downstream areas. Further discussion can be found in the Responses to Master Comments 583 (Chapter 10), 587 (Chapter 9), and 365942 (also Chapter 10). Finally, as noted elsewhere in this Responsiveness Summary and in the Record of Decision, the results of EPA's modeling of the No Action and MNA alternatives may overestimate the rate of decline of PCBs in fish. Thus, the actual benefits of the selected remedy relative to No Action and MNA may be even greater than the percentage figures set forth in the preceding text.

Studies have consistently shown that dredging has beneficial results and does not increase the amount of contamination in an area (Response to Master Comment 337860, Chapter 11). For example, a US Army Corps of Engineers' Vicksburg District dredging project in the Steele Bayou in 1994 has shown significant short-term decreases in the concentration of DDT in sediment and fish (USACE, 2001). Since fish testing began at that Site, DDT concentrations in fish tissue have decreased by more than 85 percent. Both PCBs and DDT have a strong affinity to bioaccumulate in fish, thus the findings of reduced DDT concentrations in fish after dredging at Steele Bayou provides evidence from field studies that dredging bioaccumulative chemicals from sediments is expected to yield reduced concentrations of these chemicals in fish.

Reference

US Army Corps of Engineers (USACE). 2001. Press Release. Corps Test Results: Dredging Decreases DDT in Fish Tissue. June 26, 2001.

Master Comment 559

Regarding the table entitled Years to Reach PCB Target Concentration in Fish Averaged Over Entire Upper Hudson River on page 9-2 of the FS, one commenter wanted clarification on whether the years to reach PCB target concentrations in fish include years prior to initiation of construction and until completion of construction.

Response to Master Comment 559

The years to reach PCB target concentrations in fish are calculated beginning from the year of the FS until the end of the modeling run (2067), and include the years prior to the initiation of remediation through the completion of remediation.

Master Comment 831

The question was raised as to how many years are required to attain the PRG of 0.05 ppm PCBs in fish in the Lower Hudson River. Commenters said that this goal has been cited as being 40 times stricter than the Federal Food and Drug Administration's commercial fish limit of 2.0 ppm. A number of other commenters questioned when the fish would be "edible." Other commenters

questioned in what year(s) would average fish concentrations over the Upper Hudson expect to be reduced to 0.09 to 0.14 ppm.

Response to Master Comment 831

The time it takes to achieve particular PRGs or target levels in fish is species- and location-specific for a given upstream PCB boundary condition. Some fish will achieve target levels sooner than others based on feeding and habitat preferences. The yellow perch, brown bullhead, white perch, and striped bass were modeled in the lower river using the results of the Farley model for input into the FISHRAND model (White Paper — Relative Reduction of Human Health and Ecological Risks in the Mid- and Lower Hudson River). EPA's FISHRAND modeling predicts that a concentration at or below the PRG of 0.05 ppm wet weight under the selected remedy in the Lower Hudson River will be achieved as follows:

- Yellow perch: in 2022 at RM 152, in 2019 at RMs 113 and 90, and in 2020 at RM 50.
- Brown bullhead: in 2028 at RM 113, in 2033 at RM 90, in 2029 at RM 50, and a concentration of approximately 0.06 ppm at RM 152 in 2046.
- White perch: in 2033 at RM 90, in 2029 at RM 50, and concentrations of approximately 0.09 and 0.06 ppm at RMs 152 and 133, respectively, in 2046.
- Largemouth bass: largemouth bass in the Lower Hudson River will not achieve 0.05 ppm prior to the end of modeling in 2046. Concentrations at that time are estimated to be 0.12 ppm at RM 152, 0.10 ppm at RM 113, and 0.09 ppm at RMs 90 and 50.

Under the No Action alternative, Lower Hudson River fish concentrations do not achieve 0.05 ppm for any of the fish species within the modeling time frame and are several times higher than under the selected remedy.

The different timing (e.g., five-year versus six-year implementation schedule) and sediment resuspension (e.g., 0.13 percent or 2.5 percent) assumptions do not appreciably impact the time to achieve target levels as predicted fish body burdens stabilize rapidly following dredging.

The FDA Tolerance Level of 2 ppm is based on a "market basket" of commercially caught fish obtained from supermarkets, and is an upper bound, not an average PCB concentration in commercially marketed fish. Therefore, this level is not protective of recreational anglers or subsistence fishers who frequently consume fish from one single source, such as the Hudson River (Responses to Master Comments 545 and 447, Chapter 3).

The time required to achieve between 0.09 and 0.14 ppm in fish tissue in the Upper Hudson River under the selected remedy depends on the fish species and location being modeled. Predicted largemouth bass body burdens are approximately 0.38 ppm in the Thompson Island Pool (RM 189) by 2067, and achieve 0.14 ppm in approximately 2044 at RM 184. At RM 154, largemouth bass are expected to achieve 0.14 ppm by 2015 and 0.09 ppm by 2023. Brown bullheads achieve 0.14 ppm in approximately 2060 at RM 189. At RM 184, predicted brown bullhead body burdens are approximately 0.2 ppm by the end of the modeling period (2067). At RM 154, brown bullheads are expected to achieve 0.14 ppm by 2021 and 0.09 ppm by 2028. Under the No Action alternative, concentrations of 0.09 and 0.14 ppm are not achieved in the upper river at any river mile (i.e., 189, 184, and 154) for any of the three fish species modeled

(i.e., largemouth bass, brown bullhead, and yellow perch). Concentrations for some species at the end of the modeling period in 2067 under the No Action alternative are up to an order of magnitude higher under the selected remedy.

Results of additional simulations for the selected remedy under different assumptions are provided in White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River and White Paper – Relative Reduction of Human Health and Ecological Risks in the Mid- and Lower Hudson River.

Human health and ecological risks are discussed in White Paper – Human Health and Ecological Risk Reduction under Phased Implementation, the Response to Master Comment 799 (Chapter 6), and White Paper – Relative Reduction of Human Health and Ecological Risks in the Mid- and Lower Hudson River.

Master Comment 565

Commenters contend that EPA's preferred alternative did not offer significant human health risk reduction; the remedy may increase the amount of time that would be necessary to achieve target PRGs relative to the source control (MNA) alternative. Comments stated that the risk reduction achieved by EPA's remedy cannot be distinguished from the risk reduction for other alternatives examined by EPA because of the inability to demonstrate statistically significant differences in modeled future PCB trends in fish consumed by anglers. Other comments argued that unrealistic assumptions were adopted regarding dredging operations, and that fish ingestion rates were overstated, thus target PRGs should be raised (fourfold increase suggested).

It was suggested that when "realistic" assumptions regarding the timing and ultimate effects of dredging are considered, and adjustments to EPA's risk analysis are made, source control will lower PCB concentrations in fish more quickly than dredging in most of the Site, and the proposed dredging remedy will do more harm than good.

Furthermore, commenters said that the current fish advisories render any risk reduction hypothetical because significant populations of anglers are not currently consuming fish. Other commenters said that EPA should provide further detail and comparisons of predicted PCB concentrations in fish over time for the remedial alternatives examined in the FS.

Comments in support of EPA's proposed remedy indicated the remedy would hasten the reduction of PCBs in fish, thereby reducing human exposure to PCBs, accelerating the time to achieve human health risk objectives, and accelerating the time to when less stringent fishing advisories may be required. Some commenters feel that EPA should select a more aggressive alternative that includes greater sediment removal, thereby further hastening the time to achieve target PRGs and providing greater risk reduction than EPA's proposed remedy. These commenters indicated that the greater PCB removal would also accelerate the time when fishing advisories might be removed or lessened.

Response to Master Comment 565

EPA believes it has developed a balanced approach and plan for remediation and has appropriately considered both the technical feasibility of the selected remedy and the degree of risk reduction expected to result from the remediation. As first described in the FS, and further supported in this responsiveness summary, EPA has adopted reasonable and technically feasible assumptions regarding the operational conditions associated with the selected remedy (*e.g.*, expected duration of dredging operations, degree of sediment resuspension, etc.). The models used to generate sediment, water, and fish concentrations used in hazard and risk calculation have been peer reviewed by a panel of independent experts (USEPA, 2000a). Consequently, EPA does not agree with the comments that the hydrodynamic fate and bioaccumulation models used to project PCB concentrations in fish predict unrealistic or unattainable reductions in PCBs. A sensitivity analysis of model parameters (e.g., surrogate for conditions during active remediation alternatives) was performed in the FS to examine a range of conditions, and even under conditions of greater sediment/PCB release than expected, significant reductions in risk will be achieved by the selected remedy.

In addition, as discussed in Response to Master Comment 789 in Chapter 6, the claim that model predictions show little if any statistical difference across alternatives is based on an inaccurate methodology. It is not appropriate to use the measure of variability from observed fish concentrations in estimating uncertainty in future model predictions. In fact, on a relative basis, comparison of modeling results across different modeling assumptions effectively reduces uncertainty. Model uncertainty applies to all predictions, such that there is greater uncertainty in absolute predicted values than there is in comparing predicted values.

The risk assessment methods adopted for the baseline HHRA (USEPA, 2000b) and the assessment of future risks under each of the remedial alternatives are fully consistent with CERCLA and the NCP goal of protecting the Reasonable Maximum Exposure (RME) individual. The methods adopted for the baseline HHRA (which were also used for the FS) were subject to external peer review, and found to be consistent with EPA Superfund practice. As discussed in the Response to Master Comment 569 in Chapter 3, the methods employed by EPA in its Monte Carlo risk analysis in the HHRA yield results quite comparable to those of GE's microexposure risk analysis.

EPA disagrees with the comments indicating that risks have been overstated in the HHRA and FS by adopting fish ingestion rates that are too high (fourfold too high, as suggested by one commenter). EPA also disagrees with other commenters who hold the opposing view that the fish ingestion rates are perhaps too low. As discussed in the Response to Master Comment 569 and the HHRA, EPA developed risk estimates based on RME assumptions for its exposure parameters, including the fish ingestion rate. The RME approach, which is consistent with CERCLA and the NCP, protects for exposures to individuals at the high end of the exposure distribution within a population, yet is not set to the maximum exposure within a population. Furthermore, during the peer review of the HHRA, the reviewers found the fish ingestion rate adopted by EPA to be appropriate for this Site (USEPA, 2000c). The 1996 and 1991-1992 Hudson angler surveys have shown that the risk from fish ingestion is not a hypothetical risk (RHHRA. p. 40 and NYSDOH, 1999).

It is recognized that there is inherent statistical variability and/or uncertainty in observational data (i.e., fish monitoring data). Uncertainty is also introduced by the use of models. Yet, the hydrodynamic models and the bioaccumulation models have consistently been used as appropriate tools for comparison among different remediation scenarios. While one can argue about the accuracy of their predictions on an absolute scale, the relative predictions when run with different PCB removal scenarios is considered to be an appropriate use of the models.

The selected remedy (REM-3/10/Select) achieves a 71 to 79 percent RME non-cancer hazard index reduction compared to No Action, and a 58 to 75 percent RME hazard index reduction compared to MNA in the upper river. Comparisons to the central tendency (CT) scenario and comparisons by river section show similar reductions in hazard indices in River Sections 1 and 2. Reductions are lower in River Section 3, where risks are lower. The RME non-cancer time frame covers a 7-year period for the RME scenario and 12-year period for the CT period, beginning in 2010 after the completion of the 6-year dredging program. For further information on risk see White Paper – Human Health and Ecological Risk Reduction under Phased Implementation.

For cancer risk reduction, the selected remedy achieves a 76 to 85 percent RME risk reduction compared to No Action and a 50 to 80 percent RME cancer risk reduction compared to MNA in the upper river. Comparisons to the CT scenario and comparisons by river section show similar reductions in cancer risk in River Sections 1 and 2 and lower reductions in River Section 3. The RME cancer time frame covers a 40-year period for the RME scenario and 12-year period for the CT period, beginning in 2010 after the completion of the 6-year dredging program.

Based on these non-cancer health hazard and cancer risk reductions, the implementation of the selected remedy would provide significant human health benefits. EPA disagrees that the selected remedy will do more harm than good; see Response to Master Comment 485 in Chapter 11.

References

New York State Department of Health (NYSDOH). 1999. Health Consultation: 1996 Survey of Hudson River Anglers, Hudson Falls to Tappan Zee Bridge at Tarrytown, New York. February. (Raw survey data received electronically from Edward Horn of NYSDOH in June, 1998.)

USEPA. 2000a. Response to Peer Review Comments on the Revised Baseline Modeling Report (RMBR), Hudson River PCBs Reassessment RI/FS. Prepared for the USEPA Region 2 and USACE by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie Cura & Associates, Inc. and Tetra-Tech, Inc. November 2000.

USEPA. 2000b. Further Site Characterization and Analysis, Revised Human Health Risk Assessment (HHRA/RHHRA) Volume 2F, Hudson River PCBs Reassessment RI/FS. Prepared for the USEPA Region 2 and USACE by TAMS Consultants, Inc. and Gradient Corporation. November 2000.

USEPA. 2000c. Peer Review Responsiveness Summary for Volume 2F - Human Health Risk Assessment, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS Consultants, Inc. and Gradient Corporation. March.

Master Comment 797

Commenters said that increased dredging time will decrease risk reduction between alternatives. Some cite the most significant factor that would impact the time differences between alternatives as an increase in the time to complete dredging, and contend that EPA's dredge times appear unrealistically short and have not been justified. Since it is felt that longer dredge times would reduce already marginal risk reductions, commenters suggested that EPA show the impacts of longer dredge times on PCB concentrations in fish and risks.

Response to Master Comment 797

As discussed in the Response to Master Comment 671 (Chapter 10), White Paper – Dredging Productivity and Schedule, and White Paper – Delays and Downtime, a phased six-year dredging period is a realistic time frame. However, even if dredging does extend beyond the envisioned time frame, risk reductions are expected to stay relatively constant. Tables 797-1 and 797-2 show non-cancer hazard indices and cancer risks, respectively, using the assumption that dredging extends to a period of ten years. Hazard indices and cancer risks are slightly lower than calculated for the phased six-year dredging time frame, but relative risk reductions are within a few percentage points (in both directions) of the original estimates. The non-cancer hazard indices and cancer risks shown in Tables 797-1 and 797-2 were estimated by calculating average PCB concentrations beginning ten years after initiation of remediation. The model projections used were those estimated for a six-year remediation, and the exposure point concentrations were calculated by starting the averaging four years later than those calculated for a six-year remediation period (i.e., the bioaccumulation model was not rerun for a ten-year period). Future PCB concentrations in fish were provided in Table 7-4 of the FS, which showed that reductions in PCB concentrations begin before the completion of remediation.

7.2 Alternative-Specific ERA Issues

Master Comment 817

Some commenters asserted that risks to other ecological receptors (in addition to the mink and otter) should have been described in the FS, as ecological risks are not limited to piscivorous birds and mammals. It was suggested that a more complete description of the risk reduction to receptors in addition to otter and mink would demonstrate a shorter recovery time for other receptors and more benefit from any remedial action.

Response to Master Comment 817

Receptors selected for use in the FS were based on the results of the Revised Baseline Ecological Risk Assessment (RBERA) (USEPA, 2000). The RBERA modeled future risks for insectivorous, omnivorous, and piscivorous birds and mammals. For 2010 and beyond (the year remediation is scheduled for completion), toxicity quotients (TQs) above one were calculated for the mallard, belted kingfisher, great blue heron, bald eagle, little brown bat, raccoon, mink, and river otter.

Both Total PCBs and toxic equivalencies (TEQs) were calculated (RBERA, pp. 58- 61). The total PCBs calculations have greater compatibility and less uncertainty associated with them than the TEQ estimates. Future total PCB risks for eggs of piscivorous birds (i.e., belted kingfisher, great blue heron, and bald eagle), little brown bat, mink, and river otter are above the no-observed-adverse-effect-level (NOAEL) basis for 2010 and for subsequent years modeled in the RBERA. The insectivorous little brown bat was not evaluated in the FS because risks 2010 and beyond were less than three on a NOAEL basis.

Piscivorous mammals (mink and river otter) were selected to show risk reduction in the FS rather than piscivorous birds, which showed risks for eggs but not for adults. There is greater uncertainty in modeling risks to eggs due to the use of a biomagnification factor to estimate egg concentrations (RBERA, pp. 79-80).

The results of the RBERA show that species other than piscivorous birds and mammals may be at risk from PCB exposure. Reductions in PCB concentrations in the Hudson River sediments will reduce risks to biota living or foraging in the river.

Reference

USEPA. 2000. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E- Revised Baseline Ecological Risk Assessment (RBERA), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS/MCA. November 2000.

Master Comment 313261

Some commenters attributed a large part of the projected decline in fish concentrations in the Upper Hudson for the No Action alternative to transport of PCBs from the Upper Hudson to the Lower Hudson, or other losses of PCBs to the environment. PCBs do not readily degrade, so natural attenuation is actually just another way of saying that they will end up somewhere else within the environment, either in the New York Harbor, in the fatty tissue of fish and mammals of the Upper Hudson, or on the floodplain. Much of the PCBs lost from the Upper Hudson will be transported downriver and redistributed, and will contribute to sediment concentrations and bioconcentration all the way to New York Harbor. Thus, the "recovery" of the Upper Hudson River under the No Action and MNA alternatives has negative consequences for downstream ecosystems and communities.

Response to Master Comment 313261

Declines of PCB concentrations in fish forecasted by EPA’s peer-reviewed fate and transport and bioaccumulation models of the Upper Hudson River, HUDTOX and FISHRAND, are a result of calibration of the models to the historical dataset, which shows long-term downward trends of PCB concentrations in river water and fish. The historical downward trends are due mostly to reduction and eliminations of PCB sources to the river and dilution of PCB concentrations in sediment through burial and mixing. EPA’s analysis of recent fish data shows little or no

reduction in PCB concentrations in the past five or more years (FS, Appendix D.1), suggesting that the models may overpredict the future benefits of natural attenuation processes.

Natural attenuation processes that may contribute to a downward trend in the future include biodegradation, biotransformation, bioturbation, diffusion, dilution, adsorption, volatilization, chemical reaction or destruction, resuspension, downstream transport, and burial by clean material, as described in the FS (Section 4.2.2). There is evidence for some aerobic destruction of PCBs (Response to Master Comment 613, Chapter 2), and burial accounts for much of the benefit attributed to MNA. MNA allows greater PCB mass transport downstream than the active capping or removal alternatives (FS, Table 8-3). This increased mass results in higher fish concentrations (Table 799-1, Chapter 6) and higher risks to downstream receptors (Table 799-4, Chapter 6). The selected remedy shows up to an 87 percent reduction in risks to ecological receptors when compared to No Action and up to a 71 percent reduction when compared to the MNA alternative.

Master Comment 364780

A number of commenters contended that the CAP-3/10/Select alternative is not as protective of ecological and human health as the other active remedial alternatives. They stated that the CAP-3/10/Select alternative will leave almost half of all PCBs in place, and flooding and scouring may damage the cap. Some commenters said that there appears to be a typographical error in the FS report stating that it will take 45 years to achieve the LOAEL for mink in River Section 1 for this alternative versus 22 years for the MNA alternative.

Response to Master Comment 364780

EPA concurs that the CAP-3/10/Select remedy is not as protective of human health and the environment as the other active remedies. EPA agrees that there is also the possibility of cap damage with this alternative. Therefore, CAP-3/10/Select was not selected as the preferred alternative.

Table 7-8 of the FS clearly lists the CAP-3/10/Select alternative as requiring 5 (not 45) years to reach the mink LOAEL in River Section 1. This is in contrast to the No Action alternative, which does not meet the LOAEL within the 60-year modeling time frame, and to the MNA alternative, which would take 22 to more than 60 years to achieve the LOAEL (FS, Sections 7.3.2.4 and 7.3.3.4).

8. COMMUNITY IMPACTS

8.1 Transportation (Infrastructure)

Master Comment 649

Some comments ask whether there are sufficient energy resources in the region needed for the proposed plan. Commenters to EPA's Feasibility Study (FS) have suggested that it will be difficult to meet the energy needs of the proposed remedial plan and have expressed concerns about effects on local energy consumers as well as spill response procedures.

Response to Master Comment 649

Energy for the selected remedy will consist mainly of diesel fuel, gasoline, and electricity. Prior to addressing the energy requirements of the project in the following text, it is important to note that EPA has not yet determined the locations of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the FS, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the upper Hudson River valley and farther downstream, are possible.

Petroleum Products

It is assumed here that fuel will be delivered to a northern sediment processing/transfer facility by truck and staged there for distribution. An alternative assumption would be that fuel is delivered by barge from the areas downriver and either offloaded at a northern facility or stored in and distributed from the delivery barge.

The total diesel fuel requirements for this project under the mechanical dredging alternative are approximately 550,000 gallons per season for a northern facility and 875,000 gallons for a southern facility. Under the hydraulic alternative the seasonal estimate is 630,000 gallons and 960,000 gallons at the northern and southern facilities, respectively. Assuming that all fuel is delivered from outside the region, under the hydraulic alternative there would be a maximum of approximately four fuel deliveries per week at a northern facility and six trucks per week at a southern facility. Based on the actual requirements, it is likely that at least part of the fuel for the project can be obtained locally without affecting the area consumers. In fact, it is expected that these local energy purchases will constitute a benefit to the local economy. A southern sediment processing/transfer facility is expected to be located in a more urbanized area; as a result, there should be sufficient fuel available locally.

Approximately 150 gallons of gasoline per week at each site, or about 9,100 gallons of gasoline per season, will be required for gasoline-powered vehicles. This fuel will be obtained from area service stations and these purchases are expected to be beneficial to the regional economy.

Petroleum products will be stored on-site in accordance with federal and State regulations. Contract specifications will require that the contractor develop and carry out a spill control and response plan. That plan will require the contractor to take appropriate actions to limit the potential for accidental releases of fuel. If a spill should occur, the plan will call for trained personnel and appropriate equipment to be available to respond. Such contract requirements are routine and EPA will audit the contractor's conformance to these requirements throughout the term of the project. A more detailed discussion of spill control measures can be found in Response to Master Comment 661 in Chapter 10 of this responsiveness summary.

The table below breaks down the total diesel-fuel requirements for operations associated with example northern and southern sediment processing/transfer facilities. Fuel consumption rates were obtained from manufacturers and the general literature (Stonehocker, June 15, 2001). Consumption rates for excavators and front-end loaders were generated based on the conservative assumption that the equipment will run at maximum capacity (Stonehocker, June 15, 2001). Requirements identified in the table for example northern and southern facilities can be added to obtain a general assessment of overall project demand in a given dredging season.

Fuel Requirements for Sediment Processing/Transfer Facility Operations

Energy Item	Proposed Operation	EPA Estimate: Mechanical	EPA Estimate: Hydraulic
NORTHERN TRANSFER FACILITY			
Diesel Fuel (gal)	Dredge	149,483	189,350
	Debris Collectors	98,791	98,791
	Barge Transport (sediments)	77,973	250,614
	Sediment Offloading (heavy equipment/trucks)	132,860	N/A
	Work Boats	90,944	90,944
Diesel Total:		**550,051**	**629,699**
Gasoline (gal)	Non-diesel-powered vehicle	4,550	4,550
SOUTHERN TRANSFER FACILITY			
Diesel Fuel (gal)	Dredge	74,741	160,524
	Debris Collectors	98,791	98,791
	Barge Transport (sediments)	250,614	250,614
	Sediment Offloading (heavy equipment/trucks)	283,920	283,920
	Barge Transport (backfill)	167,076	167,076
Diesel Total:		**875,142**	**960,925**
Gasoline (gal)	Non-diesel-powered vehicle	4,550	4,550

Electrical Energy Requirements

The sediment processing/transfer facilities will generate an electric power demand associated with operation of motors, lights, and electronic systems. The following table entitled Electrical

Requirements for Mechanical and Hydraulic Dredging Scenarios provide electrical requirements for both those dredging operations, since there are substantially different power requirements associated with each dredging technology. In addition, the power requirements of the two sediment processing/transfer facilities would differ, since the scale and type of processing will differ between the sites.

Electrical Requirements for Mechanical and Hydraulic Dredging Scenarios

Energy Item	Proposed Operation	EPA Estimate: Mechanical	EPA Estimate: Hydraulic
NORTHERN TRANSFER FACILITY			
Electrical (kw)	Water Treatment (Indoor/outdoor)	15.00	149.00
	Lights and Buildings	61.00	59.00
	Pug Mills	149.00	N/A
	Conveyors	187.00	75.00
	Sediment Offloading	299.00	N/A
	Belt Filter Press	N/A	1300.00
Total:		711.00 (790.0 kva)	1583.00 (1759.0 kva)
SOUTHERN TRANSFER FACILITY			
Electrical (kw)	Water Treatment (Indoor/outdoor)	15.00	15.00
	Lights and Buildings	54.00	54.00
	Pug Mills	149.00	149.00
	Conveyors	224.00	224.00
	Sediment Offloading	167,076	167,076
Total:		442.00 (491.00 kva)	442.00 (491.00 kva)

The example southern sediment processing/transfer facility will likely be located in an industrial zone where it is expected that adequate electrical capacity already exists to satisfy project demand. Under both the mechanical and hydraulic dredging scenarios, peak demand will be around 442 kilowatts. At the example northern transfer facility, it has been estimated that hydraulic dredging will produce a peak demand of 1,583 kilowatts. The mechanical dredging scenario's peak demand will be approximately 711 kilowatts. Representatives of the local utility have indicated that the power requirements of a northern sediment processing/transfer facility can be accommodated for either the mechanical or hydraulic dredging operations, as shown on the preceding table. However, it may be necessary to reactivate an existing electrical substation to support operations at a northern sediment processing/transfer facility.

It is anticipated, therefore, that diesel fuel, electrical, and other energy needs can be met without disruption to supplies in the region.

Reference

Stonehocker, Stephen. Caterpillar Inc. June 15, 2001. Personal communication.

Master Comment 705

Numerous commenters raised concerns that implementation of the selected remedy would be generally disruptive to communities in the project vicinity. One major source of disruption was thought to be project-generated traffic, including truck, rail, and vessel movements.

Response to Master Comment 705

Estimates of project-generated truck, rail, and vessel movements have been presented in a series of white papers (White Paper – Project-Related Traffic, White Paper – Rail Operations, and White Paper – River Traffic). The quantitative analyses in these white papers were developed using generalized engineering concepts for each principal component of the selected remedy. (*e.g.,* transfer facility concepts). Using the generalized concepts, estimates were developed for the number of trucks that the project would require both during mobilization and during dredging operations. Similarly, estimates were made of rail movements to landfills and barge movements to processing/transfer facilities.

In addition to enabling estimates of road, rail, and river traffic, the generalized concepts were also used to evaluate other potential project impacts. Among these other impacts are project-related noise and air emissions, project energy and lighting requirements, and project odor potential. These potential impacts are addressed in Responses to Comments. In addition, the following white papers contain discussions of some of these other project effects: White Paper – Noise Evaluation, White Paper – Air Quality Evaluation, and White Paper – Odor Evaluation.

The following summarizes the principal findings of the analysis conducted for project traffic. It is concluded that project-generated traffic will not be disruptive to local communities.

Project Truck and Auto Traffic

EPA's selected remedy would generate truck and auto traffic both during the mobilization phase and during operations. Expected traffic generators include workers, construction equipment, maintenance equipment, and project supplies (*e.g.,* stabilization agent), among others. EPA assessed the load this traffic would place on nearby roads and determined, based on available traffic data, that the increased burden on local roads would be relatively modest. The most intense project-related vehicular activity would occur at entrances to transfer and processing sites. At these locations there may be a need to install temporary traffic control devices.

Further, EPA has made several publicly stated commitments with regard to the project that contribute to minimization of project-related traffic. EPA has stated that stabilized or dewatered sediments would not be shipped via road to final disposal facilities. In addition, a commitment has been made that backfill material would be transported within the Upper Hudson River area by rail or barge. Thus, the two potentially most significant generators of truck movements have been eliminated as a result of the approach EPA has taken to project implementation.

EPA has concluded, therefore, demonstrated by the foregoing discussion and further described in White Paper – Project-Related Traffic, that project-related vehicular traffic would not be significantly disruptive to local communities.

River Traffic

EPA has also evaluated movements of barges, towboats, and other vessels that would need to operate on the Upper Hudson River. Operation and movement of project-related equipment within the river is not expected to interfere significantly with other uses of the Hudson River and Champlain Canal. This is principally due to the fact that project equipment will be dispersed over a considerable length of river and is therefore unlikely to impede other users of the system. There is some possibility that congestion may occur at several canal locks during the peak recreational boating period. At such times it will be possible for project-related barge movements to be staged to non-operating hours on the Champlain Canal. Consequently, in-river equipment movements associated with the selected remedy are not likely to be disruptive to local communities (White Paper – River Traffic).

Rail Traffic

Concerns have been expressed that the freight rail system serving the Upper Hudson River would be overtaxed as a result of project-related shipments. However, based on conversations with operators of the principal rail freight line in the project area, it has been determined that sufficient capacity exists to accommodate project-generated rail movements, including capacity on the main freight corridor and capacity at local rail yards. In addition, the mode of operation planned by EPA is considered compatible with operations of the principal freight railroad in the upper Hudson River valley. Thus, it not expected that project rail activity would be disruptive to local communities (White Paper – Rail Operations).

Master Comment 709

Commenters say that EPA's project will bring massive damage, disruption, and injury to those who use and live near the river, contending that the communities between Fort Edward and the Northumberland Dam, an agricultural region of beauty, full of the values of the scenic Hudson, will endure the loss of those values to an industrial construction project with noise, lights, smell, inevitable rail and road traffic, and boat congestion on the river 24 hours per day, 6 days a week, 30 weeks a year, during the period that EPA plans to work. Construction and disruption will start every year about the time one is ready to open the windows and enjoy the spring, and end each year when the first snows are threatening.

Response to Master Comment 709

EPA and the Natural Resource Trustees believe that active remediation of contaminated sediments in the Upper Hudson River is necessary in order to address the continued unacceptable threat to human health and the environment posed by the PCBs in the river sediments, and to restore this natural resource for the use and enjoyment of all citizens in the region, both upriver and downriver.

EPA strongly disagrees with the premise of the comments. Much time has been spent analyzing such concerns, and these analyses are reflected in the white papers related to specific subject

areas. Please refer to the following white papers for further discussions related to potential impacts identified: White Paper – Example Sediment Processing/Transfer Facilities; White Paper – Air Quality Evaluation; White Paper – Odor Evaluation; White Paper – Project-Related Traffic; White Paper – River Traffic; White Paper – Noise Evaluation; White Paper – Socioeconomics; White Paper – Rail Operations. Responses to Master Comments throughout this chapter also contain additional discussion on these subjects.

8.1.1 Rail

Master Comment 312982

Some commenters have raised concerns about the ability of the existing infrastructure to accommodate project-related increases in freight train traffic, and the effects of this increased volume on the region. Commenters are concerned that the additional freight train traffic could interfere with passenger train service, potentially affect availability of non-project related freight train service, and result in an increased need for maintenance along rail lines. In addition, there is concern about the availability of a sufficient number of rail cars and the size of the rail yards required at the transfer facilities.

Response to Master Comment 312982

EPA has estimated the rail movement that will occur in order to implement the selected remedy in the context of the capacity and current operation of the regional rail line operated by the Canadian Pacific Railroad (CPR). This analysis can be found in White Paper – Rail Operations. After speaking with representatives of the CPR, it has been determined that the current Ft. Edward/Albany rail line is dominated by freight service, and that there is additional capacity available on the line. Increased train volumes are not expected to impact passenger or non-project-related freight service in the region. There are currently six passenger trains and up to 14 freight trains per day (through and local) operating along this corridor. This level of activity does not approach the capacity of the line.

With regard to rail yard requirements for a northern transfer facility, it would be necessary to store 16 gondolas on site. There will be daily pick-ups of these gondolas by the railroad. It is expected that existing rail yards in the project vicinity can be used to store rail cars and assemble larger trainloads for movement to remote landfill sites. CPR has indicated that their existing rail yard facilities can accommodate gondola cars generated by the project, as well as the daily transport and assembly of these railcars into unit trains. No new rail yards will have to be constructed in the region to support the remedial activities. The availability of rail cars/gondolas in the region has also been assessed. The number of gondolas required for the project can be obtained by leasing them on the open market, and will not necessarily be provided by CPR. Current rail car leasing costs are low due to market demand; many are actually being scrapped at this time. The shipping of two commodities, specifically TSCA and non-TSCA materials, will moderately increase the project's complexity, but will still be manageable.

The CPR and, it should be assumed, any rail carrier, routinely maintains its track system and all associated equipment. This maintenance is schedule-oriented, dictated by stringent regulatory

and safety requirements, and is impacted only by significant increases in volume of rail traffic. Therefore, addition of project-related rail traffic to existing rail lines is not anticipated to have any adverse impact on, or to add any costs to, any railroad's ongoing maintenance program.

White Paper – Rail Operations contains extensive additional detail.

8.1.2 River

Master Comment 312942

Concerns have been raised about the potential of the selected remedy to create vessel traffic congestion on the Upper Hudson in the form of bottlenecks at various locks along the Champlain Canal. Commenters have suggested that this work may also interfere with routine passage of vessels along the canal navigational channel, potentially resulting in a disruption to recreational traffic. Specific questions have been raised about the effects of a hydraulic dredge's pipeline and booster pump on river traffic. Some ask whether the resulting congestion and dredging activity would allow clear and safe passage of other vessels. A number of other comments argue that the selected remedy will result in benefits to the canal system and ultimately to the economy of the area.

Response to Master Comment 312942

The potential impacts of EPA's remedy on river traffic are discussed in greater detail in White Paper – River Traffic. The analysis presented in this white paper indicates that the greatest movement of pleasure crafts typically occurs in July and August. During these months, Locks 5 and 6 are the most heavily used in the entire canal system.

The white paper provides an estimate of the number of project-related vessels expected to move through the Champlain canal locks on a daily basis. At Lock 6, for instance, the remedy would add approximately nine vessels per day under a mechanical dredging alternative and approximately three vessels per day under a hydraulic dredging alternative. There is a potential for congestion to occur at Locks 5 and 6 during the peak canal season. However, if project-related vessels utilize the locks after hours, lock congestion as a result of EPA's remedy is reduced, if not eliminated.

With regard to concern that work will interfere with routine passage of vessels, it should be noted that most work will take place outside of the navigation channel, and the width of the river in most targeted areas can accommodate both project equipment and current vessel traffic. EPA will expect contractors to arrange equipment such that non-project-related vessels have clear and safe passage through the canal. However, some work will occur in the channel itself. This work is not very different from the navigational dredging done by the Canal Corporation prior to the time the PCB problems were known. When work is occurring in the channel, warning lights and buoys will be placed around the work area. The contractor will be expected to configure equipment in order to provide sufficient room for passage of pleasure vessels. For instance, the contractor could position the materials-handling barge either upstream or downstream of the dredge instead of along side the dredge to eliminate channel blockage.

Some concerns have been raised about the potential for interference between the hydraulic pipeline (if one is used) and booster pumps with non-project-related vessels. The pipeline and booster pumps may be located on land or in the river. If they are located in the river, there are several approaches that could be implemented in areas where it is determined that navigation may be impeded, including pipeline re-routing (overland in some areas) and pipeline burial.

Removal operations associated with the remedy include both remedial dredging and navigational dredging. Historically, the Canal Corporation routinely dredged the canal to maintain a water depth of 12 feet. Dredging in the project area has not occurred since 1979, with the exception of the area where the Hoosic River discharges coarse grain materials into the canal between Locks 3 and 4. Since this time, the Canal Corporation has performed annual canal sweeps to determine areas of increased sedimentation and decreased water depth in the navigation channel. The most recent canal sweep data collected during the 2000 river season concluded that in the vicinity of buoy R160, located north of Lock 5 and south of the Route 4 bridge, as little as four feet of water exists along the west side of the river and on average, only seven feet of water is available for vessel passage. This implies that movement from the north and south of this area is significantly impeded by current conditions. Conversations with Canal Corporation representatives indicated that vessels must swing to the east side of the channel to allow passage in this relatively narrow area, resulting in some risk to passage.

The remedy will require removal of sediments down to depths of six and eight feet from the current river bottom at this location. Given the existing water level in this area, this dredging activity would return the channel in the vicinity of buoy R160 to its intended depth of 12 feet, thus greatly increasing navigability of the river at this location. Similar sedimentation has occurred in other river sections, according to the 2000 canal sweep data, though to a lesser degree. Removal of these sediments would re-open portions of the river and allow commercial traffic to pass from Lake Champlain south to Albany with no draft limitations. It is expected that opening the canal will increase recreational and commercial traffic, thus promoting commerce at ports and marinas located along the river, as detailed in White Paper – River Traffic.

8.1.3 Road/Highway

Master Comment 663

Commenters have raised concerns about the ability of the existing infrastructure to accommodate project-related increases in vehicular and truck traffic, and the potential disruption to regional roadways that could result from these increases. Concerns have been expressed that implementation of the selected remedy will generate additional truck and auto trips principally in the vicinity of the processing facilities. It has been suggested that project-related traffic will create congestion on adjoining roadways at these locations and increase the need for road maintenance, and that increases in road hazards resulting from increased truck traffic need to be addressed.

Response to Master Comment 663

It is important to note that EPA has not yet determined the location(s) of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the FS, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the upper Hudson River valley and farther downstream, are possible.

The example facility locations presented in the FS have also been used in this Responsiveness Summary in order to clarify material presented in the FS and Proposed Plan, and in connection with additional noise, odor and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after the Agency performs additional analyses and holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, all information provided in this Responsiveness Summary relative to potential impacts of the sediment processing/transfer facilities on communities, residents, agriculture, the environment, and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during design.

Impacts from vehicle and truck traffic at a southern processing/transfer facility site are not anticipated to be significant, since much of that locale is already highly industrialized and experiences much greater activity than would be generated by Hudson River PCB remedial project operations.

EPA has estimated the project-related road traffic that will be generated by the selected remedy and evaluated it in the context of current volumes and capacities of roads in the vicinity of a northern processing/transfer facility. These analyses can be found in White Paper – Project-Related Traffic; the results are discussed in the following text.

Initial Construction Phase

It has been estimated that 34 truckloads/day of construction materials will be required during the first three months of construction and five truckloads/day will be required over the remaining six months of construction in order to develop a northern processing/transfer facility. It is not expected that the 34 arriving trucks will create congestion on local roadways, as there is substantial existing capacity for additional movements along roads in the vicinity of a northern processing/transfer facility. In addition, in the design phase, operational parameters can be established to see that material deliveries occur primarily during the workday and not during

peak commuting hours when roads are the most used. Employment is expected to average 50 workers over the nine-month construction period for this facility.

Operational Phase

Dredging is expected to occur over a six-year period between May and November. There will be daily truck deliveries of supplies required during the seven-month operation of the processing facilities. The number of deliveries required at a northern facility, assuming a six-day work week, will be approximately nine trucks per day. Trucks are not expected to contribute to roadway congestion because the numbers are low relative to the capacity of the roadways in the area assumed for a northern facility. In addition, truck deliveries would not likely be made at peak commuter hours. It should be noted, as stated by EPA, that backfill and dredged sediment will not be transported within the Upper Hudson River area by trucks.

It is estimated that there will be 106 employees commuting in the vicinity of the TI Pool. During peak traffic conditions, when transfer facility work shifts change, approximately 53 employees will be arriving at, and 53 will be departing from, the facility (assume between 5:00 PM and 6:00 PM). Using available traffic data, analysis conducted for select roadways in the general area assumed for the northern processing/transfer facility has shown that project-related employee traffic will not be disruptive to local communities, as the volume increase on nearby roadways will be minor, less than 10 percent (White Paper – Project-Related Traffic). Because the increase in road usage is relatively small, it is not likely that there will be an increase in road hazards or a need for increased road maintenance as a result of implementing the selected remedy.

8.2 Noise

Master Comment 699

Commenters say that long-term dredging and sediment processing operations would contribute intrusive, repetitive, jarring noise for 24 hours a day, 6 days per week, 30 weeks a year each year for the duration of the project. The increased river, rail, and roadway traffic and the operation of various equipment would result in disruptive long-term noise, especially during evening and night hours in local communities. It was suggested that EPA should conduct and make publicly available an acoustical study of noise generated by the project. Some particular questions/comments regarding noise are as follows:

- Will the planned project comply with federal, State, and local laws, regulations, guidelines, permit requirements and ordinances regarding noise?
- What are expected decibel levels of dredging, barging, and treatment/processing operations, and what are existing noise levels in project areas?
- What measures will be employed to monitor and mitigate noise impacts associated with the project?

Response to Master Comment 699

The potential noise impacts during both short-term dredging activities and long-term sediment processing/transfer operations were evaluated using the applicable federal and State noise impact criteria and noise analysis guidelines. A detailed analysis is presented in White Paper – Evaluation of Noise. In the white paper, decibel levels were identified for various major noise sources associated with the proposed short- or longer-term operations, and these decibel levels were then used for estimating noise levels at the representative noise receptor locations.

Following are the estimates of noise levels associated with the proposed sediment processing/transfer facility operations:

- Hydraulic dredging (short-term). At a location 50 feet landward of the shoreline, noise from hydraulic dredging operations could reach levels as high as 79 dBA (the level of a telephone ringing). Noise impacts are expected to be greatest during the nine-week period in which the trailing booster would move in a zone from 3,000 feet upstream to 2,000 feet downstream of any given receptor. Noise levels would increase from 57 dBA (the level of sound generated by an electronic toothbrush) to the 79-dBA maximum, and then decrease to 59 dBA.

- Mechanical dredging (short-term). With mechanical dredging, noise levels would be lower than during hydraulic dredging. Noise impacts from mechanical dredging are expected to be greatest during the ten-week period in which the mechanical dredge would move in a zone from 1,000 feet upstream to 1,000 feet downstream of any given receptor. Noise levels would range between 57 and 70 dBA (similar to the audio level of a television).

- Transfer facilities (long-term). Noise levels would be below 65 dBA (a typical urban office area background level of noise) at the closest receptor (house or club) to each transfer facility. However, noise levels would be considerably higher at the transfer facility boundary.

The white paper evaluates the potential impacts from example facilities located in Port of Albany (southern transfer facility) and near the Moreau Landfill (northern transfer facility), and for the dredging. The decibel levels were identified for various major noise sources associated with the proposed short-term or long-term operations, and these decibel levels were then used for estimating noise levels at the representative noise receptor locations. The white paper concluded that:

- The short-term noise associated with construction of the sediment transfer/processing facilities and hydraulic and mechanical dredging operations would not exceed the New York State Department of Transportation (NYSDOT)-established short-term construction impact guideline.

- The long-term noise associated with sediment processing operations would not exceed Federal Highway Administration (FHWA) Noise Abatement Criteria (NAC) or the US Department of Housing and Urban Development (USHUD) housing guideline.

- The long-term noise associated with stationary booster pump operations, under the hydraulic dredging scenario, would exceed FHWA NAC in areas within an 800-ft radius of the booster and USHUD housing guideline in areas within a 1,000-ft radius of the booster. However, in this case, a series of mitigation measures (such as use of electric pumps) can be implemented to mitigate this situation.

EPA will consider pertinent local regulations concerning noise (if such regulations exist) during the design of the sediment processing/transfer facility(ies).

Prior remediation and major construction projects in the Upper Hudson River area also provide qualitative indications that potential noise impacts, particularly from short-term construction operations, are not likely to unreasonably disrupt the affected communities. Although smaller in scope, these projects have been significant, and include:

- Remedial work by General Electric for the Hudson River PCBs Site Remnant Deposits during the early 1990s.
- Reconstruction of the Bakers Falls hydroelectric facility by Niagara Mohawk Power Corp. during the early 1990s.
- Past and ongoing remedial work by General Electric at the Hudson Falls plant, including construction and operation of a water treatment facility, all in proximity to residential areas.

It is important to note that EPA will not determine the actual facility location(s) until after EPA performs additional analyses and holds a public comment period on proposed location(s) and considers public input in the final siting decision during remedial design. Thus, all information provided in this response relative to noise impacts of the sediment processing/transfer facilities should be considered representative and illustrative. During design, as part of the siting process for the sediment processing/transfer facilities, an on-site noise monitoring study will be performed to determine potential long-term noise impacts (based on net change in operational noise compared to the background). Appropriate mitigation of potential noise impacts will also be addressed during remedial design.

Possible noise mitigation, if needed, may involve alteration or modification of the source noise output or interception/deflection of the noise to avoid impacts to the community. The following are examples (but not an exhaustive list) of possible noise mitigation measures:

- Requiring the use of newer models of machinery that are quieter, and maintaining equipment so that noise-related performance is also optimal throughout the remedial program;
- Substituting electric drives for diesel engines where practicable;
- Using electric conveyor belts for material handling where practicable;
- Enclosing noise producing equipment and areas where possible;
- Reducing vehicle running speed (locomotives, trucks, etc.);
- Avoiding excessive gear shifting and throttling;
- Isolating and damping vibrating elements;

- Performing routine maintenance;
- Using high performance mufflers for dredges and other diesel-driven equipment;
- Placing operating restrictions on equipment where engineered approaches are not otherwise available; and
- Installing portable noise barriers where necessary.

Master Comment 767

Noise from dredging operations is described as having an especially negative effect on dairy cattle operations. Commenters say that noise causes adverse stress on dairy herds. Some other commenters suggested that noise might affect milk production in dairy cows and sheep.

Response to Master Comment 767

As already discussed in the foregoing Response to Master Comment 699 (Section 8.2), White Paper – Evaluation of Noise provides estimates of noise levels associated with the proposed dredging and transfer facility operations.

Kovalcik and Sottnik (1971) found that a noise level of 80 dB (unspecified scale) increased feed intake and the rate of milk-releasing indices, but did not affect the milk yield of dairy cows, and presumed that this noise level was within the limits of the normal tolerance of the animal. A noise level of 80 dB is comparable to the estimated maximum noise level for hydraulic dredging, but well above the estimated noise levels associated with mechanical dredging.

Domestic animals appear to acclimate to some sound disturbances (Manci *et al.*, 1988) and will readily adapt to reasonable levels of continuous sound such as white noise, instrumental music, and miscellaneous sounds (Grandin, 1997). For example, milk production was not lowered when a jackhammer was used in the barn of dairy cows that had become accustomed to a variety of sounds and activity (*e.g.*, children playing in the barn aisle [Grandin, 1997]).

As the dredge will not be in any fixed location for an extended period of time, the exposure of penned domestic animals to dredging noise will be limited. Depending on the location of the transfer facilities relative to existing farms, exposure of livestock to the noise from sediment processing operations may be more prolonged. It is important to note, therefore, that the sediment processing/transfer facilities are expected to be situated in industrial or other non-agricultural locations. In addition, due to the apparent tolerance of livestock to continuous noise and to their ability to acclimate to such disturbances, it is not anticipated that this disturbance will be significant.

References

Bond, J., T. S. Rumsey, J. R. Meaear, L. I. Colber, D. Kern, and B. T. Weinland. 1974. Effects of simulated sonic booms on eating patterns, feed intake, and behavioral activity of ponies and beef cattle. Proc. Int. Livest. Environ. Symp., University of Nebraska, Lincoln. Am. Soc. Agric. Eng., St. Joseph, MI. *As cited in*: Manci, K. M., D. N. Gladwin, R. Villella, and M. G. Cavendish. 1988. Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: a

Literature Synthesis. US Fish and Wildlife Service (USFWS), National Ecology Research Center (NERC), Fort Collins, CO. NERC-88/29.

Casady, R. B., and R. P. Lehmann. 1967. Response of Farm Animals to Sonic Booms, Studies at Edwards Air Force Base, June 6-30, 1966. Interim Report, US Department of Agriculture, Agricultural Research Division, Beltsville, MD. *As cited in*: Manci, K. M., D. N. Gladwin, R. Villella, and M. G. Cavendish. 1988. Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: a Literature Synthesis. USFWS, NERC, Fort Collins, CO. NERC-88/29.

Espmark, Y., L. Falt, and B. Falt. 1974. Behavioral responses in cattle and sheep exposed to sonic booms and low-altitude subsonic flight noise. Vet. Rec. 94(6):106-113. *As cited* in: Manci, K. M., D. N. Gladwin, R. Villella, and M. G. Cavendish. 1988. Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: a Literature Synthesis. USFWS, NERC, Fort Collins, CO. NERC-88/29.

Grandin, T. 1997. Adapting Bovine Behavior to Improve Performance. Website accessed June 28, 2001 at http://www.afns.ualberta.ca/wcds/wcd97/ch29-97.htm.

Kovalcik, K., and J. Sottnik. 1971. The effect of noise on the milk efficiency of cows. Zivocisna Vyroba 16:795-804. *As cited* in: Manci, K. M., D. N. Gladwin, R. Villella, and M. G. Cavendish. 1988. Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: a Literature Synthesis. USFWS, NERC, Fort Collins, CO. NERC-88/29.

Manci, K. M., D. N. Gladwin, R. Villella, and M. G. Cavendish. 1988. Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: a Literature Synthesis. US Fish and Wildlife Service, National Ecology Research Center, Fort Collins, CO. NERC-88/29. Available at http://www.nonoise.org/library/animals/litsyn.htm.

Nixon, C. W., H. K. Hille, H. C. Sommer, and E. Guild. 1968. Sonic booms resulting from extremely low-altitude supersonic flight: measurements and observations on houses, livestock, and people. Defense Documentation Cent., Alexandria, VA, Aerospace Med. Res. Lab. Rep. No. TR-68-52. *As cited in*: Manci, K. M., D. N. Gladwin, R. Villella, and M. G. Cavendish. 1988. Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: a Literature Synthesis. USFWS, NERC, Fort Collins, CO. NERC-88/29.

Parker, J. B., and N. D. Bayley. 1960. Investigation of Effects of Aircraft Sound Milk Production Of Dairy Cattle 1957-1958. Us Department of Agriculture, Washington, DC. *As cited in*: Manci, K. M., D. N. Gladwin, R. Villella, and M. G. Cavendish. 1988. Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: a Literature Synthesis. USFWS, NERC, Fort Collins, CO. NERC-88/29.

Master Comment 358188

Commenters worried that noise associated with dredging and operation of the transfer facilities could be disruptive to local wildlife, particularly territorial species.

Response to Master Comment 358188

White Paper – Evaluation of Noise provides the following estimates of noise levels associated with the proposed dredging and transfer facility operations:

- Hydraulic dredging (short-term). At a location 50 feet landward of the shoreline, noise from hydraulic dredging operations could reach levels as high as 79 dBA (the level of a telephone ringing). Noise impacts are expected to be greatest during the nine week period in which the trailing booster would move in a zone from 3,000 feet upstream to 2,000 feet downstream of any given receptor. Noise levels would increase from 57 dBA (the level of sound generated by an electronic toothbrush) to the 79-dBA maximum, and then decrease to 59 dBA.

- Mechanical dredging (short-term). With mechanical dredging, noise levels would be lower than for hydraulic dredging. Noise impacts from mechanical dredging are expected to be greatest during the ten-week period in which the mechanical dredge would move in a zone from 1,000 feet upstream to 1,000 feet downstream of any given receptor. Noise levels would range between 57 and 70 dBA (similar to the audio level of a television).

- Transfer facilities (long-term). Noise levels would be below 65 dBA (a typical urban office area background level of noise) at the closest receptor (house or club) to each transfer facility. However, noise levels would be considerably higher at the transfer facility boundary.

The operation of heavy machinery and equipment, as well as aircraft overflights, recreational activities such as the use of snowmobiles and motorboats, and automobile traffic, are among the sources of noise that have the potential to affect wildlife (Noise Pollution Clearinghouse, undated). The effects of aircraft noise have been studied intensively.

Physiological responses to aircraft noise range from mild, such as an increase in heart rate, to more damaging effects on metabolism and hormone balance (Noise Pollution Clearinghouse, undated). Long-term exposure to noise can cause excessive stimulation to the nervous system and chronic stress that is harmful to the health of wildlife species and their reproductive fitness (Fletcher, 1980; 1990). Behavioral responses range from head raising and body shifting to panic and escape behavior (National Park Service, 1994). Physiological and behavioral responses have the potential to cause injury, energy loss, decrease in food intake, habitat avoidance and abandonment, and reproductive losses (National Park Service, 1994).

Sound levels that result in adverse physiological and behavior responses, however, are relatively high. Sound levels above about 90 dB are likely to adversely affect mammals and are associated with several behaviors, such as retreat from the sound source, freezing, or a strong startle response (Manci *et al.*, 1988). Sound below about 90 dB usually causes much less adverse behavior (Manci *et al.*, 1988).

Dredging and dredged material processing operations would result in increased noise levels that could disturb wildlife in the area. However, because the estimates of the noise levels associated with the proposed operations are below 90 dB, it is not anticipated that this disturbance would be

significant. The dredge will advance on the river, and will not occupy the same space on the river on a constant basis. Therefore, the dredge will not be in any fixed location for an extended period of time and the noise impacts to territorial wildlife will be limited. Some wildlife will temporarily leave areas affected by higher noise levels, but are expected to return when the dredge moves downstream. However, wildlife occupying habitats close to the transfer facilities may abandon these areas for several years, although it is noted that wildlife's abandoning habitat during construction occurs at essentially any significant construction project. In addition, mitigative measures can be taken to reduce overall noise levels; such measures will be considered in the design phase.

References

Fletcher, J. L. 1980. Effects of noise on wildlife: a review of relevant literature 1971-1978. *In*: Tobias, J. V., G. Jansen, and W. D. Ward, eds. Proceedings of the Third International Congress on Noise as a Public Health Problem. Am. Speech-Language-Hearing Assoc., Rockville, MD. *As cited in*: Noise Pollution Clearinghouse. Undated. Fact Sheet: Noise Effects on Wildlife.

Fletcher, J. L. 1990. review of noise and terrestrial species: 1983-1988. *In*: Berglund, B., and T. Lindvall, eds. Noise as a Public Health Problem, Vol. 5: New Advances in Noise Research Part II. Swedish Council for Building Research, Stockholm. *As cited in*: Noise Pollution Clearinghouse. Undated. Fact Sheet: Noise Effects on Wildlife.

Manci, K. M., D. N. Gladwin, R. Villella, and M. G. Cavendish. 1988. Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: a Literature Synthesis. USFWS, NERC, Fort Collins, CO. NERC-88/29. Available at http://www.nonoise.org/library/animals/litsyn.htm.

National Park Service. September 12, 1994. Report to Congress: Report on Effects of Aircraft Overflights on the National Park System. Available at http://www.nonoise.org/library/npreport/intro.htm.

Noise Pollution Clearinghouse. Undated. Fact Sheet: Noise Effects on Wildlife. Website accessed June 11, 2001 at http://www.nonoise.org/library/fctsheet/wildlife.htm.

8.3 Lighting

8.3.1 Impact of Lighting on Livestock

Master Comment 645

Some commenters observed that in order to meet the project schedule, there may be a need for nighttime activities, in which case artificial lighting will be necessary. It may be needed in backfill, processing and/or dredging activities. Concern was expressed that continuous lighting could be disruptive to dairy cattle.

Response to Master Comment 645

EPA has examined the types of artificial lighting that will likely be used in support of the project. Artificial lighting systems will be used as necessary to illuminate nighttime operations. Positioning of lights, as well as their brightness and direction, are key factors that create the opportunities to minimize potential for off-site impacts.

In the initial construction and mobilization phase, work is scheduled only for daylight hours. Lighting is not required for removal of Site sediments by mechanical or hydraulic dredging. Instead, sediment removal is monitored by on-board instrumentation, limiting the amount of lighting necessary to support the dredging operation to safety lighting in areas with active personnel. It should also be noted that the dredge will not occupy the same position for extended periods of time.

Nighttime lighting requirements for the proposed work will conform to established industry safety standards. The lighting required for in-river transport will conform to the Coast Guard standards for commercial towboats and barges and New York State navigation law requirements, and is not expected to be disruptive. Lighting at the land-based processing facilities will meet OSHA standards for construction. Appropriate intensity can be accomplished without the use of high-mast or stadium-type lighting. In fact, it will not be necessary to use high-mast or stadium-type lighting systems at either dredging sites or at the sediment processing facilities. Lighting at the land-based facilities will be directed toward work areas and away from neighboring properties. In addition, the use of low-mast lights will limit off-site glare.

Photoperiod manipulation is a management technique used by some dairy farmers to improve production efficiency and cash flow by increasing feeding activity and milk production (Dahl, 2000). Daily milk production has been shown to increase in lactating cows exposed to long days, *i.e.*, between 16 and 18 hours of light and between 6 and 8 hours of darkness (Kearnan, 1998; Janni, 1999; Tucker, 2000). Continuous (24-hour) light does not provide additional milk yield response (Dahl *et al.*, 1998; Erickson, 2001; Reid, 2001). Further, according to Tucker (2000), six to eight hours of darkness are required to achieve the optimal increase in milk production.

Conversely, a short period of light and a long period of dark is required by dry cows to optimize production increases in the subsequent lactation (Dahl, 2000; Tucker, 2000). Researchers recommend providing cows with 8 hours of light and 16 hours of dark during the dry period (Shoemaker, 2000). Dry period exposure to long-day photoperiods reduces milk production in the subsequent lactation in comparison exposure to the recommended short-day photoperiods (Tucker, 2000).

Activities that decrease the period of darkness to which lactating or dry dairy cows are exposed could eliminate the response of cows to photoperiod manipulation (Dahl, 2001) and result in milk yields below optimum. However, factors other than photoperiod are critical to realizing optimum production increases, including lighting location and intensity (Reid, 2001).

During the light period, light should target the eye level of the cows (Tucker, 2000; Erickson, 2001; Reid, 2001). Research has set the desired light-period light intensity between 10 and 30 foot-candles (Kearnan, 1998; Tucker, 2000; Erickson, 2001; Reid, 2001). Illumination at 10 to

30 foot-candles is typical of auditoriums, banks, hotel corridors and lobbies, hospital corridors during the day, conference rooms, offices, and factories (Hoke, 1988). During the dark period, light levels should be maintained at two to three foot-candles, according to Janni (1999), or, according to Shoemaker (2000), five foot-candles or less, the illumination typical of hospital corridors at night (Hoke, 1988).

How much artificial light enters the barns occupied by the cows and for how long will determine the extent to which project nighttime lighting will impact dairy cattle and milk production (Shoemaker, 2001). Given that lighting will be directed away from neighboring properties, and that the sediment processing facilities are expected to be located on industrial or other non-agricultural land and in as remote an area as possible, project nighttime activities are not expected to increase illumination inside area dairy barns to levels exceeding the two or three foot-candle maximum required during the dark period. This is particularly true in the case of photoperiod manipulation for dry cows, as to achieve the required 16 hours of darkness the cows already would be confined for extended periods in darkened barn areas to exclude daylight. Therefore, nighttime lighting for the proposed work will not reduce milk production by dairy cattle.

References

Dahl, G. E. 2000. Photoperiod Management of Dairy Cattle. Website accessed June 26, 2001 at http://www.gov.on.ca/OMAFRA/english/livestock/dairy/facts/info_photoperiod.htm.

Dahl, G. E. June 29, 2001. Associate Professor. Department of Animal Sciences, University of Illinois. Personal communication by e-mail.

Dahl, G. E., J. P. Chastain, and R. R. Peters. 1998. Manipulation of photoperiod to increase milk production in cattle: biological, economical and practical considerations. *In*: Proc. fourth Int. Dairy Housing conf., ASAE, St. Joseph, MI. *As cited in*: Janni, K. Summer 1999. Lighting Dairy Facilities. Minnesota/Wisconsin Engineering Notes.

Erickson, P. June 27, 2001. Assistant Professor of Dairy Management and Extension Dairy Specialist. University of New Hampshire. Personal communication by e-mail.

Hoke, J. R. (editor in chief). 1988. Architectural Graphic Standards, Eighth Edition. John Wiley & Sons, Inc., New York.

Janni, K. Summer 1999. Lighting Dairy Facilities. MN/WI Engineering Notes. Website accessed June 26, 2001: http://www.bae.umn.edu/extens/ennotes/ensum99/lighting.html.

Kearnan, J. March 1998. Supplemental lighting for dairy cattle. Dairy Biz. Website accessed June 28, 2001 at http://www.dairybiz.com/archive/prod-18.htm.

Reid, J. 2001. More Milk with Extended Light. Website accessed June 26, 2001 at http://www.cce.cornell.edu/yates/AgCorner12.13.00.htm.

Shoemaker, D. February 10, 2000. Light Improves Milk Production. Farm and Dairy. Available at http://www.ag.ohio-state.edu/~bediabr/nedairy/excel/articles/light.htm.

Shoemaker, D. June 27, 2001. District specialist - Dairy, Ohio State University Extension. Personal communication by e-mail.

Tucker, H. A. January 2000. Light-up in the new millennium. Michigan Dairy Review 5(1):7-8.

8.3.2 Impact of Lighting on Community

Master Comment 358825

Various comments were offered relative to potential impacts of lighting related to the proposed remedy on area residents and communities, highlighted as follows: In order to meet the project schedule there may be a need for nighttime activities. If this is the case, artificial lighting will be necessary. It may be needed in backfill, processing and/or dredging activities. Project lighting may be disruptive to local communities and, depending on the duration of the project, it may have potential to devalue property.

Response to Master Comment 358825

EPA has examined the types of artificial lighting that will likely be used in support of the project. Artificial lighting systems will be used as necessary to illuminate nighttime operations. Positioning of the lighting systems, as well as their brightness and direction, are the key variables that can be controlled to limit potential off-site impacts. These factors are considered in the following text for each component of the selected remedy**.** Mobilization phase work, *i.e.*, construction of sediment processing/transfer facilities and backfill operations, are expected to occur during daylight hours and, therefore, will not generate nuisance impacts from lighting**.** It should also be noted that the dredge will not occupy the same position on the river for extended periods of time, further minimizing potential impacts.

During nighttime dredging operations, lighting would be needed for vessel navigation, illuminating decks and railings of work equipment, and interior lighting for operating instrumentation spaces. Lighting is not required for removal of Site sediments by mechanical or hydraulic dredging. Sediment removal is monitored by on-board instrumentation. Lighting necessary to support the dredging operation is limited to safety lighting in areas with active personnel, to a specifically directed light to illuminate the cutterhead area on hydraulic dredges, and to other occasional lights. Nighttime lighting requirements for the proposed work will conform to established industry safety standards.

Hydraulic Dredging

The type of lighting necessary for implementation of the selected remedy is that which is standard for safe operations. It is very similar to night illumination used on tugboats. The dredge includes a directed light for illuminating the cutterhead area; however, it is anticipated that this directed light would only be used occasionally, as most dredging occurs without a need for

illumination. This light may sometimes be used to observe the dredge head or to check ongoing operations, but on most occasions it will be in the 'off' mode so that operating personnel need not adjust their vision to varying light conditions.

Mechanical Dredging

The types of lighting used for mechanical dredging operations will be similar to those for hydraulic dredging, with the exception of some low-intensity lights needed to illuminate the storage barge. It is expected that the levels of lighting needed to delimit the storage barge will not create a nuisance, as the lights will be relatively close to the water and only intended to provide direction to the dredge operator. Also, changeover of storage barges at night will be avoided as much as possible to further limit lighting impacts.

In-River Transport

The lighting required for in-river transport will conform to the Coast Guard standards for commercial towboats and barges, and is not expected to be disruptive. The US Coast Guard requires the use of nighttime running lights to ensure safe passage of vessels underway. Running lights include a masthead forward light, sidelights, a stern light, and a towing light (US Coast Guard Navigational Rules International – Inland, 33 USCG § 2001). Section 43 of the New York State Navigation Law also contains lighting requirements for vessels, depending on the size of the craft. Unlike a car, a barge does not light its own path, but rather is guided by channel markers in the canal. Therefore, in-river transport activities will not create a lighting nuisance.

Land-Based Operations

It is important to note that EPA has not yet determined the locations of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the FS, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the upper Hudson River valley and farther downstream, are possible.

The example facility locations presented in the FS have also been used in this Responsiveness Summary in order to clarify material presented in the FS and Proposed Plan, and in connection with additional noise, odor and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after the Agency holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, all information provided in this Responsiveness Summary relative to potential impacts of the sediment processing/transfer facilities on communities, residents, agriculture, the

environment, and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during design.

Since there is a low population density at the northern end of the project area, careful layout of a northern processing/transfer facility should effectively eliminate any lighting nuisance to the local community. Given the nature of the remedial work and the fact that the sediment processing/transfer facilities are expected to be located in industrial or other non-residential areas, it is not expected that actual installed lighting will create a nuisance for nearby residents. Since the example STF location is near the Port of Albany, in an industrial area, no significant lighting impacts on the community are expected.

Potential impacts to property values are addressed in White Paper – Socioeconomics. For properties along the river proximate to dredging, the brief duration of operations and the limited impacts as described are not anticipated to have any effect on property values. For properties in proximity to the processing/transfer facilities, the controlled emission of lighting is not anticipated to create significant or discernable impacts on property values.

Lighting requirements for the sediment transfer and processing facilities, including the wharf area, rail yards, staging areas, administrative buildings, parking lots, and roads, have been estimated based on approximate square footage necessary for a typical materials-processing facility. For safety reasons, heavy work zones require an intensity of five foot-candles per square foot for operating areas (OSHA Regulations 29 CFR 1926.56; US Coast Guard 33 CFR 154.70). Less active zones, such as parking lots, are normally provided with illumination intensities approaching three foot-candles per square foot. The intensity levels required for safety can be provided without the use of high-mast or stadium-type lighting (In fact, it will not be necessary to use high-mast or stadium-type lighting systems at either dredging sites or at the sediment processing facilities.). It is expected that nuisance light glare can be minimized by careful layout of the processing operation; mounting fixtures closer to grade levels and directing the beam onto working areas and away from off-site land uses can minimize off-site glare.

Reference

US Coast Guard Navigational Rules International – Inland. Rule 22, Rule 23, and Rule 24. Website accessed June 8, 2001 at: www.uscg.mil/vtm/navrules/navrules.pdf.

8.3.3 Impact of Lighting on Agriculture and Ecological Resources

Master Comment 805

Concerns were expressed that impacts associated with the use of lighting during dredging and processing could adversely affect local wildlife. Commenters worried that lights will disrupt the migration patterns and diminish the day/night discerning ability of birds, and that exposure to artificial light for prolonged periods may also affect insects.

Response to Master Comment 805

Comments pertaining to the artificial lighting effects on wildlife do not cite any pertinent references to this project. For example, one commenter cited the Fatal Light Awareness Program (FLAP) to show that the artificial lighting planned for the remediation would adversely affect the local wildlife. However, FLAP's mission is to "preserve the lives of migratory birds in urban areas" (FLAP, 2001) and concentrates its efforts on structures such as towers/skyscrapers and windows that cause bird deaths. This focus has little relevance to the planned lighting on the dredging barges and processing facilities. Other organizations, such as the New England Light Pollution Advisory Group (NELPAG), also concentrate their efforts on urban areas with constant light. In a phenomenon that is not fully understood, migratory birds become confused by building lights, particularly on cloudy or misty nights. They circle around the light until they are exhausted, or crash into windows that either appear transparent or reflect the surrounding terrain or sky (NY Times, 2001). The Hudson River remediation will not take place in an urban area and will not involve tall towers, buildings, or high mast stadium-type lighting. Therefore, it is not anticipated that project-related lighting will cause difficulties for migrating birds.

Another comment proposed a study "examining the likely disruption of bird migration and disruption over the term of the five-year construction and operation period" (GE, 2001) to comply with Executive Order 13186 (Responsibilities of Federal Agencies To Protect Migratory Birds). However, there is no reason to conduct such a study, as there was not a single study cited showing any adverse impacts associated with a dredging, processing, or remediation project such as the Hudson River remediation program. The Hudson River Valley serves as a flyway, a route followed by birds as they migrate north in spring and south in the fall. During these travels, many species settle on the river and its wetlands to rest and feed (Stanne *et al.*, 1986). The overall long-term benefits of reduced contaminant concentrations in fish outweigh any temporary loss of feeding area due to artificial lighting or other remediation-related activities.

Artificial lighting can have implications for other wildlife, in particular for insect populations and nocturnal mammal species (Outen, 2001). Moths navigate by the moon but they are easily fooled such that they and other night-flying insects may be attracted to light, sometimes from considerable distances. Continuous usage of bright light sources could cause congregation of these insects in the vicinity where they can be an easy prey for bats, or, the following morning, for birds. Protective measures, such as careful selection of the type of lighting used, will limit the potential affect of artificial lighting. Sodium lights do not attract insects to the same extent as mercury vapor lights (Rydell and Baagoe, 1996). Low-pressure sodium lamps are less likely than other lamps to elicit flight-to-light behavior and to shift circadian rhythms and can be used to reduce adverse effects of lighting (Frank, 1988). Reducing exposure to lighting may help protect moths in small, endangered habitats (Frank, 1988); however, in a large area such as the Hudson River, the reduced lighting is not expected to significantly affect insects, including moths. Impacts to moth populations cited by the commenter (*e.g.*, Frank, 1996) refer to moth populations in urban areas, such as Washington, D.C., Philadelphia, and Boston, which have little in common with the upper Hudson River valley.

One commenter also stated that nighttime lighting was of such concern that the National Parks Service implemented a nighttime light monitoring program. In reality, however, the monitoring program in five National Parks was implemented to protect stargazing, not wildlife (National

Parks Conservation Association, 2000). The negligible effect of lights used for the project on stargazing is not considered to be an issue of concern for local residents.

Nighttime lighting requirements for the proposed work will conform to established industry safety standards, which do not require the use of intrusive lighting systems such as high mast, stadium-type lighting systems. Smaller, more directed artificial lighting systems will be used as necessary to illuminate nighttime dredging and in-river transport operations, as well as land-based facility processing operations (Response to Master Comment 358825, above). Positioning of the lighting systems, as well as their brightness and direction, are the key variables that can be controlled to limit potential impacts to local wildlife. Mobilization phase work, *i.e.*, construction of processing/transfer facilities, as well as backfill operations, are expected to occur during daylight hours; therefore, such activities will not generate nuisance lighting impacts on biota.

Lighting requirements for in-river transportation activities will be typical of commercial vessels. The US Coast Guard requires the use of nighttime running light to ensure safe passage of vessels underway. The lights include a masthead forward light, sidelights, a stern light, and a towing light. Section 43 of the New York Navigation Law also contains lighting requirements for vessels, depending on the size of the craft. Unlike a car, a barge does not light its own path; rather, a barge is guided by channel markers in the canal.

It should be noted that the dredge will not constantly occupy the same space on the river. Rather, it will move downstream with production. Consequently, the dredge should not be in the same place for extended periods of time. This facet of the removal operations will reduce the potential for lighting-related impacts on wildlife.

References

Bower, J. 2000. The Dark Side of Light. *Audubon* Magazine. March/April. http://magazine.audubon.org/darksideoflight.html

Fatal Light Awareness Program (FLAP). *http://www.flap.org/home2.htm*

Federal Register. 2001. Executive Order 13186 of January 10, 2001, Responsibilities of Federal Agencies To Protect Migratory Birds. Vol. 66, no. 11, pp. 3853-3856. Wednesday, January 17, 2001. http://www.epa.gov/owow/wetlands/regs/eo13186.pdf

Frank, K. D. 1996. Impact of outdoor lighting on moths: In *Information Sheet 109*, July 1996. International Dark-Sky Association, Tucson, AZ. http://www.darksky.org/ida/info109.html.

Frank, K. D. 1988. Impact of outdoor lighting on moths: An assessment. Journal of the Lepidopterists' Society 42(2): 63-93.

General Electric (GE). 2001. Comments of the General Electric Company on the Feasibility Study and the Proposed Plan for the Hudson River PCBs Superfund Site (December 2000). Appendix C Environmental Impacts Analysis for the Hudson River. April 17, 2001.

Outen, A. 2001. The Problem for Ecology. Hertfordshire Biological Records Centre. http://enquire.hertscc.gov.uk/hbrc/currentprojects/lep.htm. Accessed 28 June 2001.

National Parks Conservation Association. 2000. *National Parks*, September/October. http:7/208.226.12.12/magazine.
New England Light Pollution Advisory Group (NELPAG. 2001). http://cfa-www.harvard.edu/cfa/ps/nelpag.html

New York Times (NY Times). 2001. Skyscrapers Turn Out Lights to Save Migrating Birds. May 31.

Rydell, J. and H. J. Baagoe (1996). Street lamps increase bat predation on moths. Entomologisk Tidskrift 117(part 4): 129135, as summarized in Effects of lighting of wildlife flora and fauna. http://www.geocities.com/maltastro/1pag/enviroimpact.htm.

Stanne, S.P., R.G. Panetta, and B.E. Forist. 1996. The Hudson an Illustrated Guide to the Living River. Rutgers University Press. New Brunswick, NJ.

8.4 Air Emissions

Master Comment 423734

Commenters voiced concern that the dredging is likely to cause airborne diseases.

Response to Master Comment 423734

The impacts of dredging PCB-contaminated sediment have been evaluated in this RS. (White Paper – Air Quality Evaluation, White Paper – Odor Evaluation, and White Paper – PCB Releases to Air). The risk associated with these contaminants was found to be much below the allowable risk. Moreover, EPA is not aware of any particular disease associated with dredging a river. EPA therefore believes that implementation of the project will be safe and will not cause spread of any diseases to the surrounding communities.

8.4.1 Odor

Master Comment 647

Commenters were concerned about the fact that this project will involve the removal of sediments with organic matter and the subsequent processing and transport of these sediments. Some worried that project activities, including dredging and treatment, may generate nuisance odors. Others said that backfill, dredging, and transport operations have the potential to negatively impact air quality. Comments asserted that odors and/or degraded air quality may be disruptive to local communities, industries such as tourism, and area wildlife, and that prolonged activity could negatively impact property values. It has been proposed that potential amounts of H_2S generated be defined, areas of exposure be determined, and ultimately, that steps should be taken to avoid or mitigate any adverse impacts.

In addition, commenters requested information on what measures will be employed to monitor and mitigate nuisance odors generated from project activities.

Response to Master Comment 647

Several potential sources of nuisance odor, associated with EPA's selected remedy, have been evaluated. These include construction of processing facilities, dredging, in-river sediment transport and handling, and sediment processing.

Construction Activities

Developing two processing/transfer facilities could involve construction of rail spurs, water treatment plants, wharfs, and temporary staging areas. Additional activities would include grading, drainage, and construction of on-site roadways.

EPA has not yet determined the locations of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidates based on screening-level field observations which considered potential facility locations from an engineering perspective. In the FS, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the upper Hudson River valley and farther downstream, are possible. In any event, given the nature of the construction activities that would be involved at any location, nuisance-level odor is not expected to be associated with these activities.

Dredging and Processing Activities

Some commenters argue that hydrogen sulfide, ammonia, and diesel-fume odors may be generated by dredging and sediment processing. Since sufficient relevant data are not available for Hudson River sediments, data from Mississippi River sediments were used to evaluate the odor generation potential of the selected remedy.

Hydrogen Sulfide Gas

As detailed in the White Paper - Odor Evaluation, one-hour and annual maximum H2S concentrations at the receptor locations outside the beyond the processing/transfer facility boundary and at various dredging locations were calculated using the ISCST3 model. The predicted airborne H_2S concentrations were found to be lower than the corresponding applicable State or OSHA standards; therefore, the release of H_2S is not expected to cause regulatory exceedances or adverse health effects.

The H_2S recognition threshold level is the minimum concentration at which a typical person can perceive and recognize H_2S odor. Based on porewater data from other riverine sites (*i.e.*, Mississippi), the predicted short-term airborne H2S concentrations beyond the transfer/processing facility boundary and near dredging locations indicates the hypothetical possibility of brief episodes of H_2S odor if no mitigation measures are taken.

During remedial design, site-specific porewater H_2S data will be collected and the odor generation potential of the selected remedy will be evaluated in greater detail. A number of mitigation measures may be employed to address potential H_2S odor generation, if necessary. The predicted H_2S concentrations within and beyond the processing/transfer facility boundaries as well as at dredging locations, were projected to comply with applicable ambient and workplace standards.

It should be emphasized that the evaluation described above is hypothetical as no Site-specific data are currently available. The likelihood of nuisance odors occurring is low based on experience at other sites.

Ammonia

Ammonia may be released during dredging if porewater pH is high (above 8) and there is sufficient ammonia present in the porewater. Since aqueous phase un-ionized ammonia concentration data is unavailable for the Upper Hudson River sediments, porewater data from the Mississippi River was employed to assess the ammonia odor generation potential of EPA's selected remedy. One-hour, 8-hour and annual maximum NH_3 concentrations were calculated using the ISCST3 results and the values were compared with the New York State and OSHA standards and the recognition threshold value. The predicted airborne NH_3 concentration values were found to be several orders of magnitude lower than the corresponding applicable standards or threshold value; therefore, the air phase NH_3 release is not expected to cause odor problems or adverse health effects.

Other Dredging Projects

Other remedial projects were reviewed to determine if community odor impacts had occurred. Personnel associated with the Fox River project and the New Bedford Harbor dredging project indicated that odor was not noticed during dredging operations at those sites. White Paper – Odor Evaluation contains details from several other remedial projects. In addition, previous dredging completed around Rogers Island in the mid-1970s did not generate noticeable odor. Similarly, it is not expected that dredging of the Hudson River's targeted sediments will generate a nuisance odor impact. Nevertheless, measures to address odor (in the highly unlikely event that such impacts occur) will be considered during remedial design.

White Paper – Odor Evaluation contains a more detailed analysis of the odor producing potential of EPA's selected remedy.

8.4.2 Diesel

Master Comment 729

Commenters claimed that the dredging project will produce elevated levels of diesel fumes and exhaust; possibly release contaminants to the ambient air; and will produce dust and other particles. Comments said that this would result in localized air pollution, inconvenience, and human health risk to area residents. Suggestions were made that air monitoring in the vicinity of the dredging areas and *ex situ* treatment facilities should be conducted to assure the community that human health impacts are minimized.

Response to Master Comment 729

An air quality impact analysis (for NO_x, CO, PM_{10}, and SO_2) was conducted and the details are presented in White Paper – Air Quality Evaluation. The analysis consisted of:

- Potential long-term air quality effects from the proposed continuous operations were considered.
- A broad variety of emission sources (including exhaust emissions from diesel equipment, trucks, locomotives, tugboats, and boosters, as well as roadway dust emissions) were considered and modeled.
- The worst-case concentrations for the Clean Air Act's criteria pollutants were predicted for the above-listed emission sources.
- Conservative assumptions and dispersion-modeling approaches were utilized in order to predict reasonably conservative concentration levels.

It is concluded that the total concentration of pollutants (including the background monitored levels) from the processing facility operations, the stationary booster pump operation, and dredging activities would be within the National Ambient Air Quality Standards (NAAQS) established by USEPA to protect public health.

Based on the results, it is unlikely that the project would result in a significant air quality impact. However, EPA will implement an air monitoring program to address any community concerns. The details of this monitoring program will be developed during remedial design.

8.4.3 PCB Transport (Particulates; Volatilization)

Master Comment 253186

It was suggested that volatilization of PCBs should be included among the factors to be considered when determining what remedial technologies are going to be used. Necessary steps need to be taken to minimize exposure to workers and local communities to airborne PCBs.

Response to Master Comment 253186

A number of laboratory field studies have documented the volatilization of PCBs from contaminated water, sediment, and soil. It is one of the significant transport routes controlling the

fate and transport of PCBs in the environment. The mechanism of PCB volatilization from dredging and subsequent dewatering processes may be described as a two-step process. It involves desorption of PCBs from the solid into the liquid phase, followed by volatilization of the solubilized PCBs from the liquid to the air phase. The resulting PCB emission rate from the dredging or the sediment processing facilities, the air-water PCB transfer area, and weather data were used as input to an air dispersion model for estimating the air phase PCB concentration at a sediment processing/transfer facility and at a specific receptor location outside a facility boundary.

The resulting PCB concentrations were used to quantify the risk associated with the dredging or the operation of sediment processing/transfer facilities. The PCB flux from liquid to air and the resulting air phase concentration and the associated risks are presented in White Paper – PCB Releases to Air.

The calculated cancer risks and non-cancer hazards for sediment processing facility workers and outside facility boundary adult, adolescent, and child residents were de minimis (*i.e.*, below a cancer risk of 10^{-6} and a hazard index of 1.0). It should be noted that the calculated PCB flux associated with the total suspended particles (TSP) are about three orders of magnitude lower than the calculated PCB flux due to volatilization; therefore, exposure from TSP is not included in the risk calculations.

A detailed air phase risk characterization due to the volatilization of PCBs from the Hudson River is presented in the Revised Baseline Human Health Risk Assessment.

Air monitoring, engineering controls, and standard safety procedures will be used to protect the processing facility workers and the nearby community. In addition, facility workers will wear appropriate personal protection equipment. EPA will also conduct a detailed analysis to quantify the exposure potential of PCBs from the dredging and the sediment processing/transfer facilities during design, and will implement a comprehensive air monitoring and health and safety program to address community concerns.

Master Comment 253191

Several comments argue that EPA's apparent dismissal of volatilization as insignificant needs to be revisited. Some commenters contend that volatilization of PCBs from the Hudson River may be a significant source of PCBs to the ecosystem. It was stated that the FS pays little attention to the potential for redistribution via atmospheric transport to upland areas, including crops, all forms of habitat, and inland waters both near and far. Other commenters said that dredging PCB-contaminated sediments substantially lowers the release of PCBs to the ecosystem from volatilization.

Response to Master Comment 253191

EPA disagrees that it "dismissed" the issue of PCB volatilization at the Site. EPA's Revised Baseline Human Health Risk Assessment (Revised HHRA, November 2000) included an evaluation of cancer risks from inhalation of PCBs in air. In the Revised HHRA, EPA

determined that such cancer risks are below EPA's levels of concern. EPA stated that it was not possible to quantify non-cancer health hazards from inhalation of volatilized PCBs due to the lack of non-cancer toxicity values for this pathway. An analysis of the cancer risks associated with the release of PCBs to the surrounding air due to dredging and sediment processing/transfer facilities is presented in White Paper – PCB Releases to Air. The discussion of terrestrial exposure pathways in the Revised Baseline Ecological Risk Assessment includes exposure to PCBs by inhalation of air; however, this pathway was not evaluated because PCBs enter the terrestrial food chain primarily via food uptake (Revised Baseline Ecological Risk Assessment, November 2000). An analysis of whether PCBs volatilizing from the Hudson River are a significant source of PCBs to the ecosystem beyond the Site is outside the scope of the Reassessment RI/FS.

The release of PCBs in the surrounding air (amount) and the resulting impact (risks) due to dredging and sediment transfer/processing facilities is presented in detail in White Paper – PCB Releases to Air.

8.5 Socioeconomic Issues

8.5.1 Aesthetics and Tourism

Master Comment 505

Commenters asserted that disruption from the planned project would adversely affect the region in terms of aesthetics, recreational and scenic use of the river, and tourism. Some particular comments are highlighted as follows:

- For area residents, outdoor activities on the Hudson, including swimming, wading, boating, and catch and release fishing are an integral benefit of residing in the upper Hudson valley; some feel that the proposed project threatens to deny them this critical benefit of living in this region.

- In the short term there may be a significant loss of tourism in the area. One of the primary reasons the Upper Hudson River region is visited by so many tourists each year is because of the peaceful pastoral setting it provides; concern is that this would be diminished by the proposed dredging project.

- In the past, tourism in the region has suffered from the stigma of the Hudson’s being a toxic waste site/dumping ground. Some groups think the remedial activities may reinforce that stigma and drive tourists to other areas; others think it will restore the image of the Hudson.

- Some feel that the proposed project would result in disruption of recreational uses and boating access to the river. For example, increased turbidity may inhibit recreational uses such as swimming in the river.

- It was suggested that the dredging project is likely to deplete the fish populations for many years in the areas being dredged, and would devalue substantially the pleasure and attraction of catch and release fishing in those areas.

- Some say the proposed project would curtail New York State plans to transform the canal system into a historic tourist destination. Potential projects related to this plan include the expansion and development of parks, walking or biking paths, and other waterfront revitalization projects along the Hudson.

- There are many parks along the river, many of which host festivals. It was suggested that the nuisance conditions created by project activities could preclude such uses.

Response to Master Comment 505

The comments on the proposed remediation's impacts on aesthetics, scenic or visual impacts, recreation, fishing, parks and festivals relate substantially to the larger concept of tourism and impacts on this important economic activity. White Paper – Socioeconomics provides a discussion of existing and potential tourism-related economics in the region, as well as a review of economic and property value impacts; the Responses to Master Comments 499 (economic benefits), 717 (agricultural impacts), and 689 (regional stigma) are also relevant. The conclusions of the white paper discussion are that the limited duration, limited scale, and limited areas targeted for dredging are unlikely to generate other than some limited short-term impacts on tourism that are confined to very specific areas and situations. Further, there is a major potential for growth of recreational tourism with a cleaned-up river. A summary of relevant sections of the white paper is included in the discussion below.

Aesthetics

Aesthetic issues typically relate to visual intrusions into the existing landscape and, in this case, may be generated both by the dredging along the river and the presence of transfer and processing facilities at the northern and southern ends of the project area.

The dredging operations will be conducted in a six-year phased approach over the 30-week annual season, with dredges on average operating up to 14 to 16 hours per day, six days a week. However, it is important to understand that the dredging will apply to limited sections of the river. The most northern section (River Section 1, about 6.3 miles between Fort Edward and the Thompson Island Dam) would experience the most concentrated dredging activity, with most of this six-mile section subject to dredging activity. Along River Section 2 (about 5.1 miles between Thompson Island Dam and the Northumberland Dam), about two miles would be subject to dredging, typically near only one bank. Of River Section 3's 29.5-mile length, a total of only 1.75 miles comprising three locations on one bank of the river is subject to PCB dredging, although additional isolated areas (total of about one mile) would be dredged for navigational purposes. Thus, in linear terms, only eleven of the 40 miles of the river would experience any dredging activity; the remaining 73 percent of the upper river would not be subject to dredging. In surface area terms, only 13 percent of the upper river is targeted for dredging. Moreover, less than one percent of the Upper Hudson River would be involved with dredging operations at any particular time. In any event, navigational dredging will have to be carried out.

Although low density residences are scattered along both river banks, the great majority of residences of the study area would not be near the dredging operation. In terms of the major urban centers along the river (Fort Edward, Stillwater, Mechanicville, Pleasantdale, Waterford, Lansingburgh, and Troy), dredging would be adjacent only at Fort Edward and Stillwater. At Mechanicville, there would be some navigational dredging on the other side of the island separating the navigational channel from this town.

Proximity effects of dredging, including visual impacts, would be limited by the geography of the targeted dredging, as well as by the relatively brief duration when dredging activity would be proximate. Dredging is expected to occur directly in front of a particular location in a targeted area for about one week, and within view for only a few weeks longer. Thus, potential visual impacts from the dredging would apply to only a small portion of the 40 miles of river, and would be very temporary where they would occur. Once the dredging and backfill operations have passed by, the only remediation-associated activity would be ongoing monitoring activities in the river. It should also be recognized that navigational dredging activities were commonplace on this section of the river (prior to its designation as a Superfund site), as they continue to be on other sections of the Hudson River and the NYS Canal System.

Operations at the processing facilities would be continuous over the planned six-year period. These facilities are assumed to operate 24-hour days during the 30-week annual operating season. However, the processing facility locations will be carefully sited and designed to minimize potential impacts. They are likely to be in areas with an industrial or commercial land use and have access to rail and water transportation for the movement of materials. Potential impacts from the processing plants would thus be relatively limited and would apply only to areas of close proximity. Aesthetic and visual impacts would be minimized or mitigated to the extent practicable.

The aesthetic, visual, and scenic significance of the river particularly relates to important recreational uses, including boating, fishing, visiting waterfront parks, and various water-oriented festivals, much of which can be considered under the heading of tourism.

Tourism

Section 3 of White Paper – Socioeconomics provides a discussion of existing and potential tourism-related economics in the region, with additional discussion (Section 4) on recreational fishing.

With respect to recreational boating, the dredging would be organized so that river navigation would continue to function during the day, with the possible exception of short-term restrictions when maneuvering barges/pipelines in limited areas is required. As noted above, actual dredging would be limited to less than one percent of the upper river at any time.

The dredging operation's potential impacts on navigation would be primarily limited to traversing the section of the river where dredging would be in operation or sharing the locks with barges hauling the dredged material. Because of the relatively small area of the river affected at

any particular time, the recreational experience on the river would remain substantially unaffected in those areas away from the dredging operation.

Travelers on the river or moving along adjacent roadways would pass through areas where dredging was in progress in a matter of minutes. For these individuals, project-generated noise, odor, and visual intrusion will be of little consequence once they are beyond the immediate work area by only several hundred feet. In these situations the impacts would be quite minimal and the river travelers, in particular, would have 99 percent of the Upper Hudson River unaffected by the physical presence of the dredging barges. Noise impacts and concerns about potential for odor generation are detailed in other white papers. Noise levels are expected to be below NYSDOT construction impact guidelines a relatively short distance from the dredging equipment and odor is not expected to be an issue at all.
With respect to the potential congestion of the river and canal locks, the operational demands and lock capacities are discussed in White Paper – River Traffic. The conclusions of the analysis are that, based on 1999 use patterns by pleasure vessels and projections of dredging operations, there would continue to be excess lock capacity with generally no congestion for pleasure vessels at locks under all reasonable scenarios. There is a potential for congestion to occur at Locks 5 and 6 during the peak canal season. However, if project-related vessels utilize the locks after hours, lock congestion as a result of the remedy is reduced, if not eliminated altogether. Consequently, few adverse impacts are anticipated for recreational boaters during the remediation. Moreover, a significant portion of the dredging is oriented to navigational dredging that, when completed, would provide an expanded and safer capacity for recreational and commercial use of the river, and would likely enhance the area's economy through increased tourism.

For those tourists that would be non-mobile (*e.g.*, staying at an inn on the river), the dredging operations would be slowly moving into proximity and then receding. The rate of movement would depend on the amount of dredging targeted at that location; however, on average, the dredging operation would be adjacent to a particular location for about one week. Assuming the river has no bends, islands, or other obstructions close to the hypothetical inn, the operation would be audible for only about two to six weeks. It is true that during this relatively brief period, the river may lose some of its aesthetic attraction for tourists staying at such an inn. However, there is also a possibility that the dredging work will engender some interest for tourists since it will be viewed as a temporary activity with a unique environmental objective.

Public information on the schedule and location of the dredging activities during particular weeks/months would help mitigate any unexpected disappointments for tourists. It is also appropriate to consider that such impacts would be far less severe than if, for example, another hotel were to be built near to our hypothetical inn. Building construction impacts of any kind would likely to be of much longer duration and would involve far more landside impacts from trucks and workers than a river-based dredging barge.

Much of the Hudson River along the 40 miles from Troy to Fort Edward is rural, with relatively few built tourist amenities. Washington County, as a whole, is more representative of this stretch of the river than would be, for example, Saratoga County, which has numerous tourist attractions although mostly oriented to Saratoga Springs, the Saratoga Spa State Park, to I-87, and to other attractions away from the river. The 1999 data from *County Business Patterns* cites 52 accommodation establishments in Saratoga County and 62 amusement and recreation

establishments; equivalent data for Washington County show no accommodation establishments and 15 amusement and recreation establishments reported (US Census Bureau, 1999). The discussion on river-oriented accommodations in White Paper – Socioeconomics does identify one motel in Fort Edward, Washington County that was open in 1999, implying that the *County Business Patterns* data source may not be completely inclusive.
White Paper – Socioeconomics also examines tourism and recreation-oriented activities in each of the affected counties along the river and compares these with other counties in upstate New York that have freshwater recreation resources but are outside the region, *i.e.*, Herkimer, Cayuga, and Seneca Counties. The data reveal that Washington County's small tourist-oriented employment has declined since 1988, whereas Cayuga County's has grown 63 percent over the period 1988-99. If Washington County had increased this sector at the same rate as Herkimer County (23 percent) it would have added 500 tourism-oriented jobs or, similarly, Albany County would have added 3,266. With Washington County so far behind the tourism growth of other counties, both in the upper Hudson region and elsewhere in the State, it is quite apparent that the county that typifies the target area for dredging has not shared in this important growth industry. The presence of PCB contamination in the Hudson River, its key tourist amenity, may well have contributed to this poor performance.

Scenic Hudson's consultant, KLIOS, Inc. noted in Appendix A of its comments, for example, that the value of recreational boating in Maryland exceeded $1 billion in 1993, that Lake Michigan festivals in 1992 grossed revenues of $51 million, and that recreational boating on the Ottawa River added $14 million in sales to the local economy. The authors note that specific studies on the value of tourism in the Hudson Valley are not available.

Tourism involves a wide variety of recreational activities. Among those most relevant for the upper Hudson valley would be outdoor recreation, as compared to visiting museums or movie theaters. Data from the National Survey of Recreation and the Environment conducted in 1994 and 1995 (Outdoor Coalition of America, 1997) show high annual participation rates in the US for activities relevant to the upper Hudson River valley:

- Viewing/studying (76.2 percent or 152.6 million persons).
- Visiting beach/waterside (62.1 percent or 124.4 million persons).
- Sightseeing (56.6 percent or 113.4 million persons).
- Freshwater fishing (24.4 percent or 48.8 million persons).
- Boating (29 percent or 58.1 million persons).

Major increases in participation over the previous decade were recorded for bird watching (an increase from 21.2 million to 54.1 million persons) and hiking and backpacking (an increase from 33.5 million to 63 million persons). Another key database on this type of tourist activity is the National Survey of Fishing, Hunting and Wildlife Associated Recreation (USFWS, 1998). This source reported 3.3 million wildlife-watching participants in New York State, of whom 1.173 million were nonresidential (*i.e.,* away from home). Total expenditures for wildlife watching in New York were almost $1.3 billion, of which trip-related expenditures were $139.7 million and $1.1 billion was for equipment and other expenditures.

It is clear that the Upper Hudson River ought to be a major participant in these outdoor, nature-oriented modes of recreation. The available data on the economic significance of these activities

points to their substantial scale; however, the riverside communities of the four counties adjacent to the PCB dredging appear to participate much less than would be expected, especially given the world class resource that the river provides in its own right along this reach of the river, and as a connector to other magnificent resources, such as Lake Champlain to the St Lawrence River, and the Mohawk River/Erie Canal to the Great Lakes. With the remediation of the PCB contamination, the river would have a much greater likelihood of securing and expanding its fair share of these tourism and recreational benefits.

Recreational Fishing

After the 1976 ban, catch-and-release sport fishing alone has been permitted in the Upper Hudson River, and only since 1995. Consumption advisories remain in effect and it is illegal to possess fish from a large portion of the upper river. It is interesting to note that the NY Canal Corporation, responsible for the entire New York canal system including the Erie Canal and the Champlain Canal (of which the Upper Hudson River is part), markets the waterways as a major tourist/recreational resource, with fishing as one of the key activities (NY Canal Corporation, Recreationway Plan, 1995). It is the PCB contamination that prevents the Champlain Canal south of Fort Edward from joining with this world class recreation resource.

If the proposed remediation operations were to inhibit the presently limited fishing, it would be from one or more of the following:

- The proximity of the dredging barges.
- The resuspension of PCBs.
- The destruction of fish habitat.

In the case of proximity to the dredging, such operations would occupy less than one percent of the 40 mile reach of the upper river such that, at any particular time, anglers would be able to find alternate sites to fish where the dredging and backfill operations are not proximate. Moreover, only 13 percent of the upper river bottom area will be dredged. In the case of the resuspension of PCBs, the threat of contamination would be only marginally greater than at present and would be closely monitored to assure that this remains so; resuspension should not affect catch-and-release fishing. The impacts to habitat would be temporary and affect only certain species over the short term. Some species of fish are likely to return sooner than others, but within several years the waterway is expected to return to conditions that would support a major recreational fishery. Effective removal of PCBs in the Upper Hudson River should result in considerable reductions in PCB levels in fish taken downstream; thus, remediation will also help restore the value of potential recreational and commercial fishing downstream of Troy.

Recreational fishing along this section of the river is likely to be a much more significant economic activity than its commercial counterpart. An estimated 78,000 fishing licenses were issued in 1998-1999 fishing season to anglers in the five counties surrounding the Upper Hudson. The 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation indicates that in New York State there are 1,493,000 NY resident anglers (over age 16) who spend an average of 18 days at this activity, with average annual expenditures of $942 each, and $1.3 billion spent in New York. Of New York's resident anglers, 996,000 (or 67 percent) fished in freshwater (excluding the Great Lakes), making 13.5 million trips covering 16.2 million days.

In 1996, of the $1.3 billion fishing expenditures in New York, trip-related expenditures, including food, lodging, and transportation and boat rentals, came to $601 million, and each angler spent an average of $353 on trip-related costs.

In addition to these direct expenditures by anglers, there are secondary economic benefits as these dollars circulate in the local economy generating additional indirect jobs and earnings. Employment multipliers from service activities, such as hotels and eating/drinking places in the upper Hudson region, are on the order of 18 to 28 jobs per million dollars expended (US Bureau of Economic Analysis, 2001b). Thus if, for example, the Upper Hudson were to generate a direct increment of $100 million of expenditures in these service industries important to anglers, another 1,800 to 2,800 new jobs would be created.

It is important to recognize that with the bans and advisories in effect, the communities along the Hudson River south of Fort Edward have barely participated in these huge recreational expenditures, despite some of the most magnificent scenery and fishing opportunities in the State. It is also appropriate to note that the benefits of recreational fishing are hardly limited to economics. The social, physical, psychological, and educational benefits of intimate contact with nature, while intangible, provide significant opportunities for personal renewal and reflection, accounting for much of fishing's broad popularity.

The PCB remediation offers the long-term prospects of a renewed and enhanced recreational fishing-associated industry. This would generate a range of positive benefits that include a substantial boost to local economies and, indirectly, a greater sensitivity to preservation of the natural environment, an intrinsic quality of recreational fishing.

Parks and Festivals

A number of parks and other recreational attractions are located on or near the 40 miles between Fort Edward and the Troy Dam. Many of these are considerable distances from the proposed dredging sites and potential transfer and processing facility locations. Depending upon the distance of each facility from proposed dredging or processing, the type of dredging (hydraulic or mechanical), and whether or not the public facility is available for use at night, there could be short-term impacts at some locations that EPA would seek to mitigate to the extent practicable.

A few of the 22 public venues discussed in detail in White Paper – Socioeconomics are close enough to project activities to have the potential for short-term impacts. Among these are:

- Sites along the Champlain Canal Scenic Byway, stretching for 64 miles from Waterford to Whitehall.
- Rogers Island Visitors Center, a historical attraction on Rogers Island in Fort Edward.
- Fort Edward Yacht Basin, a public marina located in downtown Fort Edward.
- Fort Miller recreation area alongside the Hudson River in Fort Miller.
- A golf course in Mechanicville whose river border is about 2,000 feet from proposed dredging sites.

A series of events and festivals are associated with the parks and/or the waterway. Of the 16 annual events identified from the 2001 calendar, it is anticipated that only four events would

have the potential to be affected by the dredging activity, based on the proximity of these activities and potential scheduling conflicts:

- Annual Canal Cruise and Trek – boating and cycling along the canal system that occurs in July.
- Antique Auction and Country Fair, Fort Edward – arts and crafts vendors, also in July.
- Summer Concerts at the Yacht Basin, Fort Edward, one night per week in August.
- Fort Edward Heritage Days, occurring in July of 2001.

Although the brief duration of the dredging at any particular location minimizes potential conflict with any of these annual events, EPA would work with the community to mitigate impacts to the extent practicable.

Marinas

Of 11 marinas located between Fort Edward and the Troy Dam, potential short-term impacts are anticipated at only one location, the West River Road Marina in Moreau; however, at the time of this writing, it appears that this marina may no longer be operating.

Lodgings and Accommodations

Sixteen hotels, motels, and bed and breakfast inns have been identified in the communities along the 40-mile section of the Hudson River from Fort Edward to the Troy Dam. Depending upon the distance from the dredging sites and the type of dredging that occurs there (mechanical or hydraulic), there could be some short-term nighttime noise impacts at some of these locations that would be mitigated as much as practicable. Noise impacts from the processing/transfer facilities would also be mitigated.

8.5.2 Economics

Master Comment 499

An economic impact analysis was performed by KLIOS, Inc. and submitted as a comment to the EPA.

Response to Master Comment 499

KLIOS, Inc. has prepared a document entitled Hudson River Regional Economic Impact Analysis: Impact of Environmental Remediation (KLIOS, April 12, 2001) that examines: regional economic impacts along the Hudson River; economic benefits and potential of the Hudson River; economic value of Hudson River Fisheries; economic potential of Hudson River Valley tourism; and the impact of environmental remediation on property values. Major issues and conclusions of the KLIOS report are discussed below.

KLIOS' report makes a strongly positive case for the economic benefits of the PCB remediation. The report distinguishes near-term benefits from longer-term benefits and includes among the near-term benefits the economic activity associated with expenditures for the remedial dredging in Saratoga and Washington Counties. The report uses an econometric input-output model developed by REMI, Inc., allocating $225 million in direct expenditures to the region. The resulting benefits are 3,543 new direct jobs and 1,028 new indirect jobs, with a total payroll of $141 million, and a regional product of $800 million.

Section 2 of White Paper – Socioeconomics discusses the creation of an alternative input-output model by the US Bureau of Economic Analysis (BEA) for a larger (five-county) region of the upper Hudson, but with somewhat different input data that produces rather less in the way of jobs, earnings and output than the REMI model. This BEA model (RIMS II) generates $576.2 million in output; 3,214 new direct and indirect jobs spread over the five (or more) years (*i.e.*, 643 jobs per year if spread over five years); and $126.8 million in earnings. Differences in the models include the counties incorporated, the dollars assigned as inputs, and other proprietary factors internal to the REMI model. The KLIOS/REMI estimates may represent something of an upper boundary of potential near-term benefits from the direct dredging expenditures, while the BEA RIMS II model may represent a more conservative baseline of estimated economic impacts.

In another analysis, KLIOS estimates economic benefits from the Hudson River as at least $288 million in 1999, much less than its full potential because of the additional costs of waterfront redevelopment and restoration caused by the PCB pollution. With the remediation of this problem, KLIOS estimates longer-term benefits of 3,700 to 8,900 new jobs, and wages of $144 million to $346 million. While no attempt is made by EPA to validate these inherently difficult-to-predict impacts, the waterfront revitalization potential of the river is presently handicapped by additional costs of dredge disposal for restored piers, unmaintained navigational channels; and public perceptions of a polluted river. With the effective clean-up of one the major sources of contamination, development costs will be lower and the public's interest in living near the river and enjoying its recreational amenities will be enhanced, logically stimulating economic activity. The KLIOS estimates appear quite conservative in that they focus only on bringing the water-related economic sectors in the Hudson River counties to the average levels for the State. Given the historical significance of this waterway, and its continuing magnificence as a recreational resource, it is not unreasonable to expect that these counties should substantially exceed the Statewide average for water-related industries.

Among the economic losses attributable to PCBs is that of commercial fishing in the Hudson, which was suspended in 1976 and remains suspended, except for a brief annual shad run. KLIOS cites the economic value of the commercial and recreational fishing industries at $40 million when they were closed in 1976. Since 1995, catch-and-release recreational fishing has been permitted in the upper Hudson. White Paper – Socioeconomics, Section 4, discusses both commercial and recreational fishing. It notes that in 1999 more fully functioning commercial fisheries, as for example, Cape May County, New Jersey, or Washington County, Rhode Island, directly supported 204 jobs and 65 jobs, respectively, with a substantial multiplier creating additional secondary employment at those locations. Recreational fishing is likely to be a much more significant economic activity, and the white paper cites data from the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation showing expenditures of over $1.3 billion on freshwater fishing (excluding the Great Lakes) in New York, again generating substantial

multipliers for secondary economic benefits. Unfortunately, the upper Hudson region presently shares a very minor portion of this revenue. As KLIOS notes, recreational fishing along the entire river south of Hudson Falls is likely to experience a major resurgence once the bans on commercial fishing and advisories on recreational fishing are relaxed.
KLIOS notes the loss of potential tourism in the Hudson Valley as a result of Superfund site stigma, citing the value of water-oriented tourism in other parts of North America. White Paper – Socioeconomics, Section 3, also examines tourism in relative context, noting that Washington County, as more typical of the upper Hudson waterfront region, has actually declined in its tourist-related employment since 1988, compared to gains in, for example, Herkimer County, which saw gains of 23 percent over 1988-99. The white paper also notes the growing interest in wildlife watching, boating, and other outdoor recreation, activities in which the region is well equipped to participate at much greater than current levels.

Finally, KLIOS notes the positive impact that remediation will have on property values on the Hudson River waterfront. Details in White Paper – Socioeconomics, Section 5, address the potential evidence of the PCB contamination's influence in depressing riverfront prices, citing a 1990 NY Canal Corporation study of property values along the river that shows those properties to be substantially lower than median residential values in the respective counties. The white paper also reviews the literature on the effects of hazardous waste sites on surrounding property values and the typical improvement in property values following remediation.

White Paper – Socioeconomics addresses several related topics, as do the Response to Master Comments 505 (scenic and tourism concerns), 689 (regional stigma), 691 (property values) and 717 (agriculture).

Master Comment 689

Commenters suggested that the planned project would harm local businesses and the local economy in many ways:

- Dredging will impact businesses along the river (*e.g.*, marinas) because it may curtail access to the river (*e.g.*, erection of silt curtains) as well as prevent use of the navigable channel.
- Businesses may find it difficult to attract new employees from outside the area. A limited labor pool could cause the overall wages to increase and local businesses would suffer.
- A massive dredging project could consume most of the available rail transportation in the region; some businesses may be forced to incur higher operating costs as they switch to truck transportation.
- The region would be unable to attract new businesses because of the stigma that would be attached to the entire region and the increased cost of doing business that would result from the dredging project.

Response to Master Comment 689

Comments on impacts of the proposed remedy on the regional economy and local businesses are substantially addressed in White Paper – Socioeconomics, which discusses the proposed

dredging and its direct and indirect short-term impacts on the regional economy, existing and potential tourism economics, commercial and recreational fishing, and impacts on property values along the river and near the processing facilities. The conclusions reflected in this white paper are that the limited duration, limited scale, and limited areas targeted for dredging are unlikely to generate a regional stigma or noticeably raise business costs. Further, there is a major potential for growth of recreational tourism, particularly of recreational boating and fishing, once the PCBs in the river are cleaned up.

Stigma and the Regional Economy

The concerns relative to the remediation program are associated with proximity to dredging operations on sections of the 40.9 miles of the Hudson River/Champlain Canal between the former dam at Fort Edward and the Federal Dam at Troy, and to perhaps two sediment processing/transfer facilities.

The dredging operations will be conducted in a six-year phased approach over the 30-week annual season, with dredges on average operating up to 14 to 16 hours per day, six days a week. However, it is important to understand that the dredging will apply to limited sections of the river. The most northern section (River Section 1, the 6.3 miles between Fort Edward and the Thompson Island Dam) would experience the most concentrated dredging activity, with most of this six-mile section subject to dredging activity. Along River Section 2 (the 5.1 miles between Thompson Island Dam and the Northumberland Dam), about two miles would be subject to dredging, typically near only one bank. Of River Section 3's 29.5-mile length, a total of only 1.75 miles comprising three locations on one bank of the river is subject to PCB dredging, although additional isolated areas (total of about one mile) would be dredged for navigational purposes. Thus, in linear terms, only eleven of the 40.9 miles of the upper river would experience dredging activity; the remaining 73 percent of the upper river would not be subject to dredging. In terms of surface area, only 493 (or 13 percent) of the 3,900 acres of the upper river would be involved in remedial activities. Moreover, less than one percent of the upper river would be involved with dredging operations at any particular time. In any event, navigational dredging will have to be carried out.

Although low density residences are scattered along both river banks, the great majority of residences of the study area would not be near the dredging operation. In terms of the major urban centers along the river (Fort Edward, Stillwater, Mechanicville, Pleasantdale, Waterford, Lansingburgh, and Troy), dredging would be adjacent only at Fort Edward and Stillwater. At Mechanicville, there would be some navigational dredging on the other side of the island separating the navigational channel from this town.

Proximity effects of dredging, including noise and visual impacts, would be limited by the geography of the targeted dredging, as well as by the relatively brief duration of proximate dredging activity. Dredging is expected to occur directly in front of a particular location in a targeted area for about one week, and within view for only a few weeks longer. Thus, potential visual impacts from the dredging would apply to only a small portion of the 40 miles of river, and would be very temporary where they would occur. Once the dredging and backfill operations have passed by, the only remediation-associated activity would be ongoing monitoring activities in the river. It should also be recognized that navigational dredging activities were commonplace

on this section of the river (prior to its designation as a Superfund site), as they continue to be on other sections of the Hudson River and the NYS Canal System.

Operations at the processing sites would be continuous over the planned six-year period. These facilities are assumed to operate 24-hour days during the 30-week annual operating season. However, the processing facility locations will be carefully selected to minimize potential impacts. They are likely to be areas with an industrial land use history, would likely be substantially screened and buffered from residential and other sensitive land uses, and would have access to and rely on rail and water transportation for the movement of materials. Potential impacts from the processing plants would thus be relatively limited and apply only to areas of close proximity. Aesthetic and visual impacts would be minimized by the fact that these sites would likely be substantially buffered from neighboring properties. Impacts to local highway networks would be minimal. Stabilized or dewatered sediments would be transported by rail or barge.

Concerns that the remediation will displace and/or overcrowd other users of the highways, rails, and the river are also unfounded and are addressed elsewhere in detail (White Paper – Project-Related Traffic, White Paper – River Traffic, and White Paper – Rail Operations). However, to summarize these discussions, it is important to note that the processing facilities are likely to generate an estimated nine truck deliveries per day; these will generally not occur during peak commuter hours. There would be an increase in traffic volumes of less than eight percent, which would not disrupt traffic on the local network near the potential northern processing facility. Interstates I-87 and I-787 serve the general area being considered for a southern processing facility, providing easy access to the entire area; thus, local highways will not be significantly affected.

On the river, the remedial activity will primarily take place outside the navigational channel, so there will be limited interference with non-project related river traffic. However, when remedial activity is necessary in the navigational channel, the dredge equipment and barges will be positioned to allow clear and safe passage of other vessels. With respect to potential congestion at locks along the river, it has been determined that even at the busiest locks there will be sufficient capacity available to accommodate both project and non-project related traffic. Use of locks out of hours is anticipated to be an option for minimizing congestion at peak season. (White Paper – River Traffic).

With respect to rail transportation, the regional rail carrier is the Canadian Pacific Railroad (CPR). Project rail requirements have been discussed with them at length. CPR has stated that there is sufficient available capacity to accommodate project-related rail traffic without effects to current regional freight and passenger train service. Thus, the transportation movements associated with the proposed remediation plan would not impact these transportation networks enough to drive up business costs and thereby create economic hardship for the region.

One comment claims that existing businesses would have difficulty in recruiting new employees and, with a limited labor pool, dredging would cause labor costs to rise and local businesses to suffer. It is true that the resurgent regional economy has seen a decline in the number of unemployed. Nonetheless, in April 2001, the numbers of unemployed in the region remain substantial, with 10,500 unemployed in the four-county region, and 11,700 when Warren County

is added. This is a substantial pool of labor actively seeking work, compared to the 533 direct and indirect jobs to be generated by the dredging for each of the six years of the project's duration (Section 2 of the White Paper – Socioeconomics discusses these impacts in greater detail). Moreover, to assume that the stigma of dredging would inhibit recruiting new employees to the region is hardly credible given the limits to the affected area (a narrow swath along eleven miles of river in a five-county region of almost 3,700 square miles) and the duration of impacts, which, except for the processing sites, would impact a particular location on the river for only a matter of weeks.

White Paper – Socioeconomics presents an input-output model customized for the upper Hudson region indicating the patterns of short-term earnings and employment that would be directly and indirectly generated by the proposed dredging program. The key findings of this model are that of the total of 3,200 jobs generated in the five-county region over the six years, the construction sector would account for 25 percent (almost 800 jobs) of the employment generated by the expenditures on dredging. Construction employment is followed by various business services, with about 670 jobs (21 percent), and transportation 560 jobs (17 percent). A variety of other services account for the bulk of the remaining projected employment, notably in retail, health, and eating and drinking places.

Employment in construction in the region has experienced a slower rebound than other economic sectors, with 11.8 percent (or 2,898) fewer employed in 1998 than in 1989 (US Bureau of Economic Analysis, 2001a). It is likely, therefore, that the dredging activity with the greatest demand upon the labor pool would, in fact, be a welcome addition to this economic sector of the region. The combined direct and indirect increase in employment in the region that would be generated from the dredging operation is estimated at 3,200 jobs over the six years or, if the expenditures were evenly distributed over the period, an average of 533 jobs per year. As a percent of current employment, this would represent an increment of 0.16 percent to the April 2001 employed population of 386,000 in the five-county region (NYS Department of Labor, June 2001). Of the presently unemployed population of 11,700, the 640 jobs would represent 5.5 percent; if all the employees were to be drawn from this unemployed pool, it would reduce the unemployment rate from 3 percent to 2.8 percent. Therefore, the expected scale of the dredging employment is not of a scale sufficient to create discernable labor shortages or wage pressures that would adversely impact business. No loss of livelihood as a result of direct or indirect impacts of remedial dredging on any particular business is anticipated. Potential impacts on marina operators, perhaps the most directly affected class of business, is discussed below.

Any potential for a regional scale and long-lasting stigma is quite remote under the conditions described of very temporary and limited impacts on particular locations along the 40 miles of river, and the finite operations (approximately six years) of substantially buffered processing/transfer facilities that rely on water and rail transportation. The positive opportunities for businesses presented by project-related activities appear to obviate the concerns of adverse impacts to the cost of doing business in the area or to the availability of labor. Indeed, the selected remedy is expected to help remove the long-standing stigma associated with the PCB contamination in the river.

Recreational Navigation

White Paper – Socioeconomics (Section 3) discusses existing tourism and its potential for growth in the upper Hudson region. Section 4 of the white paper also discusses recreational fishing. With respect to recreational boating, the dredging would be organized so that the river navigation channel would continue to function normally, with the possible exception of short-term restrictions when maneuvering barges/pipelines in limited areas is required. As noted above, actual dredging would be limited to less than one percent of the Upper Hudson River at any time.

The dredging operation's potential impacts on navigation would be primarily limited to traversing the section of the river where dredging would be in operation or sharing the locks with barges hauling the dredged material. Because of the relatively small area of the river affected at any particular time, the recreational experience on the river would remain substantially unaffected in those areas away from the dredging operation.

Travelers on the river or moving along adjacent roadways would pass through areas where dredging was in-progress in a matter of minutes. For these individuals project generated noise, odor, and visual intrusion will be of little consequence once they are beyond the immediate work area by only several hundred feet. In these situations the impacts would be quite minimal and the river travelers, in particular, would have 99 percent of the Upper Hudson unaffected by the physical presence of the dredging barges. Noise impacts and the potential for odor generation are detailed in other white papers; noise levels are expected to be below NYSDOT construction impact guidelines a relatively short distance from the dredging equipment and odor is not expected to be an issue at all. There is also a possibility that the dredging work will engender some interest for tourists since it will be viewed as a temporary activity with a unique environmental objective.

With respect to the potential congestion of the river and canal locks, the operational demands and lock capacities are discussed at length in the White Paper – River Traffic. The conclusions of the analysis are that, based on 1999 use patterns by pleasure vessels and projections of dredging operations, there would continue to be excess lock capacity generally with no congestion for pleasure vessels at locks under all reasonable scenarios. There is a potential for congestion to occur at Locks 5 and 6 during the peak canal season. However, if project-related vessels utilize the locks after hours, lock congestion as a result of the remedy is reduced, if not eliminated altogether. Consequently, few adverse impacts are anticipated for recreational boaters during the remediation. Moreover, a portion of the dredging is oriented to navigational dredging that, when completed, would provide an expanded and safer capacity for recreational and commercial use of the river, and would likely enhance the area's economy through increased tourism.

Marinas along the river are major participants in the recreational boating activity and comprise a class of local business with concerns about remediation -related impacts. Eleven marinas have been identified as being located on the river between Fort Edward and the Troy Dam. White Paper – Socioeconomics identifies each marina, its proximity to any proposed dredging, and likelihood of any adverse impacts.

Only one marina, the West River Road Marina near Moreau, would be adjacent to any proposed dredging. At the time of this writing, however, it seems that this particular marina may no longer be operating.

Longer Term Economic Effects

In the post-remediation phase, the upper Hudson region is likely to experience a notable improvement in its economy, particularly in those activities relating to recreation and tourism, expanding employment and earnings in the many sectors of the economy that relate to these activities. This in turn will be likely to improve property values in the region and especially along the river.

Much of the Hudson River along the 40 miles from Troy to Fort Edward is rural, with relatively few built tourist amenities. Washington County as a whole is more representative of this stretch of the river than would be, for example, Saratoga County, which has lots of tourist attractions but largely oriented to Saratoga Springs, the Saratoga Spa State Park, to I-87, and other attractions away from the river. The 1999 data from County Business Patterns cites 52 accommodation establishments in Saratoga County and 62 amusement and recreation establishments; equivalent data for Washington County show no accommodation establishments and 15 amusement and recreation establishments reported. (US Census Bureau, 1999). The discussion on river-oriented accommodations in White Paper – Socioeconomics identifies one motel in Fort Edward, Washington County, that was open in 1999, implying that the County Business Patterns data may not be completely inclusive.

White Paper – Socioeconomics examines tourism and recreation-oriented activities in each of the affected counties along the river and compares these with other counties in upstate New York that have freshwater recreation resources but are outside the region, *i.e.*, Herkimer, Cayuga, and Seneca Counties. The data reveal that Washington County's small tourist-oriented employment has declined since 1988, whereas Cayuga County's has increased 63 percent over the period 1988-99. If, for example, Washington County had increased this sector at the same rate as Herkimer County (23 percent), it would have added 500 tourism-oriented jobs or, similarly, Albany County would have added 3,266. With Washington County so far behind the tourism growth of other counties, both in the upper Hudson region and elsewhere in the State, it is quite apparent that the county that typifies the target area for dredging has not shared in this important growth industry. The image of one of its key tourist amenities, the Hudson River, as being contaminated with PCBs may well have contributed to this poor performance.

Scenic Hudson's consultant, KLIOS, Inc., (in Appendix A of its comments) noted, for example, that the value of recreational boating in Maryland exceeded $1 billion in 1993, that Lake Michigan festivals in 1992 grossed revenues of $51 million, and that recreational boating on the Ottawa River added $14 million in sales to the local economy. The authors note that specific studies on the value of tourism in the Hudson Valley are not available.

Tourism involves a wide variety of recreational activities. Among those most relevant for the upper Hudson valley would be outdoor recreation, as compared to visiting museums or movie theaters. Data from the National Survey of Recreation and the Environment conducted in 1994

and 1995 (Outdoor Coalition of America, 1997) show high annual participation rates in the US for activities relevant to the upper Hudson valley:

- Viewing/studying (76.2 percent or 152.6 million persons).
- Visiting beach/waterside (62.1 percent or 124.4 million persons).
- Sightseeing (56.6 percent or 113.4 million persons).
- Freshwater fishing (24.4 percent or 48.8 million persons).
- Boating (29 percent or 58.1 million persons).

Major increases in participation over the previous decade were recorded for bird watching (an increase from 21.2 million to 54.1 million persons) and hiking and backpacking (an increase from 33.5 million to 63 million persons). Another key database on this type of tourist activity is the National Survey of Fishing, Hunting and Wildlife Associated Recreation (USFWS, 1998). This source reported 3.3 million wildlife-watching participants in New York State, of whom 1.173 million were nonresidential (*i.e.,* away from home). Total expenditures for wildlife watching in New York were almost $1.3 billion, of which trip-related expenditures were $139.7 million and $1.1 billion was for equipment and other expenditures.

It is clear that the Upper Hudson River ought to be a major participant in these outdoor, nature-oriented modes of recreation. The available data on the economic significance of these activities points to their substantial scale; however, the riverside communities of the four counties adjacent to the PCB dredging appear to participate much less than would be expected, especially given the world class resource that the river provides in its own right along this reach of the river, and as a connector to other magnificent resources, such as Lake Champlain to the St Lawrence River, and the Mohawk River/Erie Canal to the Great Lakes. With the remediation of the PCB contamination, the river would have a much greater likelihood of securing and expanding its fair share of these tourism and recreational benefits.

Recreational fishing is another key activity but, following the 1976 fishing ban in a portion of the Upper Hudson River (Hudson Falls to Troy), catch-and-release sport fishing has been allowed only since 1995. Fish consumption advisories remain in effect, and it is illegal to possess fish from this portion of the river. It is interesting to note that the NY Canal Corporation, which is responsible for the entire New York canal system including the Erie Canal and the Champlain Canal (of which the Upper Hudson River is part), markets the waterways as a major tourist/recreational resource, with fishing as one of the key activities (NY Canal Corporation, Recreationway Plan, 1995). It is the PCB contamination that prevents the Champlain Canal south of Fort Edward from joining with this world class recreation resource.

Recreational fishing along this section of the river could be a significant economic activity. An estimated 78,000 fishing licenses were issued in 1998-1999 fishing season to anglers in the five counties surrounding the Upper Hudson. The 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation indicates that in New York State, there are 1,493,000 NY resident anglers (over age 16) who spend an average of 18 days at this activity with average annual expenditures of $942 each, with $1.3 billion spent in New York. Of New York's resident anglers, 996,000 (or 67 percent) fished in freshwater (excluding the Great Lakes), making 13.5 million trips covering 16.2 million days. In 1996, of the $1.3 billion fishing expenditures in New

York, trip-related expenditures, including food, lodging and transportation, and boat rentals, came to $601 million, and each angler spent an average of $353 on trip-related costs.

In addition to these direct expenditures by anglers, there are secondary economic benefits as these dollars circulate in the local economy, generating additional indirect jobs and earnings. Employment multipliers from service activities such as hotels, and eating/drinking places in the upper Hudson region are on the order of 18 to 28 jobs per million dollars expended (US Bureau of Economic Analysis, 2001b). Thus if, for example, the Upper Hudson were to generate a direct increment of $100 million of expenditures in these service industries important to anglers, another 1,800 to 2,800 new jobs would be created.
With the bans and advisories in effect, the communities along the Hudson River south of Fort Edward have barely participated in these huge recreational expenditures, despite some of the most magnificent scenery and fishing opportunities in the State. It is also appropriate to note that the benefits of recreational fishing are hardly limited to economics. The social, physical, psychological and educational benefits of intimate contact with nature, while intangible, provide significant opportunities for personal renewal and reflection, accounting for much of fishing's broad popularity.

The PCB remediation offers the long-term prospects of a renewed and enhanced recreational fishing-associated industry. It is expected to generate a range of positive benefits that include a substantial boost to local economies and, indirectly, a greater sensitivity to preservation of the natural environment, an intrinsic quality of recreational fishing.

Master Comment 313952

A number of comments said that the Feasibility Study should have considered potential economic impacts of the preferred remedy on the local community, including impacts to local businesses and property values.

Response to Master Comment 313952

CERCLA and the NCP establish criteria that EPA must consider when evaluating remedial alternatives for a Superfund site. In accordance with 40 CFR § 300.430(e)(9), these criteria include overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; cost; State acceptance; and community acceptance. Potential economic impacts of remedial alternatives is not one of the evaluation criteria established by CERCLA or the NCP, and therefore EPA did not collect data on such issues prior to the Proposed Plan. Nevertheless, EPA can address public comments concerning potential economic impacts of a remedy under the "community acceptance" criterion, although community acceptance cannot be fully assessed until after the public comment period on the draft RI/FS and proposed plan is completed. *See* 55 Fed. Reg. 8666, 8719 (March 8, 1990).

EPA has received a number of comments on potential economic impacts of the selected remedy. These comments are addressed in this RS throughout this chapter, Chapter 8, and in White Paper – Socioeconomics.

Master Comment 691

Some commenters expressed concern that the planned project would impact local property values and harm the real estate industry due to nuisances caused by the construction, dredging, and processing activities.

Response to Master Comment 691

White Paper – Socioeconomics addresses the potential for adverse impacts on property values created by the remediation program. The white paper notes that existing property values along the Upper Hudson River appear to have suffered some depreciation from the presence of PCB contamination in the river, and that the cleanup is likely to substantially enhance their value over the longer term. Further, the limited locations targeted for dredging and their brief duration are unlikely to generate adverse impacts on the values of these waterfront properties. Properties in close proximity to the processing sites may experience some temporary property value impacts but these would be minimized by their careful selection at former industrial sites, with water and rail access for the movement of materials, and their design as substantially indoors and buffered from adjacent properties.

Data on property values along the Hudson River and Champlain Canal were studied in detail in the Canal Corporation's study of Economic Benefits of Operation, Appendix A13, on Flood Damages (Canal Corporation 1990). The Canal Corporation collected and refined data on property values for 1,592 residential properties along the river's floodplain in the following municipalities: Village of Waterford, Town of Waterford, Mechanicville, Schaghticoke, Village of Stillwater, Town of Stillwater, Schuylerville, Fort Miller, and Fort Edward. While the purpose of the study was to assess potential flood damages on different types of residences (*e.g.*, with and without basements, second floors, trailers, etc.), it also allows an identification of the average values of the residences near the water. For such residences in Saratoga County, the average value in 1990 was $61,218; for those in Rensselaer County it was $68,331; and for those in Washington County it was $50,406.

The 1990 Census records median owner-occupied values of $107,600, $92,500, and $69,900, respectively for Saratoga, Rensselaer, and Washington Counties. While *average* and *median* values as indicators of centrality may not be identical, the differences between values along the river's flood plain and the rest of the county are very substantial. In Saratoga County those in the flood plain were 43 percent less than the county as a whole; in Rensselaer County 26 percent less; and in Washington County, 28 percent less. Exactly what specific factors account for this variation in values are uncertain, but the potential that the PCB issue was a contributing factor in lowering these values must be considered. Only if these data were reversed, and property along the river was valued more highly, could proximity to the PCB Superfund site issue be discounted.

Property brokers in Saratoga County have noted reluctance of purchasers to look at property near the river. Although, as noted, the existing property values along the river may have already suffered because of their proximity to a designated Superfund site, comments that it is the proposed remedial dredging that would depress property values (ARCC, pp. 23-25) may be discounted once the scale and operational patterns of the dredging are understood. The dredging

scenario presents a remediation effort that would involve dredge barges and their support vessels steadily moving along the river for six years. The pace of the barges would be such that its adjacency to most locations would be limited to only a few weeks. At other times, loaded and empty barges and supply vessels are likely to pass by a few times a day. These are patterns of operation that are reminiscent of the 1970s and earlier, when numerous commercial barges used the canal and navigational dredging was regularly performed.
The operational characteristics of the proposed PCB dredging, the relatively small scale, the brief duration of the dredging at any particular location (less than one percent of the upper river at any one time), and the targeted dredging for only 13 percent of the river's surface area (affecting 27 percent of the river length) between Fort Edward and the Troy Dam, are highly unlikely to generate any significant or permanent adverse impacts on the adjacent waterfront properties. Over the longer term, after the PCB remediation, owners would likely enjoy the prospect of substantially enhanced property values. Similarly, owners along the entire Hudson River south of Troy would obtain an increased amenity from the cleanup of the river that could translate into substantial gains in aggregate property value.

The remediation program also requires sediment processing/transfer sites where the dredged material is dewatered and stabilized (by adding Portland cement or another stabilization agent), and from which the stabilized material would be transported by rail to sites situated well beyond the Hudson Valley. These facilities would operate for approximately six years (*i.e.,* until completion of active remedial activities). The careful selection of these sites at industrial or other appropriate locations with water and rail access for the movement of materials, and their being substantially buffered from adjacent properties, would minimize their potential for adverse impacts on nearby property values.

With regard to PCB volatilization and general air quality, no significant off-site hazards are likely to be associated with operations of the transfer and processing sites (see White Paper – PCB Releases to Air). The handling of PCBs at the processing/transfer facilities will not pose an undue risk to nearby communities since EPA will impose strict operating controls on the contractor and will then monitor site operations to confirm adherence to the project's technical specifications. It is expected that the overall perception of the transfer and processing sites will appropriately be that of modest industrial complexes that operate for several years and are then recycled for other uses.

White Paper – Socioeconomics addresses nuisance factors as follows:

- Traffic - The processing/transfer facilities will generate traffic both during the project's mobilization phase and during the six-year period of dredging operations. However, the anticipated level of vehicular activity is not expected to generate a significant impact on roadways near the transfer and processing facilities.
- Odor - Activities at the transfer/processing facility sites are not expected to be a source of odor to nearby communities.
- Noise - Operations at the processing/transfer facilities will generate low though perceptible levels of noise in their immediate vicinity.
- Lighting - Nighttime operations at the processing/transfer facilities will require lighting for worker safety reasons. It is expected that site lighting can be designed so as to avoid nuisance impacts to nearby residential land uses.

Despite the foregoing, it is possible that the processing/transfer facilities would have the potential for temporarily impacting property values in close proximity. The literature of empirical studies on the negative effects of Superfund sites on property values is reviewed in White Paper – Socioeconomics. Generally, adverse impacts created by hazardous waste facilities range from two to eight percent, with such negative effects declining with distance from the site. A variety of factors appear to influence the level of effect, among which a powerful influence can be negative publicity by the media, in the mode of a “self-fulfilling prophecy.”

In conclusion, the brief operational characteristics and duration of dredging at any particular location (usually only about one week) and the limited geographic targeting of the dredging (13 percent of the river surface or 27 percent of its length between Fort Edward and the Troy Dam) are not sufficient to generate significant or permanent adverse impacts on property values along the river. Effects on adjacent properties, in fact, would be much less than if a landside construction project were to occur. After the cleanup of the river, property values, particularly of waterfront properties, would be expected to substantially improve, overcoming what appears to be a historical depression from their proximity to PCB contamination. Potential impacts on property values adjacent to the processing facilities would be substantially mitigated by the careful siting and design of these facilities. Such conditions, together with their approximate six-year design life, will limit potential adverse property value impacts and offer the prospect of their full recovery once remediation is complete. Thus, over the long term, the remediation program offers a permanent means of overcoming the PCB-contamination stigma and improving property values in the region.

EPA has supported a literature review of the effects of Superfund sites on local property values (web site: www.epa.gov/superfund/programs/recycle/stigma.htm). This paper, entitled "Property Values, Stigma and Superfund," is a working document recording current knowledge and understanding of the role of stigma in retarding or limiting the post-remediation recovery in the value of properties on or near hazardous waste sites.

8.5.3 Quality of Life

Master Comment 733

Commenters, including individuals and such organizations as Scenic Hudson, NOAA, NYPIRG, NYOAG, NRDC, and USFWS, felt that the remedy was needed despite any temporary inconveniences caused by it. These commenters felt that the improvement reached by the dredging remedy and long-term advantages to the economy more than justified the temporary disruptions.

Other commenters expressed concerns that dredging operations would severely compromise their overall quality of life, the bucolic life of the Upper Hudson, and the aesthetic value of living in that area.

Response to Master Comment 733

A number of the longer term benefits that a number of commenters view as worth the investment of some inconvenience have to do with the economy of the area and the prospect of reduced PCB contamination in fish, which would benefit human health and the environment and contribute to the overall recovery of the river. Such benefits include the following:

- The estimated total expenditure for dredging and related disposal and monitoring activities (in year 2000 dollars) is $461.9 million (US EPA FS Table 8-11b). Of these dollars, $262.2 million, or 38 percent, are conservatively assigned as expenditures within the five-county region (Albany, Rensselaer, Saratoga, Warren, and Washington Counties). This will generate an estimated 3214 jobs.

- The Upper Hudson River region stands to improve its tourist-based economy from the cleanup of the river, attracting more recreational use of the river and surroundings than it does presently; current data indicate that Washington County, for example, enjoys significantly lower levels of tourism-related activities and associated employment than comparable counties elsewhere in New York State.

- Dredging the sediment-laden navigational channel of the Champlain Canal can only increase the potential for commercial and recreational navigation, with associated economic benefits to area marinas, lodgings, and restaurants.

- Property values along the river, which today lag behind waterfront property values elsewhere in the State, are expected to increase as a result of removal of PCBs and diminishing of the "Superfund site" reputation.

White Paper – Socioeconomics and responses to comments in Section 8.5 for more details concerning potential economic benefits of the remedy.

The concerns having to do with the bucolic life and aesthetics of the Upper Hudson River region fall largely into the following general areas of disturbance:

- Visual intrusion, light, and noise generated by the dredging and transfer/processing facility operations.
- Disruptive increases of traffic on local roadways and in the river.

Several white papers and responses to master comments in this chapter address elements of these concerns, including the following white papers: Socioeconomics; River Traffic; Project-Related Traffic; and Evaluation of Noise. Highlights addressing the foregoing concerns are as follows:

- **Visual intrusion:** The dredging operation is a mobile one, targeted to limited areas of the river and progressing about 150 feet per day, so that visual impact from dredges will be short-term and limited by the geography of the targeted dredging. The great majority of residences in the study area would not be near the dredging operation, and as to more urban settings, dredging would be adjacent only at Fort Edward and Stillwater. Some navigational dredging would occur at Mechanicville, but on the other side of the island separating the

navigational channel from this town (Response to Master Comment 505 in Section 8.5.1). Potential visual impact from the processing sites will be longer term, approximately six years, but also ultimately finite. Careful siting and design would minimize these impacts.

- **Lighting** - Nighttime operations at the transfer and processing facilities will require lighting for worker safety reasons. It is expected that site lighting can be designed so as to avoid nuisance impacts to nearby residential land uses (Response to Master Comment 645, Section 8.3.1).

- **Noise** - Operations at the processing/transfer facilities will generate low though perceptible levels of noise in their immediate vicinity (Response to Master Comment 699, Section 8.2).

- **Traffic** - The processing facilities will generate traffic both during the project's mobilization phase and during the six-year period of dredging operations. However, the anticipated level of vehicular activity is not expected to generate a significant impact on roadways near the transfer and processing facilities. Principal roadways in the vicinity of the example northern processing site that would be used by project employees and for delivery of materials are not operating at capacity and the additional project load will increase vehicular flows by only four to eight percent under peak hour conditions. Further, barges will be used extensively at the northern facility for delivery of mechanically dredged sediments. Project activity in the general area of the example southern facility will not impact traffic congestion because of the assumed industrial nature of the site, the presence of both interstate highways, and anticipated extensive use of rail and barges.

There is a potential for congestion to occur at Locks 5 and 6 during the peak canal season. However, after-hours use of locks by project-related vessels is anticipated to mitigate any congestion problems. Most dredging work will take place outside of the navigation channel, and the width of the river in most targeted areas can accommodate both project equipment and current vessel traffic (Response to Master Comment 312942, Section 8.1.2).

Master Comment 422786

Commenters felt that dredging PCBs would improve the quality of life in the Hudson River area by increasing fishing, boating, swimming and other recreational activities and reducing concerns associated with current levels of PCBs (*e.g.*, drinking water, agriculture, effects on fish and wildlife).

Response to Master Comment 422786

EPA agrees that active remediation as outlined in the selected remedy would ultimately improve the overall quality of live and the economy in the Hudson River Valley, in addition to being protective of human health and the environment. Response to Master Comment 499 in Section 8.5.2 and Response to Master Comment 505 in Section 8.5.1 contain discussions of the benefits that are anticipated, such as improved fishing and recreational activities and economic advantages.

8.5.4 Historic and Cultural Resources

Master Comment 362961

Several commenters cited the presence of cultural resources (variously described as historic events, historic sites, archaeological treasures, historic and archaeological sites, and landmarks) located within the Upper Hudson River. The commenters said such resources should be identified, or that they would be adversely impacted by the proposed remediation.

One particular commenter discussed historic preservation legislation applicable to federal undertakings, National Register-listed resources located within the general project area, and possible impacts to cultural resources from dredging and associated activities. This commenter also suggested that the schedule for the proposed remediation makes it unlikely that cultural resources will be afforded the consideration required by State and federal law.

Response to Master Comment 362961

This response provides the following subsections: a brief summary of federal and State regulations that offer protection to cultural resources; a response to significant public comments regarding the impacts of the proposed dredging action upon cultural resources; a summary of EPA's Stage 1A Cultural Resources Survey (CRS), provided as Appendix B to this Responsiveness Summary; and a general discussion of the National Historic Preservation Act (NHPA) Section 106 process, the most directly relevant legislation concerning the EPA's obligations to consider cultural resources.

National Historic Preservation Act (NHPA)

The NHPA of 1966, as amended (16 USC 470 et seq.), was enacted to integrate the consideration of historic preservation issues into the early stages of project planning by a federal agency. Under Section 106 of NHPA, and its implementing regulations (36 CFR Part 800), the head of any federal agency having direct or indirect jurisdiction over a proposed federal or federally financed undertaking is required to take into account its effect on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places. Effects are evaluated with regard to the Criteria of Adverse Effect set forth in 36 CFR 800.9. The federal Advisory Council on Historic Preservation (ACHP) oversees the NHPA.

Response to Comments Concerning Impacts to Cultural Resources

Through a survey of the files of the New York State Historic Preservation Office (NYSHPO), EPA has determined that a number of previously identified cultural resources are located within approximately 2,000 feet of the Hudson River coastline between Hudson Falls and the Port of Albany. These resources include over 85 buildings, structures, sites, or historic districts that are listed on the National Register of Historic Places (primarily buildings and districts, although two listed resources include archaeological sites), approximately 300 identified but unevaluated archaeological sites, and an undetermined number of National Register-eligible resources. In addition, through preliminary analysis of the project area, there is the high potential for

additional historic architectural resources and archaeological sites (located both along the coastline and buried within the river sediments) to be present in the immediate vicinity of the proposed remediation area.

Preliminary Section 106 analyses of the impact of the selected remedy on National Register-listed resources and identified archaeological sites appears to indicate that the remedy would have no effect on the resources either because of the nature of the resource or because they are far removed from the remediation area. However, preliminary Section 106 analyses appear to indicate that the selected remedy may have an adverse effect upon three National Register-listed and one known National Register-eligible resource in the project area, as summarized below.

It is possible that there may be some impact to Rogers Island, the Mechanicville Hydroelectric Plant, and the Old Champlain Canal (National Register listed), and the Champlain Barge Canal (National Register-eligible) from the selected remedy. If a sediment processing/transfer facility were to be located near the example site proximal to the Old Moreau Dredge Spoils Area, there could be some visual impacts to Rogers Island. Although it is post-World War II sediments that contain targeted PCBs, either mechanical or hydraulic dredging along the channel between the island and the east bank of the Hudson River does have the potential to disturb some older sediments that might have some prehistoric and historic sensitivity. Dredging near the Mechanicville Hydroelectric Plant may have a temporary visual impact on this historic resource but no damage to the facility itself is anticipated as a result of the project. The Champlain Barge Canal route follows the channel of the Upper Hudson for most of its length, beginning at the Federal Dam in Troy, and dredging has occurred in the past both there and in the Old Champlain Canal without damage to historic stone features, locks, and dams; neither is such damage anticipated to be associated with the proposed dredging operation. However, the presence of booster pumps and pipelines associated with hydraulic dredging could temporarily alter the historic character and feeling of the canal area.

Potential methods to mitigate adverse effects to Rogers Island, the Old Champlain Canal, the Champlain Barge Canal and the Mechanicville Hydroelectric Plant include devising dredging plans that minimize impacts to elements that qualify these resources for listing in the National Register (*i.e.*, preserve historic character-defining features of the resources while implementing dredging activity).

Additionally, there is the potential that the proposed dredging may impact cultural resources that may be present but have not been identified. Such resources could include historic buildings, structures, sites, objects and districts located along the river bank or within the river itself in areas that will be dredged.

Comments also identified potential adverse effects to historic properties due to a decline in tourism and the siting of processing/transfer facilities. EPA believes that the selected remedy would result in an expansion, rather than a decline, in tourism in the Hudson River Valley (White Paper – Socioeconomics). Therefore, EPA does not believe that the remedy will adversely affect tourism. With regard to transfer facilities, it is important to note that EPA has not yet determined the locations of sediment processing/transfer facilities necessary to implement the selected remedy. EPA will comply with substantive requirements of the NHPA in connection with the facility siting process. For purposes of the Feasibility Study, example locations were identified

from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the Feasibility Study, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable bounding assumptions with regard to distance from the dredging work and cost. Other locations, both within the upper Hudson River valley and farther downstream, are possible.

The example facility locations presented in the FS have also been used in the Responsiveness Summary in order to clarify material presented in the FS and Proposed Plan, and in connection with additional noise, odor, and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after the Agency holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, all information provided in this RS relative to potential impacts of the sediment processing/transfer facilities on communities, residents, agriculture, the environment, and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during design.

Stage 1A Cultural Resource Survey

In compliance with Section 106, EPA has prepared a Stage 1A CRS. EPA has prepared this document as a preliminary step in the identification of cultural resources in the area of potential effect (APE) in order to evaluate the potential impacts of the selected remedy upon such resources. As mentioned earlier, this CRS is provided as Appendix B of this Responsiveness Summary and will also be distributed separately from this document. The CRS provides the following major sections:

- **Methodology** – a description of the EPA's APE, goals and research methods, the information repositories visited, and substantive issues regarding limitations of the collected data.
- **Selected Remedy** – a description of the selected remedy as it applies to potential impacts to cultural resources. This chapter also summarizes the other alternatives considered.
- **Environmental Setting** – background information on the physiology, glacial history, hydrology, and sediments of the project area to provide an environmental context for subsequent discussions of cultural resources.
- **Prehistoric and Historic Background** – an overview of the prehistoric and historic development of the upper Hudson River valley. This chapter provides a baseline contextual framework against which to consider the cultural resources of the project area in particular. Given the size of the project area, and its considerably long and complex history, this chapter necessarily focuses on broad themes such as settlement, economic development, transportation innovations, and military conflicts.
- **Results of Survey** – summary information, as well as lists and tables, regarding the substantive information collected during EPA's research at the NYSHPO. This chapter

includes information concerning National Register-listed resources, National Register-eligible resources, unevaluated resources, and relevant compliance and planning surveys.

- **Effects of Selected Remedy** – a discussion of potential effects to known resources, as summarized earlier in this response.
- **Future Steps** – an outline of additional steps EPA may take, in compliance with Section 106, to identify National Register-eligible resources.

Section 106 Process of the NHPA

With the preparation of the CRS, EPA has completed its first step in compliance with substantive requirements of Section 106. As stated above, the CRS establishes baseline information and provides an overall framework for possible future identification and evaluation efforts. The EPA's next step will be to initiate consultation with the NYSHPO and identified consulting parties. Consultation will likely be ongoing during this process and could serve to identify additional resources, survey strategies, and to evaluate effects. It is expected that additional surveys may be necessary to complete EPA's identification of potentially affected cultural resources. Such studies could include additional topic-specific research, walkover surveys, development of an archaeological sensitivity model of the coastline and riverbed, subsurface testing, radiometric dating of riverbed sediments, and intensive-level surveys of historic resources located adjacent to impact areas. If unavoidable impacts are subsequently identified, mitigation strategies would be developed in consultation with the NYSHPO and relevant consulting parties.

References

New York Canal Corporation. 1995. Recreationway Plan.

New York State Department of Labor. 2001. Local Area Unemployment Statistics, June.

Outdoor Coalition of America. 1997. Emerging Markets for Outdoor Recreation in the United States: Results of the National Survey of Recreation and the Environment.

US Bureau of Economic Analysis, Department of Commerce (US BEA). 2001a. Regional Economic Information System.

US BEA. 2001b. Regional Input-Ouput Modeling System II (RIMS II), customized computer model for the five-county upper Hudson region.

US Census Bureau, Department of Commerce. 1999. *County Business Patterns* (Washington County).

US Fish and Wildlife Service, Department of the Interior. 1998. National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

8.6 Siting of the Facilities

8.6.1 Site Selection Criteria

Master Comment 745

Commenters expressed concern about the lack of detailed information regarding site selection criteria for the sediment processing/transfer facilities. Also of concern is that the facilities could ultimately be in undesirable locations such as near residential areas. A related concern was raised with regard to final disposition of the processing/transfer facilities once the project has been completed.

Response to Master Comment 745

EPA has not yet determined the location(s) of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility location(s) from an engineering perspective. In the Feasibility Study, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified, one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations meets many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the upper Hudson River valley and farther downstream, are possible.

The example facility locations presented in the FS have also been used in the RS in order to clarify material presented in the FS and Proposed Plan and in connection with additional noise, odor, and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after EPA performs additional analyses and holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, all information provided in this RS relative to potential impacts of the sediment processing/transfer facilities on communities, residents, agriculture, the environment, and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during design.

Important characteristics of a potential site are as follows:

- **Shoreline**: The immediate river bank area should have good water access or be easily dredged to provide good access for barges and other floating equipment. The immediate upland area should not be elevated more than five to 10 feet above water level to facilitate transfer of dredged material and other operations. If a bulkhead does not already exist at a particular location, then subsurface conditions should lend themselves to construction of a bulkhead wall and/or a dock. It would be preferable to find a shoreline reach where a heavy-duty bulkhead already exists.

- **Landside**: The property selected for transfer operations should be fairly level so that transfer operations, material processing, and rail/truck facilities are situated at approximately the same elevation. It would be preferable to select an industrial site so as to avoid impacting residential, recreational, and institutional land uses.

- **Roadway Access**: Transfer locations should have good roadway access for construction equipment and employees. Roadways that connect the site should optimally avoid densely populated residential communities and should either be two-lane truck routes or should connect directly to such route(s).

- **Rail Access**: Sites with good rail access are preferable, to facilitate sediment hauling and probably reduce the overall cost of transportation through movement of relatively large loads by rail.

- **Site Area:** Ideally the site should be an industrial one. In the case of a northern facility, the site, if not completely industrial, should be in as remote an area as possible with regard to residences to minimize any nuisance inconveniences. Further, access to off-site storage of gondolas and other associated equipment should be considered.

It is not anticipated that there will be risks to residences associated with operation of facilities at these sites. Relative location of residences and land use in proximate areas are factors that will be considered as part of the facility siting process. Further, given the result of preliminary assessment, it is unlikely that a residential area would meet the selection criteria as outlined above. A health and safety plan and contingency plan will be in effect during operation of the transfer and processing facilities, as in the case of any similar operation. EPA will solicit public comment on potential facility locations before selecting final locations.

White papers containing discussions relevant to facilities include PCB Releases to Air; Example Sediment Processing/Transfer Facilities; and Air Quality. The results indicate that the risks associated with the operation is insignificant compared to the published standards. Finally, facility design and layout, lighting, and screening and buffering of the facility as much as practicable, and minimization of truck traffic, among other considerations, will mitigate potential impacts on surroundings.

With regard to final disposition of the processing/transfer facilities, as indicated in the Proposed Plan (p.24), EPA expects that the sediment processing/transfer facilities will be removed after completion of active remedial activities. In the event any unanticipated contamination on facility property results from remedial activities, the property will be cleaned up in connection with the facility removal process. Though purely speculative at this time, it is conceivable that one or more of the facilities may not be removed if the local municipality or owner of the facility property wishes to keep the facility (or parts of it) in place for another use after the remediation project is complete.

8.6.2 Implications of the Facilities

Master Comment 743

Commenters were concerned that placement of the processing facilities would have a major negative impact on their lives through adverse effects on their financial situation as well as their overall quality of life.

Response to Master Comment 743

It is not anticipated that the processing/transfer facilities would have a negative impact on overall quality of life. Ideally the facility(ies) will be located in industrial areas, or in areas that are as remote as possible with regard to residences in order to minimize any nuisance inconveniences.

Although some adverse impacts upon proximate property owners are possible, these will be minimized by the careful siting and design of the facilities. A review of the literature on potential property value impacts indicates that while there may be some negative impact, the exact impact is difficult to predict, and property values are likely to rebound upon the cessation of these facilities' operations.

Details concerning potential economic and quality of life impacts from the selected remedy are provided in White Paper – Socioeconomics. Further related discussion appears in this chapter appears in Section 8.5.

8.7 Facility Operation

8.7.1 Staging of Dredged Sediments

Master Comment 741

Commenters contended that operation of sediment processing/transfer facilities and storage of operating materials and dredged sediments prior to transport could be dangerous and hazardous, and would be disruptive of the neighborhood quality of life.

Response to Master Comment 741

Ideally, in order to minimize any nuisance inconveniences, sediment processing/transfer facilities will be located in industrial areas, or in areas that are as remote as possible with regard to residences. Relative location of residences and land use in proximate areas will be factors in consideration of sites for these facilities. It is not anticipated that storage of stabilizing agents (*e.g.*, Portland cement) or other chemicals will impact the communities in the general area of a facility.

White Paper – Example Sediment Processing/Transfer Facilities contains a conceptual facility layout for processing the mechanically or hydraulically dredged sediment. For mechanically dredged sediment, processing will include barge unloading, pumping and treatment of excess

water, removal of large debris, chemical stabilization, transfer to rail car loading area, and rail load-out. The water treatment would consist of coagulation/flocculation, filtration, and granular activated carbon treatment. For hydraulically dredged sediment, the slurry flow and its solids content would be equalized before the dewatering process. The vibrating screen and the Hydrocyclone would remove the debris and large sandy particles. The coagulation/flocculation process would remove the fine particle from the slurry stream. The settled solids would be dewatered using belt filter presses and the supernatant would be treated in a water treatment unit.

The processed sediment will be classified as TSCA and non-TSCA material based on PCB content for off-site disposal. It should be noted that the selection of disposal facilities has not been made yet. The disposal facilities located in western New York and Texas are example sites and were used for preliminary conceptual design and cost analysis and comparison purposes. The disposal site selection will be finalized just prior to construction phase of the project. The selected disposal sites will have State and federal permits and prior EPA approval.

The processing facilities will be designed to handle and stabilize the dredged material on a continuous basis. For the mechanical dredging option, a temporary staging area will be used to handle the stabilized dredged material (*e.g.*, mixed with Portland cement) prior to sending it to a railcar loading area. For the hydraulic dredging option, a covered surge tank will be provided for flow and concentration equalization. There will be no short-term or long-term storage facility at either of the proposed processing facilities, as indicated in White Paper – Example Sediment Processing/Transfer Facilities. The discharge of water from the facilities will comply with all substantive State and federal requirements. The release of PCBs in the surrounding air and other air pollutants from the processing/transfer facility and the resulting impact is variously discussed in: White Paper –PCB Releases to Air, White Paper – Example Sediment Processing/Transfer Facilities, and White Paper – Air Quality Evaluation. The results indicate that the risks associated with the operation are insignificant compared to the published standards.

After issuance of the ROD, EPA will perform additional analyses and seek public comment on a possible location(s) for the sediment processing/transfer facility(ies) before selecting a final location(s). EPA also intends, as a matter of policy, to provide the public with opportunities to provide input regarding design aspects of the remedy so that community concerns and suggestions can be considered by EPA during remedial design.

8.7.2 Processing

Master Comment 717

Several commenters argued that the FS does not address potential impacts to the agricultural community due to the dredging project and in particular, the processing facilities. Among potential impacts to the agricultural community raised by commenters are:

- Changes to the drainage dynamics of farmland directly adjacent to and near the river.
- The possibility of adverse effects on floodplain farmland during spring flooding.
- Impacts on wells that are hydrologically influenced by the river.

- Depending on the location of the processing facilities, possible damage to agricultural soils and water conservation systems due to use of heavy equipment during construction.
- Depending on the size and location of the processing facilities and of the source(s) of material for backfill, possible consumption of large areas of agricultural land for the duration of the project for the processing facilities, and permanently for the backfill source(s).
- Whether topsoil from agricultural lands be needed as part of the backfill program, and if topsoil is required, identification of the areas from which it will be obtained.
- Hindrances to planting, spraying and harvesting throughout the period of construction.
- The possibility that sediment resuspension during dredging may impact quality of the river water which some farms located adjacent to the river are using as irrigation water.

Response to Master Comment 717

Impacts on Agriculture

The Farm Bureau and Farmers Against Irresponsible Remediation (FAIR) raise a variety of concerns with regard to the potential impacts of the remedial dredging on the agricultural community. The Farm Bureau provides a series of exhibits providing data from the New York Agricultural Statistics Service demonstrating the significance of farming in the Hudson Valley region. Among the data provided are the numbers of farms in Washington and Saratoga Counties in 1999, *i.e.*, 910 and 570, respectively. No data are provided on the actual numbers of farms located along the portion of the river near the remedial activity, but these would represent a very small proportion of the total farms in each county. Data from the US Bureau of Economic Analysis presented in the table below show farm proprietor employment and farm employment in 1998 in three counties adjacent to the planned dredging areas.

Farm Proprietorships and Employment 1998

	Rensselaer County		Saratoga County		Washington County	
	Employment	% of Total Employment	Employment	% of Total Employment	Employment	% of Total Employment
Farm Proprietors	579	0.9	587	0.7	1,026	4.5
Farm Employment	774	1.2	821	1.0	1,459	6.3
Source; US Bureau of Economic Analysis, Regional Economic Information System, 2001.						

Farm employment in the three counties is most significant in Washington County, where the number of employees reaches 6.3 percent of total employment in the county. In general, farm employment in the region has been slightly declining over the 1990s.

As indicated in the Proposed Plan (pp. 17-18 and 26), sediments that are removed from the Hudson River will be disposed of at off-site, licensed facilities. Disposal of the sediments will not impact farmland. No new disposal facilities will be created for this project.

Specific concerns raised by these organizations about the dredging operations and sediment processing/transfer facilities are addressed in the following text.

Drainage Dynamics of Farmland Adjacent to the River

The dredging will have no effect on the drainage characteristics of farmland adjacent to the river. At some locations the dredging may disturb riverbanks, but this would not affect drainage patterns and these areas would be restored after the few weeks involved in removing any contaminated materials near these locations.

Effects on Floodplain Farmland during Spring Flooding

Dredging cannot be conducted during spring floods. Work in the river will commence after spring runoff has abated each year. Thus there is not likely to be any additional PCB input to floodplain farmland as a direct result of sediment resuspension during dredging. During typical spring floods the solids dynamics are dominated by external solids input, and the DOSM modeling indicates that only minimal scour of cohesive sediment hot spots is expected during such events. Much of the current spring pulse of PCB load appears to be due to mobilization of PCB-contaminated oil seeps in the vicinity of the GE Hudson Falls plant, which should be addressed by GE's source control activities. In the longer term, dredging will remove PCBs from the system, and thus actually reduce the potential for contamination of farmland.

Impact on Wells

The dredging will not affect the water levels of the river and hence will not affect the hydrology of any nearby wells. The potential for contamination of wells is addressed under Response to Master Comment 253421 in Chapter 9.

Processing Facilities' Impacts on Farms

The processing/transfer facilities will be carefully sited to minimize any potential for adverse impacts on surrounding properties. Among the key criteria considered will be:

- Access to water and rail transportation, thereby eliminating almost all reliance on local roadways for the movement of materials.
- Preference for sites with prior industrial use as opposed to other sites with other land uses.
- Buffering of operations within the sites (substantially within structures, screened, and as far away from property boundaries as feasible).

These criteria will eliminate almost any potential for adverse impacts on existing farms, including any potential hindrance to planting, spraying, and harvesting.

Backfill

Backfill in dredged areas will involve sand and gravel to be obtained from existing industrial operations within reasonable distance of the project. Such sand and gravel mines are constantly being opened and closed in response to demand, and the availability of supply at existing

facilities. Such material may be brought by barge carrying from as far north as Lake Champlain. Obtaining backfill for the project is not expected to have an impact on farmland.

Irrigation Water

Concern is raised that any resuspension of PCBs could contaminate farmlands that are irrigated by river water. Based on the analyses presented in White Paper – Resuspension of PCBs during Dredging, PCB releases during dredging are not expected to result in the contamination of farms that use Hudson River water for irrigation. As indicated in the FS, increases in PCB concentration associated with the dredging are expected to be well below the year-to-year and season-to-season variations regularly observed in the Upper Hudson River. Releases of other contaminants during dredging are likewise not expected to significantly impact Hudson River water quality (White Paper – Potential Impacts to Water Resources). In fact, the overall water quality in the Hudson River will improve following implementation of the selected remedy.

Master Comment 364871

It was asserted that only one water treatment facility is needed. The suggestion was made that dredged sediment can be barged or piped to one location, rather than building a second dewatering facility in the Albany area. It was suggested that the facility can offer a win-win solution to the host community and the project if it is sited in exchange for full remediation of existing upland hazardous waste sites containing PCB-laden dredged sediments.

Response to Master Comment 364871

From a strictly operational standpoint, it is conceivable that the full amount of (mechanically or hydraulically) dredged sediment could be processed at a single location somewhere along the Upper Hudson River. However, constraints on rail capacity in the Old Moreau Dredge Spoil area, used as an example for the purpose of engineering analysis conducted for the FS and the Proposed Plan, would prohibit transporting all material from that location. The number of processing/transfer facilities, as well as their location(s), will be determined during remedial design, as part of the public participation process outlined in the ROD.

8.8 Remedy Health and Safety Issues

Master Comment 555

Several commenters asserted that EPA has not adequately quantified the risks of performing the remedy, contending that a dredging project would threaten the health and well-being of the local communities and workers. It was suggested that the risk of accidents, injury, and remedy-related fatalities would outweigh the benefits of reducing human health risks due to consumption of fish.

Response to Master Comment 555

All operations associated with the selected remedy will be conducted in accordance with OSHA rules and regulations. EPA recognizes that there are inevitable risks of accidents associated with the selected remedy. By the same token, workers would face a similar possibility of occupational accidents in the normal course of their work regardless of whether they are working on the Hudson River remediation or at some other job location. That is, the workers are not facing an increased risk because of the selected remedy. In addition, a site-specific health and safety plan will be developed for this project by the contractor and reviewed by EPA to ensure that all operations are conducted as safely as possible to protect workers and minimize accidents.

Railroad Traffic Injuries

In one set of comments, GE has submitted specific claims as to the estimate of the number of fatalities (from 0.06 to 1.6) and injuries (up to 56) that could result from the project. While accidents may occur, EPA believes the implication raised by GE's quantitative estimates skews the conclusion that the project would be unduly dangerous.

In GE's analysis, the only fatality estimate that exceeds 1.0 is based on fatal accidents occurring during rail transport. The estimate of fatalities for other remediation-related activities range from 0.06 to 0.092 fatalities. In addition, the statement that the total number of train derailments and accidents have risen from 1997 to 2000 by somewhat over 20 percent (GE, p. 104) gives the impression that rail transport is becoming more dangerous. Without normalizing the accident rates to the total number of rail-miles or another normalizing factor, the absolute value of the total accidents in itself is not meaningful. In addition, the narrow window of time examined by GE also skews the trend within the rail industry. For example, the train accident rate fell 67 percent from 1980 to 1998, and 20 percent since 1990. Furthermore, while the number of accidents may have risen from 1997 to 2000, the number of fatalities has actually fallen by 41 percent during the same time-period. Thus, GE's estimate of train-related fatalities is likely to be high based on the industry trend indicating reduced numbers of fatal accidents.

While it is impossible to estimate with certainty whether fatalities may occur as a result of the Hudson River remediation project, the amount of rail traffic that would be required for the project is small relative to nationwide rail traffic. For example, in 1997 freight rail-miles totaled 475 million miles (AAR, 1998), of which approximately 170 million miles occurred in the eastern United States. (GE, Appendix E, Table 1). Less than 2 million rail-miles are anticipated in the FS for hauling sediment to disposal facilities. Thus, the rail traffic related to the proposed remedy represents less than 0.4 percent of the national class I traffic, and approximately one percent of the rail traffic in the eastern United States. Finally, as discussed in White Paper – Rail Operations, approximately 20 trains per day (passenger plus freight combined) run along the local rail line, and the rail operator indicates the lines can readily handle greater capacity. It is anticipated that rail traffic to and from the dewatering transfer facilities and local switching yards will account for two trips per day (*e.g.*, one round-trip per day). It is also expected that between one and two train trips to the out of State disposal facility will occur per week. Thus, compared to the 140 weekly trains (20 per day x 7 days per week) serving the region, the proposed remedy would add approximately 16 trips per week, or an increase of approximately 11 percent.

Other comments questioned the safety at rail crossings. As discussed in White Paper – Rail Operations, one comment states that there are 26 at-grade crossings between Saratoga and Ft. Edward, and that 19 of these crossings have no electronic controls or signals. The contention is that this circumstance poses safety issues and has even dictated Amtrak's mode of operation along the line. However, Canadian Pacific Railroad (CPR), which is the principal rail system that serves the upper Hudson valley, has indicated that the 19 uncontrolled crossings are all private roads (*e.g.*, on farm property). Furthermore, with regard to public crossings between Ft. Edward and Saratoga, all are equipped with Automatic Highway Warning devices consisting of gates, flashers, and bells. Thus, the attempt to characterize road crossing conditions along the Ft. Edward/Albany corridor as unsafe is without merit.

In terms of safety around the transfer/facility, the entire area in which processing and rail activities are planned to occur will be fenced off from the public and the surrounding areas. Warning signs will be posted stating that trespassing is not allowed. The fence will essentially form the exclusion zone. All visitors to the site will have to sign in upon entering. This area will be inaccessible to the public for the entire project duration. All personnel within the exclusion zone will wear proper clothing and be advised of the health and safety plan to be followed while on the premises.

Boating Injuries

Several commenters have suggested that implementation of the selected remedy will create untenable vessel traffic congestion on the Upper Hudson. In particular, they are concerned that congestion would take the form of bottlenecks at various locks along the Champlain Canal and interference with routine passage of vessels along the canal's navigational channel. GE stated that while it is not possible to estimate quantitatively the fatality and injury rates for collisions in the water, it is believed that increased recreational boating accidents will occur because of the dredging project in the river.

As discussed in White Paper – River Traffic, an estimated total of 39 vessels and other in-river equipment will be required to support the project. It is important to note that these vessels will be dispersed over 40 miles of river. There will be barges located at the dredge site, barges and towboats in transit, barges secured at transfer facilities, and other supporting equipment in various river sections conducting surveys and other work. It is expected that the worst-case situation for in-river congestion would occur when 4 dredges and required supporting equipment are located in the TI Pool (River Section 1). In the worst case scenarios, 24 and 18 of the 39 project vessels are likely to be actively involved at TI Pool work sites at any one time for mechanical and hydraulic dredging, respectively, (*i.e.*, dredging, restoring shorelines, backfilling, planting). Given that the length of the TI Pool (River Section 1) is approximately 6.3 miles, it is not expected that this number of vessels actively involved in remedial work will generate either an actual or perceived congestion problem. Several factors warrant this conclusion:

- Much of the work will occur off-channel in shallower sections of the river. Thus, the working equipment will not unduly inconvenience movements of pleasure craft and tour boats in the channel.

- Some of the working vessels are not significantly different in scale than tour boats and pleasure craft already using the river. This is particularly the case for various survey vessels and also possibly vessels engaged in restoration activities.

- Major pieces of equipment will tend to work in clusters and, therefore, the number of possible interactions between working vessels and other river traffic will be fewer than otherwise expected. The equipment clusters will include dredges and associated barges, debris collector and associated barge, and backfill system and barge.

Most importantly in this regard, the remedial contractor will be required to develop a work plan that limits the potential for interference with other river traffic. The contractor will be required to maintain sufficient clearance in the navigation channel for other river users to move past work zones, and while dredging in the channel, to avoid delays to other river users to the extent possible. In addition, movements through the locks associated with the remedial work will be directed to favor off-peak hours as necessary to avoid potential inconveniences to other canal users, and will be coordinated with the Canal Corporation. Finally, EPA expects that the contractor will be required to position both the working equipment and the equipment movements so as to reduce the potential for project caused congestion.

Overall, the analyses presented in White Paper – River Traffic conclude that there may be some interference with other vessels passing through the canal; however, it is expected that impacts can be controlled with proper management of remedial work and that, overall, project-related interference will not be significant. As a result, increased recreational boating accidents are not expected to occur because of the dredging project in the river.

Road Traffic Injuries

GE has stated that road traffic fatalities and injuries would increase as a result of transporting material via truck to and from the river. Implementation of the selected remedy would generate additional truck and auto trips principally in the vicinity of the transfer and processing facilities. It has been suggested that project-related traffic will create congestion on adjoining roadways at these locations increasing the need for road maintenance and resulting in a higher occurrence of accidents.

As discussed in White Paper – Project-Related Traffic, the accident rate associated with project-related movements will be no different than that associated with any other operation of a comparable size. According to an analysis that was conducted using available traffic data for select roadways in the vicinity of a potential northern transfer/processing facility, minimal increase in traffic volume is projected (*i.e.,* the additional project load will increase vehicular flows by four to eight percent under peak hour conditions). The principal roadways that would be used by project employees and for delivery of materials are not operating at capacity, so there is sufficient available capacity to handle project-related traffic. Truck deliveries will occur mainly during non-peak commuter hours. In addition, the entrance area to the processing facilities will be clearly marked with proper traffic control devices to minimize any potential effects in the immediate vicinity of the processing site.

Occupational Injuries

GE estimates 42 to 56 project-related injuries for all aspects of the project (GE, p. 106). The implication is that the remediation project is unnecessarily endangering the health and safety of the workers, or that the injuries would somehow not occur if the project is not adopted. This is not the case. The statistics relied upon by GE for its analysis merely indicate the normal risk of injury faced by workers in the respective industry sector analyzed. Workers within their respective professions will face no more risk of injury on the Hudson River remediation project than they would on other work-related projects in which they would otherwise be engaged. Furthermore, the accident rates for workers on the project are comparable to, and in many cases lower than, other common activities, as shown in the table on the following page.

As the information in the following table indicates, the injury incidence rates for the types of work categories used by GE in its analysis range from 1.6 to 9.5 work-related injuries per 100 full time workers per year, or equivalently 1.6 to 9.5 injuries per 200,000 hours (BLS, 2000a). These injury rates are comparable to workers involved in auto repair, carpentry, dairy farming, plumbing and heating, and fishing, hunting, and trapping activities.

The table below also indicates the seriousness of the injuries incurred by indicating the incidence rate involving workdays lost due to the injury. Again, workers involved in the Hudson River remediation project face no greater risk of serious injury than that associated with other common activities.

Finally, EPA was unable to confirm the accuracy of the non-train related injury claims by GE (p. 106), and has reason to believe the estimates are incorrect. In GE Appendix E, Table 4, it is reported that the estimated number of fatalities for “people working on the project” is 0.092 and the injury estimate range is from 42 to 56. The ratio of injury to fatality is thus 456 to 619 (42/0.092 to 56/0.092). Yet, according to Bureau of Labor Statistics (BLS, 1999; 2000b), the ratio of deaths to total accidents is 136 for sand and gravel mining (SIC 144), and the ratio is 218 for heavy construction excluding highways (SIC 162). Both SIC 144 and 162 were primary occupational categories adopted as a surrogate for dredging activities by GE in its analysis. (BLS, 2000). Thus, the ratio of injuries to fatalities calculated by GE is in disagreement with underlying data from which the fatality and injury estimates were calculated, and calls into question the validity of the GE fatality and injury claims.

Comparison of Incidence Rates for Different Occupations/Activities

Industry (SIC Codes)	**Injury Incidence Rates***	
	Total	Total With Lost
Plumbing, heating and air conditioning (171)	10	3.5
Auto repair, services, and parking (75)	5.9	2.3
Dairy Farming (024)	8.2	3.7
Fishing, hunting, trapping (09)	6.3	2.9
Carpentry (175)	10.8	4.2
Example Categories Used in GE Analysis		
Heavy construction, except highway (162)	7.1	2.7
Sand and gravel mining (144)	3.8	1.9
Sanitary services (495)	9.5	3.4
Engineering and Architectural Services (871)	1.6	0.4
Water transportation of freight (444)	7.5	4.3
Trucking and courier services, except air (421)	8.6	3.6

*Incidence per 100 full time workers per year.
Source: US Department of Labor, Bureau of Labor Statistics (BLS, 2000a)

Occupational Injury Risks are not Comparable to PCB Chemical Risks

As stated earlier, workers within their respective professions will face no more risk of injury on the Hudson River remediation project than they would on other work-related projects in which they would otherwise be engaged. Because workers are aware of the inherent risks involved in their line of work, while anglers and individuals along the Hudson River may *not* be aware of the risks involved with exposure to PCBs, it is not appropriate to compare the two types of risk to each other. In effect, risks involved in remediation work can be viewed as voluntary, while risks due to PCB exposure from recreating and living along the Hudson River can be viewed as involuntary. It is important that EPA protect those that are involuntarily put at risk by their surrounding environment when those risks exceed guidelines set to protect public health.

References

Association of American Railroads (AAR). 1998. Railroad Facts 1997.

Hoskin, A. F., Leigh, J.P., and Planek, T.W. 1994. Estimated Risk of Occupational Fatalities Associated with Hazardous Waste Site Remediation. Risk Analysis, 14(6): p.1011-1017

US Department of Labor (USDOL), Bureau of Labor Statistics (BLS). 1999. Census of Fatal Occupational Injuries. Fatal occupational injuries by industry and event or exposure, 1999.

USDOL, Bureau of Labor Statistics (BLS). 2000a. Incidence rates of nonfatal occupational injuries and illnesses by industry and selected case types, 1999. December, 2000.

USDOL, Bureau of Labor Statistics (BLS). 2000b. Number of nonfatal occupational injuries and illnesses by industry and selected case types, 1999. December, 2000.

US Department of Transportation (USDOT), National Transportation Statistics (NTS). 1999

USDOT, Federal Railroad Administration (FRA). August, 1996. Accident/Incident Bulletin, No. 164 Calendar year 1995.

USDOT, Federal Railroad Administration (FRA). 2001. Total Accidents/Incidents, JA – DEC (Final). http://safetydata.fra.dot.gov/Prelim/2000/r01.htm.

9. IN-RIVER IMPACTS (SHORT- AND LONG-TERM)

9.1 Issues Related to SAV and other Ecological Resources

Master Comment 366264

Some commenters stated that hydraulic dredging will destroy the river bottom by "sucking up everything in its path."

Response to Master Comment 366264

Dredging is intended to completely remove the targeted sediments. In this process, benthic organisms and vegetation in the path of the dredging operation will also be removed, although mobile species will most likely move away from the dredge. As discussed in the Responses to Master Comments 253458 and 807, recovery of benthic invertebrates in an area of previous disturbance generally commences soon after the disturbance, if suitable habitat conditions exist. As noted in the Response to Master Comment 537, SAV does not cover the entire river or, more specifically, even all the areas targeted for dredging. A program for SAV replacement has been included in the selected remedy and is intended to offset the impacts of dredging. Habitat replacement monitoring, implemented as an essential and integrated component of the overall program, will help to ensure the successful reestablishment of SAV and its associated fauna. Moreover, the selected remedy includes targeted dredging which will affect just 13 percent of the bottom of the Upper Hudson River.

Master Comment 507

Some commenters suggested that no detailed data collection or analysis on existing habitats has been conducted. Some commenters said that EPA's Proposed Plan lacks detail on existing habitats and potential impacts from the proposed remedy. Others stated that the status of the existing SAV populations has not been evaluated, no wetland functional assessment has been performed, and that a biotic inventory should be undertaken to establish pre-remediation conditions.

Response to Master Comment 507

EPA has studied the various habitats of the Upper Hudson River (*e.g.*, main channel stream, palustrine systems, deep emergent marsh, shallow emergent marsh, and forest) and has characterized these habitats in the Ecological Risk Assessment (USEPA, 2000). A preliminary assessment of wetlands has been performed and is attached as Appendix A. A detailed delineation of the Upper Hudson River habitats (including SAV), collection of baseline habitat data, and a wetland functional assessment will be conducted during remedial design. All available information, including the GE SAV report (Exponent, 1998), will be used in the delineation of Upper Hudson River habitats and collection of baseline habitat data. The detailed delineation of habitats and collection of baseline data will be used to formulate the habitat replacement program.

The habitat replacement program description in the FS, Appendix F, p. 1, identifies the potential habitat impacts that may result from implementation of a remedial alternative (*i.e.*, removal or capping of substrate used as spawning and foraging habitat by fish and benthic invertebrate species; displacement of benthic organisms; loss of vegetation communities; loss of freshwater wetlands acreage and wetlands functional values; and disturbance of riparian habitat and shoreline stability). The habitat replacement program will be implemented to mitigate these potential disturbances to aquatic and wildlife habitat. Response to Master Comment 422647 in Section 9.4 contains more detailed information on habitat replacement.

References

Exponent. 1998. Data Documentation and Interpretation Report: Submerged Aquatic Vegetation and Fish Community Analysis. Prepared for General Electric Company.

US Environmental Protection Agency (USEPA). 2000. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E - Revised Baseline Ecological Risk Assessment, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the US Army Corps of Engineers (USACE), Kansas City District by TAMS/MCA. November.

Master Comment 509

A number of comments suggest that additional areas of critical habitat should be remediated. They pointed out that extensive areas characterized by SAV are excluded from remediation under the REM-3/10/Select alternative. These SAV areas, which serve as important habitat for certain fish and invertebrate species, will continue to act as a source of localized contamination to biota if left unremediated.

Other commenters viewing the same areas of SAV felt that dredging activities would endanger nursery and spawning habitats, remove habitat for benthic organisms, and cause bank erosion, which could in turn smother benthic organisms and fish eggs and cause oxygen depletion.

Response to Master Comment 509

This comment illustrates the different lines of thinking regarding areas of SAV. The federal Trustees have stated that important habitat areas that are prime habitat for juvenile fish should be remediated. They have urged EPA to select a remedy that to the maximum extent practicable improves the environmental quality of the Hudson River by removing PCBs. Given what is now known regarding recovery of riverine ecosystems following dredging, advances in dredging technology, and EPA’s proposed habitat replacement programs, the Trustees do not believe that such a dredging program would cause long-term environmental damage. The Trustees concur with EPA's conclusion that the adverse impacts of targeted dredging on river habitat will be temporary and this temporary loss will be offset by the accelerated recovery of the entire river. Any short-term impacts from dredging can be minimized through appropriate habitat replacement activities. EPA believes that the selected remedy minimizes adverse impacts, while also achieving protection of human health and the environment.

EPA will consult with appropriate federal and State agencies in determining whether any especially sensitive or unique habitats exist in the Upper Hudson River that warrant special consideration during remedial design.

Master Comment 537

Commenters expressed concern that substantial amounts of submerged aquatic vegetation (SAV) and their associated fauna will be adversely impacted by dredging, thereby seriously jeopardizing the recovery of the river after dredging. Meadows of SAV create essential habitat and form a basis of primary production that supports ecologically and economically important species. Some commenters argued that once SAV has been destroyed, there may be significant effects to fisheries, not only for the reach of river from which SAV is removed, but for adjacent areas of the river as well. It was suggested that ecological risks be weighed against anticipated benefits from contaminant removal. Another comment suggested that targeted dredging would allow recolonization from undisturbed areas and that removal of PCBs would benefit the ecosystem. New York State, federal Natural Resource Trustees, and various environmental organizations have expressed support for removal of PCB-contaminated sediment, as it will improve the environmental quality of the river and reduce injury to environmental resources.

Response to Master Comment 537

The Trustees have stated that important habitat areas for Trust resources, such as near shore areas, quiescent areas, and those containing SAV beds, which are prime habitat for juvenile fish, should be remediated. Given what is now known regarding recovery of riverine ecosystems following dredging, advances in dredging technology, and EPA's proposed habitat replacement program, the Trustees do not believe that a dredging program that is more aggressive than the selected remedy would be environmentally damaging.

It should be noted that SAV is present in observable, discrete areas in the river. SAV does not cover the entire river or, more specifically, even all the areas targeted for dredging. SAV replacement, therefore, would only be needed in a portion of the dredged area. Nonetheless, during the design phase a habitat replacement program, with SAV replacement as an integral component, will be formulated. The SAV replacement program is intended to offset the impacts of dredging. Habitat replacement monitoring, implemented as an essential and integrated component of the overall program, will help to ensure the successful reestablishment of SAV and its associated fauna. Adaptive management will enhance the capacity of the habitat replacement program to achieve its objectives by integrating the following elements:

- Articulation of existing interdisciplinary experience and scientific information.
- Delineation of Upper Hudson River habitats and collection of baseline habitat data.
- Formulation of a dynamic Upper Hudson River habitat replacement model.
- Formulation of specific habitat replacement goals and objectives, evaluation criteria, and an unambiguous definition of replacement success.
- Formulation of a monitoring, appraisal, and feedback program.
- Design, prioritization, scheduling, and implementation of habitat replacement actions.
- Monitoring of habitat variables and of the ecosystem's response to the replacement actions.

- Periodic evaluation of the dynamic model, the effectiveness of replacement actions undertaken, and progress toward the replacement objectives. Periodic revision of the dynamic model.

Under this management program, successful habitat replacement can be achieved such that there will be no long-term impacts to the Upper Hudson ecosystem. There will be some unavoidable short-term impacts, such as displacement of the benthic community, but the benefits of long-term PCB removal are expected to outweigh temporary impacts. With successful habitat replacement, ecological risks associated with the proposed action will be minimized and there will be ecosystem improvements through contamination removal. Targeted dredging will allow for benthic recolonization from undisturbed areas, and the resulting removal of PCBs will benefit the entire ecosystem.

Master Comment 253458

Commenters contend that, of the nine orders of insects that reside at the bottom of most rivers, the two most important in the Hudson River are caddisflies (trichopterans) and mayflies (emphemeropterans), saying that these two orders supply 75 percent of the fish food. Commenters expressed concern that if the river is dredged as proposed, these two orders along with the other seven will be removed from the bottom of the river and the fish will have no food. These insects have a one-year life cycle. When they hatch from a larva or nymph stage once per year they fly upstream to mate and lay their eggs. The distance they fly will typically be one quarter to one-half a mile. Commenters worry that it will take 80 to 160 years to regain the fish food supply.

Response to Master Comment 253458

EPA conducted a survey of benthic fauna (*i.e.*, bottom-dwelling invertebrates that include insects) in the Upper Hudson River in 1993. The five most abundant types of organisms collected were sowbugs (isopods), midge larvae (chironomids), earthworms (oligochaetes), freshwater shrimp or "scuds" (amphipods), and small clams (pelecypods). No mayflies were observed. While caddisflies were collected, their abundance was relatively low as compared to the five most abundant taxa collected. These findings were corroborated by studies by Exponent (1998). Thus, it is unlikely that caddisflies and mayflies serve as the principal food source for fish in the Upper Hudson.

The comment that it will take 80 to 160 years for fish to regain their food supply is not correct. First, since dredging will occur in targeted areas, there will be portions of the river bottom where bottom-dwelling invertebrates will be undisturbed and will always be available as food to fish. Secondly, even in those targeted areas that are dredged, the recolonization of benthic invertebrates will begin soon after the dredging is complete.

With respect specifically to recolonization, there are four principal mechanisms for benthic dispersal: downstream drift, upstream migration, vertical migration from within the substrate, and aerial sources (*i.e.*, flying adults depositing eggs upstream). For certain major disturbances (*e.g.*, elimination of fauna along an entire channel without upstream sources of drift), aerial colonization represents the major, if not only, source for recovery. However, where present, as in

the case of the Hudson River, downstream drift, a continuous stream of benthic organisms (larval and adult) that is generally represented in the currents of streams and rivers, is the most important recovery mechanism of the benthos (Petts, and Calow, 1996). Given this continual source of benthic invertebrates, recovery of benthic invertebrates in an area of previous disturbance generally commences soon after the disturbance, if suitable habitat conditions exist. In a study of the recovery rates of macroinvertebrate communities following disturbance, Niemi, *et al*. (1990) found that 90 percent of the cases reviewed indicated recovery times within one year.

Channel relocation and reconstruction projects provide an indication of recovery times where a major physical modification of the river channel occurs. In a colonization study of a newly formed channel in the Tongue River, Wyoming, maximum densities of macroinvertebrates were obtained in less than 90 days, with equilibrium levels reached in about 200 days (Gore 1979, 1982). For a new stream channel in Scotland, Doughty and Turner (1991) reported maximum diversity and similarity to a reference site 80 to100 days after invertebrate recolonization began. Malmqvist *et al*. (1991) found that invertebrate diversity in a man-made channel was similar to that in reference streams within one year.

References

Doughty, C. R., and M. J. Turner. 1991. The Ponesk Burn Diversion: Colonization of Benthic Invertebrates and Fish. Technical Report No. 98. Clyde River Purification Board, East Kilbride, Scotland. As reported in: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Exponent. 1998. Data Documentation and Interpretation Report: Submerged Aquatic Vegetation and Fish Community Analysis. Prepared for General Electric Company.

Gore, J. A. 1979. Patterns of initial benthic recolonization of a reclaimed coal strip-mined river channel. Canadian Journal of Zoology 57:2429-39. As reported in: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Gore, J. A. 1982. Benthic invertebrate colonization: source distance effects on community composition. Hydrobiologia 94:183-93. As reported in: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Malmqvist, B., S. Rundle, C. Bronmark, and A. Erlandson. 1991. Invertebrate colonization of a new, man-made stream in Sweden. Freshwater Biology 26:307-24. As reported in: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Niemi, G. J., P. DeVore, N. Detenbeck, D. Taylor, J. D. Yount, A. Lima, J. Pastor, and R. J. Naiman. 1990. Overview of case studies on recovery of aquatic systems from disturbance. Environmental Management 14: 571-88. As reported in: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Master Comment 359545

Some commenters expressed concern that construction and operation of the northern and southern sediment processing facilities along the river may have both short- and long-term effects on freshwater wetlands and resident wildlife (including threatened and endangered species).

Response to Master Comment 359545

This response is broken into two parts: 1) potential impacts to wetlands; and 2) potential impacts to wildlife habitat and threatened and endangered species.

First, it is important to note that EPA has not yet determined the location(s) of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the Feasibility Study, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the Upper Hudson River valley and farther downstream, are possible.

The example facility locations presented in the Feasibility Study have also been used in the Responsiveness Summary in order to clarify material presented in the Feasibility Study and Proposed Plan and in connection with additional noise, odor and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after EPA performs additional analyses and holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, all information provided in this Responsiveness Summary relative to potential impacts of the sediment processing/transfer facilities on communities, residents, agriculture, the environment and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during design.

Wetlands

There are known freshwater wetlands in the general vicinity of the example locations of the northern and southern sediment processing/transfer facilities. Under the Office of Solid Waste and Emergency Response August 1985 Directive 9280.0-02, Policy on Floodplain and Wetland Assessments for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Actions, Superfund actions must meet the substantive requirements of Executive Order 11990, Protection of Wetlands (USEPA, May 1994, Considering Wetlands at [CERCLA]

Sites). Executive Order 11990 directs all federal agencies to avoid, if possible, adverse impacts to wetlands, and to preserve and enhance the natural and beneficial values of wetlands.
During remedial design, when final facility location(s) are identified, a wetland delineation will be conducted to determine the extent of wetlands that occur at those location(s). Wetlands will be delineated consistent with the USACE 1987 Wetland Delineation Manual, which utilizes the "three-parameter approach" (*i.e.*, the presence of wetland hydrology, hydric soils, and hydrophytic vegetation). The wetland boundaries will be flagged and surveyed.

Wetland boundaries will be determined so that during the actual siting of the sediment processing/transfer facilities, wetland impacts can be avoided or minimized. EPA will confer with USACE, the federal Trustees, and NYSDEC in order to determine what resources will be delineated as wetlands and to discuss options for avoidance, minimization, and mitigation. The general hierarchy with respect to potential wetlands impacts will be as follows:

- **Avoidance**: Avoid potential impacts to the maximum extent practicable.
- **Minimization**: Take appropriate and practicable steps to minimize the adverse impacts (*e.g.*, limit the anticipated impact to an area of the wetland with lesser value than other areas, or reduce the actual size of the impacted area).
- **Compensatory Mitigation**: Take appropriate and practicable compensatory mitigation action for unavoidable adverse impacts that remain after all appropriate and practicable minimization has been performed (create a new wetland area, restore existing degraded wetland, or enhance low-value wetland into improved wetland).

If it is determined that there would be wetland impacts resulting from the construction and operation of the sediment processing facilities that cannot be avoided or further minimized, compensatory wetland mitigation will be implemented. The goal of any compensatory mitigation will be to fully compensate for (replace) wetland acreage and all functions and benefits lost as a result of the construction and operation of the proposed northern and southern sediment processing facilities.

Additional measures to avoid or minimize impacts to wetlands and associated habitats, habitat loss, habitat fragmentation, and human disturbance will be formulated and integrated into site development design and operations planning during the design phase. These are discussed in the following section.

Wildlife Habitat and Threatened and Endangered Species

The construction and operation of the proposed sediment processing facilities may result in impacts to wildlife due to potential habitat loss or fragmentation and/or human disturbance. These potential impacts will be analyzed during the design phase, as will the possibility of impacts to threatened and endangered species.

Wildlife/Wildlife Habitat

In the design phase, when final sites are identified, wildlife habitats (*i.e.*, cover types) will be investigated, surveyed, and mapped. A cover type map will be drawn for the affected sites and the area within 0.5 miles from the perimeter of those sites that will show major vegetative

communities, including wetlands, aquatic habitats, and NYSDEC significant habitats. The NYSDEC Natural Heritage Program descriptions and classifications of natural communities (Ecological Communities of New York State, NYSDEC, 1990) and the New York GAP project database (http://www.dnr.cornell.edu/gap) will be utilized to identify the cover types. Fish and wildlife species will be described for each cover type. An assessment will be made of the general ability of the areas within 0.5 miles of the affected sites to support fish and wildlife. The degree to which the habitats meet the requirements for food, cover, breeding areas, and roosting sites will be determined. Potential impacts to wildlife and wildlife habitat will be evaluated requisite to site selection for the sediment processing facilities.

Once the final sites have been identified, an ecological impact analysis will be prepared to determine potential impacts of the proposed action to wildlife. Potential impacts resulting from habitat loss will be documented, as will potential impacts resulting from habitat fragmentation and human disturbance (*i.e.*, increased traffic, noise, and lighting).

The findings of the ecological impact analysis will be used to guide the planning, design, and operation of the sediment processing facilities so as to avoid or minimize habitat loss, habitat fragmentation, human disturbance, and impacts to wetlands and associated habitats. Among the methods that, as appropriate, will be formulated and integrated into project design and operations planning during the design phase are:

- **Facility Siting and Layout:** Siting and layout of project elements so as to avoid habitat fragmentation and direct or indirect impacts to wetlands, associated habitats, and other sensitive habitats.

- **Facility Design:** Incorporation of vegetative buffers, screens, barriers, and other site and project elements to avoid or minimize impacts to wetlands, associated habitats, and other sensitive habitats. Such elements will address, for example, physiological and behavioral impacts to wildlife of construction- and operation-phase increases in noise and nighttime lighting, soil erosion and sedimentation control, and water quality protection.

- **Construction Controls:** Specification in construction documents of required procedures for protecting fish and wildlife resources (*e.g.*, prohibitions against unnecessary removal of vegetation or disturbance of waterways, soil erosion and sediment control plans, and seasonal limitations on certain construction activities in specific areas).

- **Operation Controls:** Wildlife and habitat protection restrictions for sediment processing facility operations that would, as necessary, specify acceptable procedures, limits, and controls for certain operations.

- **Habitat Restoration/Replacement**: Habitat restoration and replacement (as determined by the appropriate resource agencies) will be designed during the design phase and implemented after completion of sediment processing operations.

Threatened and Endangered Species

Consultation will occur with the appropriate federal and State agencies (USFWS, National Marine Fisheries Service [NMFS], and NYSDEC) to identify sensitive and unique habitats, as well as areas known to be utilized by threatened and endangered species. USFWS has identified the bald eagle as a federally-listed threatened species that is known to occur in the area of the selected remedy for the Hudson River, and the Karner blue butterfly and Indiana bat as federally-listed endangered species that may be found within or adjacent to the project area. The NMFS has indicated that the range of the shortnose sturgeon includes the Hudson River PCBs Site. EPA will conduct biological assessments (BAs) for the bald eagle and shortnose sturgeon, as they have been identified as being in the project area. Since the sediment processing/transfer-facilities have not been sited or designed, it cannot be determined at this time if the Karner blue butterfly or Indiana bat, or potential suitable habitat for either species, may be affected by the selected remedy. Nevertheless, once the locations for the transfer facilities and other necessary land-based infrastructure have been established, EPA will evaluate the habitat that will be affected to determine if it is suitable to support either species. If suitable habitat is found, additional biological assessment work will be conducted for these species.

Any completed BAs will include an effects determination, which will state what conclusions regarding potential impacts to the local population of the species discussed can be supported from the information presented in the BAs. The BAs will be submitted to the FWS or NMFS for review and a final determination of effect. The BAs will be completed before remedial construction, and the remedial design will reflect appropriate measures to protect these species that result from the consultation process.

References

New York State Department of Environmental Conservation. March 1990. Ecological Communities in New York State. New York Natural Heritage Program.

US Army Corps of Engineers. 1987. Corps of Engineers Wetlands Delineation Manual. Environmental Laboratory, Technical Report Y-87-1. January.

US Environmental Protection Agency. 1994. Considering Wetlands at CERCLA Sites. Office of Solid Waste and Emergency Response, EPA/540/R-94/019. May.

Master Comment 313331

Commenters recommended that ecosystem impacts should specifically include SAV as being impacted by remedial activities (as discussed in section 5.6.2 of the FS report).

Response to Master Comment 313331

EPA concurs that SAV would be impacted by dredging activities. The generic term "vegetation" was intended to include SAV, but it is acknowledged that SAV is part of the impacted vegetation.

Master Comment 807

A number of commenters contend that dredging is required to preserve critical habitats. Some, however, expressed concern that dredging may result in habitat loss and displacement of wildlife. Some felt that remedial activities will result in impacts to aquatic and wildlife habitat of the Upper Hudson River, including removal of substrate for spawning and foraging habitat by fish; displacement of benthic organisms; reduction of food sources; loss of vegetation; loss of freshwater acreage; and disturbance of riparian and shoreline stability. It was suggested that the potential (even if temporary) loss of parts of the river ecosystem due to dredging should be evaluated for the mink and river otter.

Response to Master Comment 807

Concerns associated with dredging result from the physical disturbance involved in removing sediment and relate to increases in turbidity, nutrients, and contaminants in the short-term and loss of habitat in the long-term. To minimize short- and long-term impacts, a habitat restoration program will be implemented (Section 9.3). Prior to the start of remediation of the Upper Hudson River, habitats will be delineated and baseline habitat data will be collected. Replacement of submerged aquatic vegetation (SAV) will be one of the prime objectives of the revegetation plan. Replacement will depend on the actual extent of dredging and backfilling, the geomorphical response of the river in redistributing sediments, the habitat replacement goals formulated during the design phase, and navigational requirements. SAV replacement may not be desirable or feasible in certain situations (*e.g.*, to enable recreational use of the river or accommodate gravel substrate for fish spawning).

Riparian and shoreline stability will be maintained through determining the hydrology, sediment texture, and sediment stability of an area prior to initiating work. Biologically based state-of-the-art methods will be used to enhance the environment and accomplish engineering requirements. Parameters will be verified through monitoring, which will also be used to identify needed mid-course corrective actions, such as adjustments to the Site hydrology, replanting/reseeding, and routine maintenance. Monitoring for natural recovery will help to reduce the need for artificial reestablishment. Such an activity recognizes that the river has historically been and still is impacted by agricultural runoff and other land use practices resulting in increased siltation and enrichment, to the extent that the remedial activities may benefit the system in removing excess build-up of sediments and nuisance vegetation.

Benthic organisms will be disturbed during environmental dredging operations. However, recovery is expected to be quick because the majority of the benthic species present have life-history characteristics that make them resilient to disturbance (Response to Master Comment 253458, Section 9.1). These characteristics include high productivity and turnover rates, high dispersal ability, planktonic larvae, and most importantly a source of benthic invertebrate recovery (downstream drift, aerial dispersal, etc.). In a study of the recovery rates of macroinvertebrate communities following disturbance, Niemi *et al.* (1990) found that 90 percent of the cases reviewed indicated recovery times within one year.

Impacts of environmental dredging on fish vary to some degree with life stage. Potential short-term effects result from increases in turbidity, temporary loss of a benthic food source, and increases in contaminant concentrations. Early life stages are more sensitive than adults to increases in turbidity. Although turbidity is transient in nature, increases in turbidity can affect the survival of fish eggs that are attached to underwater surfaces. Adult fish would be mobile enough to avoid areas of environmental dredging activity and will leave an affected area while environmental dredging is being undertaken, thereby avoiding direct impacts. Recolonization of remediated areas by benthic invertebrates will lead to recolonization by fish and wildlife that feed on these organisms. Fish spawning habitat will be replaced with suitable substrata, and SAV used for foraging will be replaced.

There may be temporary loss of parts of the Hudson River habitat for wildlife receptors such as the mink and river otter during remediation. These receptors can move to other areas of their home range during environmental dredging activities and return once environmental dredging is completed. Due to the rate of advancement of the dredge (approximately 400 feet per day), the dredge will not be in any fixed location for an extended period of time, so any individual den would only be directly impacted by environmental dredging for a short period. Individual mink may use several denning areas within their home range (Birks and Linn, 1982) and are expected to move temporarily from dens close to remedial activities. As the home range of river otters is larger than that of mink, it is anticipated that otters will move to areas within their range, but away from remedial activities.

Mink are opportunistic piscivores/carnivores and during remediation may utilize a larger component than usual of terrestrial prey such as birds, reptiles, and insects in their diet. (Note: mink PCB exposure was modeled based on consumption of 50.5 percent river-related food sources). Although river otters have a larger component of fish in their diet, they are also opportunistic feeders (USEPA, 1993) and are likely to feed upon other prey such as birds and small mammals if fish are temporarily unavailable or difficult to capture.

The Natural Resource Trustees, *i.e.*, NYSDEC, NOAA, and USFW, and various environmental organizations have expressed support for active sediment remediation, as it will improve the environmental quality of the river and reduce injury to environmental resources (Response to Master Comment 801, Chapter 3). In fact, the federal Trustees have indicated support for an even more extensive dredging program (*i.e.*, the REM-0/0/3 alternative). The Trustees have stated that important habitat areas for Trust resources, such as near shore areas, quiescent areas and those containing vegetative beds, which are prime habitat for juvenile fish, should be remediated. Further, the Trustees believe that as currently proposed, the selected remedy would leave unacceptable residual injury to river ecosystems in the form of PCBs left behind, and have urged EPA to select a remedy that to the maximum extent practicable improves the environmental quality of the Hudson River by removing as much of the resident PCBs as possible. Given what is now known regarding recovery of riverine ecosystems following dredging, advances in dredging technology, and EPA's proposed habitat replacement programs, the Trustees do not believe that a more aggressive dredging program such as the REM-0/0/3 alternative would be environmentally damaging.

References

Birk, J.D. and I.J. Linn. 1982. Studies of home range of the feral mink, *Mustela vison*. Symp. Zool. Soc. Lond. 49:231-257 as cited in: United States Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, Washington, DC. EPA/600/R-93/187a. December.

Niemi, G. J., P. DeVore, N. Detenbeck, D. Taylor, J. D. Yount, A. Lima, J. Pastor, and R. J. Naiman. 1990. Overview of case studies on recovery of aquatic systems from disturbance. Environmental Management 14: 571-88. *As reported in*: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

USEPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, Washington, DC. EPA/600/R-93/187a. December.

9.2 Effect on Water Quality

Master Comment 587

It has been suggested in comments that dredging will remobilize sediments and PCBs into the water column. Undisturbed *hot spot* sediments in the TI Pool have also been cited as a passive source of PCBs in the water column, possibly declining in concentration through historical mass removal. Some commenters contend that remobilized PCBs in the water column will increase exposure to the food chain and impact irrigation users, and that increased turbidity will impact aquatic organisms. Comments also reflect the belief that burial of exposed *hot spot* sediments through natural and artificial mechanisms reduces PCB resuspension. While some commenters suggest that PCBs are being buried through natural sedimentation processes, others indicate that the DEIR, Low Resolution Coring Report and high concentrations observed in surface sediments at *Hot Spot* 14 disprove this. Some commenters contend that the selected remedy may leave PCB reservoirs in place, and increase PCB concentrations in areas like River Section 3 where little backfilling is proposed.

Response to Master Comment 587

Resuspension of PCBs and sediments due to dredging is addressed in the Response to Master Comment 365942 later in this section as well in the Response to Master Comment 583 in Chapter 10. It is concluded in these responses that water-column PCB levels as a result of downstream transport of dredging-induced resuspension will be a minor fraction of currently existing levels. The increased loads will also be small relative to current conditions. Therefore, dredging-induced releases, which are short-term in nature, will not result in significant impacts to the river nor significantly affect the ensuing decline of PCB concentrations in sediments and water resulting from sediment removal. Model forecasts documenting the rate of river recovery including dredging-induced resuspension are described in White Paper – Model Forecasts for Additional Simulations in the Upper Hudson.

Water column parameters will be monitored during dredge operations in order to ensure that a minimal amount of PCBs will be transported downstream. Because PCB levels naturally fluctuate within the water column due to seasonal variables, EPA will, during remedial design, determine a threshold level for a PCB concentration increase as a result of dredge operations. If the water samples during dredge operations indicate that the downstream PCBs transport is within the natural variation, then there will be no impact of dredging downstream. On the other hand, if sampling finds levels of PCBs above the variation in "naturally" occurring concentrations, then further preventative measures will be employed in order to minimize the downstream impact. Related issues are discussed in Response to Master Comment 583 in Chapter 10 (the mechanism of PCB resuspension).

With regard to impacts to conventional water quality parameters, an assessment is provided later in this chapter in the Response to Master Comment 735; further discussion can be found in White Paper – Potential Impacts to Water Resources. Based on the analyses described in these discussions, it is concluded that NYS water quality standards will either not be contravened or the increases will not be significant where those standards are already being exceeded.

The concern over impacts of resuspended solids and their impacts to water clarity and municipal use is discussed in Response to Master Comment 362637 below. This response concludes that the suspended solids increases due to dredging will be largely local (within a few hundred meters of the dredging operation) and not detectable above natural variation beyond this distance. Additionally, typical spring suspended solids levels are well above those predicted within the dredging plume.

With regard to impacts to the biota, EPA is aware that there may be an increase in fish and animal body burdens during or shortly after the dredging program. Over the long-term, body burdens will decrease because exposure concentrations in sediment and water will have been greatly reduced. Model forecasts of fish body burdens are presented in White Paper – Model Forecasts for Additional Simulations in the Upper Hudson.

Long-term, secure storage of PCBs in the sediments of the Hudson is not guaranteed, as demonstrated by several observations made during the Phase 2 investigation. There is a statistically significant loss of PCB inventory from highly contaminated sediments in the TI Pool between 1984 and 1994. A number of GE's 1998-99 sediment samples were co-located with the EPA 1994 samples and the NYSDEC 1984 samples. Both the 1994 and 1998 samples indicate a large decrease in sediment PCB inventory relative to 1984; however, no consistent decrease in surface concentrations between 1994 and 1998-99 is evident. Actually, slightly more than half of the 25 co-located samples showed an increase in concentration, suggesting that surface concentrations remain largely unchanged in those areas. These results support the conclusion that significant concentrations of PCBs remain near the surface in the Upper Hudson, at depths where they impact biota. The occurrence of high PCB concentrations in the surface sediments (0-5cm) of Hot Spot 14 as documented by GE in 1999 (QEA, 2001) also supports this conclusion. See also the Responses to Master Comments 619 and 577 in Chapter 2.

Having identified the sediments of the Upper Hudson as the primary source of PCBs (USEPA, 1997, 1998, and 1999), it was then necessary to identify those sediments whose remediation would have the greatest impact in reducing fish body burdens and PCB transport. Also, it was

important to identify those sediments with the greatest potential for subsequent PCB release, considering PCB concentration and inventory as well as susceptibility to remobilization. The selection of sediment areas for remediation was based mostly on geochemical and statistical interpretations of the data, including observations concerning PCB transport, changes in sediment inventory, sediment PCB distribution, and biological impacts. PCB inventory, PCB surface concentration, sediment texture, and proximity to shore must all be considered in the selection of sediment remedial areas.

With regard to the removal of PCB reservoirs, the purpose of the selected remedy is not to remove all PCB-contaminated sediments exceeding some specified threshold or to target every isolated contaminated area. Rather, the goal is to achieve the remedial action objectives through sufficient reduction of PCB mass and concentration. Engineering considerations determined that the minimum unit of area selected for remediation should be 50,000 sq ft. Nonetheless, as noted in Response to Master Comment 597 in Chapter 4, the selected remedy removes more than 85 percent of historical locations with concentrations or MPA values above the selection criteria. Additionally, future plans call for extensive additional sampling and collection of geophysical data to further discern and refine the target areas. Thus, it is unlikely that significant regions of PCB contamination will be left unremediated (see also Response to Master Comment 362631 in Chapter 10).

References

Quantitative Environmental Analysis, LLC. (QEA). 2001. General Electric Database Transmittal from Michael Werth (QEA) to Doug Tomchuk (USEPA). June 1, 2001.

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

USEPA. 1998. Further Site Characterization and Analysis. Volume 2C-A Low Resolution Sediment Coring Report (LRC), Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS Consultants, Inc., Gradient Corporation, and TetraTech, Inc. July.

USEPA. 1999. Responsiveness Summary for Volume 2C-A Low Resolution Sediment Coring Report, Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS and TetraTech, Inc. February.

USEPA. 2000. Response to Peer Review Comments on Volume 2C-(DEIR) and 2C-A-(LRC), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE by TAMS Consultants, Inc. and TetraTech, Inc. November.

Master Comment 365942

Commenters were concerned that PCB release to the water column due to resuspension will increase the PCB water column concentration significantly and result in the transport of PCBs downstream, even to the Lower Hudson River. It was suggested that the increased PCB concentration in the water column will pose a threat to water intakes from the Hudson and could generate the need for changes to or addition of extra steps to the water treatment procedure.

Response to Master Comment 365942

Downstream transport of PCBs as a result of dredging-induced resuspension (in grams per day) has been estimated for each river section and dredge type. The complete analysis is presented in White Paper – Resuspension of PCBs during Dredging, and in FS Appendix E.6. The FS and white paper evaluate the two dredging technologies considered applicable to the Hudson River (mechanical and hydraulic). Based on data from numerous other remedial sites, an estimate of the resuspension rate for each dredge type has been formulated. Thus, knowing the resuspension rate, the sediment PCB concentration, and the dredging production rate, it was possible to estimate the PCB flux 10 meters downstream of the dredge head by application of a basic gaussian dispersion model that accounts for some sediment settling between the dredge and the ten-meter point. Results of the analysis are shown below in the table entitled Estimated PCB Flux at 10 Meters Downstream of Dredge Head.

Given the fluxes presented in this table, it is possible to estimate dredging season PCB loads generated by dredging operations and, as well, induced water column PCB concentrations (table entitled Estimated Additional PCB Load and Concentration Compared to the Background Level, below). As shown, the estimated dredging-induced seasonal increase in water column PCB load is 5 percent for River Section 1 and 39 percent for River Section 2, compared to the average load experienced in the past 5 years. These are relatively modest increases that are well within the range of natural variation: the seasonal load over the past 5 years, 1996 to 2000, ranged from 158 kg to 278 kg. Moreover, PCB concentrations in the early 1990's frequently fell within the range of 300 to 1000 ng/L, but there were no reported exceedances at the Waterford Water Works.

The water column PCB concentrations presented in the table Estimated Additional PCB Load and Concentration Compared to the Background Level have been generated using a flowrate of 2,300 cfs, representing the minimum 30 day flow for a 10-year period (30Q10) as specified by NYSDEC. This is a conservatively low flowrate that would not be expected to persist. For River Section 1, the dredging-induced water column PCB concentrations have been estimated to be about 11 percent of the average background level (Table entitled Estimated Additional PCB Load and Concentration Compared to the Background Level, below). For River Sections 2 and 3, the increase was about 77 and 31 percent of the average background level, respectively. However, these increases are well below water column concentrations often experienced during the dredging season (May through November), as noted in this same table.

Several commenters expressed concern over uptake of dredging induced PCBs by the Waterford water supply system. Based on the analysis presented in the FS and in White Paper – Resuspension of PCBs during Dredging, it can be concluded that dredging-related water column PCB increases are only a fraction of the typical water column levels routinely experienced

throughout the river. Consequently, dredging operations are not expected to impact ongoing uses of the Hudson River. In addition, once the project has been completed, PCB levels will drop well below those now occurring throughout the river.

Estimated PCB Flux at 10 Meters Downstream of Dredge Head

	Tri+ PCB in Sediment (mg/kg)	TPCB in Sediment (mg/kg) (1)	Cutterhead Dredge		Enclosed Bucket	
			PCB Flux in water column (g/day) (3)			
			Section 1	Section 2&3	Section 1	Section 2&3
Section 1	8.4	28.6	43.0		51.8	
Section 2	23	78.2		191.4		354.7
Section 3	13	35.1		85.9		159.2
Avg Resuspension Rate TSS (kg/sec)(2)			0.025	0.040	0.012	0.030

Notes:
(1) The total PCB concentrations were calculated by multiplying the tri+ concentration by 3.4 for section 1 and 2 and 2.7 for Section 3.
(2) TSS flux at 10 meters downstream of dredge head, as presented in White Paper – Resuspension of PCBs during Dredging
(3) 14 operating hours per day for mechanical dredging and 17operating hours for hydraulic dredging.
The dredging season is 188 days.

Estimated Additional PCB Load and Concentration Compared to the Background Level

	Max Additional Load (1)		Background Load	Regulatory Flow (2)	Max Additional Conc.(3)	Background conc.(4)	
			Average			Average	Max
	g/day	kg/season	kg/season	cfs	ng/L	ng/L	ng/L
Section 1	51.8	9.7	193.6	2300	9.2	81.4	488.2
Section 2	354.7	66.7	171.0	2300	63.0	82.0	211.3
Section 3	159.2	29.9		2300	28.3	91.4	234.6

Notes:
(1) Estimated fluxes from mechanical dredging are higher than those of hydraulic dredging.
(2) 2300 cfs represents NYSDEC-specified low-flow conditions.
(3) Maximum additional concentrations calculated based on the maximum load and the regulatory flow.
(4) Background average concentration is based on dredging season samples.

Master Comment 362637

Comments were raised and recommendations were made relative to turbidity and resuspension during dredging. Commenters asked how EPA will monitor turbidity and resuspension during dredging. Recommendations were made to use real-time continuous monitoring sensors for turbidity, TSS, and total PCBs. Commenters also asked whether EPA will monitor for metals and other contaminants. Some commenters asked about the feasibility of float surveys; some asked if the surveys would be used, and others specifically recommended using them. Commenters

questioned whether the Lower Hudson will be monitored or only the Upper Hudson. Commenters also asked what mitigative procedures or contingencies will be in effect in case measurements exceed acceptable levels during turbidity and resuspension monitoring and how municipal drinking water supplies will be monitored and/or protected.

Response to Master Comment 362637

A conceptual dredging monitoring program is outlined in Section 6.3.5.4 and Appendix G of the FS. It should be noted that the actual monitoring program will be established in the first year of remedial design. The public will be invited to provide input during development of the monitoring program. The construction monitoring program will involve monitoring of the water column in the Upper Hudson and in the freshwater Lower Hudson. A time-of-travel sampling program will be conducted, in which samples are collected sequentially from upstream to downstream in accordance with the river flow rate. The samples will be analyzed for congener-specific PCBs, total suspended solids, and fraction of organic carbon on the suspended solids. As part of the remedial design phase, additional samples will be taken and tested for other possible contaminants. Based on the results of these samples, EPA will consider whether or not to monitor for other contaminants.

In addition to these samples, turbidity measurements will be collected upstream and downstream of dredge areas at various depths. These measurements will serve to monitor the escape of suspended solids from the dredging operations. It is expected that the turbidity threshold will be established based on the anticipated correlation between turbidity and PCB concentrations in the water column. Exceedances of the threshold could result in adjustments or modifications to the dredge operating procedures and construction practices, or other corrective measures.

Regardless of the form of its monitoring program, the EPA intends to establish a notification system for the various public water supplies located downstream of the remediation area. In this manner, these supplies can be protected in the event of a major release by temporarily closing their river intakes. The notification process will use data supplied by the time-of-travel monitoring to be initiated by EPA in the event of a major release. This information will help to protect the water supplies while minimizing their downtime. In addition to event-driven sampling, EPA will also make its sampling results available to the municipalities. These data will document the river conditions and provide information necessary to assess the need for any additional control actions, either by the dredging operation or by the public water supply intakes.

Historical records for the last 10 years (1990-2000) indicates that no exceedances of PCB standards in finished water (*i.e.*, water supplied by the municipalities to residents) were reported in any of the water supplies currently utilizing the Hudson River water. Given that measured water column PCB levels in the Fort Edward area during this period were as high as 4 ug/L (4,000 ng/L) during the Allen Mill event, this suggests that the existing facilities can handle river waters far more contaminated than any to be produced by the remediation. Current annual maximum concentrations in the Upper Hudson are typically less than 300 ng/L. Even with a 2.5 percent loss under summer conditions, water column concentrations would remain under 1000 ng/L. Thus, while EPA will endeavor to protect the water supplies of the Hudson, it is unlikely that dredging will yield PCB levels that will truly impact the use of water from the river. Response to Master Comment 253421 in Section 9.2 contains a discussion of related issues.

Master Comment 735

Commenters stated that the activities involved in the proposed plan, including dredging and construction and operation of the sediment processing/transfer facility, will degrade the Hudson River water quality and, therefore, impact the use of Hudson River for irrigation and drinking water supplies. It was suggested that due to the resuspension of sediment associated with dredging, the TSS/turbidity would increase in the water column. Besides PCBs, the dredging may also release other contaminants, such as metals, organics, PAHs, nutrients, and pathogens into the water column. Further, commenters contended that oxidation of certain species, such as ferrous iron and sulfur, and the biochemical oxidation demand (BOD) exerted by the organics, may deplete the dissolved oxygen (DO) concentration and adversely affect the aquatic life. It was also suggested by some commenters that EPA conduct additional "runs" of its computer models based on more accurate assumptions on water quality impact.

Response to Master Comment 735

For the selected remedy, one or more facilities will be needed to process sediments that have been dredged from targeted areas of the upper Hudson. Construction of these processing/transfer facilities will be accomplished by conventional construction methods using readily available construction machinery. EPA will require that the construction specifications developed for the transfer/processing facilities contain a number of conditions focused on controlling construction-related water quality impacts. Given that the contract documents will specifically address the matter of construction-related impacts on water quality, and that EPA will oversee contractor activities, it is not expected that construction of the sediment processing/transfer facilities will result in significant water quality impacts.

Operation of the sediment processing/transfer facilities may result in either direct or indirect discharges to surface waters. While a discharge permit pursuant to Section 402 of the Clean Water Act and State law is not required for the processing/transfer facilities, it is expected that point source discharges at these facilities will achieve effluent limitations that would otherwise be specified in a discharge permit. To control the non-point sources, EPA will require development and implementation of an operating phase stormwater management plan that will include detailed best management practices that the contractor must follow to control indirect discharges. Based on EPA's approach to managing direct/indirect discharges, which will also include Agency oversight of the contractor's efforts, it is not expected that discharges from processing/transfer facilities will significantly impact water quality.

The Hudson River TSS transport model detailed in the White Paper – Resuspension of PCBs during Dredging estimates the total suspended solids that could be expected from dredging operations. Model results are as follows:

TSS model results for Hudson River

Type of Dredge	TSS Concentration (mg/L) [1]		
	River Section 1	River Section 2	River Section
Hydraulic	1.1 / 0.3	1.4 / 0.5	1.4 / 0.5
Mechanical	1.0 / 0.4	1.2 / 1.1	1.2 / 1.1

Note:

1. First value in each box represents the TSS concentration increase at a distance of 10m downstream of the dredge head. The second value represents the TSS concentration increase in the river when the TSS release has been fully mixed into the river, assuming no further settling beyond 10m of the dredge head. Both estimates are calculated for a flow of 3,000 cfs.

For comparison, spring runoff produces increased flows and increased TSS concentrations throughout the entire river. USGS data for Fort Edward show average levels of 13 mg/L in April over the period 1978-1995; Schuylerville averaged 21 mg/L in April from 1977-1989; Stillwater averaged 27 mg/L in April from 1977-1996, and Waterford averaged 40 mg/L in April from 1976-1996. Thus, normal spring run-off produces far greater TSS levels than any increase estimated from dredging operations. Additionally, spring TSS loads encompass the entire river while dredging operations are projected to increase levels by less than 1.5 mg/L within 10 meters of the dredge. TSS increases associated with dredging are not likely to impact the use of Hudson River.

As detailed in the White Paper – Potential Impacts to Water Resources, concentrations of other contaminants that could be released into the water column during dredging were calculated based on the estimated TSS release. The results are presented below in the table entitled Estimated Release Into Water Column Due to Dredging for Conventional and Trace Compounds.

For all trace contaminants and nutrients evaluated, except mercury, the estimated water column increases due to dredging are relatively minor and do not represent a significant concern relative to New York State ambient water quality standards. Mercury is estimated to approach the NYSDEC standard for consumption of fish based on the conservative analysis conducted for this Responsiveness Summary. Given the transient nature of dredging operations and the low flowrate used for this analysis, it is not expected that temporary project-induced mercury level increases will generate significant impact.

The possible consumption of oxygen by resuspended sediment was estimated based on the TOC, iron, and sulfur concentration in sediment. As shown in the table, the post-dredging dissolved oxygen concentration in the Upper Hudson River will remain above 5 mg/L, which is the level set by NYSDEC. Therefore, there should be no concern in this regard.

Estimated Release into Water Column Due to Dredging for Conventional and Trace Compounds

	Concentration in the sediment	Max Concentration Increase due to Dredging	Background Water Column Concentration	Most Stringent Standard Level	Relative Increase to Background / Standard
Nutrient	**ppm**	**mg/L**	**mg/L**	**mg/L**	**percent**
Nitrogen	3000	0.0023	1.1		0.2
Phosphorous	1500	0.0012	0.05		2.4
Metals	**ppm**	**ug/L**		**ug/L**	**percent**
Cadmium	16	0.03		4.4	0.7
Chromium	440	0.39		50	0.8
Copper	54	0.10		13.5	0.8
Lead	250	0.26		4.8	5.5
Manganese	570	0.50		300	0.2
Mercury	1.2	0.001		0.0012	86.8
Nickel	24	0.025		40	0.06
PAHs	**ug/kg**	**ug/L**			
Fluoranthene	1000	0.00029	NA	50	0.001
Pyrene	890	0.00031	NA	4.6	0.007
Phenanthrene	820	0.00028	NA	5	0.006
Chrysene	520	0.00015	NA	0.002	8
Benz(a)anthracene	440	0.00015	NA	0.002	8
Benzo(b)fluoranthene	400	0.00012	NA	0.002	6
Benzo(k)fluoranthene	390	0.00011	NA	0.002	6
Benzo(a)pyrene	320	0.00009	NA	0.002	5
Anthracene	300	0.00010	NA	3.8	0.003
Oxidizable Compounds	**percent**	**mg/L**	**Consumption of DO (mg/L)**	**NYSDEC Standard**	**DO in water column mg/L**
TOC	11.54	0.16	0.42	>5.0	7.2
Ferrous Iron (Iron)	2.8	0.04	0.005	>5.0	7.2
Sulfide (Sulfur)	0.15	0.002	0.004	>5.0	7.2

The sources of pathogens in sediments can include animal feed lots, dairy farms, combined sewer overflows (CSOs), wastewater treatment facilities, and storm water runoff, among others. Due to various natural processes, pathogen levels in the water column decrease with distance downstream from the source. The only water supply intake in the study area is at Waterford, at approximately RM 157. A second water intake is currently being planned for Halfmoon, New York, also around RM 157. The intake is more than four miles downstream from the southernmost targeted dredging area. In fact, most of the dredging will occur between RM 195 and 183, more than 25 miles upriver from the Waterford intake. The Waterford water treatment

facility includes a full treatment train (coagulation, prechlorination, flocculation, two-stage settling, filtration and post-chlorination) that effectively removes pathogenic organisms routinely present in river water. Given the distance from dredging areas to the Waterford intake, and the treatment facility, no impact to the water supply is expected from dredging operations. White Paper – Potential Impacts to Water Resources contains additional information related to water quality impacts.

Master Comment 253421

Commenters were concerned that there may be adverse impacts on drinking water supplies due to resuspension of PCBs. Commenters were also concerned that wells are hydrologically connected with the Upper Hudson and may become contaminated with PCBs. One comment stated that dredging operations at New Bedford Harbor lowered the water table and caused all the water to flow out of the wells in the vicinity.

Response to Master Comment 253421

This comment is answered in two parts, concerns about the effects on drinking water supplies and about effects on groundwater and drinking wells. It is important to note that in neither case is the dredging operation anticipated to cause PCB contamination of drinking water.

EPA recognizes the concern over the possible impacts to drinking water supplies downstream of the dredging operations. For this reason, EPA will implement both a monitoring program and a notification network to reassure the public about protection of surface water supply intakes along the river (Response to Master Comment 362637, Section 9.2). However, as discussed in detail in White Paper – Potential Impacts to Water Resources and White Paper – Resuspension of PCBs during Dredging, the anticipated impacts to water quality within the Hudson due to dredging operations will be very minor, at most, and probably not detectable beyond a few hundred yards downstream from dredging operations. The impacts to water quality from resuspension of PCBs are discussed in Chapter 10 (Response to Master Comment 365942), and for potential impacts from other contaminants in Section 9.2 (Response to Master Comment 735).

Generally the treatment train at drinking water supply facilities such as Waterford, which utilizes a surface water source for water, involves filtration. Even in the early 1990s when total PCB levels in the Upper Hudson River were five to 10 times greater than current levels, the filtration process was able to remove the PCBs effectively. Evidence for this comes from the fact that during this period (1991-1993) there were no violations with regard to total PCB levels in the drinking water. As mentioned previously, the impacts to the water quality are anticipated to be minor and total PCB levels will not approach the historically high levels. Since the treatment train at the water supply facility has been shown to be able to deal with PCBs in general and has been shown to effectively remove them in the past despite significantly higher levels at the time, no adverse effects on drinking water due to dredging are expected.

From this analysis, it also can be concluded that impacts to groundwater from resuspension are also likely to be imperceptible. This can be concluded based on the following:

- The Hudson is a river of great age in a region of moderate rainfall. Rivers in this part of the country in general represent areas where groundwater contributes to the base flow of the river rather than the river recharging a groundwater system. Thus the Upper Hudson is expected to be the receptor for groundwater flow from unconsolidated and/or bedrock aquifers throughout the region. Given its great age, it is highly likely that the freshwater river has eroded its bed such that extensive areas of groundwater discharge exist along its length to Troy. Groundwater supplies in these areas would be completely unaffected by any dredging operation in the river since the dominant flow direction is from surficial aquifers into the river, rather than the river contributing to the groundwater system.

- Man-made alterations to water surface elevations caused by the construction of dams in the river may have changed the nature of recharge in some areas. In some areas upstream of the dams, the increased hydraulic head may cause some water to flow from the river into the surficial aquifer. In a TI Pool study (HSI GeoTrans, 1997 for GE) which characterized groundwater and river water fluxes across the sediment-water interface, it was determined that the measurements were generally positive, *i.e.*, flow was in the direction from groundwater into the Hudson River. This study found only one location (at site S5 from that report), about one mile upstream of the TI Dam, where groundwater flow was consistently negative. In these isolated areas where river water may be flowing into the groundwater system, however, the low permeability and low hydraulic conductivity of these aquifers will prevent significant infiltration of river water into the overall groundwater system. This is due to the glacial tills and weathered bedrock (saprolite) which generally comprise the aquifers in the region. Most water supply wells in this area are completed within fractured bedrock and do not withdraw water directly from the unconsolidated aquifer. Regardless of whether the well is completed into the bedrock or into the unconsolidated material, the travel time of the groundwater is so slow that any infiltrated PCB contamination will either be sorbed to the clays and tills which comprise the aquifer matrix, or be discharged back into the river slightly downstream, where the regional flow <u>into</u> the river is once again the dominant direction of flow. The anticipated change in water column PCB concentrations within the river will not have a measurable impact on local groundwater supplies, since the concentration change within the river itself is expected to be small and within the natural variability that occurs annually.

Lastly, the EPA is unaware of the New Bedford Harbor dredging project's having lowered the water table and caused wells to dry. It seems unlikely that this would have occurred, as the water table in the area is approximately at sea level. In addition, the area is highly industrialized and the majority of residences in the area would receive drinking water from municipally provided public water.

Master Comment 803

Commenters had a number of concerns about resuspended sediment: 1) biota downstream of dredging operations may be impaired by resuspended sediment; 2) resuspension of sediments

during dredging may affect fish and filter feeding bivalves, due to physical impairment of feeding processes and from toxicity caused by mobilization and downstream transport of contaminated sediment; and 3) sediment resuspension may also interfere with light penetration and feeding of benthic organisms. Concerns were raised that effects on lower trophic levels would impact higher trophic level animals.

Response to Master Comment 803

Suspended sediments may adversely affect aquatic habitat by accumulating in the interstices of coarse substrata, thereby limiting habitat for aquatic invertebrates. Fine sediments can also settle on coarser sediments, smothering the eggs of fish and other aquatic animals and covering filter feeding animals, such as bivalves, so that they have difficulty obtaining adequate food. Under extreme conditions, fish and aquatic invertebrates that feed by sight may have difficulty in finding prey, gills may become clogged (killing fish or reducing their growth rate), and disease may occur. Increased sediment can also alter aquatic communities. For example, agricultural sites that received a four- to five-times greater suspended load than forested sites had fish communities dominated by disturbance-tolerant fish (Sutherland *et al.*, 2001).

Suspended sediments may also adversely affect plant communities by reducing light penetration into the water column. This reduces the ability of algae to produce food and oxygen and affects animals that feed on algae. As suspended sediment settles out and drops to the bottom, it may smother plants, thereby reducing the extent of submerged aquatic vegetation (SAV).

Water column TSS levels (mg/L) for the hydraulic and mechanical dredging technologies have been estimated in White Paper – Resuspension of PCBs during Dredging. The impact of increased TSS due to dredging on water quality is discussed in the Response to Master Comment 735 (Section 9.2). The table below, TSS Model Results for the Hudson River, presents the results of plume TSS concentrations estimated to occur 10 meters downstream of the dredging work. These concentrations do not reflect complete mixing of resuspended sediment within the Upper Hudson, which can be expected to occur at some point further downstream of the dredging operations. For the purpose of comparison, the impact of complete mixing on TSS concentrations is also presented for the case where one hydraulic dredge is used to remove targeted sediments.

These minimal increases in TSS concentrations incorporate several conservative assumptions including:

- No further removal of PCBs by settling beyond 10 meters downstream of the dredge head.
- No adjustment made for the silt curtains, which serve to reduce downstream movement of sediment.
- A low flow rate (3,000 cfs) that serves to maximize PCB concentrations in the water column.

A further discussion can be found in Appendix E.6 of the FS.

Baseline TSS concentrations vary considerably in the river throughout the year, and particularly during the spring, when snow melts enter the river and cause high flows. Spring runoff produces increased flows and TSS concentrations throughout the entire river. Using available USGS data, Fort Edward showed average TSS levels of 13 mg/L in April from 1978-1995; Schuylerville averaged 21 mg/L in April from 1977-1989; Stillwater averaged 27 mg/L in April from 1977-1996, and Waterford averaged 40 mg/L in April from 1976-1996 (Figure 803-1). The highest TSS concentrations are generally seen in March and April. Dredging is anticipated to occur from May through November, which would not coincide with the major part of the spring runoff.

Figure 803-1 shows that aquatic organisms in the Hudson River experience a wide range of total TSS concentrations over the course of a year, and that TSS tends to increase downriver, where only limited dredging is planned (the southernmost dredging site is currently planned at RM 163.5). Springtime, when the highest TSS concentrations are generally seen, is also the spawning/reproductive season for many fish and invertebrates. Any increases in resuspension attributable to remediation would be well within the variability already experienced by aquatic organisms in the system and would not be noticeable given the wide range of natural variation. As discussed in Chapter 8 and Appendix E.6 of the FS, increases in PCB load and concentration during the dredging period would be relatively minor as compared to the ongoing releases of PCBs from the sediments of the river, as well as from the Hudson Falls source.

NYSDEC Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (NYSDEC, 1998) does not contain, and EPA does not have, a guideline for dissolved total solids, with the exception of 1,000 mg/L guideline that applies only in the counties of Nassau and Suffolk. British Columbia Canadian guidelines (British Columbia, 1998) state that during *clear flow period*, the portion of the hydrograph when suspended sediment concentrations are low (*i.e.*, less than 25 mg/L), TSS level should remain below 25 mg/L in 24 hours, or a mean of 5 mg/L in 30 days. During the *turbid flow period* when background levels are relatively elevated (*i.e.*, greater than or equal to 25 mg/L), the guidelines are 25 mg/L when background is between 25 and 250, or 10 percent of the measured background level when background is greater than or equal to 250. Guidelines in Alberta, Canada, recommend a suspended solids Surface Water Quality Guideline (SWQG) not above 10 mg/L over background (Alberta, 2001). The European Union has a directive in force (1979) that states that a discharge affecting shellfish waters must not cause the suspended solid content of the waters to exceed by more than 30 percent the content of waters not so affected.

A National Academy of Sciences study (NAS, 1973) concluded that a TSS level of 80 mg/L typically provides for a moderate level of protection of aquatic life in freshwater streams, and a level of 25 mg/L provides good protection. A level of 400 mg/L provides poor protection for aquatic life. The NAS also recommends that the concentration of TSS should not reduce light penetration by more than 10 percent.

TSS Model Results for Hudson River

Distance	Additional TSS concentration in mg/L		
	River Section 1	**River Section 2**	**River Section 3**
Hydraulic Dredging			
10 m downstream of dredge head	1.12	1.37	1.37
Hydraulic Dredging			
fully mixed with 3000 cfs	0.29	0.47	0.47
Mechanical Dredging			
10 m downstream of dredge head	1.01	1.24	1.24

Alabaster and Lloyd (1982) summarized the quality of fishery that may be expected with different levels of suspended sediments:

- Normally less than 25 milligrams/liter - no harmful effects.
- Normally between 25 and 80 milligrams/liter - good fishery maintainable.
- Normally between 80 and 400 milligrams/liter - moderate to poor fishery maintainable.
- Normally greater than 400 milligrams/liter - poor quality fishery maintainable.

In an evaluation of this guideline on the urbanized Don River near Toronto in Canada, the Toronto and Region Conservation Authority (TRCA) found that suspended sediment levels varied dramatically with flow conditions, where dry weather flows tended to have much less suspended material than high flows. In response to this, the Don Watershed Report Card (Don Watershed Regeneration Council and TRCA, 1997) suggested the target for suspended sediment should be to achieve less than 80 milligrams/liter more than 75 per cent of the time.

The localized increases in TSS anticipated from dredging are more than an order of magnitude below available guidelines for aquatic health. Based on the TSS concentrations discussed above, therefore, the Hudson River can easily support a healthy fishery.

A study examining potential relationships between exposure to increased suspended sediment concentrations associated with dredging activities and striped bass (*Morone saxatilis*) hatching success, larval foraging, and adult migration and spawning in San Francisco Bay and the Sacramento-San Joaquin Delta (Hanson and Walton, 1990) suggested that striped bass were not adversely impacted by exposure to increased suspended sediments caused by dredging. In fact, striped bass have been able to establish an abundant population in San Francisco Bay and the Sacramento-San Joaquin Delta system.

Laboratory studies of white perch (*Morone americana*), spot (*Anchoa mitchilli*), bay anchovy (*Leiostomus xanthurus*), and other species in San Francisco Bay indicate that the highest suspended sediment levels in the estuary would pose no threat to even the most sensitive species (USEPA, 2001). More than six million cubic yards of sediments enter the estuary each year, mostly from the Sacramento and San Joaquin rivers, and as many as 286 million cubic yards of

existing sediments in the shallows of San Francisco Bay are resuspended by currents and wind-driven waves. Even at suspended sediment concentrations adjacent to disposal barges or in the water column immediately following disposal, fish would have to be exposed for several hours in order for death to occur, while plumes of highly concentrated suspended solids last only for minutes.

In summary, normal spring run-off produces far greater TSS variation than the minimal increases estimated from dredging operations. Spring TSS loads encompass the entire river, while dredging operations are projected to increase levels by less than 1.5 mg/L within 10 meters of the dredge. These increases are well below the levels where aquatic life may be impacted based on available guidelines. Beyond 10 meters, the incremental TSS levels would be further reduced as water column mixing continues. Given the low resuspension levels anticipated, the relatively modest area which dredging influences, and the fact that further mixing will quickly reduce dredging-induced increases, aquatic life in the river and the organisms that feed upon them will not experience any adverse effects caused by sediment resuspension during dredging.

References

Alabaster, J.S. and R. Lloyd. 1982. Water quality criteria for freshwater fish. Alabaster, J.S. Butterworths, London. 361 pp.

Alberta Ambient Surface Water Quality Interim Guidelines. 2001. http://www.biology.ualberta.ca/alms/Parameter.htm. Accessed August 13, 2001.

British Columbia, Canada, Water Management Branch, Environment and Resource Division, Ministry of Environment, Lands, and Parks. 1998. Ambient Water Quality Criteria for Turbidity, Suspended and Benthic Sediments. Accessed from website http://www.env.gov.bc.ca/wat/wq/BCguidelines/turbidity.html August 9, 2001.

Don Watershed Regeneration Council and the Toronto and Region Conservation Authority (TRCA). 1997. Turning the Corner: the Don Watershed Report Card. The Toronto and Region Conservation Authority. 35pp.

European Union (EU). 1979. Community legislation in force. Council Directive 79/923/EEC of 30 October 1979 on the quality required of shellfish waters. http://europa.eu.int/eur-lex/en/lif/dat/1979/en_379L0923.html. Accessed August 13, 2001.

Hanson, C.H., and C.P. Walton. 1990. *Potential effects of dredging on early life stages of striped bass (Morone saxatilis) in the San Francisco Bay area: An overview*. Effects of Dredging on Anadromous Pacific Fishes: Workshop Proceedings, Seattle, WA (USA), 8-9 September 1988, pp. 38-56.

National Academy of Sciences (NAS), National Academy of Engineering. 1973. Water Quality Criteria 1972. EPA Ecol. Res. Series. EPA-R3-73-033, USEPA, Washington, D.C. 594 p.

New York State Department of Environmental Conservation (NYSDEC). 1998. Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations**.** Division of Water Technical and Operational Guidance Series (1.1.1). Reissued June 1998.

Sutherland A., J. Meyer, and N. Gardiner. 2001. Effects of Land-Use on Sediment Regime and Fish Assemblage Structure in the Southern Appalachians. http://coweeta.ecology.uga.edu/webdocs/meta/html/str/ronstr-andsediment-doc.html. Accessed August 13, 2001.

USEPA, Office of Water. National Estuary Project (NEP). San Francisco Estuary Project. 2001. State of the Estuary Report 8a Dredging and Waterway Modification (Part A) http://www.abag.ca.gov/bayarea/sfep/reports/soe/soe8a.htm#10

9.3 Habitat Replacement

Master Comment 511

A number of commenters stated that the adverse impacts of targeted dredging on river habitat will be temporary and this temporary loss will be offset by the accelerated recovery of the entire river. They contend that any short-term impacts from dredging can be minimized through appropriate habitat replacement activities.

Response to Master Comment 511

EPA agrees. Potential adverse impacts resulting from dredging activities will be temporary and will be offset by implementation of the habitat replacement program.

Page 1 of the habitat replacement program description (Appendix F of the FS) identifies the potential habitat impacts that may result from implementation of a remedial alternative (*i.e.*, removal or capping of substrate used as spawning and foraging habitat by fish and benthic invertebrate species; displacement of benthic organisms; loss of vegetation communities; loss of freshwater wetlands acreage and wetlands functional values; and disturbance of riparian habitat and shoreline stability). The habitat replacement program will be implemented to mitigate these disturbances to aquatic and wildlife habitat.

Master Comment 513

Commenters suggested that the thickness and type of backfill material to be placed should depend on the type of restoration to be achieved. In some instances, no fill may be required and in others, more than one foot may be required. Also, commenters said that details of recolonization of backfill should be provided.

Response to Master Comment 513

Details regarding backfill type and thickness in specific locations will be determined during remedial design. These details, along with other decisions that pertain to the habitat replacement

program, will be formulated in consultation with the federal Trustees and NYSDEC. The need to place backfill and backfill specifications will be determined in accordance with the habitat replacement objectives, but within the context of the more fundamental objectives and requirements of the proposed remediation. Backfilling is proposed to isolate residual contaminants that remain after dredging and is critical to attaining the modeled decreases in PCB concentrations sediment. Backfilling could be omitted in specific locations only if such action would not compromise attainment of the target PCB concentrations.

With respect to recolonization of backfill, the intent of the habitat replacement program is to return the river bottom to a stable, well-sorted substrate with a complex mixture of sediment sizes that provides suitable habitat diversity to enable the recolonization of a variety of benthic invertebrates. As such, remediated areas in the deep river and shallow river habitat zones would be backfilled with gravel and sand and, over time, some silt and other fines would be transported by the river into these backfilled areas. This varied substrate would provide habitat for the recolonization of a variety of epifaunal (attached to the sediment surface, such as snails) and infaunal (occurring within the sediment, such as oligochaete worms) invertebrates. The reestablishment of SAV beds would provide habitat for benthic species that thrive in areas of submerged aquatic vegetation, such as freshwater scuds (amphipods).

Master Comment 517

Some commenters expressed concern that several of the suggested plant species are not appropriate for revegetating areas impacted by remedial actions. Commenters recommended that only species native to the Upper Hudson River should be replanted or reseeded. For example, at least one species of Ruppia (*Ruppia maritima*) is characteristic of brackish marshes and should be deleted from the target list. *Pistia stratiotes* is a pantropic species and should not be introduced to the Hudson River. The web site mentioned was http://florawww.eeb.uconn.edu.acc_num/199600001.html. *Zenobia pulverulenta* is native to the coastal plain ranging between North Carolina and Florida and is not a suitable candidate for mitigation along the Upper Hudson.

Response to Master Comment 517

A final list of SAV and wetland vegetation species to be planted will be detailed during remedial design, although it is anticipated that the list of species will be modified at times during the implementation of the habitat replacement program as experience with the conditions on the Upper Hudson River is accumulated. This list, along with all other aspects of the habitat replacement program, will be formulated in consultation with the federal Trustees and NYSDEC. Only vegetation species native to the Upper Hudson River will be planted or seeded.

As addressed in Response to Master Comment 529, sequencing and scheduling of habitat replacement actions will be analyzed for opportunities to preclude or minimize establishment of invasive, exotic species, notably Eurasian water milfoil (*Myriophyllum spicatum*), curly pondweed (*Potamogeton crispus*), and water chestnut (*Trapa natans*) in the river, and purple loosestrife (*Lythrum salicaria*) and common reed (*Phragmites australis*) in the emergent wetlands.

Master Comment 313373

Commenters recommended that the plan to backfill dredged non-capped non-channel areas be further discussed with the State and federal Trustees. Some contended that backfilling may not be warranted in all circumstances and may lead to re-colonization by nuisance species. Further, some suggested that decreasing the amount of backfill required will decrease mitigation cost estimates.

Response to Master Comment 313373

It is agreed that from a habitat replacement perspective, backfilling may not be warranted in all circumstances and could increase the potential for invasion by nuisance species, and that decreasing the amount of backfill could decrease remediation cost estimates. Further, the need to consult the federal and State Trustees is acknowledged.

Details regarding backfill type and thickness in specific locations will be determined during remedial design. These details, along with other decisions that pertain to the habitat replacement program, will be formulated in consultation with the federal Trustees and NYSDEC. The need to place backfill and backfill specifications will be determined in accordance with the habitat replacement objectives, but within the context of the more fundamental objectives and requirements of the proposed remediation. Backfilling is proposed to isolate residual contaminants that remain after dredging and is important in attaining the modeled decreases in PCB concentrations. Backfilling could be omitted in specific locations only if such action would not compromise attainment of the target PCB concentrations.

Master Comment 313365

Some commenters pointed out that backfill material can provide appropriate elevations and substrate for emergent and submerged aquatic vegetation.

Response to Master Comment 313365

EPA concurs that backfill material can provide appropriate elevations and substrate for emergent and submerged aquatic vegetation. Details regarding backfill type and thickness in actual specific locations will be determined during remedial design. These details, along with all other aspects of the habitat replacement program, will be formulated in consultation with the federal Trustees and NYSDEC. EPA's backfill placement strategy will consider both the need to immobilize residual contamination and the substrate type most suitable for aquatic vegetation.

Master Comment 313336

Commenters suggested that for shallow wetland areas, backfilled sediment should contain sufficient organic matter and approximate pH to support the desired vegetative community.

Response to Master Comment 313336

It is expected that fines and other organic material will be deposited naturally. However, during remedial design, methods for augmenting the amount of organic material in the restored wetland will be reviewed. With respect to pH, while the placement of extremely alkaline or acidic sediments will be avoided, it is the pH of the river water that is most critical to plant survival.

Master Comment 313194

Several comments were submitted relative to reestablishment of the SAV beds: 1) Reestablishment of SAV beds is likely to extend beyond five years. 2) Given the scale and complexity of the proposed action, it seems likely that the reestablishment of functioning SAV beds and the recovery of fish populations dependent on those beds will require far longer than the five-year remediation period discussed in the FS. 3) Even if the vegetation is successfully reestablished, there will likely be a lag of several years following replanting before biotic communities are restored.

Response to Master Comment 313194

Reestablishment of SAV (and, in fact, much of the habitat replacement work, including wetland restoration) will extend beyond the current six-year time frame of the remediation. The actual duration of implementation of the habitat replacement program in general and SAV replacement in particular will depend on the following:

- Extent of the habitats (*e.g.*, SAV is not continuous throughout the river bottom, but occurs in discontinuous beds) and the extent of direct and indirect habitat disturbance.
- Geomorphological response of the river to the remediation activities.
- Precision and accuracy of the Upper Hudson River habitat replacement model.
- Response of the ecosystem to the disturbance of riverine habitats and to habitat replacement actions, particularly those undertaken early in the program.
- Responsiveness of the adaptive management framework.
- Other factors that may hasten or prolong reestablishment, such as the weather, river discharges, competition from invasive exotic species, predation, and the occurrence of pests.

River modification by dredging and backfilling will result in changes to the sediment supply and channel morphology, which in turn may lead to riverbed and bank erosion and sedimentation. If significant river bottom and bank instability were to occur during and following remediation, such effects would be temporary and localized, although the actual duration and extent of those effects cannot be predicted accurately. Such instability, documented through monitoring, may require substantial delays in the implementation of some components of the habitat replacement program, at least in some locations along the river. Further, various difficulties may be encountered during the implementation of the habitat replacement actions; *e.g.*, problems in developing the dynamic habitat replacement model, high failure rates in SAV bed establishment, low rates of colonization by native SAV species, or, conversely, high rates of invasion by exotic SAV species.

Although adaptive management is intended to identify such problems early in the habitat replacement program and provide an effective framework for the rapid development of appropriate solutions, *e.g.*, implementation of an aggressive program to control invasive vegetation and limit SAV predation, such difficulties could prolong the program, potentially over many years. The active habitat replacement program will be undertaken until the levels of ecosystem recovery, health, and stability defined during the design phase have been reached and sustained.

Master Comment 313187

Some commenters stated that the EPA has failed to consider how predation will be controlled. Concern was expressed that wildlife predation of both naturally colonizing and planted/seeded vegetation will be widespread.

Response to Master Comment 313187

The nature and extent of herbivory will be defined through monitoring, as will the species requiring control, *e.g.*, invertebrates, turtles, common carp (*Cyprinus carpio*), waterfowl, beaver (*Castor canadensis*), and muskrat (*Ondatra zibethicus*). The predation control element of the program, in concert with other elements, will aim to maintain predation at acceptable levels. Specification for predation control techniques such as herbivore enclosures, trapping, chemical control, and biocontrol will be detailed during remedial design, and opportunities to integrate predation control with wildlife reestablishment and management will be analyzed.

Master Comment 759

Commenters were skeptical that the river and affected environs could be returned to a beneficial state after dredging. There were questions surrounding the plans for backfill material - what it would be and what its source would be. There were some concerns that the habitat restoration process was not well defined and might cause more harm than good.

Response to Master Comment 759

A habitat replacement program will be formulated during the design phase of the project. This program will be implemented as an essential component of the overall remedy. With successful habitat replacement, ecological risk associated with the proposed action will be minimized and there will be ecosystem improvements through contamination removal. Further details on the proposed habitat replacement are addressed in Response to Master Comment 537 in Section 9.1.

Backfill material will be obtained from commercial suppliers/distributors and may originate from a number of locations ranging from Lake Champlain to coastal New Jersey. Further discussion is provided in the Response to Master Comment 653.

Master Comment 523

Some commenters suggested that EPA's proposed monitoring program is inadequate, saying that the plan fails to address both the monitoring of the success of the restoration effort and time-of-year limitations related to sampling locations, frequencies, and parameters. It has been suggested that there is no conceptual model for SAV habitat interactions that is specific to the Upper Hudson. Other comments say that there is no evidence that adaptive management is being integrated into the early planning phases of the restoration process. It was recommended that the monitoring plan should be fleshed out during the design stage, and that photo-documentation should be a required component of the monitoring plan.

Response to Master Comment 523

Habitat replacement monitoring will be implemented as an essential, integrated component of the overall program and, as such, will comprise systematic data collection and documentation before habitat replacement implementation, during implementation, and after implementation. A monitoring plan that will include photo-documentation will be formulated during the design phase of the project and will specify sampling locations, frequencies, and parameters. Per the guidelines established by the Federal Interagency Stream Restoration Working Group (1998), the following steps will be undertaken requisite to formulation of the monitoring plan:

- Define the restoration vision, goals, and objectives.
- Develop the dynamic model.
- Choose performance criteria.
- Choose monitoring parameters and methods.
- Estimate costs.
- Categorize the types of data.
- Determine the level of effort and duration.

With respect specifically to SAV, as stated by Stevenson and Davis (2001), a conceptual model for SAV habitat interactions exists and has been revised based on extensive scientific research. EPA would use this model – Chesapeake Bay Submerged Aquatic Vegetation Water Quality and Habitat-Based Requirements and Restoration Targets: A Second Technical Synthesis (Batiuk, *et al.*, 2000), or similar – as a basis for constructing a dynamic model specific to the Upper Hudson River and the replacement of the SAV habitats.

References

Batiuk, R. A., P. Bergstrom, M. Kemp, E. Koch, L. Murray, J. C. Stevenson, R. Bartleson, V. Carter, N. B. Rybicki, J. M. Landwehr, C. Gallegos, L. Karrh, M. Naylor, D. Wilcox, K. A. Moore, S. Ailstock, and M. Techberg. August 2000. Chesapeake Bay Submerged Aquatic Vegetation Water Quality and Habitat-Based Requirements and Restoration Targets: A Second Technical Synthesis. US Environmental Protection Agency/Chesapeake Bay Program, Annapolis, MD.

Federal Interagency Stream Restoration Working Group. October 1998. Stream Corridor Restoration: Principles, Processes, and Practices.

Stevenson, J. C., and R. C. Davis. April 2001. Assessment of EPA's Habitat Replacement Program for the Hudson River Proposed Remedial Plan (REM 3/10/Select). *In*: Comments of the General Electric Company on U.S. EPA's Hudson River PCB Feasibility Study and Proposed Remedial Action Plan, Volume 4, Appendix D-1.

Master Comment 525

Commenters stated that EPA's description of benthic community restoration is overly simplistic. Some commenters said that the Proposed Plan does not adequately differentiate between epifaunal and benthic invertebrate communities and potential differences in the feasibility of their restoration, and that EPA has not evaluated potential effects on the benthic community (and concomitant fisheries resources) from change of substrate type.

Response to Master Comment 525

The intent of the habitat replacement program is to return the river bottom to a stable, well-sorted substrate with a complex mixture of sediment sizes that provides benthic habitat diversity and a productive benthic community as a source of food for fish. As such, remediated areas in the deep river and shallow river habitat zones would be backfilled with gravel and sand and, over time, some silt and other fines would be transported into these backfilled areas. This varied substrate would provide habitat for a variety of epifaunal (attached to the sediment surface, such as snails) and infaunal (occurring within the sediment, such as oligochaete worms) invertebrates. The reestablishment of SAV beds would provide habitat for benthic species that thrive in areas of submerged aquatic vegetation, such as freshwater scuds (amphipods).

As benthic invertebrates will readily reestablish in the remediated areas, fish and wildlife that depend on those resources for food are expected to experience, at most, temporary food shortages in localized areas. Downstream migration or drift is typically the most important mechanism of benthos dispersal (Petts and Calow, 1996). There is generally a continuous stream of benthic organisms (larval and adult) represented in the currents of streams and rivers. As there is a continual source of benthic invertebrates in the downstream drift, the recovery of benthic invertebrates in an area of previous disturbance generally commences soon after the disturbance, if suitable habitat conditions exist. In a study of the recovery rates of macroinvertebrate communities following disturbance, Niemi, *et al*. (1990) found that 90 percent of the cases reviewed indicated recovery times within one year.

Channel relocation and reconstruction projects provide an indication of recovery times where a major physical modification of the river channel occurs. In a colonization study of a newly formed channel in the Tongue River, Wyoming, maximum densities of macroinvertebrates were obtained in less than 90 days, with equilibrium levels reached in about 200 days (Gore 1979, 1982). For a new stream channel in Scotland, Doughty and Turner (1991) reported maximum diversity and similarity to a reference site 80 to100 days after invertebrate recolonization began. Malmqvist *et al*. (1991) found that invertebrate diversity in a man-made channel was similar to that in reference streams within one year.

References

Doughty, C. R., and M. J. Turner. 1991. The Ponesk Burn Diversion: Colonization of Benthic Invertebrates and Fish. Technical Report No. 98. Clyde River Purification Board, East Kilbride, Scotland. *As reported in*: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Gore, J. A. 1979. Patterns of initial benthic recolonization of a reclaimed coal strip-mined river channel. Canadian Journal of Zoology 57:2429-39. *As reported in*: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Gore, J. A. 1982. Benthic invertebrate colonization: source distance effects on community composition. Hydrobiologia 94:183-93. *As reported in*: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Malmqvist, B., S. Rundle, C. Bronmark, and A. Erlandson. 1991. Invertebrate colonization of a new, man-made stream in Sweden. Freshwater Biology 26:307-24. *As reported in*: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Niemi, G. J., P. DeVore, N. Detenbeck, D. Taylor, J. D. Yount, A. Lima, J. Pastor, and R. J. Naiman. 1990. Overview of case studies on recovery of aquatic systems from disturbance. Environmental Management 14: 571-88. *As reported in*: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Master Comment 527

Commenters stated that EPA has failed to adequately evaluate the challenges of replacing and protecting the emergent wetlands. Some say there is no mention as to whether monitoring will be used to ensure appropriate hydrology before planting occurs. Others expressed concern that the current plan does not consider the potential for water quality degradation. Concerns were expressed that there is no mention of how invasive species such as common reed (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria*) would be controlled and prevented from colonizing the disturbed areas. Some contend that the replacement of wetlands disturbed by dredging should consist of regrading to appropriate elevations for desirable hydrophytic species. Recommendations were made that other habitat replacement objectives specific to wetlands should include replacement of bird and mammal habitat.

Response to Master Comment 527

The goal of the wetland replacement actions generally will be to replace the wetland functions and values that existed before remediation. This will include the replacement of bird and mammal habitat.

This effort will require the collection and documentation of extensive hydrology, soil, and biological data on the pre-remediation conditions of the wetlands. In some cases, a return to pre-remediation conditions may not be feasible; *e.g.*, in situations where the post-remediation hydrology does not permit restoration to pre-remediation conditions. In such cases, hydrology, soil, and biological data will be collected and documented for both the original pre-remediation wetland and local reference sites. Reference sites are nearby wetlands with physical characteristics (*e.g.*, elevation, hydrology, and soil texture) that closely match those of the subject replacement wetland after remediation.

Wetlands disturbed by remediation activities will be regraded to elevations suitable for supporting target hydrophytic vegetation. Elevation requirements will be detailed initially during remedial design, but will be modified during program implementation in response to knowledge gained through monitoring, evaluation, and feedback. Replacement design plans for each wetland will specify all elevation requirements. After initial grading, resulting elevations will be surveyed and the wetland hydrology will be monitored, at a minimum throughout one year but potentially through several consecutive years. Some wetland replacement sites and all of the wetland reference sites will be monitored throughout the habitat replacement program. If appropriate, the wetlands will be regraded to establish the required hydrology.

Requisite to wetland replacement, specific objectives will be designated for each wetland for all stages of the replacement process. Monitoring before, during, and after implementation will be used to ensure that the objectives for each stage are achieved prior to progressing to the next stage. As examples, appropriate hydrology, sediment texture, and sediment stability, verified through monitoring, will be required before planting or seeding is initiated; and monitoring will be used to identify needed mid-course corrective actions, such as adjustments to the site hydrology, replanting/reseeding, and routine maintenance. Of paramount importance will be establishing the required hydrology, as hydrology typically is the most critical factor affecting the success of wetland restoration projects (Lowry, 1989).

Monitoring, performed at a frequency that allows for intervention, will also be critical to the early identification of colonization by invasive wetland vegetation, *e.g.*, common reed (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria*), and the extent of their spread, as well as to the assessment of the effectiveness of measures undertaken to control invasive vegetation. The invasive vegetation control element of the program, in concert with other elements of the program, will seek to minimize the spread and prevalence of exotic species. The invasive vegetation control element will be formulated during remedial design.

References

Interagency Workgroup on Wetland Restoration. May 2001. An Introduction to Wetland Restoration, Creation, and Enhancement – Review Draft. USEPA, NOAA, USACE, USFWS, and Natural Resources Conservation Service.

Lowry, D. J. October 1989. Restoration and creation of palustrine wetlands associated with riverine systems of the glaciated Northeast. *In*: Kusler, Jon A., and Mary E. Kentula (eds.). Wetland Creation and Restoration: The Status of the Science, Volume I: Regional Reviews. USEPA, Environmental Research Laboratory, Corvallis, OR, document EPA/600/3-89/038.

Master Comment 529

Commenters stated that EPA has not considered how it will control/prevent exotic species from colonizing disturbed areas; only species native to the Upper Hudson should be replanted or reseeded. Some commenters said that if the river were dredged, in the absence of native plant communities, the aquatic ecosystem would likely be recolonized by nuisance exotic species that can tolerate disturbed conditions. Commenters recommended that every effort should be made to avoid creating conditions that optimize recolonization of the invasive exotic, water chestnut (*Trapa natans*). While *Trapa* inhabits slower, more depositional areas of the river, wild celery (*Vallisneria*) and pondweed (*Potamogeton*) dominate in faster-moving water where sediments are characteristically non-cohesive.

Response to Master Comment 529

The habitat replacement program to be formulated during remedial design will integrate invasive vegetation control, predation control, and reseeding/replanting program elements with implementation of habitat replacement actions. Only vegetation species native to the Upper Hudson River will be planted or seeded. Sequencing and scheduling of habitat replacement actions will be analyzed for opportunities to preclude or minimize establishment of invasive, exotic species, notably Eurasian water milfoil (*Myriophyllum spicatum*), curly pondweed (*Potamogeton crispus*), and water chestnut (*Trapa natans*) in the river, and purple loosestrife (*Lythrum salicaria*) and common reed (*Phragmites australis*) in the emergent wetlands.

Despite efforts to preclude or minimize their establishment, colonization by invasive, exotic species will occur. The monitoring element of the habitat restoration program coupled with the dynamic model will be used to predict the location and extent of invasive species problems, potentially using predictive approaches currently being developed, such as that reported by Madsen (1999).

The invasive vegetation control element of the program, in concert with other elements of the program, will seek to minimize the spread and prevalence of exotic species. Species-specific candidate control techniques – mechanical, chemical, and biological – will be evaluated, selected, and integrated into both the invasive vegetation control element and the overall habitat replacement program. Integration will strive to resolve management conflicts (*e.g.*, incidental harm to non-target, native species resulting from the control of invasive, exotic species) and exploit synergies (*e.g.*, opportunities to control more than one species with a technology, or manage a desirable, native herbivore to control an invasive, exotic plant).

Reference

Madsen, J. D. Fall/Winter 1999. A quantitative approach to predict potential nonindigenous aquatic plant species problems. ANS Update 5(4):1.

Master Comment 531

Some commenters stated that EPA has not considered the source and availability of plant material and transplanting requirements, and worry that the large number of plants required for restoration may not be readily available. Others say that the proposed plan also lacks information on sequencing and prioritization.

Response to Master Comment 531

Natural seeding/relocation of SAV will be the central component of SAV replacement. Only if the monitored rates of natural seeding/recolonization do not satisfy the evaluation criteria will extensive SAV propagation and planting be initiated. Natural seeding/recolonization of SAV will be a central component of the SAV replacement. SAV reproduce sexually through flower and seed production.

Acre-for-acre replacement of SAV beds may not be desirable or feasible. This will depend on the actual extent of dredging and backfilling; the geomorphological response of the river in redistributing sediments; and the habitat replacement goals formulated during remedial design, particularly in terms of competing uses of the river (*e.g.*, recreational use and navigation, and fish spawning by species requiring unvegetated gravel substrate). If it is determined that acre-for-acre replacement is either not desirable or not feasible, the number of plants required could be reduced substantially.

A final list of SAV and wetland vegetation species to be planted will be detailed in the remedial design phase. This list, along with all other aspects of the habitat replacement program, will be formulated in consultation with the federal Trustees and NYSDEC. The list of species will be modified at times during the implementation of the habitat replacement program based on accumulation of experience with the conditions on the Upper Hudson River and the findings of other habitat replacement projects. Likewise, planting requirements and the sources and availability of plant materials will be detailed initially in the design phase, but as knowledge is gained, these, too, will be modified during program implementation. SAV will be reestablished in locations where the post-remediation physical conditions, specifically sediment substrate, water quality, water circulation and mixing, and light regimes (Batiuk, *et al*., 2000; Cerco and Moore, 2000; Korschgen and Green, 1988; Sager, *et al*., 1998; Sheriden, *et al*., 1998; Smart and Dick, 1999), would support the community and where its presence would not conflict with other objectives.

It is expected that the source of plant materials will include wild collection, purchase from existing nurseries, and transplanting from nurseries established specifically for the program. (Several nurseries in the region currently supply plant material for restoration projects and will be candidates for supplying this project.)

Prioritization, sequencing, and scheduling will be addressed during remedial design. Scheduling of habitat replacement actions can be accomplished only after the dynamic model has been formulated and in concert with scheduling of the remediation actions, both of which will be addressed during the remedial design phase as well. The integration of the habitat replacement program schedule with the schedule for the remediation activities will be important to the

success of the program, particularly in terms of preventing the loss of unprotected backfill, fully utilizing opportunities to establish restoration plantings, precluding damage to restoration plantings through sediment re-suspension, and control of invasive vegetation.

References

Batiuk, R. A., P. Bergstrom, M. Kemp, E. Koch, L. Murray, J. C. Stevenson, R. Bartleson, V. Carter, N. B. Rybicki, J. M. Landwehr, C. Gallegos, L. Karrh, M. Naylor, D. Wilcox, K. A. Moore, S. Ailstock, and M. Techberg. August 2000. Chesapeake Bay Submerged Aquatic Vegetation Water Quality and Habitat-Based Requirements and Restoration Targets: A Second Technical Synthesis. US Environmental Protection Agency/Chesapeake Bay Program, Annapolis, MD.

Cerco, C. F., and K. Moore. January 1, 2000. System-Wide Submerged Aquatic Vegetation Model for Chesapeake Bay.

Korschgen, C. E., and W. L. Green. 1988. American Wildcelery (*Vallisneria americana*): Ecological Considerations for Restoration. US Fish and Wildlfie Service Report 19, Northern Prairie Wildlife Research Center.

Sager, E. P. S., T. H. Whillans, and M. G. Fox. June 1998. Factors influencing the recovery of submersed macrophytes in four coastal marshes of Lake Ontario. Wetlands 18(2):256-265.

Sheridan, P., G. McMahan, K. Hammerstrom, and W. Pulich, Jr. June 1998. Factors affecting restoration of *Halodule wrightii* to Galveston Bay, Texas. Restoration Ecology 6(2):144-158.

Smart, R. M., and G. O. Dick. February 1999. Propagation and Establishment of Aquatic Plants: A Handbook for Ecosystem Restoration Projects. USACE, Waterways Experiment Station, Vicksburg, MS, Technical Report A-99-4.

Master Comment 533

Several comments were received relative to restoration of SAV: 1) Natural seeding/recolonization of SAV should be used. 2) Restoration of desirable SAV lost because of dredging activities should factor in optimal light attenuation, nutrient levels, flows, and sediment type for their survival and growth. 3) Planting of SAV is not recommended unless pilot studies demonstrate success and at a much faster rate of restoration compared to natural reseeding/recolonization. 4) Relying on natural recolonization processes should also decrease costs of habitat replacement.

Response to Master Comment 533

Natural seeding/recolonization of SAV will be a central component of the SAV replacement. SAV reproduce sexually through flower and seed production. Redhead grass or clasping leaved pondweed (*Potamogeton perfoliatus*) reproduces primarily by seed, and the seeds are dispersed readily by currents to new locations. Wild celery (*Vallisneria americana*) produce fruit capsules,

some of which rupture and release a gelatinous matrix containing seeds (Korschgen and Green, 1988). Often, the seed-containing matrix settles to the bottom in close proximity to the parent plant (Kaul, 1978). Otherwise, if the fruits do not rupture until the plants have broken free of the substrate and floated away to a suitable location, dispersal of the wild celery can occur (Korschgen and Green, 1988).

The monitoring and evaluation elements of the habitat replacement program will be used to gauge the effectiveness of natural seeding/recolonization of establishing SAV on suitable, post-remediation substrates. Establishment of SAV communities by natural seeding/recolonization will be measured against evaluation criteria to be formulated during remedial design. The evaluation criteria would specify percent cover thresholds for native SAV species for several years following remediation, as well as percent cover limits for exotic species.

References

Kaul, R. B. 1978. Morphology of germination and establishment of aquatic seedlings in *Alismataceae* and *Hydrocharitaceae*. Aquatic Botany 5:139-147. *As reported in*: Korschgen, Carl E., and William L. Green. 1988. American Wildcelery (*Vallisneria americana*): Ecological Considerations for Restoration. US Fish and Wildlife Service Report 19, Northern Prairie Wildlife Research Center.

Korschgen, C. E., and W. L. Green. 1988. American Wildcelery (*Vallisneria americana*): Ecological Considerations for Restoration. US Fish and Wildlfie Service Report 19, Northern Prairie Wildlife Research Center.

Master Comment 535

Commenters stated that EPA collected no data and conducted no pilot project that could serve as a basis to evaluate the likelihood of success or the time necessary for ecological restoration after dredging. Some said that there is no information on the substrate necessary for the growth and sustenance of aquatic vegetation or the problems of reestablishing native vegetation. Others assert that the status of the science does not support EPA's conclusion that the habitat replacement effort, in particular the SAV habitat restoration, will be successful. It was suggested that if restoration efforts are unsuccessful, the Natural Resource Trustees claim should seek compensation for such losses as part of the NRD. It was said that in defending its proposal publicly, EPA has claimed that independent groups believe restoration is likely. The Biological Technical Assistance Group (BTAG) November 3, 2000 letter offered as an example does not report successful restoration at sites analogous to the Upper Hudson. Commenters say that no hard evidence has been presented to indicate that impacts would be short-term and transient. Numerous commenters stated that the short-term disturbance of the local ecosystem is justified by the medium and long-term benefits of PCB removal.

Response to Master Comment 535

During remedial design, a habitat replacement program, with SAV replacement as an integral component, will be formulated in an adaptive management framework, as the most appropriate management framework for implementing as large a scale habitat replacement program as is

envisioned for the Hudson River PCBs Superfund Site. The decision to employ an adaptive management framework is founded on the conclusion that, although gaps currently exist and will continue to exist in our understanding of the Upper Hudson River ecosystem, a comprehensive and responsive science-based program will be required to replace and restore the habitats disturbed by remediation. Adaptive management would facilitate going forward with habitat replacement activities despite uncertainties regarding the specific responses of the ecosystem to the replacement actions to be undertaken.

Although the specific outcomes of the habitat replacement program cannot be predicted, adaptive management will enhance the capacity of the program to achieve the habitat replacement objectives by integrating the following elements into the habitat replacement program, as appropriate:

- Articulation of existing interdisciplinary experience and scientific information.
- Delineation of Upper Hudson River habitats and collection of baseline habitat data.
- Formulation of a dynamic Upper Hudson River habitat replacement model.
- Formulation of specific habitat replacement goals and objectives, evaluation criteria, and definition of replacement success.
- Formulation of a monitoring, appraisal, and feedback program.
- Design, prioritization, scheduling, and implementation of habitat replacement actions.
- Monitoring of habitat variables and the response of the ecosystem to replacement actions.
- Periodic evaluation of the dynamic model, the effectiveness of replacement actions undertaken, and progress toward the replacement objectives.
- Periodic revision of the dynamic model.

The proposed SAV replacement program would be implemented based, in part, on experience gained in SAV restoration projects in brackish and marine environments and in smaller-scale SAV restoration projects. The SAV replacement program will also rely on available guidance, mostly for SAV restoration in marine environments (*e.g.*, Fonseca *et al*., 1998).

As stated by Stevenson and Davis (2001), a conceptual model for SAV habitat interactions exists and has been revised based on extensive scientific research. EPA would use this model – Chesapeake Bay Submerged Aquatic Vegetation Water Quality and Habitat-Based Requirements and Restoration Targets: A Second Technical Synthesis (Batiuk, *et al.*, 2000), or similar – as a basis for constructing a dynamic model specific to the Upper Hudson River and the replacement of the SAV habitats. The habitat replacement model would be developed during remedial design.

References

Batiuk, R. A., P. Bergstrom, M. Kemp, E. Koch, L. Murray, J. C. Stevenson, R. Bartleson, V. Carter, N. B. Rybicki, J. M. Landwehr, C. Gallegos, L. Karrh, M. Naylor, D. Wilcox, K. A. Moore, S. Ailstock, and M. Techberg. August 2000. Chesapeake Bay Submerged Aquatic Vegetation Water Quality and Habitat-Based Requirements and Restoration Targets: A Second Technical Synthesis. US Environmental Protection Agency/Chesapeake Bay Program, Annapolis, MD.

Fonseca, M. S., W. J. Kenworthy, and G. W. Thayer. November 1998. Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters. NOAA Coastal Ocean Program Decision Analysis Series No. 12. National Oceanic and Atmospheric Administration, Coastal Ocean Office, Silver Spring, MD.

Stevenson, J. C., and R. C. Davis. April 2001. Assessment of EPA's Habitat Replacement Program for the Hudson River Proposed Remedial Plan (REM 3/10/Select). *In*: Comments of the General Electric Company on U.S. EPA's Hudson River PCB Feasibility Study and Proposed Remedial Action Plan, Volume 4, Appendix D-1.

9.4 Time to Recovery

Master Comment 422647

Several commenters have asked how long it would take for the river to recover following implementation of REM-3/10/Select.

Response to Master Comment 422647

Implementation of the selected remedy may result in the following riverine impacts:

- Removal and/or backfilling of substrate used as spawning and foraging habitat by fish and benthic invertebrate species.
- Displacement of benthic organisms.
- Loss of submerged aquatic vegetation.
- Loss of freshwater wetlands acreage and wetlands functional values.
- Disturbance of riverbank.
- Resuspension.

A habitat replacement program will be implemented to mitigate these disturbances. The habitat replacement program will be formulated in an adaptive management framework. Adaptive management is intended to identify problems early in the habitat replacement program and provide an effective framework for the rapid development of appropriate solutions (*e.g.*, implementation of an aggressive program to control invasive species and predation on newly established vegetation communities). The active habitat replacement program will be undertaken until levels of ecosystem recovery, health, and stability defined during the design phase have been reached and sustained. Following is a general discussion of riverine recovery following implementation of the selected remedy.

Substrate Removal and Replacement of Benthic Organisms

Since dredging will occur in targeted areas and will not be bank-to-bank, there will always be portions of the river bottom where bottom-dwelling invertebrates will be undisturbed and will be available as a food resource to fish. Further, even in those targeted areas that are dredged and/or

backfilled, the recolonization of benthic invertebrates will begin in a given area soon after remediation activities are complete.

The intent of the habitat replacement program is to return the river bottom to a stable, well-sorted substrate with a complex mixture of sediment sizes that provides benthic habitat diversity and a productive benthic community as a source of food for fish. With respect to benthic invertebrate recovery following remediation and habitat replacement activities, the most important recovery mechanism is downstream drift dispersal. There is generally a continuous stream of benthic organisms (larval and adult) represented in the currents of streams and rivers. As there is a continual source of benthic invertebrates in the downstream drift, the recovery of benthic invertebrates in an area of previous disturbance generally commences soon after the disturbance, if suitable habitat conditions exist. In a study of the recovery rates of macroinvertebrate communities following disturbance, Niemi, *et al.* (1990) found that 90 percent of the cases reviewed indicated recovery times within one year.

Channel relocation and reconstruction projects provide an indication of recovery times where a major physical modification of the river channel occurs. In a colonization study of a newly formed channel in the Tongue River, Wyoming, maximum densities of macroinvertebrates were obtained in less than 90 days with equilibrium levels reached in about 200 days (Gore 1979, 1982). For a new stream channel in Scotland, Doughty and Turner (1991) reported maximum diversity and similarity to a reference site 80 to100 days after invertebrate recolonization began. Malmqvist *et al.*, (1991) found that invertebrate diversity in a man-made channel was similar to that in reference streams within one year. Thus, it is anticipated that recolonization of benthic invertebrates in a given remediated area of the Hudson River would commence soon after remediation activities were complete, and that recovery of benthic communities could occur within one year of implementation of the selected remedy at the area. As it is expected that benthic invertebrates will readily reestablish in the remediated areas, fish and wildlife that depend on those resources for food are expected to experience, at most, temporary food shortages in localized areas.

Submerged Aquatic Vegetation (SAV)

Reestablishment of SAV (and, in fact, much of the habitat replacement work, including wetland restoration) will extend beyond the current six-year time frame of the remediation. The actual duration of implementation of the habitat replacement program in general, and SAV replacement in particular, will depend on the following:

- Extent of the habitats (*e.g.*, SAV is not continuous throughout the river bottom, but occurs in discontinuous beds) and the extent of direct and indirect habitat disturbance.
- Geomorphological response of the river to the remediation activities.
- Precision and accuracy of the Upper Hudson River habitat replacement model.
- Response of the ecosystem to the disturbance of riverine habitats and to habitat replacement actions, particularly those undertaken early in the program.
- Responsiveness of the adaptive management framework.
- Other factors that could also hasten or prolong reestablishment, such as the weather, river discharges, competition from invasive exotic species, predation, and the occurrence of pests.

As mentioned above, the active habitat replacement program will be undertaken until levels of ecosystem recovery, health, and stability defined during remedial design have been reached and sustained.

Wetlands

The goal of the wetland restoration actions generally will be to restore the wetland conditions that existed before remediation.

Wetlands disturbed by remediation activities will be regraded to elevations suitable for supporting target hydrophytic vegetation. Elevation requirements will be detailed initially during the design phase, but during program implementation will be modified in response to knowledge gained through monitoring, evaluation, and feedback. Restoration design plans for each wetland will specify elevation requirements. After initial grading, resulting elevations will be surveyed and the wetland hydrology will be monitored, at minimum throughout one year, but potentially through several consecutive years.

Riverbank Rehabilitation

Riverbanks immediately adjacent to sediment removal locations may require stabilization to control bank erosion, slumping, and sloughing. Restoration objectives for the riverbank zone are to replace vegetation communities and to stabilize shorelines. Banks with well-developed riparian vegetation are protected from erosion and provide a source of food for small fish. The actual riverbank stabilization method to be employed along a given shoreline segment will be specified during remedial design. Vegetative and structural-vegetative methods will be employed, the choice being dependent on the extent of bottom sediment removal in the adjacent river and the magnitude of erosive forces. Riverbank restoration measures would commence soon after remediation activities along a given shoreline segment are completed.

Resuspension

As described in the Response to Master Comment 735, Section 9.2, total suspended solids (TSS) modeling indicates that the Hudson River will be minimally impacted by resuspension. The model indicates that normal spring runoff produces far greater TSS variations than those predicted as a result of dredging. The relatively small TSS increase and the small area affected by dredging indicate that the river will be minimally impacted by resuspension. Further, as also described in the Response to Master Comment 735, resuspension will not release significant amounts of contaminants into the water column compared to the background level. Thus, recovery time is not an issue with respect to water quality.

References

Doughty, C. R., and M. J. Turner. 1991. The Ponesk Burn Diversion: Colonization of Benthic Invertebrates and Fish. Technical Report No. 98. Clyde River Purification Board, East Kilbride, Scotland. As reported in: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Gore, J. A. 1979. Patterns of initial benthic recolonization of a reclaimed coal strip-mined river channel. Canadian Journal of Zoology 57:2429-39. As reported in: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Gore, J. A. 1982. Benthic invertebrate colonization: source distance effects on community composition. Hydrobiologia 94:183-93. As reported in: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Malmqvist, B., S. Rundle, C. Bronmark, and A. Erlandson. 1991. Invertebrate colonization of a new, man-made stream in Sweden. Freshwater Biology 26:307-24. As reported in: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Niemi, G. J., P. DeVore, N. Detenbeck, D. Taylor, J. D. Yount, A. Lima, J. Pastor, and R. J. Naiman. 1990. Overview of case studies on recovery of aquatic systems from disturbance. Environmental Management 14: 571-88. As reported in: Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

Petts, G., and C. Calow. 1996. River Restoration. Blackwell Science, Inc., Malden, MA.

9.5 Effect on Navigation Channel/Bathymetry

Master Comment 757

The New York State Office of the Attorney General and, at a number of public meetings, representatives of boating concerns operating on the Hudson River, stated that environmental dredging would facilitate navigational dredging, thereby improving access to and the economy related to the waterway. Some commenters stated that dredging operations would have an adverse effect on navigation in the Upper Hudson River.

Response to Master Comment 757

The selected remedy includes navigational dredging as necessary for implementation. It is anticipated that dredging and associated supporting activities will have a positive impact on Hudson River navigation**.** Analysis presented in White Paper – River Traffic suggests that mechanical dredging will result in an additional 18 lockages per 24-hour day at Lock 6 and an additional six lockages per 24-hour day at Lock 5. A lockage represents a vessel passage – either pleasure craft or commercial craft – in one direction through the locks. Therefore, the additional 18 lockages per 24-hour day at Lock 6 are actually nine lockages heading downstream and nine lockages heading upstream. The same logic applies to the six lockages at Lock 5: three lockages heading downstream and three lockages heading upstream.

It is important to note that Locks 5 and 6 are not currently used to full capacity, and that the lock-operating schedule has available capacity for project-related barge and associated towboat traffic. In addition, the Proposed Plan suggests the use of locks on a 24-hour-per-day basis. Off-hours will be available for project vessel passage. During busy days and weekends, it is anticipated that

a majority of project traffic can pass through the locks in the off hours, thus mitigating excessive lock congestion or interference with either recreational or commercial boaters.

As a rule, hydraulic dredging requires fewer barge and towboat movements through the locks compared to the mechanical dredging alternative. This is largely due to the fact that hydraulic dredging uses extended pipelines instead of barges to transport much of the dredged material. Hydraulic dredging would have dredged sediments pumped to a northern transfer facility for processing and final disposal[1]. Therefore, fewer disposal barges are needed in the hydraulic dredging scenario. In total, an additional six lockages per 24-hour day are anticipated from the hydraulic dredging alternative at Locks 6 and 5. Due to the current available capacity at Locks 5 and 6, hydraulic dredging is not expected to interfere with traffic at the locks. In addition, off-hours will be available each day for project vessel passage. Also see the White Paper – River Traffic for details and specific information regarding the complete analysis of navigation on affected areas of the Hudson River.

It is anticipated that debris removal will occur throughout the entire project area prior to dredging in any particular target area. Overall navigation in the river will be improved through the removal of underwater obstructions and debris, and the process slightly deepens the river in multiple locations. This debris removal is also beneficial to the overall health of the river system, greatly reducing potential obstructions, choking debris, and excessive organic matter that can strain a river's biological systems.

It is important to note that removal operations associated with the remediation include both environmental dredging and navigational dredging. Historically, the Canal Corporation routinely dredged the canal to maintain a water depth of 12 feet. Dredging in the project area has not occurred since 1979, with the exception of the area where the Hoosic River discharges into the Hudson River between Locks 3 and 4. Since that time, the Canal Corporation has completed annual canal sweeps to determine areas of increased sedimentation and decreased water depth in the navigation channel. The most recent sweep data, collected during the 2000 river season,

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[1] It is important to note that EPA has not yet determined the location(s) of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the Feasibility Study, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the Upper Hudson River valley and farther downstream, are possible.

The example facility locations presented in the Feasibility Study have also been used in the Responsiveness Summary in order to clarify material presented in the Feasibility Study and Proposed Plan and in connection with additional noise, odor and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after EPA performs additional analyses and holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, all information provided in this Responsiveness Summary relative to potential impacts of the sediment processing/transfer facilities on communities, residents, agriculture, the environment and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during remedial design.

determined that the area near Buoy R160, located north of Lock 5 and south of the Route 4 Bridge, contains only seven feet of water. This suggests that the navigation of vessels from the north or from the south of this area is significantly impeded by the current conditions. This area of passage is very narrow and presently prohibits safe and adequate passage.

The selected remedy includes removal of sediments to depths of six and eight feet to open up this area and return it to a depth of 12 feet. This will facilitate navigation of the river both north and south of this location. Similar sedimentation has occurred in other river sections as well, and removal of these sediments would allow commercial traffic to pass from Lake Champlain down to Albany with no significant limitations, which is expected to have a beneficial impact on the region's economy. Economic impacts of the project are discussed in greater detail in White Paper – Socioeconomics.

10. IMPLEMENTABILITY OF REMEDIAL ALTERNATIVES

10.1 Dredging Schedule and Production Rates

Master Comment 659

Several commenters advocate environmental dredging as the preferred remedy, while others consider the technology to be unreliable and costly. Commenters have raised questions concerning which dredging method will be used, and presented their own analysis of hydraulic versus mechanical dredging. Some suggest particular dredging systems while others specify performance criteria for either hydraulic or mechanical dredging technologies. Some commenters have asked for additional clarification as to how particular equipment will operate and suggested that further evaluation of specific innovative technologies should be done. It has also been recommended that information on past navigational dredging in the Hudson River be gathered in order to understand the environmental impacts of dredging in the area.

Response to Master Comment 659

As presented in Chapters 4 and 5 of the FS, both mechanical and hydraulic dredging technologies are considered to be applicable to dredging upper Hudson River PCB-contaminated sediments. Within the mechanical dredging category, the Horizontal Profiler bucket mounted on a hydraulic excavator is the preferred system. In the hydraulic equipment category, the cutterhead suction dredge is preferred. See the Response to Master Comment 671 for additional information on the engineering reliability of dredging systems and White Paper – Post-Dredging PCB Residuals on effectiveness of dredging systems. EPA has determined the selected remedy is cost-effective.

The final selection of dredging equipment will occur during the project's design stage. Numerous factors will influence the selection, including data obtained from the pre-construction sediment sampling program; the results of more detailed engineering planning and analysis required during the design phase of the project; and information obtained from potential contractors. It should be noted, however, that River Section 3, the reach south of Lock 5, would be dredged using mechanical methods in any event, as discussed in the FS. The reason is that there are practical limitations to the distance that a sediment slurry (discharged by a hydraulic dredge) can be reliably pumped. Thus, it is expected that some mechanical dredging will occur irrespective of which technology is selected for the bulk of removal work.

Beyond the two principal dredging technologies identified in the FS, it may be necessary for the contractor to use any one of several specialty dredges to conduct removal operations in particularly shallow river sections. EPA will review the contractor's recommendations concerning specialty dredging equipment before it is actually employed on the river.

Finally, while there has been historical navigational dredging activity on the Upper Hudson River, the equipment was different from that which will be used to implement the selected remedy. Therefore, evaluation of historical dredging work is not relevant in evaluating environmental impacts of the selected remedy. Environmental impacts of the selected remedy are discussed at length in Chapters 8 and 9.

Master Comment 669

Commenters have raised questions as to the order in which the sections of the river will be dredged.

Response to Master Comment 669

The precise sequence of dredging work has not yet been determined. There will be a general preference to dredge the river in the upstream-to-downstream direction to limit recontamination of completed target areas. As discussed later in this chapter, there will be exceptions to this approach, irrespective of which dredging technology is selected for the bulk of removal operations. However, as also will be discussed, it is not expected that recontamination of completed work areas will be significant.

It is likely that initial dredging work will be focused on improving navigation along the Hudson River/Champlain Canal between Locks 1 and 6. One reason for this is to enable project-related equipment to navigate the Champlain Canal system with minimal interference from in-river obstructions. Another reason is to limit, as much as possible, interference between project-generated river traffic and traffic otherwise occurring on the river. One way to reduce such in-river interference is to clear out shoal areas and thereby restore the navigation channel to its designated width.

In addition to the aforementioned navigational dredging considerations, logistical planning relative to use of equipment may preclude achieving a completely upstream-to-downstream work plan. Under both the mechanical and hydraulic dredging scenarios, multiple dredges will be working at the same time. It can be expected that this equipment would be distributed to a number of upstream and downstream locations so that the appropriate piece of equipment is being used to remove material in each targeted area. While a strict north to south approach may, therefore, not be possible, several factors mitigate concern over this circumstance.

As presented in White Paper – Resuspension of PCBs during Dredging, both the mass of sediment and of PCBs re-mobilized during dredging operations is estimated to be minimal. In addition, most remobilized sediment will be deposited within the immediate vicinity of the ongoing work and will be captured as dredging progresses downstream within a work area. Thus, it is not expected that dredging work in an upstream area will have significant potential to impact completed downstream target areas. Also, modern positioning systems on dredges enable removal of minimum amounts of material from very specific areas. Should post-remedial sampling reveal the presence of a veneer of material that needs to be removed, this could be readily accomplished by modern dredging systems.

If river dynamics result in significant recontamination under a particular sequence of dredging work, it may be necessary to develop an approach that involves some redredging. An example may be the vicinity of *Hot Spot* 34, where navigational dredging is required in order to move equipment through the area for work to be performed upstream. At this location, the targeted area may be dredged and backfilled initially, and then at some future date the surface materials

would be tested to determine if a veneer of newly deposited sediment would still need to be removed. This strategy could be cost-effective if it enabled the work to be expedited.

Master Comment 671

Questions have been raised with regard to the EPA's ability to achieve the proposed project schedule during both the design and construction phases. The Hudson River remedy has been compared to other Superfund projects and, based on experiences at those sites, it has been stated that EPA's proposed production rates are unrealistic and that the EPA will not complete all construction work in a five-year period. Commenters have stated that dredging will take twice as long or longer to accomplish, depending on the technology selected. Finally, concern has been expressed that various factors will lead to delays and downtime and frustrate timely completion of the program.

Response to Master Comment 671

In addition to the following response, White Paper – Dredging Productivity and Schedule and White Paper – Delays and Downtime contain additional information relevant to these questions.

Remedial Design Period

EPA has developed a conceptual approach to implementing the selected remedy under the assumption that the government will perform the remedial work. The project's remedial design period will entail sediment sampling to finalize dredge cut lines, selection of a contractor, selection of dredging technology, construction of sediment processing/transfer facilities, and finalization of agreements with landfills, rail companies, backfill material suppliers, and energy providers.

It is expected that many of these tasks will occur in parallel. EPA will begin sediment sampling and analysis subsequent to issuance of a ROD, and will also initiate contractor selection. Contractor selection involves preparation of requests for qualifications followed by review of contractor submittals and then release of bid packages to qualified contracting teams. It is currently anticipated that there will be approximately 30 months available to accomplish remedial design; this is considered adequate time to complete the associated tasks.

Remediation Phasing

As indicated in the ROD, EPA will conduct a phased remedial program, with dredging commencing in 2005 and continuing for six construction seasons. In the first phase, the first construction season of remedial dredging will be implemented initially at less than full-scale, during which extensive monitoring of operations will be performed. The second phase will be the remainder of the dredging operation, which will be conducted at full-scale and is expected to last five years.

Mechanical Dredging

One commenter focused largely on Saginaw River removal work conducted during calendar year 2000, where removal rates approached only 50 percent of rates planned for the Hudson. However, the comparison is inappropriate, as discussed in the White Paper – Dredging Productivity and Schedule. For example, the Saginaw River project employed one mechanical dredge to accomplish all work, whereas the Hudson River analysis is based on four mechanical dredges operating simultaneously. Thus, there is little relevance to comparing outcomes at Saginaw to results expected on the Hudson River.

Commenters also compared removal rates attained at New Bedford Harbor to those proposed for the Hudson River. Prior to calendar year 2000, all dredging programs conducted at New Bedford used hydraulic equipment. During calendar year 2000, mechanical equipment, similar in capacity and design to that proposed in the FS, was demonstrated. During that New Bedford demonstration, sediment removal rates between 50 and 60 cubic yards per hour (cy/hr) were achieved. In addition, program participants concluded that the mechanical dredge could have achieved production levels greater than 75 cy/hr with further pre-planning of the work (White Paper – Dredging Productivity and Schedule). This compares favorably with the production goals set for the Hudson River, which are 82 cy/hr for the large dredge (4 cu yd) and 27 cy/hr for the small dredge (2 cu yd).

Hydraulic Dredging

Estimated production rates for the selected hydraulic dredging system were presented in the FS (Appendix H) and are discussed further in White Paper – Dredging Productivity and Schedule. The hydraulic cutterhead dredge system that is proposed for use in the Upper Hudson will be specifically designed to reflect the physical and environmental constraints imposed by the river. EPA is aware that at many other remedial locations there has been a tendency to apply off-the-shelf equipment simply to avoid devoting time and resources to developing focused and tailored solutions.

As described in the White Paper – Dredging Productivity and Schedule, commenters attempting to compare the Hudson River to other Superfund sites did not present sufficient information to generate a truly valid comparison for hydraulic dredging systems. Factors such as the type of dredge (auger, cutterhead, etc.), type of sediment, depth of cut, presence of debris, horsepower of pump, size of cutterhead, dimensions of ladder, etc., all have a bearing on the results obtained. For instance, comparing the performance of auger dredges (designed for work in sludge ponds and industrial lagoons) to the 12-inch cutterhead proposed for use on the upper Hudson, has little technical merit and would not produce a valid conclusion.

Delays and Downtime

Factors that could create delays and downtime such as river congestion, weather, and equipment problems have been reviewed (see White Paper – Delays and Downtime). Since productivity estimates applied in the FS were based on dredging equipment operating between 48 percent (mechanical) and 61 percent (hydraulic) of the week, considerable margin has been left to manage potential delaying factors such as those mentioned herein.

Additionally, an analysis of current canal traffic and usage indicates that river congestion can potentially occur during the months of July and August. EPA believes that congestion problems can be avoided if project equipment movements are scheduled, as much as possible, for off-peak periods (White Paper – River Traffic). Weather-related downtime includes delays from high flows, low temperatures, and high winds. After reviewing meteorological data, the potential for weather-related delays has been accounted for in the calculation of downtime (see White Paper – Delays and Downtime), and does not appear to be significant. Finally, delays from equipment malfunctions and equipment unavailability need not represent major difficulties because extensive planning will occur at the outset of work and attention will be given to management of the overall remedial program.

Master Comment 422186

There are two categories of comments concerning dredging and floods:

- Concern about how implementing the remedy would affect flooding.
- Concern about how flooding would affect dredging operations.

Response to Master Comment 422186

This response is in two parts as per the comment. Potential impacts of EPA's selected remedy on flooding are evaluated first and then a discussion follows addressing the impacts of flooding on dredging operations.

Impacts of Selected Remedy on Upper Hudson Valley Flooding

Implementation of the selected remedy is not expected to influence flooding in the Upper Hudson valley since the volume of active storage of the river will not be changed substantially. EPA will place considerable fill in the river's floodway as a follow-up activity to dredging operations. However, the volume of fill material will only be a fraction of the sediments removed by the dredging operations. The selected remedy entails removal of approximately 2.65 million cubic yards of sediment. Upon completion of the remedy, about 0.8 million cubic yards of fill material will have been placed. Thus, EPA will remove considerably more material from the river bottom than it will place as fill. Furthermore, in the context of the Hudson River's being a series of impounded pools, backfilling will not utilize the river's active storage capacity. For both of these reasons backfilling, as per EPA's selected remedy, is not expected to exacerbate flooding effects.

Another aspect of the selected remedy that potentially involves placement of fill in the river's floodway and flood fringe is construction of sediment processing/transfer facilities, particularly a new wharf or dock to facilitate unloading sediment-laden barges. EPA would prefer to construct the sediment processing/transfer facility at locations where wharf facilities already exist. However, in the event that in not possible, then a wharf would need to constructed at the river's edge to receive loaded barges. The type of structure likely to be used is an open lattice pile supported deck that would involve placement of little fill material. However, the final selection

of wharf structure will depend on subsurface conditions at the transfer site as well as on the loads the structure will need to carry. Since the processing/transfer site has not been selected at this stage, it would be speculative to proceed further with a flooding assessment. EPA is aware of the need to minimize encroachments within floodplains and will consider the matter in detail during the project's design stage.

As stated elsewhere in this Responsiveness Summary, the principal benefit of EPA's selected remedy is removal of a considerable sediment-bound contaminant mass from the river's floodway. As removal work proceeds, the mass of PCBs available to be carried over onto residential and farm land during flood events will diminish. In this context, the selected remedy will have a significant positive impact during flood events when the potential for sediment resuspension is greatest.

Impacts of Flooding on Dredging Operations

It is expected that weather will have some impact on dredging operations each construction season. For instance, it is expected that in-river operations, particularly dredging, will be temporarily halted when river discharges approach levels in the 10,000 to 15,000 cfs range to avoid worker injuries and property damage. These discharge rates are relatively modest flows, well below the peak levels that occur during storm events with only a five- or 10-year return frequency. In addition, it may be counter-productive to work with sophisticated positioning and materials management systems under conditions where sediment targeting accuracy is likely to be impaired.

The important consideration here is that EPA will require control of dredging operations at all times. At times when environmental conditions impede maintenance of adequate control, work will be temporarily halted until the river returns to more typical discharge levels. Should it prove necessary to halt work because of high river flows, the dredges, barges, and other in-river equipment will be secured either at processing/transfer facilities or at mooring points constructed at suitable locations within the river.

As discussed in the White Paper – Delays and Downtime, impacts of weather and other factors that may reduce project throughput have been taken into consideration in determining dredging productivity. Thus, since operations will not be conducted under such conditions, it is not expected that river discharges associated with severe storm events, such as storms with a return frequency of 50 or 100 years, will delay dredging operations beyond the downtime already incorporated in productivity calculations.

Master Comment 362590

One commenter asked, will the suction of the hydraulic dredge capture the high (especially > 1000 ppm) oily NAPL better than a mechanical dredge?

Response to Master Comment 362590

Considerable sediment sampling has been conducted over the last decade within sections of the Hudson River that are now targeted for remediation. Investigators of conditions within the upper Hudson have included both GE and EPA. Results of the various sediment sampling programs show the river bottom continuing to be PCB contaminated but do not indicate the presence of PCBs, or other organic contaminants, in quantities that constitute oily free product or NAPL (non-aqueous phase liquid) as it is sometimes called. Consequently, it is neither expected nor likely that dredging operations will encounter contaminants that have the physical characteristics of an oily waste. Therefore, selection of a dredging technology, either hydraulic or mechanical, will not be based on the presence of such materials since none are expected within targeted areas.

10.2 Monitoring

Master Comment 313970

With regard to implementability, a commenter questioned how EPA could conduct a five-year review under a No Action scenario since no task is designated to monitor sediment, water, and biota.

Response to Master Comment 313970

In accordance with CERCLA Section 121(c), for any remedial action that results in any hazardous substances, pollutants, or contaminants remaining at a Superfund site, EPA "shall review such remedial action no less often than each 5 years...to assure that human health and the environment are being protected" by that remedial action. A "no action" remedy is, for this purpose, a remedial action under CERCLA. See, *e.g.*, 40 CFR § 300.430(e)(iii)(7) (evaluation of remedial alternatives for a Superfund site shall include an assessment of the "no-action alternative"). EPA can provide for monitoring and other studies required for a five-year review independently of whether the required monitoring and studies are included in a remedial decision.

Master Comment 362634

Commenters raised these two questions: How will EPA's monitoring/sampling plan be conducted to attain a residual cleanup goal of 1 ppm in dredged areas? Will cores or samples be collected from non-dredged areas to determine whether PCB concentrations have changed due to remedial activities?

Response to Master Comment 362634

As part of the construction monitoring program, an example of which is outlined in Section 6.3.5.4 and Appendix G of the FS, confirmational sediment sampling will be designed to document the degree of PCB mass and concentration reduction in remediation areas. The post-construction monitoring program, (an example which is outlined in the FS, Section 6.3.5.4 and

Appendix G) will require two separate core collection efforts, one high resolution dated core collection to monitor transport and thus to document the long-term recovery of the river, and one essentially low resolution coring effort to monitor sediment inventory, particularly in remediated areas. Both of the monitoring programs will be developed during the design phase with public input. The following discussion illustrates how these programs could address the commenter's questions.

As part of the construction monitoring program, sediment cores will be collected in remediation areas to document the removal of the PCB inventory and the attainment of acceptable PCB concentrations. Sampling in dredged areas will be fairly dense. Each sample would be tested via a field laboratory, presumably using an immunoassay technique. A fourth of the samples would be sent to a conventional laboratory for PCB, organic carbon, and radionuclide (Cs-137) analyses. An area would be certified as acceptable when a preset number of cores falls below the desired threshold value based on the immunoassay tests. Alternately, an area may be certified as acceptable when the mean value falls below a specific threshold. In this case, the threshold is expected to be 1 ppm for Tri+ PCBs and 2ppm for total PCBs. White Paper – Post-Dredging PCB Residuals and White Paper – Relationship between Tri+ and Total PCBs contain discussions of the relationship among cleanup levels.

Sampling in remediation areas after backfilling would also be implemented as part of the construction monitoring program to document that acceptable PCB levels have been achieved and that the thickness of the backfill material is sufficient. Since the backfill material will be essentially pristine prior to its placement on the river bottom, a lower rate of sampling is likely needed than noted above.

Sampling in remediation areas would also be included in the post-construction monitoring program. This sampling will document changes, if any, in the thickness of backfill material and levels of contamination, and would reveal any recontamination of the surface sediments.

As part of the Phase 2 investigation, EPA made extensive use of dated high resolution sediment cores collected from the Hudson River. Dateable cores were collected in 14 areas. They provided an integrative perspective of long-term PCB transport in the river. The cores documented both the principal source of PCBs as well as the long-term fate of PCBs within the sediments in the absence of resuspension. Dated sediments cores would be sampled as part of the post-construction monitoring program. The cores would be divided into 2- to 4-cm intervals and analyzed for both congener-specific PCBs and radionuclides. The radionuclides would provide the information to establish depositional history, and the congener-specific data could be used to identify the source of contamination. High-resolution cores partially address the issue of sediment release during dredging and subsequent accumulation in non-dredge areas by examining the long-range PCB transport. These cores would exhibit the response of the river to remedial activities. Also, as outlined in Section 8 and Appendix G of the FS, additional shallow cores and grab samples will be collected and analyzed for total PCBs on an Aroclor basis.

Master Comment 405943

Concerns have been raised regarding resuspension of PCB-laden sediments during the debris removal process.

Response to Master Comment 405943

Results of an in-river debris survey are presented in Appendix H.2 of the FS. The goal of the survey was to obtain a general assessment of the quantity of bottom debris (cobbles, logs, manmade materials, etc.) that would be encountered during dredging operations. It is concluded, and reflected in Appendix H.2, that instrumentation is available to detect most near-surface material that would interfere with dredging operations, and that the extent of observed debris is not sufficient to cause a significant removal problem. Knowing that debris is present on the river bottom, it will be possible to develop a program to retrieve much of that material prior to initiating sediment removal operations in a particular area.

The survey reported in Appendix H.2 further confirmed the presence of near-surface consolidated rock within the Upper Hudson River channel. Rocky outcrops were rather extensively documented by side-scan sonar surveys during the remedial investigation. Where pockets of contaminated sediments are present in the vicinity of rocky outcrops, it may not be possible to remove these sediments by conventional dredging methods. An allowance was made for the inability to capture contaminated sediment pockets in the FS risk analysis. During design, sonar methods will once again be employed to further refine the spatial extent of rock at targeted dredging locations.

Because contaminated sediments are primarily found in depositional areas of the Upper Hudson River, the presence of debris and rocky outcrops represent manageable problems for implementation of the selected remedy, as explained in the FS. Depositional areas are areas where fine materials accumulate and where consolidated materials, if present, are being buried. The process of sedimentation has been occurring over a much more extensive period than has the discharge of PCBs, which largely occurred in the decades following World War II. In this context, it would be expected that the contaminated sediments now overlay cleaner, historic deposits, thereby reducing the probability of interference that consolidated or rocky materials might otherwise exert during dredging operations.

As noted above, the amount of debris encountered during dredging is expected to be small and target areas will generally avoid areas of rock outcropping. Also, EPA will use silt curtains or other containment measures to the extent practicable during both debris removal and dredging. Therefore, debris removal should not have a major impact on sediment resuspension.

Master Comment 253427

Comments include a question as to why Aroclor and not congener-specific analysis will be performed on sediments under the post-construction monitoring program. This is claimed to be inconsistent with the proposal to conduct congener-specific analysis on water and fish under the MNA scenario.

Response to Master Comment 253427

Congener-specific analysis on sediments is, in fact, planned as part of the post-construction monitoring program for the selected remedy, as is radionuclide dating and Aroclor analysis, as outlined in Section 5.2.7.4 of the FS and discussed in the foregoing Response to Master Comment 362634. Post-construction monitoring of fish and water will also be conducted on a congener-specific basis since monitored natural attenuation is a component of the selected remedy following active remediation.

The post-construction monitoring program that would have been implemented under the MNA alternative, had EPA selected that as the remedy, would have been designed to track changes or lack of changes in several media. Because of their dynamic and short-term nature, water and biota are generally monitored on a congener-specific basis to examine how changes in concentration are reflected in the congener pattern. These media are the recipients of contamination, and not the sources of it. Thus, their PCB inventories are relatively small and dynamic. The analytical plan under MNA would have been designed to capture these variations. A congener-specific analysis involving collection of sediment cores for dating and testing would also have been implemented as part of a post-construction monitoring program for MNA, similar to the program to be implemented for the selected remedy but with a different start date and duration.

Master Comment 362631

Some commenters asserted that additional samples/cores should be taken before proposing a final remedy. Commenters wondered whether sediment samples will be collected in areas where there is little historical data, particularly in River Sections 2 and 3 (below the TID), to better determine PCB inventories. It was suggested that documented locations of cores should be very precise so that future cores can be collected at exactly the same location, and that in addition to contaminant concentrations, physical characteristics of core sediments should be analyzed and documented. Commenters also asked whether new bathymetry data of the Upper Hudson will be obtained prior to remedial activities, and whether bathymetric data will be used to determine the new geometry of the river bottom, as well as the quantity of sediments removed, during post-dredge assessments.

Response to Master Comment 362631

EPA recognizes the need to document the current spatial extent of PCB contamination (both vertically and horizontally) prior to beginning any remedial action. As discussed in Appendix G of the FS, an extensive sediment coring program is planned as part of the remedial design. In addition to sampling the areas already targeted, the program calls for an extensive core collection effort in areas not previously identified for removal. This portion of the program is intended to examine the areas of the Upper Hudson that have not been extensively sampled to ascertain the PCB concentrations and inventories of these areas. Those areas meeting the contamination criteria would be included in the remediation.

EPA's evaluation of the sediment contamination of the Upper Hudson and its noted correlation with sediment texture (*i.e.*, PCB concentrations and inventories are highest in areas of fine-grained sediment) would suggest that there are not many areas requiring remediation which have not already been identified. Based on this observation, it is expected that the FS estimates of volume and costs reflect the likely requirements of the remediation. Nonetheless, it is EPA's intention to examine the river bottom throughout the Upper Hudson and refine the final areas, with the expectation that some new target areas will be identified.

The sampling program for the Upper Hudson can be broken down into three zones, specifically:

- Targeted areas
- Areas with contamination slightly less than target thresholds
- Areas with low contamination levels

The sampling proposed for these areas is intense in all cases, and a conceptual program is outlined as follows. For the areas already identified, it is expected that core sampling will occur at 8 cores per acre (40 per 5 acres). For the areas with contamination slightly less than target thresholds, sampling is planned to occur at 7.2 cores per acre (36 per 5 acres). Finally for low level areas, sampling will occur at 1 core per acre (5 per 5 acres) above Lock 5 and 0.4 per acre (2 per 5 acre) below Lock 5. Thus it is clear that this program is unlikely to miss any large reservoirs of PCB in the sediment. It is anticipated that most sample locations will be guided by a grid-based sampling scheme. The program is summarized in the table below.

Conceptual Sediment Sampling Program for Selected Remedy[1]

River Section	Targeted Areas		Area to be Screened[2, 4]		Low Level Areas	
	Acres	Cores	Acres	Cores	Acres	Cores
1	266	2128	266	1915	-	-
2	74	590	74	531	169	169
3	92	736	92	662	2698	1,079
Total **Total Cores = 7,810[3]**	432	3,454	432	3,108	2,867	1,248

Notes:

1. Program is based on the selected remedy as outlined in Table 6-3 of the FS.
2. Area to be screened assumed to be equal to targeted area for these estimates. These areas are not the same physical locations as the targeted areas but are typically adjacent to them.
3. Excludes quality assurance samples whose addition would raise this value by 5 percent.
4. Includes channel area sampling.

Although the EPA has planned a large sediment sampling program for the purposes of the remedial design, it should not be inferred that the existing data are insufficient to support the selected remedy. Rather, the data to be collected are almost exclusively for the purpose of refining boundaries of the target areas and volumes of sediments to be dredged. The existing data set is quite sufficient to identify the contaminated sediments of the Upper Hudson as the current source of PCBs to the biota and to the regions downstream. It is also a sufficient basis for the engineering estimates prepared in the FS.

In addition to the planned sediment coring effort, geophysical investigations will also play an important part in the design, removal and monitoring of the sediments under the selected remedy. The geophysical investigations will be used for the following:

- establish river bathymetry and sediment type prior to the onset of remediation,
- re-examine the river bottom in conjunction with the sediment sampling program discussed above as an aid to the final delineation of remediation areas.
- examine the river bathymetry during and after dredging to assure that the appropriate volume of sediment has been removed and that the backfill material has been properly placed, and
- monitor river bathymetry and sediment texture so as to monitor any substantive changes in the backfill material over time.

For both the geophysical work as well as the sediment core collection, the EPA intends to employ accurate measures of location at a precision appropriate to the use of the data. Sediment physical characteristics will be included with the analytical data to be obtained.

10.3 Resuspension and Residual PCB Concentration

Master Comment 667

Commenters have raised questions with regard to the effectiveness of turbidity barriers (in particular silt curtains) due to their failure at other sites, and the effects of water level fluctuations on their performance, and concerns associated with their use and purpose. Commenters were skeptical with regard to the effectiveness of silt curtains due to resuspension that occurred at the Fox River (SMU-56/57) dredging project despite the use of turbidity barriers. One commenter questioned the effectiveness of silt curtains in regard to water height fluctuations associated with the operation of hydroelectric facilities.

Response to Master Comment 667

In general, EPA has determined that the level of resuspension associated with remedial activities will be relatively low, regardless of whether turbidity barriers are used. The reader is referred to the White Paper – Resuspension of PCBs during Dredging.

The FS report (Appendix E) presented a technical memorandum discussing the applicability of turbidity barriers in the Upper Hudson River. EPA proposes the use of turbidity barriers in the Upper Hudson River for removal work that is being conducted in relatively shallow areas to

reduce downstream suspended sediment load. Estimation (modeling) of downstream TSS and PCB loads from dredging did not assume the use of turbidity barriers, so those estimates would be conservative in light of the fact that barriers will be used where applicable.

While problems with turbidity barriers were noted at sites such as the Grasse River, GM Central Foundry, and the Outboard Marine site, it is important to note that the difficulties encountered at these sites were due to variable winds and current speeds in excess of those at which the barriers are effective. Conversations with various silt curtain manufacturers and users have indicated that silt curtains will work effectively in rivers with currents equal to or less than 2 feet per second (fps). River currents in the Hudson River center channel are in the range of 1.5 fps, and turbidity barriers are proposed for use in shallower river areas where river velocities are even lower.

Review of available Fox River data indicates little difference between upstream and downstream total suspended solids (TSS) concentrations (USGS, 2000) when averaged over the length of the project. The goal of turbidity barriers is to control TSS; thus, it cannot be concluded from the Fox River experience that the turbidity barriers failed to achieve the project objectives since the TSS concentrations upstream and downstream of the dredging operation were essentially the same.

Also, during the project's design phase, plans will be developed for optimal deployment and anchoring of silt curtains. Prior to deployment of a system, an analysis will be conducted to define the position of the anchor line and evaluate the forces expected to occur at each location. If this analysis determines that high currents may be encountered, causing extreme forces on a planned silt curtain, an upstream barrier such as a deflective curtain may be installed to help reduce water pressure. Additional flow-velocity data will be collected during the project's design phase for purposes of this analysis. Analysis of these data will identify specific zones where silt curtains are likely to be effective.

With regard to water level variations, it is not expected that fluctuations due to operation of upstream hydroelectric facilities will impact the effectiveness of silt curtains or other turbidity barriers.

Reference

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

Master Comment 583

Commenters contended that resuspension caused by dredging will remobilize and increase concentrations of PCBs in the water column and surficial sediments, possibly causing higher levels in surface sediments than were present before dredging. Many believe that resuspension caused by the various dredging operations cannot be fully controlled and suggest that projects such as the Fox River demonstration dredging projects support that position. According to some commenters, data collected during the Fox River demonstration projects resulted in estimates of 2.2 to 10 percent releases of dissolved PCBs to the water column. One commenter contends that

EPA has assumed an unrealistically low rate of resuspension during dredging, observing that EPA did not include a resuspension input in its model forecast simulations. GE provided comments and calculations assuming that 2.5 percent of the PCB mass in dredged material will be mobilized and transported downstream, stating that a higher assumed rate of resuspension will have a much greater effect in River Sections 2 and 3, relative to River Section 1. Concern was expressed relative to such possible negative impacts resulting from resuspension as degraded water quality, impact on downstream water uses (*e.g.*, agricultural, municipal, and industrial water supply), an increase in the bioavailable PCBs, and contamination of additional areas. Others expressed the belief that continuous, long-term resuspension occurs naturally, and that resuspension may be less of a threat than portrayed by some, since many of the hot spots occur in relatively quiet water.

Response to Master Comment 583

The issue of resuspension is discussed in some detail in White Paper – Resuspension of PCBs during Dredging. Other potential impacts of the project are addressed in White Paper – Potential Impacts to Water Resources, White Paper – PCB Releases to Air, White Paper – Air Quality Evaluation, and White Paper – Post-Dredging PCB Residuals, in addition to responses to master comments in Chapters 8 and 9. These concerns must be balanced with impacts associated with ongoing PCB releases to the water column and existing impacts to the aquatic biota. Much depends upon the extent to which (if at all) remedial operations increase the health and ecological risk. Thus, estimates of sediment resuspension and subsequent PCB releases to the water column in Appendix E.6 have generated considerable discussion and debate since the release of the FS. Considerable opinion has been offered and information proposed that seem contrary to the estimates provided in Appendix E.6. However, EPA, upon close evaluation, finds no information upon which to base changes to the original FS suspended sediment loss estimates of 0.35 percent for a conventional cutterhead dredge and 0.3 percent for an "environmental bucket" working in the Hudson River. This response summarizes the issues raised and addresses them and their pertinence to the project.

Before beginning the discussion on resuspension in general, it is important to note the following conventions. Resuspension of sediments occurs as a result of the movements of the dredge head and its appendages along the river bottom (and in the case of the mechanical dredge, upward through the water column). These disturbances serve to suspend a portion of the sediment in the water column in the immediate vicinity of the dredge head. Materials such as sands and gravels quickly fall right back down to the bottom under the river velocities typical of the Upper Hudson. Silts and clays require more time to settle and may remain in the water column for some time after resuspension. Materials that immediately fall to the river bottom after being disturbed (*i.e.*, sands and gravels) do not constitute a release of sediment (or associated PCBs) to the water column. These materials will be picked up on a second pass if needed based on tests of the residual surface concentration. Only those materials that remain in the water column for a longer period of time represent potentially important releases to the water column and downstream areas. In the discussion of resuspension, the values of 0.3 and 0.35 percent (for mechanical and hydraulic dredges, respectively) resuspension mentioned above refer to the mass of silts and clays released at the dredge head relative to the entire mass of sediment removed. As discussed in Appendix E6 of the FS, these materials are then transported away from the dredgehead to varying degrees by river currents. EPA has estimated the net escape of sediment and associated

PCBs as the amount of silt and clay remaining in the water column 30 feet downstream of the dredgehead. This value, estimated for mechanical dredging to be approximately 0.13 percent of the material removed, represents the fraction of sediment and PCBs available for downstream transport. Thus for a mechanical bucket dredge, a resuspension rate of 0.3 percent yields a downstream release of 0.13 percent (for the hydraulic dredge the resuspension rate of 0.35 percent yields a downstream release rate of 0.065 percent). It is the downstream release rate value that is used for estimating downstream impacts of dredging to downstream areas via the use of EPA's HUDTOX and FISHRAND models.

In the remainder of this response, the term "resuspension" is used to refer to the process of resuspension at the dredge head itself and not the downstream transport. Elsewhere in the report, the term is used interchangably for both the process of resuspension as well as the fraction of material that becomes available for downstream transport. It is ultimately the control of the latter value that will determine the degree of impact, if any, of the dredging process on downstream areas.

Importance of Dredge Type

Comments on the FS reveal confusion over dredging equipment and the role equipment characteristics play in sediment resuspension. This confusion at least partially results from the fact that specifics relative to equipment to be used will be determined during the design phase. Project reports to date, therefore, have described equipment options available, but have appropriately not specifically stated which individual types and specifications of dredging equipment are definitely to be used. Further confusion results from some parties misrepresenting to the public that equipment used for other, non-remedial, purposes, such as earthmoving, are intended for use in the Hudson River.

Confusing data from the Fox River dredging demonstration projects exacerbate the situation. USGS (2000) summarizes water quality data collected during the SMU 56/57 demonstration project, but does not acknowledge until the final paragraph that the data were associated with a hydraulic dredge with a horizontal auger cutter. Their report on the Deposit N, FRRAT (2000) entirely fails to describe the dredging equipment used. Only in the conclusions does the report refer to a "cutter-head." Nowhere do they mention that the dredge used was the Moray Ultra dredge. Although the Moray Ultra dredge does have a "basket-type" cutterhead, it is strikingly different from a conventional cutterhead dredge and its resuspension characteristics would be expected to be quite different from those of a conventional hydraulic cutterhead dredge. Fortunately, reports by BBL (2000) and Foth & Van Dyke (2000) do describe the dredges used on these projects.

Many environmental dredging projects utilize smaller dredges, such as the horizontal auger and Moray Ultra dredges used in the Fox River demonstration dredging studies. However, the extent and nature of the selected remedy for the Hudson River presents challenges not easily overcome by these types of dredges. In contrast, larger, more powerful dredges operate routinely under conditions similar to the selected remedy. Such dredges have a much higher likelihood of success and will reduce water quality impacts since they are operating under relatively normal conditions for their equipment. Thus, the FS considered only the application of hydraulic

cutterhead dredges and environmental bucket dredges in the implementation of the proposed remedy.

Site Conditions

Effective removal requires a dredge matched to site conditions. For many projects, several dredge types can usually effectively remove sediments. In those cases, dredge selection depends on cost-effectiveness and compatibility with sediment management alternatives. However, some site conditions can impede dredging operations and have marked impacts on dredging effectiveness, especially in terms of sediment removal and sediment resuspension rates. Site conditions substantially complicated removal efforts at some of the projects commenters used as examples to dispute sediment resuspension estimates for the selected remedy as outlined in the FS. For example, in the Grasse River, the rocky nature of the river bottom significantly interfered with and reduced the efficiency of removal operations (Thibodeaux, 2000; Alcoa, 1995).

Manistique Harbor is the primary bucket-dredging operation mentioned in disputing the loss rate used in the FS. Dredging at Manistique was primarily accomplished with a bucket dredge, although other dredges were used as well. Ray Bergeron of CableArm Clamshell (personal communication, 2001) indicated that extensive areas of dense, coarse sediments and debris inhibited the effectiveness of the dredge bucket. The Cable Arm bucket is designed to dredge soft sediments and does not perform as well where either consolidated materials or debris are present.

In fact EPA has documented several remedial dredging operations where resuspension during dredging was not significant, *e.g.*, New Bedford Harbor and GE Hudson Falls. These are further described in the White Paper – Resuspension of PCBs during Dredging.

Summary

Data from several other dredging projects were pointed to by commenters as representative of sediment resuspension rates that should be expected from the selected remedy (Hayes and Wu 2001). However, the projects from which these data are derived have site conditions different from the Hudson River, which render comparisons inappropriate. Thus, the original sediment resuspension rates estimated in Appendix E.6 still represent the best estimates that can be developed from currently available data.

References

Alcoa, Inc. 1995. Non-Time Critical Removal Action Documentation Report, Volumes I and II, Grasse River Study Area, Massena, NY. Prepared for Alcoa, Inc. by Blasland, Bouck & Lee, Inc December.

Hayes, Donald F. and Wu, Pei-Yao, “Simple Approach to TSS Source Strength Estimates,” Proceedings of the WEDA XXI and TAMU 33 Annual Conference, Houston, TX, June 25-27, 2001.

Blasland Bouck and Lee (BBL). 2000. Fox River SMU 56/57 Dredging Demonstration Project, June.

Foth & Van Dyke. 2000. "Summary Report: Fox River Deposit N," Wisconsin Department of Natural Resources, April.

Fox River Remediation Advisory Team (FRRAT). 2000. "Evaluation of the Effectiveness of Remediation Dredging: The Fox River Deposit N Demonstration Project; November 1998 – January 1999," Special Report WRI SR 00-01, Water Resources Institute, University of Wisconsin-Madison, Madison, WI.

Thibodeaux L.J. 2000. The Effectiveness of Environmental Dredging: A Study of Three Sites. Final Report. South and Southwest, Center for Hazardous Waste Research, Louisiana State University at Baton Rouge, LA. Submitted to: Environmental Science and Technology Development Environmental Health Sciences Services, North American, ALCOA.

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

Master Comment 424977

GE comments (Appendix A) stated that the EPA estimate of PCB resuspension rates during dredging was too low and hence overestimated the remedial benefit to the Hudson River. GE asserted that a more reasonable estimate of the PCB resuspension rate is on the order of one to five percent based on the studies conducted on the Fox River dredging project.

Response to Master Comment 424977

EPA analyses show that a conservative estimate for mass-weighted average PCB loss rates for conventional closed bucket dredges, based on the specific characteristics of Upper Hudson River sections, is 0.13 percent. The description of this analysis can be found in White Paper – Resuspension of PCBs during Dredging. The effects of including Tri+ PCBs resuspension in the Hudson River fate and transport modeling simulations can also be found in that white paper.

EPA believes that the Fox River results are not applicable to the Hudson River. The dredging technology that will be used for the Hudson River is different from that used in the Fox River and will achieve lower loss rates, and EPA has serious concerns about the downstream PCB release sampling approach conducted in the Fox River project.

EPA also ran its model using the 2.5 percent PCB loss rate in view of, among other things, the large number of public comments received on the dredging resuspension issue. This run was conducted for comparative purposes, even though the Agency believes that 2.5 percent resuspension is unrealistically high for the dredging equipment and methods that are expected to be used at the Site. The estimated total amount of Tri+ PCBs being remediated in the Upper Hudson River is 21,700 kg (see White Paper – Sediment PCB Inventory Estimates). The total

mass of Tri+ PCBs lost to the water column at a 0.13 percent resuspension rate[1] is about 28 kg over the entire dredging period. EPA calculations indicate that the 2.5 percent resuspension rate postulated by GE would result in about 500 kg of Tri+ PCBs being released during the whole dredging period.

GE's comments (Appendix A) present estimates of the impact of PCB resuspension using their PCB fate model. Specifically, GE reports results for PCB dredging loss rates of 1, 2.5, and 10 percent applied to the REM-3/10/Select alternative. GE did not, however, describe how these loss rates were incorporated into their PCB fate model. Results reported by GE for the cumulative increase in Tri+ PCB load to the lower river by the end of the dredging period in 2008 were about 350, 800, and 3500 kg for the 1, 2.5, and 10 percent resuspension rates, respectively. The higher predicted load might be due to GE's assumption of higher PCB residuals in the sediment. Nevertheless, GE's reported increase in load to the lower river for a 2.5 percent loss rate is approximately 60 percent greater than the total release to the water column estimated by EPA for that loss rate.[2]

EPA concludes that GE has over-estimated the amount of downstream transport of PCBs associated with a given resuspension loss rate. As described in White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River, the impacts associated with resuspension loss will be minor and transient, largely confined to the time period of active dredging. Accordingly, the substantial benefits associated with the selected remedy outweigh the reasonably expected impacts of dredging resuspension.

Master Comment 579

Commenters stated that evidence regarding previous environmental dredging projects indicates that EPA's anticipated residual sediment PCB concentration of 1 ppm is unachievable. They contend that the lowest average residual PCB levels achieved for the 10 dredging projects completed to date range from 2.2 to 5.9 ppm.

Response to Master Comment 579

As discussed in White Paper – Post-Dredging PCB Residuals, residual contamination depends upon a number of factors. Among these are:

- Type and depth of materials that underlie the dredging horizon.
- Average level of contamination above the dredging horizon prior to dredging.
- Depth of sediment to be removed.
- Ultimate cleanup goal of the project.

[1] Monitoring distance from the dredge head makes a difference in the calculated resuspension rate, due to sediment settling in the immediate vicinity of the operation. This value represents the net release via resuspension at a distance of 10 meters downstream of the mechanical dredge head. The resuspension due to the hydraulic dredge would be less.

[2] GE has since submitted corrections to their calculations with a smaller PCB load to the Lower Hudson River.

Several of the remedial dredging projects described by the commenters involved sites where contaminated sediments were underlain by hard substrate. This site-specific condition prevented overcutting of contaminated materials, a strategy that could have led to significantly lower PCB residuals. A comparable condition is not expected to be encountered in most areas being targeted under EPA's selected remedy. Within the Hudson, the targeted fine-grained sediments are generally underlain by older fine-grained sediments, thus permitting an overcut to be taken with the goal of leaving relatively clean sediments exposed.

Also, based on EPA's review of the sediment residuals, it is apparent that sites with higher initial PCB concentrations yielded higher PCB residuals after dredging than did sites with relatively lower PCB levels. In this regard the Hudson is at the lower end of the PCB contamination spectrum (in terms of sediment PCB concentration). For the Hudson River, a targeted residual of 1 mg/kg Tri+ PCBs represents a reduction of 96 to 98 percent from pre-dredging sediment concentrations (see White Paper – Post-Dredging PCB Residuals).

Several dredging operations, including the GM Massena and the Cumberland Bay site on Lake Champlain, achieved PCB residuals comparable to those expected under EPA's selected remedy. At the GM Massena site, the mean residual concentrations in two subsections represented 98.6 percent and 98.8 percent reductions from the initial mean concentrations, respectively. At Cumberland Bay, the average PCB concentration was estimated to be 135 mg/kg in the dredged sediment and the average post-dredging residual was about 2.5 mg/kg, which results in a 98.1 percent reduction. Further discussion of these results can be found in White Paper – Post-Dredging PCB Residuals. Thus, the targeted Hudson River residuals of 1 mg/kg Tri+ PCBs is comparable to that achieved at these two locations.

In reviewing outcomes at other Superfund sites, it should be noted that the PCB residual concentration actually attained at these other locations was dependent, in part, on the cleanup goal set there. For example, at the Manistique River site, the cleanup goal was to remove 95 percent of PCB mass and achieve an overall average residual concentration of less than 10 mg/kg after dredging. Therefore, the residual PCB concentration, at this location, should not be expected to be 1 mg/kg since the targeted level was actually higher.

Beyond these considerations, the conservative approach taken by EPA to estimate dredging depth and volumes for the selected remedy should also be noted:

- The depth to 1 mg/kg PCBs in sediment samples was determined either directly or by estimation from the Hudson River database.
- Reasonable work areas were identified and then the dredging depth was set equal to the greatest depth of contamination found in the work area samples; and
- Minimum dredging depths were assigned to areas designated as > 3 g/m^2 and > 10 g/m^2.

Based on this conservative strategy for selecting dredging depths and estimating dredging volumes, EPA expects to attain post-dredging residuals at or below 1 mg/kg Tri+ PCBs.

In applying these above considerations to the fate and transport and bioaccumulation modeling, it was assumed that the dredging operation would achieve, on average, a 1 mg/kg Tri + PCBs residual for the reasons stated in the foregoing text. It was further assumed that the PCB residual level would be considerably reduced after backfilling due to the presence of the backfill cap. While the result of backfilling is expected to be a near zero residual, the modeling assumed a conservative Tri+ PCBs residual of 0.25 mg/kg.

In summary, EPA's assessment of PCB residuals is reasonable. Dredging depths and volumes were estimated in a highly conservative manner. In fact, one commenter who was not analyzing removal requirements as conservatively as EPA estimated that the Agency would need to remove about 500,000 fewer cubic yards of sediment than stated in the FS. Finally, comparing conditions and results at other sites lends support to EPA's assessment; in some cases, however, comparisons to other projects is complicated by site-specific circumstances that render those comparisons either difficult or inappropriate.

10.4 Backfilling and Shoreline Restoration

Master Comment 653

Commenters stated concerns including: a) the overall volume of backfill material and the impact of the remedy on the local supply of material; b) the source, the means of transport, and the location of the handling facilities; c) the duration of the backfill operation, the rate of placement and the hours of operation per day; d) the type of equipment used for the placement; and e) the type of material. With regard to source of materials, some commenters expressed the fear that EPA was planning to take soil from private property proximal to the river for use as backfill.

Response to Master Comment 653

Overall Volume and Availability of Backfill Required

Based on refined computation, the overall quantity of fill material has been revised for the selected remedy (REM-3/10/Select) from 851,600 cubic yards to 756,000 cubic yards, including 15 percent for bank reconstruction and habitat restoration. Approximately 322 acres of riverbed will be backfilled.

The breakdown of quantities by type of material consistent with the backfill criteria stated in the Feasibility Study is as follows:

- Gravel: 112,000 cubic yards.
- Sand: 447,000 cubic yards.
- Fine material: 197,000 cubic yards.

The selected remedy is scheduled to take six years, which includes a less than full-scale first year phase-in. Calculations performed in the FS assumed a five-year construction period. Since the annual requirements calculated under this assumption represent a maximum for the phased implementation, the figures used in the FS are conservative for this presentation. Therefore,

implementation of the selected remedy will require, as a maximum, approximately 151,200 cubic yards of fill per year. According to the USGS report (1999) titled "The Mineral Industry of New York," the total annual production of sand and gravel in the eastern part of New York State north of Ulster and Duchess Counties is approximately 7,500,000 metric tons. The project backfill requirement represents only on the order of three percent of the regional production and therefore will not affect either the cost or the availability of material in the project area.

Source, Means of Transport, and Staging Areas

Backfill material will be obtained from commercial suppliers/distributors, and will not be excavated from land, agricultural or otherwise, in the vicinity of the project. In general, material to be used as backfill under water on the bed of the river will not be topsoil. A six-inch layer of topsoil may be used above the shoreline for shoreline stabilization and to promote the restoration of vegetation. This relatively minor volume of topsoil will also be obtained from commercial suppliers.

At least five large suppliers/distributors of sand and gravel were identified and contacted at various times during the course of the studies. It was determined that backfill materials may originate anywhere from Ft. Anne near Lake Champlain to coastal New Jersey. One of the suppliers indicated that his planned operation at Ft. Anne will be rail-accessible and material could be shipped to an appropriate off-loading point near a docking facility. Another supplier suggested that sand and gravel could be obtained in the coastal New Jersey area and delivered in canal-compatible barges (up to 2,500 tons per load) or by rail.

There will be several sources of material, with appropriate means of transport to temporary stockpile areas. The technical specifications for the backfill material, to be determined during the design phase of the project, will dictate to a great extent the location of the borrow areas.

At the present time, two backfill staging areas are considered to be appropriate for this project. The temporary staging of material is necessary to assure the continuity of the backfill operation. It can be either a land-based stockpile near the barge docking facility, or a set of loaded barges docked at convenient locations between the sources and the project area. EPA will ensure that the operation meets the requirements to be established during the design phase of the project. These requirements may include restriction on the hours of operation, traffic routes, etc. Transportation of the backfill material between the temporary staging areas and the project area will be via barges. EPA has stated that backfill will not be transported by truck within the Upper Hudson River area, so as to avoid roadway congestion and other disturbances that could potentially be generated by truck delivery.

As stated above, the requirements and parameters of the operation will be finalized during the design period, to include any guidelines or restriction on the staging areas for backfill material. At this time, it is assumed that two backfill staging areas will be operated, co-located with the sediment processing/transfer facilities.

Duration of Backfill Operation, Rate of Placement, and Hours of Operation

The backfill operation will follow the dredging and progress at a similar rate. It is anticipated that both operations will take place at the same time in different locations. As the dredging operation is scheduled to last for six years, so is the backfilling.

As indicated above, the average annual volume of backfill material to be placed is conservatively estimated at approximately 151,200 cubic yards. For planning purposes, it is assumed that backfilling will be done 25 weeks out of the 30 weeks of the navigation season, which would equate to an average placement rate of between approximately 5,040 and 6,050 cubic yards per week. Because this productivity rate is an average rate over a six-year period, it is anticipated that an experienced contractor will have equipment capable of handling a production rate approximately 50 percent larger so as to maintain the schedule even in areas where the operation will be more difficult.

The placement of backfill material will be essentially done during daylight hours. As the construction season may be limited to 25 to 30 weeks per year, *i.e.*, the navigation season, it is anticipated the contractor will operate six days per week.

Type of Equipment Required

It is anticipated that the equipment used for the placement of the backfill will be specifically designed and built for this project. The design will be based on contractor experience and the specific requirements of the task. Different techniques may be used for placement in the deeper portion of the river (6 to 12 feet) than would be used for the shallower areas. The applicable techniques include:

- Hydraulic washing - the material (sand and gravel) is transported to the Site in a flattop barge and washed overboard with high-pressure hoses. This technique is particularly well adapted to the gradual buildup of a thin uniform layer of backfill for the depths of water considered for this project.

- Pipeline with baffle-plate or sand-box - placement is accomplished with surface discharge from a pipeline equipped with a deflecting plate or a sand-box attached at the end. For this technique the backfill material is mixed with water and pumped through the pipeline. This technique may not be applicable to the coarser material such as gravel.

- Telescoping conveyor - for shallower areas, the unloading of material from the barge can be done using front-end loaders and telescoping conveyors.

Placement of backfill materials will be monitored to assess compliance with project requirements for turbidity control and for minimum thickness of backfill layer.

Type of Material

Backfill material characteristics were specified in general terms; a primary objective was habitat replacement. In order to create a varied habitat, both sandy and gravel bottom conditions were identified as being desirable. In addition, where wetlands would be impacted by the dredging operation, a sandy-silt type soil was identified as suitable replacement substrate for replanting emergent or rooted woody vegetation.

Master Comment 655

Some commenters questioned the length of shoreline reconstruction to be undertaken. Some commenters stated that the shoreline should not be protected with rip-rap. Others suggested that the shoreline reconstruction should not be done until data has been collected for the adjacent floodplain.

Response to Master Comment 655

The following information can be found in the FS, Section 8.5.1.6, and Tables 8-10a and 8-10b. The disturbed portions of the river shoreline will have to be restored and stabilized. The stabilization measures envisioned consist of hydro-seeding where the disturbance is minimal, and the placement of vegetative mattress where two to three feet of sediment have been removed. Where shoreline disturbance will exceed three feet of sediment removal, the stabilization will include log or wood crib revetment in addition to the vegetative mattress. Where shoreline wetlands may be affected by the dredging work, the original bottom elevation will be restored with an upper layer of silty material.

Based on the area determined to require remediation, the length of shoreline restoration is currently estimated to be approximately 17 miles. For the selected remedy it is anticipated that approximately 20 percent of the shoreline stabilization will consist of hydro-seeding, 50 percent include the placement of vegetative mattress, and the remaining 30 percent would require a log or wood crib revetment in addition to the vegetative mattress. In very limited areas where significant erosion has been observed, structural measures such as rip-rap may be required to prevent further degradation of the shoreline.

EPA will work with New York State with regard to investigation of PCB contamination in the floodplain concurrent with the remedial design.

10.5 Dredged Materials Disposal

Master Comment 665

Commenters raised questions about the lack of identification of potential landfill sites. Some commenters questioned why EPA has not released the location of disposal facilities. Commenters believe that a remedy cannot be selected until the destination of the dredged sediments is publicly known.

Cost-effectiveness of disposing of sediments outside the Hudson Valley versus the possibility of using a regional or local landfill has been questioned. One commenter suggested that, as transportation and disposal in non-regional landfills is a significant part of the remediation project's cost, disposal in a local or regional facility could potentially reduce costs if a suitable facility(ies) could be identified. The commenter stated that the decision not to landfill non-TSCA wastes locally should therefore be reconsidered. The FS conceptually evaluated disposal of TSCA-regulated material at a facility located in Texas but commenters have questioned the cost-effectiveness of doing so when compared to using the TSCA facility in Model City, New York. Numerous commenters, on the other hand, opposed disposal anywhere in western New York. Commenters also inquired if landfills exist in Canada, and if so, would this be a cost-effective alternative? It has been suggested that EPA has proposed a solution with high disposal and transportation costs when compared to other dredging projects. Also, commenters questioned whether TSCA- and non-TSCA dredged material mass has been estimated on a spatial basis. Spatial distribution may impact rail operations and landfilling.

Response to Master Comment 665

Identification of Disposal Facilities

EPA has determined that dredged sediments, after dewatering and/or stabilization, will be transported out of the Hudson Valley to approved landfills for final disposal. An initial search was conducted during preparation of the FS to identify landfills that have both the capacity and rail access to manage and handle Hudson River sediments. The search focused on two categories of landfill:

- Non-TSCA landfills approved pursuant to RCRA Subtitle D and capable of accepting sediments with PCB concentrations less than 50 ppm.
- TSCA landfills regulated by the USEPA and capable of accepting sediments with PCB concentrations greater than 50 ppm.

Results were presented in Table 4-14 of the FS report for non-TSCA landfills and Table 4-15 of the FS report for TSCA landfills. It would be ideal to identify and secure one TSCA facility and one non-TSCA facility to handle the Hudson River sediments over the proposed six construction seasons; however, landfill availability and current and projected landfill capacities during the project design phase will dictate the number of commercial facilities required to support the selected remedy. Currently viable landfills and their capacity limitations, in relation to the demand generated by the selected remedy for the Hudson River, were presented in Appendix E of the FS report

As described in the FS report, (Appendix E and Table 4-14), the only likely landfill within New York State that could receive non-TSCA material is BFI Waste Systems of North America, Inc.'s Niagara Falls Landfill (formerly CECOS landfill). The other non-TSCA landfill located in New York State is only permitted to receive PCB-contaminated soil with less than 1 ppm PCB; this level is too low for the Hudson River sediments, which typically contain significantly higher levels of PCB. The search was, therefore, expanded outside New York State in an attempt to locate additional non-TSCA disposal alternatives. Results of the search were presented in the FS

report (Appendix E) and are summarized in White Paper – Off-Site Disposal of Processed Sediments.

With regard to TSCA landfills, EPA's search within New York State identified one such facility but that operation does not have direct rail access. Thus, it proved necessary to evaluate the few nationally available rail-capable, TSCA facilities, all of which are located a considerable distance from New York State. A rail-capable, TSCA landfill in Texas was selected for purposes of generating the FS cost estimate. However, the final selection of landfills will be made during the project's design phase and cannot be presented at this time, as requested by the commenter.

Cost Effectiveness Associated with Location of Landfill Selected for Disposal

Typically, disposal costs identified during the landfill search (including tipping fee and associated state taxes) were within the range of $40-$60 per ton for non-TSCA facilities and $50-$80 per ton for TSCA facilities. These disposal costs were presented in Tables 4-14 and 4-15 of the FS. Although disposal costs vary somewhat between in-state facilities and out-of-state facilities, the cost for transportation was also evaluated to determine the cost-effectiveness of the available disposal options. Given the limited number of large capacity TSCA landfills with rail access, cost variations between candidate sites proved minor.

Appendix E of the FS presented a cost analysis between trucking to a landfill located within New York State and rail transport to a landfill located outside New York State. Comparison of total unit costs (disposal plus transportation) showed the in-state option to cost about $107 per ton while the out-of-state alternative cost $102 per ton. These results suggest that disposal outside New York State is potentially as viable as in-state disposal.

Similarly, disposal at Canadian facilities could be cost-effective. Disposal costs presented in Table 4-14 of the FS report indicated that disposal costs at Canadian facilities are comparable to disposal costs within the Unites States. It may be necessary for EPA to enter into an agreement with a Canadian provincial government before a Canadian site is used for disposal.

Beneficial Use

In addition to landfilling, EPA considered the possibility of beneficially using some portion of the dredged sediment. Chapters 5 and 8 of the FS describe the scenarios EPA considered with regard to beneficial use. EPA will continue to evaluate beneficial use of Hudson River sediments during the project's design phase as a means to improve the overall cost-effectiveness of the selected remedy. However, since the engineering and cost parameters for landfill disposal are relatively well known compared to possible beneficial use alternatives, EPA continues to view landfill disposal as a likely management option for the dredged sediments.

TSCA vs. Non-TSCA Volumes

Commenters have raised questions concerning characterization of Hudson River sediments for disposal purposes. In the FS, estimated volumes of TSCA and non-TSCA material requiring removal were indicated. This estimate assumed all material greater than 32 ppm PCBs would be disposed of at a TSCA-permitted facility. Appendix E of the FS presents the calculation of these

volumes. Logistical aspects of the remedy will be complicated by the presence of two different commodities (TSCA sediments, greater than 32 ppm, and non-TSCA sediments, less than 32 ppm); however, these difficulties can be overcome in several ways, including close coordination between the dredging operation and the transportation component of the selected remedy. This matter is also discussed in White Paper – Rail Operations.

Master Comment 405890

Commenters questioned the value of moving PCB contamination from one area to another by dredging the river and then disposing contaminated sediments in landfills; everyone would be better off if PCBs were left buried in river sediments instead of landfilled where they could leak back into the earth. Landfilling may result in contamination of groundwater, air, and land at the selected landfill location. Many commenters were concerned that EPA would locate the landfills within the vicinity of the Hudson Valley or more specifically, "in their backyard." Others opined that the placement of over two million cubic yards of sediment in a landfill is a waste of space. Additionally, commenters expressed concerns that PCB-contaminated sediment could be spilled during transportation or other operations.

Several commenters supported landfilling, stating that it is better to remove the PCBs from the river and immobilize them in a landfill specifically designed to contain them. Some commenters emphasized the need to safely treat and dispose of the sediments to achieve the benefits of protection of human health and the environment through implementation of EPA's plan.

Response to Master Comment 405890

EPA has determined that dredged sediments will be stabilized as necessary, or dewatered, and then hauled by rail (or possibly barges) to permitted landfills located well beyond the Hudson Valley. The more highly contaminated sediment would be disposed in a TSCA-permitted landfill specifically designed for and in business to safely handle hazardous and toxic waste, while the less highly contaminated sediments would be disposed in a sanitary-type landfill approved to handle such materials. EPA does not plan to use existing landfills within the Hudson Valley or to establish a new Hudson Valley facility for landfilling the dredged sediments.

Disposal of dredged sediments in permitted facilities is not simply moving contamination from one place to another, as has been suggested. Removing PCBs from the sediments of the Hudson River removes a toxic threat to human and ecological receptors that is continually entering the environment. Removal of PCBs is therefore protective of human health and the environment, which is EPA's mandate. Sequestering processed sediments in permitted landfills isolates the contamination from the environment, contrary to the current situation, and is therefore desirable. Such landfills, as has been said, are specifically designed to manage these materials and are thus protective of the environment. Permitted landfills so designed will avoid the very concerns raised by several commenters regarding spreading contamination.

Disposal facilities will be selected based on their permit status, available capacity, availability of rail access, and disposal costs. EPA conducted a comprehensive landfill search, described in the FS report. That search identified landfills that have both the required capacity and rail access to

manage Hudson River sediments. Results of the search were presented in Table 4-14 and Table 4-15 of the FS report.

There are, in fact, alternatives to landfilling, which have been described in Chapter 4 of the FS. In addition, Chapters 5 and 8 of the FS evaluate beneficial use of non-TSCA sediments in one of several ways. Viability of some of these alternatives depends upon the PCB concentrations in the processed sediments. EPA will continue to review non-landfilling options during remedial design. However, at this time, it appears that the material will be disposed of in appropriate approved landfills, an option with relatively well-known engineering and cost parameters.

10.6 Safety Concerns

Master Comment 661

Some commenters have raised concerns about discharges and spills of hazardous materials resulting from project related activities. These activities include transport of sediments as well as spillage resulting from pipeline or other equipment failures. Concerns about accidental releases of fuel have also been raised.

Response to Master Comment 661

Transport of Sediments

After dewatering or stabilization, the contaminated sediment will be hauled to landfills in covered rail cars. Use of covered gondolas will limit the loss of contaminants in the form of fugitive dust. While it is possible that some stabilized sediment may be discharged as a result of an unexpected transportation incident, it is likely that any discharged sediment can be quickly recovered since it is in the form of a readily manageable soil. Given that transportation incidents that may result in a spill of processed sediments are relatively infrequent and that released sediment will be in an easily recoverable form, it is highly unlikely that contaminants will be spread during transport of Hudson River sediments to final disposal facilities.

Spills

EPA will require a spill control, response, and counter measures plan. That plan will require measures that limit the potential for accidental releases while at the same time requiring full preparation with equipment and trained personnel available to respond to spill contingencies should they occur. Such requirements are routine and EPA will ensure conformance to these requirements throughout the term of the project.

Traffic Safety

Estimates of increased road and rail traffic demonstrate that project-related movements are within the capacity of existing upper Hudson road and rail networks, so unusual increases in the risk of accidents are not anticipated from increases in these two modes of transportation. Issues of safety are addressed further in Response to Master Comment 555 in Chapter 8.

EPA will pay particular attention to the points of access and egress to and from sediment processing/transfer sites. The truck/auto entry points to these facilities will have appropriate traffic control devices so that vehicles moving on and off the sites can merge smoothly with other traffic flows. Project-related traffic problems, including both congestion and accident risks, have been substantially mitigated as a result of EPA's commitment not to ship dredged sediment by truck. Also, EPA has determined that backfill will not be transported by truck within the Upper Hudson River area, so as to further reduce traffic-related impacts.

An increase in accident rates for project vessels (barges and towboats) is also not expected to occur. In-river work areas will be clearly delineated so as to avoid conflicts between project vessels and other craft using the Champlain Canal. EPA will ensure conformance with all US Coast Guard safety regulations over the course of the project. These regulations apply to all the vessels that will participate in the project, including sediment storage barges and barges and vessels that may bring fuels and other commodities to the work area. A detailed discussion of project-generated road, river, and rail activity can be found in White Paper – Project-Related Traffic, White Paper – River Traffic, and White Paper – Rail Operations.

Equipment

With regard to the matter of slurry pipeline failure, the slurry pipeline will be equipped with sensors that react to a drop in system pressure. When the pressure transducers sense a loss of pressure they will transmit a signal to shut down dredging and pumping operations. Thus, the slurry system will have the capability to terminate discharges should a pipeline failure occur. Moreover, the piping system will be routinely inspected, and portions of the system will be replaced on a regular basis to be determined during design. In this manner, impacts from the slurry conveyance system will be minimized or eliminated.

Area Municipal Water Supplies

EPA intends to establish a notification system for municipal water suppliers located downstream of the active remedial areas. In the highly unlikely event of an observed release of sediments, municipal water suppliers will be alerted so they can take action with regard to their river intakes. In addition, ongoing sampling results will be made available to municipalities and to reassure them the EPA is maintaining the dredging operation at predicted levels of efficiency and safety.

11. SELECTION OF THE PREFERRED REMEDY

11.1 Overall Protection of Human Health and Environment

Master Comment 313320

The Revised Baseline Human Health Risk Assessment (Revised HHRA) and Revised Baseline Ecological Risk Assessment (RBERA) showed risks to humans and wildlife consuming fish from the Hudson River to be above acceptable levels. Human health non-cancer hazards and cancer risks from fish ingestion were both calculated to be above acceptable ranges. Risks to wildlife were greatest for piscivorous species, such as the river otter and mink. A number of commenters contended that institutional controls (*e.g.*, fishing advisories and bans) will not protect wildlife exposed to the high levels of PCB in sediment, water, and fish or adequately protect human health.

Response to Master Comment 313320

EPA concurs that institutional controls are ineffective for protection of the environment (*e.g.*, ecological receptors), since environmental receptors such as the bald eagle, otter, and mink obviously do not adhere to the consumption advisories and are exposed to high levels of PCBs in sediment, water, and fish (FS, Section 8.3.2.3).

The existing fish consumption advisories and fishing bans are also not completely protective of Hudson River anglers, as discussed in the Revised BHHRA and in Response to Master Comment 543 in Chapter 3 of this Responsiveness Summary. The consumption advisories have not eliminated all fish consumption at the Site, as evidenced by a 1996 NYSDOH survey that found that eighteen percent of Upper Hudson River respondents had fish in their possession when interviewed, and eleven percent had more than one fish (NYSDOH 1999). The selected remedy will enable cancer risks and non-cancer hazards from fish consumption to reach acceptable levels more quickly than if no action is taken to remediate the PCB-contaminated sediments.

Reference

New York State Department of Health (NYSDOH). 1999. Health Consultation: 1996 Survey of Hudson River Anglers, Hudson Falls to Tappan Zee Bridge at Tarrytown, New York. February.

Master Comment 337854

The Trustees support EPA's rejection of the No Action (no Upstream Source Control) alternative (Alternative 1) and the Monitored Natural Attenuation (MNA) with Upstream Source Control alternative (Alternative 2), because selection of either of these alternatives would allow residual contaminants in sediments to be redistributed and transported throughout the ecosystem for decades into the future, thereby continuing to cause residual injury and delaying restoration of Trust resources. From the Trustees' perspective, the extent of ongoing natural resource injuries and the threat of other potential injuries caused by PCB contamination warrant immediate action.

Response to Master Comment 337854

EPA acknowledges the support of the Trustees of this valuable natural resource. As stated in the Proposed Plan (*e.g.*, pp. 27-29) and the ROD, EPA's selected remedy was chosen because EPA recognizes the continued harm to human health and the environment posed by leaving large quantities of PCBs indefinitely in this sensitive ecosystem, as would be the case under the No Action and MNA alternatives.

Master Comment 337860

Scenic Hudson asserted that the results of its recent analysis provide specific evidence that contaminated sediment cleanups can reduce contamination in sediment and fish. Table 1 in Appendix F of Scenic Hudson's comments, Contaminant Concentrations in Sediment Before and After Remediation and Contaminant Mass Removal, shows PCB sediment reductions for seven sites, ranging from 13 to greater than 99 percent following remediation. Table 2, Appendix F, Contaminant Concentrations in Fish Before and After Remediation, shows reductions in PCB concentrations in fish ranging from approximately 56 to greater than 99 percent following remediation. Four successful removal actions are summarized in Appendix G. Scenic Hudson's October 2000 Report, Results of Contaminated Sediment Cleanups Relevant to the Hudson River, contains additional information. Results vary from site to site, and some studies are subject to research limitations (*e.g.*, small sample sizes). Viewed collectively, however, the studies show consistently that dredging has beneficial results and does not make matters worse. In general, contaminant reductions at the study sites exceed reductions at control sites, and the greatest contaminant reductions are seen at monitoring locations closest to the cleanup areas. Short-term (*i.e.*, three-year) adverse impacts on fish contamination were suggested for only two sites that were looked at, the Black and Grasse Rivers, where mechanical dredges were used and where challenges were posed by bedrock and/or debris. Clear benefits were observed at these sites by the fourth year after the cleanups.

Response to Master Comment 337860

EPA recognizes that studies have consistently shown that dredging has beneficial results and does not make matters worse. When environmental dredging is conducted under properly controlled conditions, a large mass of PCBs is permanently removed. Such actions have definite benefits that, for this Site, are described in Chapters 8 and 9 of the FS Report, in the Proposed Plan and ROD, and in this Responsiveness Summary (*e.g.*, Responses to Master Comments 485 and 601, Chapter 11). EPA is also aware that there may be a relatively short-term increase in fish body burdens during and immediately after dredging (*e.g.*, Oliver and Hulberg, 1977). However, within approximately two to three years after construction is completed, EPA expects that significant reductions in fish body burdens will be observed both within the areas that are remediated as well as in downstream areas (see White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River). These reductions and subsequent further reductions in PCB fish tissue concentrations are in turn expected to continue to reduce the risks posed by PCBs to human health and the environment.

Reference

Oliver, J.S. and L.W. Hulberg. 1977. Patterns of Succession in Benthic Infaunal Communities Following Dredging and Dredged Material Disposal in Monterey Bay. Dredged Material Research Program. Technical Report D-77-27. US Army Corps of Engineers (USACE), Waterways Experiment Station, Vicksburg, MS.

Master Comment 337788

Commenters said that the No Action, MNA, or capping alternative do not adequately address reduction of the significant ecological health risks. Commenters asserted that capping at best represents an expensive Band-Aid™ that leaves a significant reservoir of PCBs in place. Further, the capping alternative would require some removal and does not adequately address the need to clear and maintain navigable channels on the upper Hudson. In addition, commenters said, the permanence of these caps is not adequate. Sooner or later PCBs will again become available as the cap is breached under the dynamic conditions that affect the river bottom. Commenters stated that removal alternatives provide a more comprehensive, protective, long-term cost-effective solution.

Response to Master Comment 337788

EPA concurs. EPA has determined that the No Action and MNA alternatives are not sufficiently protective of human health and the environment because neither of those alternatives reduces fish PCB concentrations to target levels within an acceptable time frame. EPA also believes that removal alternatives are more protective of human health and the environment because of the long-term uncertainties associated with leaving PCB-contaminated sediments in place under the No Action, MNA, and capping alternatives. An additional reason for supporting a removal alternative over a capping alternative is that exposure of deeper contaminated sediments during the interval between dredging and capping can increase exposure to ecological receptors utilizing these habitats, as discussed in Section 9.5.3 of the FS. The Proposed Plan and the ROD contain additional details on the rationale for remedy selection.

11.2 Cost

Master Comment 483

A number of commenters asserted that the remedy must be cost-effective. Commenters said that the most important mandate of CERCLA is that the remedy protects human health and the environment (per NCP 300.430(f)(1)(A) and (B)), but that EPA should choose a cost-effective remedy from among those that achieve that goal. Some commenters observed that cost-effectiveness supports a comprehensive dredging remedy: actual removal of sediment, as opposed to the hoped-for burial of PCBs by cleaner sediments, will reduce overall costs and limit the likelihood of additional dredging in the future.

Response to Master Comment 483

EPA agrees that the most important mandate of the CERCLA remedy selection provisions is that a remedy be protective of human health and the environment. EPA's selected remedy was chosen because it will reduce to acceptable levels the risks to human health and the environment from the consumption of PCB-contaminated fish within an acceptable time frame. These risk reductions are presented in Chapter 7 of the FS. Chapters 8 and 9 of the FS contain EPA's detailed analysis for all the alternatives that passed the initial screening (for effectiveness, implementability, and cost) using seven of the nine NCP criteria (the two threshold criteria and the five balancing criteria).

EPA has determined that the selected remedy is cost-effective (Declaration and Section 14.3 of the ROD). EPA believes that the selected remedy is more cost-effective than REM-0/0/3 because the incremental improvements in risk reduction under the more aggressive remedy do not justify its additional $110 million in projected costs.

Master Comment 365920

Commenters indicated that the fact that the cost of the proposed dredging remedy will be relatively large and could be imposed upon a single private party does not support selection of a less expensive remedy. Moreover, it was stated, General Electric has forfeited the right to any leniency with regard to consideration of clean-up costs in choosing a remedy. While cost is one of the nine evaluation criteria that the EPA must consider in selecting its remedy, one comment asserted that the additional cost of Alternative 5 is not an acceptable reason to go with a less comprehensive alternative. Rather than coming to the table and working with EPA to develop a clean-up plan for the Hudson River PCBs, GE has waged an aggressive public relations campaign attacking the EPA's proposal, at an estimated cost of $1-3 million per week. GE may well have already spent the $110 million cost difference for its ad campaign, lobbying activities, and federal lawsuit. Further, it was said, GE has taken an expensive gamble that aggressively fighting the cleanup will save them money in the long run. By rewarding this approach with a weaker cleanup alternative, EPA would in effect be punishing other companies that have complied to their best ability with the federal Superfund cleanup program. The opinion was also expressed that GE can afford to finance the preferred remedy without financial hardship.

Response to Master Comment 365920

EPA has determined that the selected remedy is more cost-effective than the remedial alternative REM-0/0/3. EPA is not "reward[ing]" GE by not selecting the more aggressive remedial alternative, as claimed by one commenter. As indicated in the Proposed Plan (page 27), REM-0/0/3 would cost $110 million more than the selected remedy, without substantial improvements in the amount of ecological or human health risk reduction. The ability of a potentially responsible party to pay for or perform a cleanup is not one of the remedy selection criteria established by CERCLA or the NCP, and GE's ability to pay the costs of a remedy was not a factor that was considered by EPA in making a remedy selection decision for the Site.

Master Comment 364022

A commenter contends that, pound-for-pound, EPA's proposal is projected to cost nearly three times more than the Cumberland Bay project, which, the commenter says is relatively close geographically, and therefore should have similar unit costs.

Response to Master Comment 364022

The costs of environmental dredging at a particular site depend on many factors, including the areas and volumes to be dredged, the number and location of the sediment transfer/processing facilities, the type of transportation used, and the requirements for disposal of the dredged sediments, among others. A very significant portion of the costs for EPA's selected remedy for the Upper Hudson River can be attributed to transportation and disposal costs. The estimated cost for EPA's remedy is based on transportation via rail to various disposal facilities in different parts of the country, including, for cost-estimating purposes, a licensed facility in Texas. At Cumberland Bay, the dredging was limited to a small area, whereas, for the Upper Hudson River, the dredging will be performed along miles of the river. There are many other site-specific differences that also affect the costs. Therefore, EPA believes that it is not valid to make a pound-for-pound cost comparison without considering pertinent details.

Master Comment 493

Commenters have asserted that the proposed remedy violates CERCLA Section 121(b)(1), as encapsulation with Portland cement (EPC) is more expensive and creates a larger volume of toxic materials than vitrification.

Response to Master Comment 493

EPA's remedy does not utilize "encapsulation with Portland cement" as presumed by the commenter. EPA's remedy considers the option of using Portland cement (or another stabilizing agent) for stabilizing and improving the handling properties of the mechanically dredged sediments. Although addition of a stabilizing agent will generate a somewhat larger volume for disposal, stabilization is necessary to prepare mechanically dredged sediments for transportation and acceptance at the disposal facility. Contrary to the statements made in the comment, EPA's FS Report also considered plasma-arc vitrification (developed by Westinghouse) as an option for the potential higher-value beneficial use (FS Report, Section 4.2.8.2 and Table 4-13). Final decisions regarding the use of particular stabilization agents and processes will be made during remedial design.

11.3 Long-term Effectiveness and Permanence

Master Comment 601

Several comments claim that EPA failed to consider smaller, more focused projects to examine whether they would provide comparable benefits to the EPA dredging proposal. A demonstration dredging project should be performed and utilized in the decision to implement the Proposed Plan.

Response to Master Comment 601

EPA has considered both the possibility of a short-duration demonstration project as well as smaller scale remedial efforts in the Upper Hudson River. The latter topic is discussed at length in Chapter 6 of the FS, where the initial model screening runs are described. Several model runs involving lesser areas (such as the REM-10/MNA/MNA and REM-0/MNA/MNA scenarios) were simulated and presented. These model runs failed to show a substantive improvement over the MNA scenario below the Thompson Island Dam and were dropped from further consideration. Thus, it is EPA's conclusion that smaller efforts will not achieve the desired goals in a sufficiently short period of time. The discussion of the model screening process in Chapter 6 of the FS contains further details.

A demonstration project suffers from several limitations involving the scale of the operation, the equipment involved, the added time to the overall project's duration, and a basis by which to establish success. The two last issues are particularly difficult ones. Because it would be at least several years after any removal operation before the full impact of the remediation would be seen in decreased fish-body burdens, the success of a demonstration project could not be measured on the basis of a reduction in fish tissue concentrations until at least four to five years after completion of the project.

Additionally, the effort would have to be quite large in scale (perhaps one-tenth to one-fifth of the removal under the selected remedy) in order to modify an area of sufficient size so that a local population of fish might be affected. If no further remedial operations were performed in the interim while awaiting the outcome of the demonstration project, an additional ton of PCBs would be released from the sediments of the Upper Hudson and transported to the lower river, given the current rate of release. (This estimate of a one-ton release of PCBs is based on the current rate of release of approximately 200 kg/year of total PCBs and the assumption of a five-year waiting period after completion of the demonstration project to observe improved fish body burdens.) Thus, a demonstration project could not be performed and evaluated on the basis of the improvement in fish body burdens without an unacceptable impact on downstream regions and an unacceptable expansion in the length of the overall project.

Many projects involving far larger volumes of sediment have been completed to date. For example, maintenance of the New York, Delaware River, and Chesapeake Bay harbors involves the removal of millions of cubic yards of sediment each year (*e.g.*, USACE, 1996 and 1999). Maintenance of the Mississippi River also involves the removal of similar quantities of sediment. While these projects do not involve highly contaminated sediments such as those in the Hudson, they still require land-based disposal, involving truck or rail transport. The ongoing remediation

of the Ketelmeer (Lake Kettel) in the Netherlands involves the removal of a volume of contaminated sediments much greater than that planned for the selected alternative (Ministerie van Verkeer en Waterstaat, 2001). Thus, while the design requirements for the Hudson may be challenging to the engineers and scientists involved, the effort does not represent an extraordinarily larger effort compared to other ongoing and completed efforts.

Further, evidence of the efficacy of dredging to reduce fish body burdens already exists, so there is no need to conduct a demonstration for this purpose. For example, two recent sites, the Niagara-Mohawk site at Queensbury, New York and the Steele Bayou site (part of the Big Sunflower River Maintenance Project) in Vicksburg, Mississippi have demonstrated a clear improvement of fish body burdens after sediment remediation. At Queensbury, the chief contaminant was PCBs. Data from the NYSDEC clearly document a five-fold decline in fish body burdens after partial sediment removal. (R. Sloan, Pers. Comm., 2001). The reduction in fish PCB concentrations occurred even though it was only a partial sediment removal. (A smaller source condition is still present and further remediation steps for the Queensbury site are under consideration by NYSDEC.) In the Steele Bayou, fish body burdens of DDT declined 85 percent (more than six-fold) after dredging (USACE, 2001). DDT is a pesticide with bioaccumulative properties similar to those of PCBs.

While a demonstration project might confirm the effectiveness of the engineering controls in preventing downstream transport of contamination, a better test than a demonstration project is already available. The 1996-1997 dredging program at New Bedford Harbor collected a large suite of data documenting the effectiveness of the controls implemented during the remediation. As discussed in White Paper – Resuspension of PCBs during Dredging, this project was successful with respect to a number of engineering issues, including the minimization of downstream transport. Thus, rather than relying on a small-scale demonstration effort, it is EPA's intention to employ the techniques and lessons learned at New Bedford Harbor in the remedial design phase of the remedy to minimize downstream transport. Such transport has already been evaluated as part of the FS and found to be negligible in comparison to the annual PCB loads. The original analysis was updated for this responsiveness summary and is included in White Paper – Resuspension of PCBs during Dredging**.**

Although the EPA does not believe a demonstration project would be useful given the above issues, the selected remedy will be conducted in two phases. The first phase will be the first construction season of remedial dredging. The dredging during that year will be implemented initially at less than full-scale operation. It will include an extensive monitoring program of all operations. These monitoring data will be compared to performance standards identified in the ROD or developed during the remedial design with input from the public and in consultation with the State and federal natural resource trustees. In the ROD, EPA has identified performance standards that address air and noise emissions from the dredging operations and the sediment processing/transfer facilities. Performance standards that will be developed during the remedial design phase will address (but may not be limited to) dredging resuspension, production rates, PCB residuals after dredging (or dredging with backfill, as appropriate), PCB air emissions, and community impacts (*e.g.*, odor). The information and experience gained during the first phase of dredging will be used to evaluate and determine compliance with the performance standards. Further, the data gathered will enable EPA to determine if adjustments are needed to operations in the succeeding phase of dredging or if performance standards need to be reevaluated.

References

Ministerie van Verkeer en Waterstaat, 2001. Information Centre Ketelmeer 2001 at http://www.waterland.net/rdij/ketel/exploitatie/indexe.htm accessed on November 1, 2001.

R. Sloan, Pers. Comm., 2001, NYSDEC database release.

USACE, New York Division, 1996. Dredged Materials Management Plan for the Port of New York and New Jersey. Interim report. September 1996.

USACE, New York Division, 1999. Final Feasibility Report for the New York and New Jersey Navigation Study. December.

USACE, 2001. Official News Release, Vicksburg District. "Corps Test Results: Dredging Decreases DDT in Fish Tissue." June 26, 2001.

11.4 Comparison Issues

Master Comment 491

Commenters contended that both source control and the preferred remedy achieve the same degree of compliance with chemical-specific ARARs for surface water concentration. Neither is expected to achieve the more stringent ARARs for surface water and a waiver will be required. Some comments said that the proposed remedy would not comply with location-specific ARARs relating to wetlands, submerged aquatic vegetation, and endangered species.

Response to Master Comment 491

The chemical-specific ARARs for PCBs in the water column are

- 0.5 µg/L (500 ng/L) federal MCL.
- 0.09 µg/L (90 ng/L) NYS standard for protection of human health and drinking water sources.
- 0.014 µg/L (14 ng/L) criteria continuous concentration (CCC) Federal Water Quality Criterion (FWQC) for freshwater.
- 0.03 µg/L (30 ng/L) CCC FWQC for saltwater.
- 1 ng/L federal ambient water criterion for navigable waters.
- 0.12 ng/L NYS standard for protection of piscivorous wildlife.
- 0.001 ng/L NYS standard for protection of human consumers of fish.

It is true that the first four chemical-specific ARARs for surface water listed above are met by all five remedial alternatives, while the other three chemical-specific ARARs for the surface water are not met by any of the five alternatives for the 70-year model forecast period. That these three ARARs apparently cannot be achieved does not mean that there is no difference between remedial alternatives. In fact, the selected remedy achieves a much greater reduction in PCB load to the water column than source control alone.

EPA's analysis of the ability of the different remedial alternatives to approach the lowest chemical-specific ARARs for water column concentrations is provided on page 9-14 of the FS, which is recapped here: "The benefits of active remediation of the sediments are readily apparent in the differences in the trajectories for the MNA alternative and those for the active remediation alternatives…. These differences are most apparent for the first 20 years of the forecast period, between 2005 and 2024." In other words, PCB concentrations in river water are significantly lower under the active remedial alternatives, including the selected remedy, than under MNA during this period. (Note: EPA now expects dredging to commence in 2005. Initiating dredging in 2005 would not be expected to significantly affect modeling projections or the comparative analysis of alternatives.)

EPA agrees that upstream source control alone is predicted by the model to result in reach-averaged water column concentrations that are approximately equivalent to active remediation after approximately 50 years (*e.g.*, by 2045). This convergence, however, will not occur if, as may be the case, the model provides overly optimistic projections of rates of natural recovery under source control. Further, reach-averaged model predictions may not be representative of water column concentrations in the vicinity of sediment *hot spots* under MNA. In contrast, active remediation removes PCBs from the river, and thus has a lower risk of failing to achieve the long-term predictions of water column concentrations.

Location-specific ARARs relating to wetlands (*e.g.*, Executive Order 11990 - Protection of Wetlands, Section 404 of the Clean Water Act and substantive requirements of the New York State Freshwater Wetlands Act) will be satisfied. Section 9.3 of this Responsiveness Summary provides further information on approaches to minimize long-term and short-term impacts associated with the modification or destruction of submerged aquatic vegetation (SAV) and wetlands.

The selected remedy will comply with substantive requirements of the Endangered Species Act (Response to Master Comment 358464, Chapter 1). EPA will conduct biological assessments for the bald eagle (*Haliaeetus leucocephalus*) and shortnose sturgeon (*Acipenser brevirostrum*), which are endangered or threatened species that have been identified as being in the project area. The Karner blue butterfly (*Lycaeides melissa samuelis*) and Indiana bat (*Myotis sodalis*) are also federally listed endangered species that may be found within or adjacent to the project area. Once the locations for the processing/transfer facilities and other necessary land-based infrastructure have been established, EPA will evaluate the habitat that will be affected to determine whether it is suitable to support the Karner blue butterfly or the Indiana bat. If suitable habitat is found, additional assessment work will be conducted for these species.

Long-term benefits to the Hudson River ecosystem overall as a result of PCB reduction outweigh the short-term impacts associated with dredging. With respect to individual ecosystem components (such as wetlands), SAV, and endangered species, implementation of the habitat replacement program would offset impacts associated with dredging. This is addressed extensively in Chapter 9 of this RS. The selected remedy results in greater risk reduction than source control, and in fact the federal Trustees recommend a more aggressive removal alternative than the selected remedy to further reduce risks to the biological community.

Master Comment 405926

Commenters stated their confidence in the capacity of the Hudson River to 'clean itself,' and that it will continue to improve, citing as evidence observed improvements to the health of the river during the last few decades without human intervention. Some commenters indicated that the PCBs are safely buried in the river sediments. Many of these commenters expressed their opposition to dredging and concern with the short- and long-term impacts of dredging on the environment. They stated their preference for reliance on natural attenuation combined with source control. Other commenters felt that the river is not cleaning itself.

Response to Master Comment 405926

Some commenters refer to visual improvements to the river as well as species abundance as a key indicator in their observations of improvement. While these improvements are real, they are not related to the level of PCBs within the river and its biota. Further, while substantial improvements in PCB levels have occurred since the 1970s, many of the observed improvements relate to nutrients, biological oxygen demand (BOD), coliform, etc., as a result of improvements in sewage treatment under the Clean Water Act. EPA believes that the rate of improvement has slowed markedly in recent years, that further improvement is not guaranteed to occur in the short term, and that an active remedy is required (see Response to Master Comment 635, Chapter 2). EPA has found through its analysis that there is no widespread burial of PCBs in the Upper Hudson River. In addition, PCBs stored in sediment in the river cannot be assured to remain stable, and risk recontaminating both the Upper and Lower Hudson (Response to Master Comment 619, Chapter 2).

As stated in the Proposed Plan (*e.g.*, pages 27-29), EPA identified its selected remedy because the agency recognizes the continued harm to human health and the environment posed by the PCBs remaining indefinitely in this sensitive ecosystem under the No Action and MNA alternatives. Those remedial alternatives that do not include active remediation of the sediments are not sufficiently protective of human health and the environment. Relying on the natural attenuation of PCBs in the sediments, either alone or in combination with upstream source control, would result in fish PCB levels remaining above target concentrations for an unacceptably long period of time.

With respect to potential environmental impacts, the FS included an assessment of potential impacts to the environment of the selected remedy, including impacts associated with PCB resuspension (FS, Section 8.5.2.5.), in which EPA concluded that it is unlikely that removal of PCB-contaminated sediments would yield substantively higher PCB concentrations in Upper Hudson River fish during remedial construction. Anticipated PCB resuspension during dredging operations was discussed in greater detail in Appendix E.6 of the FS (Semi-Quantitative Assessment of Water Quality Impacts Associated with Dredging Activities). The FS also included discussions of post-dredging Site reconstruction and habitat replacement (FS, Section 5.2.6), and provided a proposed Habitat Replacement/River Bank Restoration Concept (Appendix E.8) and Habitat Replacement Program Description (Appendix 9) for restoration of dredged areas following remediation.

With respect to the "overall protection of human health and the environment" criterion in the NCP, EPA concluded that the overall protection of human health and the environment afforded

by remedial alternatives that include active remediation of contaminated sediments, including the selected remedy, is "considerably more than that achieved by the No Action and MNA alternatives." (FS, Section 9.1.1.1) For example, the fish PCB target concentration of 0.2 mg/kg (1 meal/month) averaged over the entire Upper Hudson River is expected to be achieved at least 25 years more quickly under REM-3/10/Select than under MNA, while the 0.2 mg/kg target concentration is not met within the 70-year modeling time period under the No Action alternative. (FS, Section 9.1.1.1.) EPA's model also predicts that the 0.4 mg/kg PCB target fish concentration averaged over the entire Upper Hudson River is achieved at least 14 years, and possibly more than 47 years, sooner under REM-3/10/Select than under MNA. EPA also determined that remedies involving active remediation of contaminated sediments show greater reductions in risks to piscivorous mammals (river otter and mink) than either MNA or No Action. (FS, Section 9.1.2)

Based on the comparative analysis of alternatives, EPA determined that active remediation of contaminated sediments is necessary in order to significantly reduce the human health and environmental risks at the Site. Unlike the selected remedial alternative, the alternatives which do not require removal of PCB-contaminated sediments are not sufficiently protective of human health and the environment (FS, Section 9.1.1.1). Further, the potential transportation, noise, odor and lighting impacts, as well as impacts from construction and operation of the processing/transfer facility(ies) are not expected to be significant, or can be minimized through appropriate controls. Chapter 8 of this Responsiveness Summary and several white papers (*e.g.*, Project-Related Traffic; Noise Evaluation; Odor Evaluation; Example Sediment Processing/Transfer Facilities, etc.) contain additional relevant discussion.

Master Comment 337780

A commenter suggested that the FS (p. 9-13) was incorrect in stating that loads over the Federal Dam are similar by the year 2035 for the various remedial alternatives. The commenter pointed out that the modeled Tri+ PCB loads over the Federal Dam in 2035 are respectively about 16 percent, 17 percent, and 25 percent lower than MNA under CAP-3/10/Select, REM-3/10/Select, and REM-0/0/3. The commenter also stated that at the more upstream TID and Northumberland Dams the active remedies achieve a reduction in loads of greater than 30 percent relative to MNA by 2035.

Response to Master Comment 337780

The commenter is correct: The three remedial options all result in lower Tri+ PCB loads over Federal Dam in 2035 than does MNA, with the smallest predicted loads to the lower river resulting from REM-0/0/3. As noted in the comment, the 2035 annual load across Federal Dam under REM-0/0/3 is 25 percent less than the load associated with MNA, while the 2035 annual load across Thompson Island and Northumberland Dams under REM-0/0/3 is about 30 and 40 percent less than the load predicted for MNA, respectively.

The sentence on page 9-13 was intended to note that both the absolute and relative predicted differences between the remedial options and MNA, in terms of annual load across Federal Dam,

decline over time. This occurs because the predicted PCB load becomes increasingly controlled over time by the value assumed for the upstream PCB load.

The EPA recently revised the Tri+ to Total PCB ratio for various regions of the river based on the available data obtained by the EPA and GE. The description of this analysis can be found in the White Paper - Relationship Between Tri+ and Total PCBs. Due to this revision, the Total PCB transport by the river required an adjustment. The predicted annual Tri+ and Total PCB loads transported downriver for several representative years are summarized in Table 337780-1.

For comparing loads to the lower river, it is probably more informative to examine cumulative loads than loads from a single year. Table 337780-2 compares cumulative Tri+ (extracted from Table 8-3 in the FS) and Total PCB loads over Thompson Island, Northumberland, and Federal Dams from 2004 (assumed start of remediation in modeling) to 2067. (Note: EPA now expects dredging to commence in 2005. Initiating dredging in 2005 would not be expected to significantly affect modeling projections or the comparative analysis of alternatives.) As shown in the table, the three active remedial options reduce the total PCB loading to the lower river (at Federal Dam) by from 23 to 32 percent. The table also contains the estimate for the cumulative load delivered to the Lower Hudson with the assumption of 2.5 percent loss due to resuspension. Although the EPA does not consider this rate of loss to be realistic, the scenario still yields a small (2 percent) net reduction of Total PCB and Tri+ delivered to the Lower Hudson relative to the MNA alternative.

Reference

USEPA, 2000. Response to Peer Review Comments on the Data Evaluation and Interpretation Report (DEIR) and the Low Resolution Sediment Coring Report (LRC). Prepared for USEPA Region 2 and US Army Corps of Engineers, Kansas City District by TAMS Consultants, Inc. and TetraTech, Inc. November.

11.5 Benefits vs. Risks

Master Comment 421

A number of commenters contend that the potential short-term impacts of EPA's preferred remedy outweigh the benefits. Others say that EPA's failure to consider adverse impacts is arbitrary, capricious, and an abuse of discretion.

Response to Master Comment 421

EPA disagrees that the Agency failed to consider adverse short-term impacts of the selected remedy. The Feasibility Study provides information concerning potential short-term risks associated with remedial alternatives for the Site that is "sufficient to support an informed risk management decision regarding which remedy appears to be most appropriate" for the Site (USEPA, RI/FS Guidance, 1988, Section 1.1). In accordance with the NCP (40 CFR

300.430(e)(9)), the FS includes a detailed analysis of remedial alternatives that evaluated, among other things, the overall protection of human health and the environment afforded by each alternative, and an assessment of the potential short-term risks associated with each alternative (FS Chapters 8 and 9).

Under the "overall protection of human health and the environment" criterion (40 CFR § 300.430(e)(9)(iii)(A)), EPA evaluated the degree to which the remedial alternatives provide adequate protection of human health and the environment from unacceptable risks posed by PCBs at the Site, and compared the relative protection afforded by each alternative. Under the short-term effectiveness criterion, EPA evaluated and compared the potential short-term impacts of the remedial alternatives, including:

i. Short-term risks that might be posed to the community during implementation.
ii. Potential impacts on workers during implementation, including protective measures.
iii. Potential adverse environmental impacts resulting from construction and implementation, and the effectiveness of mitigative measures.
iv. Time until remedial response objectives are achieved.

The assessment of short-term effectiveness included general discussions of how certain short-term risks would be minimized during implementation (FS, Section 8.5.2.5). The FS indicated that potential short-term impacts of remedial alternatives could be sufficiently mitigated during implementation of the remedy. For example, monitoring and engineering controls will be employed to minimize short-term effects due to material processing activities at the dewatering/transfer facility(ies); access to these facilities will be restricted to authorized personnel; and potential occupational risks to workers would be addressed through a Site-specific health and safety plan, compliance with OSHA health and safety procedures, and use of appropriate personal protection equipment (FS, Sections 8.5.2.5 [Short-Term Effectiveness evaluation of REM-3/10/Select] and 9.5.1 [Comparative Analysis of Alternatives, Short-Term Effectiveness]).

Potential impacts associated with additional truck traffic are expected to be minimal because transportation of sediments for off-site disposal would be accomplished via rail. Further, potential impacts of in-river work would be minimized by restricting access to work zones, and by creating an adequate buffer zone to allow commercial and pleasure craft to avoid such zones (FS, Sections 8.5.2.5 and 9.5). It should be noted that, if a beneficial use of some portion of the dredged materials is arranged, then an appropriate transportation method will be determined (*e.g.*, rail, truck, or barge) (ROD, Section 13.1). Under a beneficial use scenario, there will be a preference for modes of transportation other than trucking.

With respect to potential environmental impacts, the FS included an assessment of potential impacts of the selected remedy to the environment, including impacts associated with PCB resuspension (FS, Section 8.5.2.5), in which EPA concluded that it is not expected that removal of PCB-contaminated sediments would yield substantively higher PCB concentrations in Upper Hudson River fish during remedial construction. Anticipated PCB resuspension during dredging operations was discussed in greater detail in Appendix E.6 of the FS (Semi-Quantitative Assessment of Water Quality Impacts Associated with Dredging Activities). The FS also included discussions of post-dredging site reconstruction and habitat replacement (FS, Section 5.2.6), and provided a proposed Habitat Replacement/River Bank Restoration Concept

(Appendix E.8) and Habitat Replacement Program Description (Appendix 9) for restoration of dredged areas following remediation.

With respect to the "overall protection of human health and the environment" criterion in the NCP, EPA concluded in the FS that the overall protection of human health and the environment afforded by remedial alternatives that include active remediation of contaminated sediments, including the selected remedy, is "considerably more than that achieved by the No Action and MNA alternatives" (FS, Section 9.1.1.1). For example, the fish PCB target concentration of 0.2 mg/kg (one meal/month) averaged over the entire Upper Hudson River is expected to be achieved at least 25 years more quickly under REM-3/10/Select than under MNA, while the 0.2 mg/kg target concentration is not met within the 70-year modeling time period under the No Action alternative (FS, Section 9.1.1.1). In the FS, EPA's model also predicts that the 0.4 mg/kg PCB target fish concentration averaged over the entire Upper Hudson River is achieved at least 14 years, and possibly more than 47 years, sooner under REM-3/10/Select than under MNA. EPA also determined that remedies involving active remediation of contaminated sediments show significantly greater reductions in risks to piscivorous mammals (river otter and mink) than either MNA or No Action (FS, Section 9.1.2).

It should be noted that the comparisons of remedial alternatives presented above are based on model runs that were performed for the Feasibility Study. In White Paper – Model Forecasts for Additional Simulation in the Upper Hudson River and White Paper – Human Health and Ecological Risk Reduction under Phased Implementation, EPA presents the results of additional model runs that were performed after issuance of the Proposed Plan. These model runs reflect the revised remediation schedule of six years (versus five years in the Feasibility Study and Proposed Plan) and possible impacts of PCBs' being remobilized during dredging. No significant differences in human health or ecological risk reduction were seen between the original five-year and new extended phasing time frames. The new model runs are consistent with EPA's determination, discussed in the Feasibility Study and the Proposed Plan, that active remediation will reduce risks to humans and wildlife, and allow fish target concentrations to be met more quickly than without active sediment remediation.

Based on the comparative analysis of alternatives, EPA determined that active remediation of contaminated sediments is necessary in order to significantly reduce the human health and environmental risks at the Site. Unlike the selected remedial alternative, the alternatives which do not require removal of PCB-contaminated sediments and the use of dewatering/transfer facility(ies) are not sufficiently protective of human health and the environment (FS, Section 9.1.1.1).

Further, the potential transportation, noise, odor, and lighting impacts, as well as impacts from construction and operation of the processing/transfer facility(ies), are not expected to be significant, or can be minimized through appropriate controls (Chapter 8 of this Responsiveness Summary and associated white papers). Consequently, EPA has determined that the potential short-term impacts of the selected remedy, which can be minimized, are substantially outweighed by the remedy's benefits to human health and the environment over the long term. These potential and controllable short-term impacts do not justify the selection of a remedy such as MNA that provides substantially less protection of human health and the environment.

Response to Master Comment 313728 in Chapter 1 of this Responsiveness Summary addresses similar issues to those raised by Master Comment 421.

Reference

USEPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (OSWER Directive 9355.3-01 [1988]).

Master Comment 485

Commenters contend that the proposed plan would be an environmental disaster and provides no obvious benefit to the environment, the citizens, or to the development, peace, and harmony of communities. Several commenters believe the river is cleaning itself naturally and will continue to improve. Some contend that the proposed remedy would do more harm than good, and cited risks associated with the remedy. Other comments expressed doubt that the selected remedy would be able to achieve the proposed degree of removal.

Response to Master Comment 485

EPA believes that the selected remedial action is necessary in order to remove the continued unacceptable threat to human health and the environment posed by the PCBs and to restore this beautiful natural resource for the use and enjoyment of all citizens in the region, including those who live near the river as well as those who live downstream. The federal Natural Resource Trustees and the State of New York also are supportive of EPA's decision to dredge and remove contaminated sediment from the Hudson River environment, although the federal Trustees believe that further natural resource benefits would accrue from additional environmental dredging.

With regard to the river's cleaning itself, while substantial improvements in river conditions have occurred since the 1970s, EPA notes that the rate of improvement has slowed markedly in recent years, that further improvement is not guaranteed to occur in the short term, and that an active remedy is required to assure continued recovery (Responses to Master Comments 405926, Chapter 4, and 635 in Chapter 2). In addition, PCBs buried in sediment in the river cannot be assured to remain stable, and present an ongoing risk of recontaminating both the Upper and Lower Hudson (Response to Master Comment 619, Chapter 2).

EPA agrees that there may be risks associated with the selected remedy, although the Agency believes that such risks, which can be minimized, are substantially outweighed by the remedy's benefits to human health and the environment. The potential risks associated with the selected remedy fall into two classes: the potential short-term risks associated with performing the remedy, and the potential long-term risk that the selected remedy will not improve conditions. These are discussed further below.

Short-term Risks

Potential short-term risks of performing the selected remedy are discussed in a number of responses to comments in this document, including particularly Responses to Master Comments

421, Section 11.4 (whether the short-term risks outweigh benefits) and 705, Chapter 8 (addressing concerns about potential disruption associated with the project). Other specific references that contain relevant detail include Responses to Master Comments 553, Chapter 7 (human health and ecological risks of performing the remedy); 505, 555, and 733, in Chapter 8 (impacts on scenic, recreational, and economic uses of the river, risks, and quality of life, respectively); 807, Chapter 3 (impacts on wildlife); 583, Chapter 10 (resuspension and downstream transport during dredging); and 313723, Chapter 1 (risks to workers). As outlined in those responses, EPA has determined that the short-term risks are both limited and manageable, and are far outweighed by the benefits of the selected remedy.

Many of the comments on short-term risks were concerned with the ability of dredging technology to achieve the projected results. There have been significant advances in dredging technology over the last decade (Response to Master Comment 657, Chapter 5), and modern hydraulic and mechanical dredging are capable of achieving low residual contamination without significant resuspension of contaminants (Response to Master Comment 583, Chapter 10 and White Paper - Resuspension of PCBs during Dredging).

EPA recognizes that there may be some short-term impacts to the local communities while the remedy is being implemented, but the Agency believes that these impact(s) will be minor, temporary, and very localized. During the design phase of the project, additional analyses of such potential impacts will be performed. EPA anticipates that its monitoring program will enable the Agency to effectively monitor and mitigate short-term adverse impacts, if any, during implementation of the remedy. In addition, as a matter of policy, EPA will seek public comment on potential locations for the sediment processing facility (or facilities) before making a final decision about facility location(s), and will also accept public input on design aspects of the facility(ies) related to potential noise, lighting and other impacts, as described in the ROD.

Long-term Risks

EPA believes that concerns that the selected remedy will fail to improve conditions or make conditions worse are not well founded. As described in the FS, EPA's simulation modeling indicates that the selected remedy will result in a substantial reduction in risks to both human and ecological health in the Upper Hudson River (FS, Chapter 9; Response to Master Comment 565, Chapter 7). The selected remedy is also expected to result in reduced risk in the Lower Hudson River (Response to Master Comment 413, Chapter 1).

The benefits of EPA's selected remedy include, among others, the following:

- Permanent remedy that reduces inventory (mass) of PCBs that are or may be bioavailable.
- Significant reduction in risks to human health.
- Reduction in time required to reach target concentrations in fish tissue.
- Decreased time to reopening of all fisheries with attendant long-term economic benefits.
- Reduced risks to ecological health.
- Ability to resume navigational dredging and maintain navigation in the Champlain Canal, New York harbor, and other areas.

- Subsequent improvements to tourism and the area's economy as a result of the improved navigability.

EPA believes that the assumptions used in GE's modeling that shows little or no benefit associated with the selected remedy relative to source control alone are inappropriate, do not reflect the abilities of current dredging technology, and are not supported by evidence from other sites. The predictions presented by GE are the result of a set of assumptions regarding production rate of dredging, releases during dredging, and residual left after dredging that differ from those developed by EPA and collectively reduce the apparent benefit of dredging. GE's alternative modeling predictions are discussed in greater detail in Response to Master Comment 823, Chapter 6.

EPA believes that concerns that the selected remedy will not achieve the projected degree of removal are misplaced. Modern dredging technology is fully capable of achieving the PCB mass removal and residual concentration targets set out in the FS (Response to Master Comment 366358, Chapter 5, and White Paper - Post-Dredging PCB Residuals). Finally, a substantial body of evidence from other sites indicates that dredging projects can indeed produce significant reductions in PCB concentrations in the environment and in biota. Response to Master Comment 337860, Section 11.4 in this chapter contains further details.

In sum, EPA has determined that the selected remedy is feasible and will provide significant long-term benefits for the Hudson River. The benefits of remediation fare outweigh potential short-term impacts, which can be minimized.

11.6 Other

Master Comment 487

Commenters asked why EPA believes it is administratively feasible to locate a sediment processing facility along the Hudson, but not a disposal facility. They noted that past experience at this Site suggests that neither can be sited, and asked whether EPA will submit itself to and abide by State and local requirements for waste storage and treatment facilities.

Response to Master Comment 487

EPA has determined that it is administratively feasible to locate a sediment processing/transfer facility(ies) close enough to the river to be considered "on site" for purposes of CERCLA Section 121(e)(1), and therefore no federal, State, or local permits would be required for such facility(ies). In accordance with CERCLA Section 121(d), such facility(ies) will comply with substantive federal or State requirements that are applicable or relevant and appropriate (ARAR). Local regulations are not ARARs under CERCLA, although EPA will consider pertinent local regulations regarding sediment processing/transfer facility(ies) (if such local regulations exist) during the design phase for the facility(ies). EPA notes that such sediment processing/transfer facilities have been used at other locations with no significant adverse or long-term impacts. Such locations include the Marathon Battery Superfund site, the Niagara Mohawk Queensbury site, and Wilcox Dock at the Cumberland Bay site on Lake Champlain.

While EPA recognizes that there may be some short-term impacts to the local communities during implementation of the remedy, the Agency believes that these impact(s) will be minor, temporary, and very localized. During the design phase of the project, additional analyses of such potential impacts will be performed. EPA anticipates that its monitoring program will enable the Agency to effectively monitor and mitigate short-term adverse impacts, if any, during implementation of the remedy. In addition, as a matter of policy, EPA will seek public comment on potential locations for the sediment processing facility(ies) before making a final decision about facility location(s) and will also accept public input on design aspects of the facility(ies) related to potential noise, lighting, and other impacts, as described in the ROD.

Master Comment 364004

One commenter states that the copy of the administrative record file for the Site located in the Crandall Library in Glens Falls, New York, is not properly maintained. According to the comment, non-privileged and privileged documents are not promptly added to the administrative record file. Further, the administrative record file index is incomplete because it does not include a list of documents considered by EPA to be privileged or confidential, or a list of administrative record documents that are not maintained at the repository. The commenter also argues that EPA has not assessed or supported the ability of the Crandall Library to maintain the administrative record file, that the library does not maintain a sign-in book to minimize document loss or damage, and that documents in the Crandall Library administrative record file are maintained in a "highly chaotic fashion" and are interspersed with documents concerning unrelated manners. The commenter further argues that by not updating the administrative record file in a timely manner, and by not assessing and supporting "the Crandall Library's ability to maintain this enormous and highly controversial record, USEPA has prevented effective public participation by the communities who will be most affected by USEPA's remedial determinations."

Response to Master Comment 364004

EPA disagrees that the administrative record file for this Site has been maintained in such a way as to "prevent effective public participation" with respect to the Site. The administrative record file has been established and maintained in accordance with CERCLA and the NCP, and has been updated a number of times during the course of the study (February 1998, December 2000, June 2001). During the public comment period on the Proposed Plan, the publicly available administrative record file for the Site contained sufficient information regarding the basis for EPA's proposed remedy for the public to provide meaningful comments on the Agency's proposal.

In accordance with CERCLA and the NCP, EPA maintains the central Hudson River PCBs Superfund Site administrative record file at EPA's Region 2 offices in New York. Copies of the administrative record are also maintained at or near the Site at the Crandall Library in Glens Falls, New York and the Adriance Memorial Library in Poughkeepsie, New York. At the Crandall and Adriance Memorial Libraries, the administrative record is maintained in binders that include an index of the original administrative record file and all updates. EPA periodically inspects each of the administrative record repositories to ensure that the administrative record file is intact and available to the public, and has generally found the administrative record file at

the Crandall Library to be in good condition. EPA is aware of no complaints from a member of the public stating that a specific document listed in the administrative record file index at the Crandall Library could not be located. Since the administrative record file documents are kept in binders, it is unclear as to how "portions of the record" are "mixed in with public documents on unrelated topics," as claimed by the commenter. In any event, all records added to the administrative record file since June 2001 are on CD-ROM, which will minimize the likelihood of administrative record documents being separated or disorganized.

Each transmittal of administrative record documents to the Crandall and Adriance Memorial Libraries includes a letter from EPA stating that the record should be made available to the public as non-circulating reference material that should not be removed from the facility. While EPA maintains a sign-in book at the central administrative file location in New York, the library repositories are not required to maintain a sign-in book. The fact that the Crandall Library may not require members of the public to sign their names before reviewing the administrative record in no way diminishes the public's access to documents in the record.

During the public comment period for the Proposed Plan, the administrative record file index did not identify any privileged documents that were included in the administrative record file because EPA had not identified any privileged documents for inclusion in the record at that time. The administrative record file index also did not include a list of documents included in the record but not maintained at the Crandall Library repository because no such documents had been formally added to the record as of December 2000.

In addition to the administrative record files in New York, Glens Falls, and Poughkeepsie, EPA also has established sixteen information repositories throughout the Hudson River valley, including the Crandall Library and Adriance Memorial Library, in which Site-related documents, including the major Reassessment RI/FS reports, are available to the public. The information in the repositories has been regularly updated throughout the Reassessment RI/FS. The major Reassessment reports as well as other information concerning the Site are also available on EPA's website for the Hudson River PCBs Site, http://www.epa.gov/hudson. These repositories and the website provided additional opportunities for the public to obtain information concerning the Site and the basis for EPA's proposed remedy.

In sum, the Administrative Record for the Site has been established and maintained in accordance with CERCLA and the NCP, and EPA disagrees that the issues raised by the commenter "prevent[ed] effective public participation" with respect to the Site.

Master Comment 362628

Comments argue that there is a contradiction in the duration (10 years or 25 years?) of the long-term monitoring of remedial actions proposed in the FS. Commenters suggest that a 30-year monitoring program be implemented in the Upper and Lower Hudson (the entire Hudson River Superfund Site) in order to evaluate the ongoing potential risks to human health and the environment, and to verify that the final results have complied with the ARARs and RAOs.

Response to Master Comment 362628

In the FS, EPA developed conceptual monitoring programs for each alternative evaluated in detail. The costs associated with these conceptual monitoring programs were estimated up to 30 years; monitoring costs were not considered beyond 30 years because such costs do not add appreciably to the present-worth costs of the remedial alternatives (year 2000 dollars).

The 10-year and 25-year monitoring durations are for different components of the conceptual monitoring programs in the FS. For the removal alternatives, the scope and frequency of water column monitoring was assumed to decrease after 10 years. For all active alternatives (capping and removal), the fish monitoring program was assumed to continue for 25 years in the Upper and Lower Hudson River.

The monitoring program for the selected remedy will be established during the design period. This monitoring program will continue, modified as appropriate, until the RAOs are achieved and the ARARs that are not waived are attained.

Master Comment 481

One comment said that there is no imminent and substantial endangerment, so EPA is precluded from issuing a unilateral order implementing its plan.

Response to Master Comment 481

EPA disagrees. The release and threatened release of PCBs to the Hudson River constitutes an imminent and substantial endangerment to the public health or welfare or the environment within the meaning of CERCLA Section 106(a), 42 U.S.C. § 9606(a). The administrative record amply supports this position.

Master Comment 359565

A commenter contends that the discussion on page ES-25 of the FS concerning the adequacy of controls again illustrates EPA's desire to cast actions contrary to its desired action in a bad light. The commenter asked why institutional controls are "inadequate" when considered with MNA but simply are "provided" when discussing the REM-3/10/Select and REM-0/0/3 alternatives. However, the commenter adds, it "is refreshing to see EPA admit institutional controls are effective and also on page 1-34 to see EPA recognize the problems introduced by the high degree of heterogeneity in the PCB distribution in the Thompson Island Pool."

Response to Master Comment 359565

EPA has provided an objective analysis of the adequacy of controls under the Long-term Effectiveness and Permanence primary balancing criterion, consistent with the requirements stated in the NCP and the 1988 RI/FS Guidance document. EPA has stated that the No Action and the MNA alternatives do not provide for engineering controls on the river sediments. This is an accurate statement based on the factual description of these two alternatives and does not

represent "EPA's desire to cast actions contrary to its desired action in a bad light" as indicated in the comment. EPA has also explained that institutional controls such as the fish consumption advisories, which rely on voluntary compliance, have not eliminated all fish consumption (and related cancer risks and non-cancer hazards) at the Site. Further, institutional controls like "posting of warnings and advisories" do not serve to protect piscivorous ecological receptors like the otter, the mink, and the bald eagle, among others.

When discussing REM-3/10/Select and REM-0/0/3, EPA has stated that institutional controls will be used in conjunction with implementation of the engineering controls (*i.e.*, removal of the sediments, backfilling, restoration, and monitoring). No Action and MNA necessarily rely much more heavily on institutional controls than the active alternatives because of the significantly longer time periods required to reach PCB target levels in fish under MNA and No Action. EPA does not believe that institutional controls alone are fully effective in preventing exposure to PCBs via consumption of contaminated fish. That is why EPA has proposed dredging of the sediments and restoring this valuable resource in New York State.

EPA has recognized the existence of a high degree of heterogeneity in the PCB distribution in the sediments of the Thompson Island Pool since the 1984 NYSDEC survey and reiterated this in several of the Reassessment Remedial Investigation reports.

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JANUARY 2002

For

U.S. Environmental Protection Agency
Region 2
and
U.S. Army Corps of Engineers
Kansas City District

BOOK 2 OF 3

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TAMS Consultants, Inc.

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ACGIH	American Conference of Governmental Industrial Hygienists
ACHP	Advisory Council on Historic Preservation
AGC	Annual Guideline Concentration
AOC	Administrative Order on Consent
ANOVA	Analysis of Variance
APEG	Alkaline (Alkali Metal Hydroxide) Polyethylene Glycol
ARAR	Applicable or Relevant and Appropriate Requirement
ARCC	Adirondack Regional Chambers of Commerce
ARCS	Assessment and Remediation of Contaminated Sediments Program
ATSDR	Agency for Toxic Substance and Disease Registry
AWQC	Ambient Water Quality Criterion
BAT	Best Achievable Technology
BBL	Blasland, Bouck, and Lee
BCD	Base-Catalyzed Decomposition
BMR	Baseline Modeling Report
CADD	Computer-Aided Drafting and Design
CDF	Confined Disposal Facility
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CIP	Community Interaction Program
CLU-IN	Hazardous Waste Clean-up Information (EPA web site)
COC	Chemical(s) of Concern
COPC	Chemical(s) of Potential Concern
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CT	Central Tendency
CWA	Clean Water Act
CZM	Coastal Zone Management
DEIR	Data Evaluation and Interpretation Report
DMR	Discharge Monitoring Report
DNAPL	Dense Non-Aqueous Phase Liquid
DOC	Dissolved Organic Carbon
DOSM	Depth of Scour Model
DOT	Department of Transportation
DRE	Destruction and Removal Efficiency
ECD	Electron Capture Detector
ECL	Environmental Conservation Law (New York)
EE/CA	Engineering Evaluation/Cost Analysis
EEC	Extreme Effect Concentration
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ESA	Endangered Species Act
ETWG	Engineering/Technology Work Group
FAIR	Farmers Against Irresponsible Remediation

FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FR	Federal Register
FRTR	Federal Remediation Technologies Roundtable
FS	Feasibility Study
FSSOW	Feasibility Study Scope of Work
FWIA	Fish & Wildlife Impact Analysis
g/m^2	Grams per meter squared
GAC	Granular Activated Carbon
GC	Gas Chromatography
GCL	Geosynthetic Clay Liner
GE	General Electric Company
GIS	Geographic Information System
GLNPO	(EPA's) Great Lakes National Program Office
GRA	General Response Action
HDPE	High Density Polyethylene
HHRA	Human Health Risk Assessment
HHRASOW	Human Health Risk Assessment Scope of Work
HI	Hazard Index
HMTA	Hazardous Materials Transportation Act
hp	Horsepower
HQ	Hazard Quotient
HROC	Hudson River PCB Oversight Committee
HSI	Habitat Suitability Index
HTTD	High Temperature Thermal Desorption
HUDTOX	Upper Hudson River Toxic Chemical Model
IBI	Index of Biotic Integrity
IRIS	Integrated Risk Information System
ITT	Innovative Treatment Technologies (database)
kg	Kilogram
KPEG	Potassium polyethylene glycol
LOAEL	Lowest Observed Adverse Effect Level
LRC, LRCR	Low Resolution Sediment Coring Report
LTI	LimnoTech, Inc.
LTTD	Low Temperature Thermal Desorption
LWA	Length-Weighted Average
MANOVA	Multivariate Analysis of Variance
M&E	Metcalf and Eddy
MBI	Macroinvertebrate Biotic Index
MCA	Menzie-Cura and Associates
MCACES	Cost Estimating Software (USACE)
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDEQ	Michigan Department of Environmental Quality
MDPR	Molar Dechlorination Product Ratio
MEC	Mid-Range Effects Concentration
mg/kg	Milligrams per Kilogram (generally equivalent to parts per million, or ppm)
mg/L	Milligrams per Liter (generally equivalent to ppm)
MNA	Monitored Natural Attenuation
MPA	Mass per Unit Area

MS	Mass Spectroscopy
NAAQS	National Ambient Air Quality Standards
NAICS	North American Industry Coding System
NAS	National Academy of Sciences
NCP	National Oil Spill and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
ng/L	Nanograms per Liter, parts per trillion
NHPA	National Historic Preservation Act
NiMo	Niagara Mohawk Power Company
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NPL	National Priorities List
NRC	National Research Council
NTCRA	Non-Time Critical Removal Action
NYCRR	New York Code of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOL	New York State Department of Labor
NYSDOT	New York State Department of Transportation
NYSPDES	New York State Pollutant Discharge Elimination System
O&M	Operation and Maintenance
OPRHP	Office of Parks, Recreation, and Historic Preservation
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response (EPA)
OU	Operable Unit
PCB	Polychlorinated Biphenyl
PCRDMP	Post-Construction Remnant Deposit Monitoring Plan
PEL	Probable Effects Level
PMCR	Preliminary Modeling Calibration Report
ppm	part(s) per million (mg/kg or mg/L)
PRG	Preliminary Remediation Goal
PSG	Project Sponsor Group
PVC	Polyvinyl Chloride
RAMP	Remedial Action Master Plan
RAO	Remedial Action Objective
RBC	Risk-Based Concentration
RBMR	Revised Baseline Modeling Report
REACH IT	Remediation and Characterization Innovative Technologies (EPA database)
RfD	Reference Dose
RI/FS	Remedial Investigation/Feasibility Study
RI	Remedial Investigation
RIMS	Remediation Information Management System
RM	River Mile
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SAV	Submerged Aquatic Vegetation
SEC	Sediment Effect Concentration
SHPO	State Historic Preservation Office
SITE	Superfund Innovative Technology Evaluation Program
SPDES	State Pollution Discharge Elimination System

SQRT	Screening Quick Reference Tables
STC	Scientific and Technical Committee
T&E	Threatened and Endangered
TAG	Technical Assistance Grant
TAGM	Technical Assistance Guidance Memorandum (NYSDEC)
TBC	To-be-considered
TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin
TCP	2,4,6-Trichlorophenol
TEC	Threshold Effect Concentration
TEF	Toxicity Equivalency Factor
TEQ	(Dioxin-like) Toxic Equivalent Quotient
TI	Thompson Island
TID	Thompson Island Dam
TIN	Triangulated Irregular Network
TIP	Thompson Island Pool
TLV	Threshold Limit Value
TOC	Total Organic Carbon
TOGS	Technical and Operational Guidance Series (NYSDEC)
TOPS	Trace Organics Platform Sampler
TQ	Toxicity Quotient
TR	Target Risk
TRV	Toxicity Reference Value
TSCA	Toxic Substances Control Act
TWA	Time-Weighted Average
UCL	Upper Confidence Limit
UET	Upper Effects Threshold
µg/kg	Micrograms per Kilogram, (generally equivalent to parts per billion, or ppb)
µg/L	Micrograms per Liter, (generally equivalent to parts per billion, or ppb)
USACE	United States Army Corps of Engineers
USBEA	United States Bureau of Economic Analysis
USBLS	United States Bureau of Labor Statistics
USC	United States Code
USDOC	United States Department of Commerce
USDOD	United States Department of Defense
USDOE	United States Department of Energy
USDOI	United States Department of Interior
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VISITT	Vendor Information System for Innovative Treatment Technologies (EPA Program)
VLDPE	Very Low Density Polyethylene
WHO	World Health Organization

CONTAMINANT RISKS AND GEOCHEMISTRY

PCB Carcinogenicity
362702

No Figures or Tables

WHITE PAPER - PCB CARCINOGENICITY

(ID 362702)

ABSTRACT

EPA classifies PCBs as probable human carcinogens based on data showing that PCBs cause cancer in animals and inadequate but suggestive evidence that PCBs cause cancer in humans. EPA's guidelines for classifying the carcinogenicity of chemicals are consistent with the approaches used by other national and international agencies. Moreover, EPA's Weight of Evidence classification of PCBs as probable human carcinogens has been externally peer reviewed and is equivalent to the classifications of the National Toxicology Program, the National Institute of Occupational Safety and Health, and the International Agency for Research on Cancer, part of the World Health Organization.

In the Human Health Risk Assessment for the Hudson River PCBs Site, EPA used the current externally peer-reviewed toxicity values for PCB carcinogenicity (*i.e.*, cancer slope factors) contained in the Integrated Risk Information System, which is the Agency's consensus database of toxicity information. In the Human Health Risk Assessment, EPA summarized recent human epidemiological studies published since the 1996 PCB Cancer Reassessment. Based on a review of these newer studies, EPA determined that no change was necessary to EPA's classification of PCBs as probable human carcinogens. In the Human Health Risk Assessment, cancer risks from dioxin-like PCBs were calculated using current Toxicity Equivalency Factors developed by the World Health Organization. EPA submitted the Human Health Risk Assessment for external peer review. The peer reviewers agreed with the toxicity values EPA used in the Human Health Risk Assessment.

INTRODUCTION

The purpose of this paper is to provide an overview of EPA's process for evaluating the carcinogenicity of a chemical, development of cancer slope factors for PCBs, and the application of this toxicity information in the Human Health Risk Assessment for the Hudson River PCBs Site.

This paper is divided into four parts. The first part describes the history and development of the Agency's guidelines for carcinogenicity (USEPA, 1976, 1980, 1983a,b, 1984, 1986, 1994, 1996a, 1999a). Specific issues addressed in the guidelines include EPA's PCB Weight of Evidence classification, procedures for evaluating human epidemiological evidence and animal toxicity studies, and the use of this information in classifying the carcinogenicity of a chemical.
The second part of this paper describes the Agency's evaluation of the carcinogenicity of PCBs. It summarizes the important human epidemiological and animal studies evaluated during the 1996 Cancer Reassessment for PCB carcinogenicity (USEPA, 1996b), presents some of the new information on the cancer toxicity of PCBs evaluated by EPA since 1996, and presents the current cancer slope factors in the Integrated Risk Information System (IRIS), the Agency's consensus database of toxicity information (USEPA, 1999b).

The third part provides a list of published papers describing some of the PCB toxicity research conducted by EPA scientists in the past five years, including studies of the mechanisms by which PCBs cause cancer and other adverse health effects.

The fourth part of this paper addresses the use of PCB cancer toxicity information in the Human Health Risk Assessment (HHRA) for the Hudson River PCBs Site (USEPA, 2000a-d). Specifically, this section discusses the use of cancer toxicity information (*e.g.*, cancer slope factors) in IRIS and the toxic equivalency factors (TEFs) for dioxin-like PCBs. This section also describes the Agency's rationale for not using blood PCB levels in workers to evaluate cancer risks for people who eat PCB-contaminated fish from the Hudson River.

DEVELOPMENT OF EPA CARCINOGEN GUIDELINES

EPA's Carcinogen Guidelines (USEPA, 1976, 1983a,b, 1984, 1986, 1994, 1996a, 1999a) were used in determining the carcinogenicity of PCBs. These guidelines provide EPA's general framework for evaluating the cancer toxicity data (human and animal) for determining the Weight of Evidence classifications and cancer slope factors of chemicals. The Carcinogen Guidelines were developed after an evaluation of the procedures used by the International Agency for Research on Cancer (IARC), which is part of the World Health Organization (WHO) and the National Toxicology Program (NTP), which is part of the National Institutes of Health.
In 1976, EPA issued interim procedures and guidelines for health risks and economic impact assessments of suspected carcinogens (USEPA, 1976). In 1979, the Interagency Regulatory Liaison Group held a meeting regarding carcinogens and methods for evaluating the technical adequacy of animal toxicity studies (IRLG, 1979).

In 1982, IARC issued a monograph on the evaluation of the carcinogenic risk of chemicals to humans (IARC, 1982). In 1984, NTP's Ad Hoc Panel on Chemical Carcinogenesis Testing and Evaluation issued a report regarding selection of dose levels for long-term animal studies (NTP, 1984).

In 1984, EPA began its work on the Guidelines for Carcinogen Risk Assessment (USEPA, 1984). Draft guidelines were developed by a workgroup composed of expert scientists from throughout the Agency. The draft was externally peer reviewed by expert scientists in the field of carcinogenesis and related scientific disciplines, from universities, environmental groups, industry, labor and other governmental agencies. The guidelines were then proposed for public comment in the *Federal Register* (USEPA, 1984).

In 1986, EPA issued the Guidelines for Carcinogen Risk Assessment (September 24, 1986), which are the product of a two year Agency-wide effort, which has included many scientists from the larger scientific community (USEPA, 1986). These guidelines incorporated comments and responses to external peer review comments and comments from the Agency's Science Advisory Board and were finalized and published in the *Federal Register* (USEPA, 1986). The guidelines incorporate information from the previous documents and also information and procedures used by NTP and IARC (*e.g.*, the Weight of Evidence classification is based on the IARC approach). The 1986 Guidelines incorporated principles of the science for chemical carcinogens issued by the Office of Science and Technology Policy in 1985 (OSTP, 1985).

On April 23, 1996, the Proposed Guidelines for Carcinogen Risk Assessment were published in the *Federal Register* (USEPA, 1996a) for a 120-day public review and comment period. The Proposed Carcinogen Guidelines are a revision of EPA's 1986 Guidelines for Carcinogen Risk Assessment (USEPA, 1986) and, when final, will replace the 1986 cancer guidelines (USEPA, 1996a). The full text of the *Federal Register* notice is available on the web at www.epa.gov/ncea/.

Changes since the 1986 Carcinogen Guidelines (USEPA, 1986) are summarized in the 1996 Proposed Carcinogen Guidelines (USEPA, 1996a), as follows:

> "Since the publication of the 1986 cancer guidelines, there is a better understanding of the variety of ways in which carcinogens can operate. Today, many laboratories are moving toward adding new test protocols in their programs directed at mode of action questions. Therefore, the Proposed Guidelines provide an analytical framework that allows for the incorporation of all relevant biological information, recognize a variety of situations regarding cancer hazard, and are flexible enough to allow for consideration of future scientific advances."

In 1999, EPA proposed revised Carcinogen Guidelines (USEPA, 1999a) in response to comments by the EPA Science Advisory Board. The approaches outlined in the proposed revised guidelines are consistent with the 1996 Cancer Reassessment for PCBs (USEPA, 1996a). The 1999 proposed guidelines were developed to address issues regarding children's risk from exposure to carcinogens. On November 21, 2001, EPA published an announcement in the *Federal Register* soliciting additional scientific information and comments on the draft revised Carcinogen Guidelines that could assist EPA in completing the final Guidelines (USEPA, 2001). *This Federal Register* notice also stated that, until final Guidelines are issued, the July 1999 draft revised Guidelines will serve as EPA's interim guidance to EPA risk assessors preparing cancer risk assessments.

As outlined above, the carcinogenicity guidelines were developed within the Agency, published in the *Federal Register* for comment, and externally peer-reviewed. EPA responded to comments on the proposed guidelines and made changes based on a review of the comments submitted by these groups and individuals. The guidelines were also submitted for review to EPA's Science Advisory Board, an external scientific review panel.

EPA'S EVALUATION OF PCB CARCINOGENICITY

EPA classified PCBs as probable human carcinogens in 1988 (USEPA, 1988) and reaffirmed this classification in 1996 (USEPA, 1996b). EPA's classification is based on a weight of the evidence. The available classifications for chemicals are a) carcinogenic to humans, b) probably carcinogenic to humans, c) possibly carcinogenic to humans, d) not classifiable as to human carcinogenicity, and e) evidence of non carcinogenicity to humans. The EPA classification of PCBs as probable human carcinogens is equivalent to the NTP, NIOSH, and IARC classifications for PCBs (NTP, 1981, 2000; NIOSH, 1977; IARC, 1978, 1987).

Following the 1988 evaluation of the carcinogenicity of PCBs, EPA conducted a reassessment of the carcinogenicity of PCBs in 1996 (USEPA, 1996b, see also www.epa.gov/ncea). In developing EPA's cancer reassessment for PCBs, EPA circulated the document within the Agency to more than 40 expert Agency scientists who reviewed and commented on the document. In addition, the document was submitted for external peer review to a panel of 16 experts in various areas of PCB toxicity, exposure and carcinogenicity including a scientist from the General Electric Company (USEPA, 1996b,c). The panel agreed with EPA's conclusions (USEPA, 1996b,c) regarding the carcinogenicity of PCBs and recommended that the Agency use the Brunner *et al.* (1996) study to develop the cancer slope factor for PCBs. Following review by the Agency and a panel of external reviewers (Koller, 1996), EPA used data from the Brunner *et al.* (1996) study in the 1996 PCB Cancer Reassessment (USEPA, 1996b). This information was also incorporated into the IRIS file for PCBs (USEPA, 1999b), submitted to Congress in October 1996 and published in an article by the Agency's lead author of the 1996 PCB Cancer Reassessment (Cogliano, 1998).

The 1996 PCB Cancer Reassessment was conducted consistent with the 1996 Proposed Cancer Guidelines (USEPA, 1996a, pp. 6, 55-56), as follows:

> "This new assessment adopts a related approach that distinguishes among PCB mixtures by using information on environmental processes. Environmental processes have profound effects that can decrease or increase toxicity, so toxicity of an environmental mixture is only partly determined by the original commercial mixture. This new assessment, therefore, considers all cancer studies (which used commercial mixtures only) to develop a range of dose-response slopes, then uses information on environmental processes to provide guidance on choosing an appropriate slope for representative classes of environmental mixtures and different exposure pathways."

The 1996 PCB Cancer Reassessment is also consistent with the 1999 Revised Carcinogen Guidelines, which address children's health (USEPA, 1999a).

EPA considered data from human epidemiological studies and animal studies in determining that PCBs are probable human carcinogens. In 1988, EPA concluded there was inadequate but suggestive evidence that PCBs cause cancer in humans and sufficient evidence that PCBs cause cancer in animals (USEPA, 1988). In 1996, EPA reaffirmed this classification, concluding (USEPA, 1996b), "Overall, the human studies have been considered to provide limited…to inadequate…evidence of carcinogenicity. The animal studies, however, have been considered to provide sufficient evidence of carcinogenicity" (USEPA, 1996b).

Human Epidemiological Studies

The peer reviewers of EPA's 1996 PCB Cancer Reassessment found inadequacies in the epidemiological data with regard to limited cohort size, problems in exposure assessment, lack of data on confounding factors, and the fact that occupational exposures may be to different congener mixtures than found in environmental exposures. The peer reviewers stated (USEPA, 1996c):

"Most researchers think that PCBs act mainly as tumor promoters. Thus, at nontoxic doses, PCBs might be expected to increase cancer risk mainly in humans that have sustained cancer initiation due to exposure to genotoxicants or to the presence of a mutant gene. For common cancers that have complex and multiple etiologies, promotive effects will be seen by epidemiology only if specifically looked for. Epidemiological studies have not thus far tested this hypothesis. "

EPA has summarized the human epidemiological studies used to classify PCBs as probable human carcinogens (USEPA, 1996b, 1999b). The human epidemiological evidence is described in USEPA (1999b) as follows (SMR=standard mortality ratio, CI=confidence interval, p=level of statistical significance):

"Inadequate. A cohort study by Bertazzi *et al.* (1987) analyzed cancer mortality among workers at a capacitor manufacturing plant in Italy. PCB mixtures with 54%, then 42% chlorine were used through 1980. The cohort included 2100 workers (544 males and 1556 females) employed at least 1 week. At the end of follow-up in 1982, there were 64 deaths reported, 26 from cancer. In males, a statistically significant increase in death from gastrointestinal tract cancer was reported, compared with national and local rates (6 observed, 1.7 expected using national rates, SMR=346, CI=141-721; 2.2 expected using local rates, SMR=274, CI=112-572). In females, a statistically significant excess risk of death from hematologic cancer was reported, compared with local, but not national, rates (4 observed, 1.1 expected, SMR=377, CI=115-877). Analyses by exposure duration, latency, and year of first exposure revealed no trend; however, the numbers are small.

A cohort study by Brown (1987) analyzed cancer mortality among workers at two capacitor manufacturing plants in New York and Massachusetts. At both plants the Aroclor mixture being used changed twice, from 1254 to 1242 to 1016. The cohort included 2588 workers (1270 males and 1318 females) employed at least 3 months in areas of the plants considered to have potential for heavy exposure to PCBs. At the end of follow-up in 1982, there were 295 deaths reported, 62 from cancer. Compared with national rates, a statistically significant increase in death from cancer of the liver, gall bladder, and biliary tract was reported (5 observed, 1.9 expected, SMR=263, $p<0.05$). Four of these five occurred among females employed at the Massachusetts plant. Analyses by time since first employment or length of employment revealed no trend; however, the numbers are small.

A cohort study by Sinks *et al.* (1992) analyzed cancer mortality among workers at a capacitor manufacturing plant in Indiana. Aroclor 1242, then 1016, had been used. The cohort included 3588 workers (2742 white males and 846 white females) employed at least 1 day. At the end of follow-up in 1986, there were 192 deaths reported, 54 from cancer. Workers were classified into five exposure zones based on distance from the impregnation ovens. Compared with national rates, a statistically significant excess risk of death from skin cancer was reported (8 observed, 2.0 expected, SMR=410, CI=180-800); all were malignant melanomas. A proportional hazards analysis revealed no pattern of association with exposure zone; however, the numbers are small.

Other occupational studies by NIOSH (1977), Gustavsson *et al.* (1986) and Shalat *et al.* (1989) looked for an association between occupational PCB exposure and cancer mortality. Because of small sample sizes, brief follow-up periods, and confounding exposures to other potential carcinogens, these studies are inconclusive.
Accidental ingestion: Serious adverse health effects, including liver cancer and skin disorders, have been observed in humans who consumed rice oil contaminated with PCBs in the "Yusho" incident in Japan or the "Yu-Cheng" incident in Taiwan. These effects have been attributed, at least in part, to heating of the PCBs and rice oil, causing formation of chlorinated dibenzofurans, which have the same mode of action as some PCB congeners (ATSDR, 1993; Safe, 1994)."

Animal Data

EPA determined that PCBs cause cancer in animals based on animal bioassay data. The NTP and IARC also conclude that PCBs are animal carcinogens (NTP, 1981; IARC, 1987). ATSDR's Toxicological Profile (ATSDR, 2000) states, "there is conclusive evidence that commercial PCB mixtures are carcinogenic in animals based on induction of tumors in the liver and thyroid". EPA's evaluation (USEPA, 1996b, 1999b) of the animal bioassay data for PCBs is summarized below:

> "A 1996 study found liver tumors in female rats exposed to Aroclors 1260, 1254, 1242, and 1016, and in male rats exposed to 1260. These mixtures contain overlapping groups of congeners that, together, span the range of congeners most often found in environmental mixtures. Earlier studies found high, statistically significant incidences of liver tumors in rats ingesting Aroclor 1260 or Clophen A 60 (Kimbrough *et al.*, 1975; Norback and Weltman, 1985; Schaeffer *et al.*, 1984). Mechanistic studies are beginning to identify several congeners that have dioxin-like activity and may promote tumors by different modes of action. PCBs are absorbed through ingestion, inhalation, and dermal exposure, after which they are transported similarly through the circulation. This provides a reasonable basis for expecting similar internal effects from different routes of environmental exposure. Information on relative absorption rates suggests that differences in toxicity across exposure routes are small."

Varying Dose Levels Tested

EPA evaluated a number of animal bioassays regarding the carcinogenicity of PCBs that were conducted at varying dose levels, not only at the Maximum Tolerated Dose (MTD). Consistent with NTP and IARC protocols (NTP, 1984; IARC, 1982, 1987), animal studies are conducted at varying levels below the MTD to aid in establishing a dose-response curve. Data at or near the MTD level were evaluated consistent with EPA's 1986 Carcinogen Guidelines (USEPA, 1986), which state: "Long-term animal studies at or near the MTD are used to ensure an adequate power for the detection of carcinogenic activity."

EPA's 1996 PCB Cancer Reassessment (Table 2-1, USEPA, 1996b), which showed the liver tumor incidences in rats from lifetime exposure studies from 1975 to 1985, generally included a control group of rats not exposed to PCBs and other groups exposed to varying concentrations of PCBs (*i.e.*, 25 ppm, 50 ppm, and 100 ppm). The cited studies include Kimbrough *et al.* (1975),

NCI (1978), Schaeffer *et al.* (1984), and Norback and Weltman (1985). The Brunner *et al.* (1996) rat study (later published as Mayes *et al.*, 1998) included doses of PCBs ranging from the control (0 ppm), to 25 ppm, 50 ppm, 100 ppm and 200 ppm. The Brunner et al. (1996) lifetime study data, in which rats were exposed to PCBs at levels less than the MTD for 104 weeks, demonstrated that the rats fed diets of PCBs had statistically significant, dose-related, increased incidences of liver tumors from each Aroclor mixture (USEPA, 1996b).

In addition, the partial lifetime studies that were evaluated by EPA also included exposures to various concentrations of PCBs. Kimbrough *et al.* (1972) included dose levels of 0 ppm, 20 ppm, 100 ppm, 500 ppm, or 1,000 ppm for Aroclor 1254 or 1260. Other studies include Kimbrough and Linder (1974), in which BALB/cJ mice were exposed to 300 ppm of Aroclor 1254 for 11 months or for six months followed by five months without exposure to PCBs. Kimura and Baba (1973) exposed Donryu rats to diets ranging from 38 to 462 ppm of Kanechlor (a trade name for PCBs) 400. Ito *et al.* (1973) exposed dd mice to 0 ppm, 100 ppm, 250 ppm or 500 ppm of Kanechlor 300, 400 or 500. Ito *et al.* (1974) exposed Wistar rats to diets of 0, 100, 500, or 1,000 ppm of Kanechlor 300, 400, or 500 ppm. Rao and Banerji (1988) exposed male Wistar rats to diets of 0 ppm, 50 ppm or 100 ppm of Aroclor 1260.

Gender Differences in Tumors

EPA followed appropriate guidelines and policies in extrapolating the data from the Brunner *et al.* (1996) rat study to humans. As stated in the PCB Cancer Reassessment (USEPA, 1996b, see p. 44), "the different responses for male and female rats (Brunner *et al.*, 1996) suggest the possibility of developing different potency values for males and females. In view of the 91% response in male Wistar rats (Schaeffer *et al.*, 1984), as well as the sensitivity of male mice (Kimbrough and Linder, 1974; Ito *et al.*, 1973), it is premature to conclude that females are always more sensitive. The PCB Cancer Reassessment (USEPA, 1996b) provides summary tables of the ranges of potency values based on data from both males and females. The potencies are based primarily on the range of Aroclors 1260, 1254, 1242 and 1016 tested in female Sprague-Dawley rats, but other studies were considered also.

Benign and Malignant Tumors

Consistent with the framework set forth in the Agency's Carcinogen Guidelines (USEPA, 1986, 1996a, 1999a), EPA considered benign as well as malignant tumors in evaluating the carcinogenicity of PCBs because both benign and malignant tumors are considered to be representative of related responses to the PCBs. Benign tumors progressed to malignant tumors in multiple studies.

EPA is not alone in using this approach to evaluate tumor data in assessing the carcinogenicity of chemicals. The Agency's 1996 proposed Carcinogen Guidelines (USEPA, 1996a) noted,

> "As in the approach of the National Toxicology Program and the International Agency for Research on Cancer, the default is to include benign tumors observed in animal studies in the assessment of animal tumor incidence if they have the capacity to progress to the malignancies with which they are associated. This treats the benign and malignant tumors as representative of related responses to the test agents, which is scientifically

> appropriate. This is a science policy decision that is somewhat more conservative of public health than not including benign tumors in the assessment. Nonetheless, in assessing findings from animal studies, a greater proportion of malignancy is weighed more heavily than a response with a greater proportion of benign tumors. Greater frequency of malignancy of a particular tumor type in comparison with other tumor responses observed in an animal study is also a factor to be considered in selecting the response to be used in dose response assessment".

With respect to PCB carcinogenicity, in 1996, EPA described a study by Norback and Weltman (1985) that demonstrated tumor progression as follows (USEPA, 1996b):

> "Norback and Weltman (1985). Groups of male or female Sprague-Dawley rats were fed diets with 0 or 100 ppm Aroclor 1260 for 16 months; the latter dose was reduced to 50 ppm for 8 more months. After 5 additional months on the control diet, the rats were killed and their livers were examined. Partial hepatectomy was performed on some rats at 1, 3, 6, 9, 12, 15, 18, and 24 months to evaluate sequential morphologic changes. In males and females fed Aroclor 1260, liver foci appeared at 3 months, area lesions at 6 months, neoplastic nodules at 12 months, trabecular carcinomas at 15 months, and adenocarcinomas at 24 months, demonstrating progression of liver lesions to carcinomas. By 29 months, 91 percent of females had liver carcinomas and 95 percent had carcinomas or neoplastic nodules; incidences in males were lower, 4 and 15 percent, respectively (see table 2–1)."

EPA also evaluated PCB carcinogenicity based on lifetime and stop studies of rats fed diets containing Aroclors 1260, 1254, 1242 or 1016, using data from Brunner *et al.* (1996). From the lifetime study data, in which rats were exposed to PCBs for 104 weeks, EPA concluded that the rats fed diets of PCBs had statistically significant, dose-related, increased incidences of liver tumors from each Aroclor mixture (USEPA, 1996b; Cogliano, 1998). From the stop study data, in which the rats were exposed to PCBs for 52 weeks and then PCB exposure was stopped, EPA determined that, for Aroclors 1254 and 1242, tumor incidences were approximately half those of the lifetime study; that is, nearly proportional to exposure duration. In contrast, for Aroclor 1016, stop-study tumor incidences were zero, while for Aroclor 1260 they were generally greater than half as many as in the lifetime study.

Earlier studies found high, statistically significant incidences of liver tumors in various strains of rats ingesting Aroclor 1260 or Clophen A60 (Kimbrough *et al.*, 1975, Norback and Weltman, 1985; Schaeffer *et al.*, 1984). Kimbrough *et al.* (1975) found significantly increased hepatocellular carcinomas in rats fed Aroclor 1260. Schaeffer *et al.* (1984) found male Wistar rats in the shortest exposed group (16.4 months) had preneoplastic liver lesions, and after 23 months had hepatocellular carcinomas. Norback and Weltman (1985) studied Sprague-Dawley rats exposed to Aroclor 1260 and found that by 29 months 91% of females had liver carcinomas. In addition, the Brunner *et al.* (1996) study found several of the tumors were hepatocholangiomas, a rare bile duct tumor seldom seen in control rats.

The data from the studies described above are the basis for EPA's determination that PCBs cause cancer in animals. Benign tumors progressed to malignant tumors in multiple studies, in different strains of rats, and at different dose levels of PCBs.

Cancer Slope Factor (CSF)

The quantification of carcinogenicity is a value called a cancer slope factor (CSF). As outlined in the EPA Carcinogen Guidelines (USEPA, 1986; 1996a), EPA favors basing CSFs on human epidemiological studies, which requires quantitative information on both exposure and response. However, for PCBs, EPA concluded that the human epidemiological data are insufficient to develop CSFs (USEPA, 1996b). During the peer review of EPA's 1996 PCB Cancer Reassessment (USEPA, 1996c), EPA included charge questions to the peer-reviewers requesting specific evaluation of human epidemiological evidence as a basis for developing the CSFs for PCBs. The peer reviewers supported EPA's conclusion that it is not feasible to use the human epidemiological data to develop CSFs for PCBs (USEPA, 1996c).

EPA used the proposed 1996 Carcinogen Guidelines (USEPA, 1996a) to develop the CSFs for PCBs. Following review of the carcinogenicity data and based primarily on the Brunner *et al.* (1996), EPA developed separate PCB CSFs for inhalation and ingestion, and provided a recommendation for exposure by dermal contact. The oral CSF for PCBs developed in 1988 (USEPA, 1988) was revised downward in 1996 from 7.7 mg/kg-day^{-1} to 2.0 mg/kg-day^{-1}. In the 1996 PCB Cancer Reassessment (USEPA, 1996b, p. 35), EPA explained,

> "This difference in cancer slope factor is attributable to three factors, each responsible for reducing the slope by approximately one-third: the rat liver tumor reevaluation (Moore *et al.*, 1994), use of the new cross-species scaling factor (USEPA, 1992) and not using a time weighted average dose."

Similarly, when these factors are applied to the CSF derived from the Norback and Weltman (1985) study, the CSF is reduced from 7.7 mg/kg-day^{-1} to 2.2 mg/kg-day^{-1}.

As part of EPA's 1996 PCB Cancer Reassessment, EPA evaluated an approach regarding PCB congener persistence in the body (Brown (1994). EPA identified some limitations of using this approach in the development of CSFs for PCBs, as follows (USEPA, 1996b):

> "Reconstruction of past exposure is problematic because different mixtures had been in use over the years, the distribution of exposure and absorption by route and congener is unknown, and congener persistence in the body varies greatly from congener to congener (Brown, 1994) and person to person (Steele *et al.*, 1986)."

Human Epidemiological Studies Since the 1996 PCB Cancer Reassessment

Since the 1996 PCB Cancer Reassessment (USEPA, 1996b), additional studies regarding the carcinogenicity of PCBs in humans have been published (*e.g.*, Gustavsson and Hogstedt, 1997; Hardell *et al.*, 1996; Rothman *et al.*, 1997; Tironi *et al.*, 1996; Yassi *et al.*, 1994; Loomis *et al.*, 1997; Kimbrough *et al.*, 1999 [discussed separately]).

EPA has noted issues with many of the studies of occupationally exposed individuals working in industrial plants in the U.S. and internationally (USEPA, 1996b). Issues include the small number of tumors found, making it difficult to associate the exposures with specific

manufacturing processes in the plant studied by the investigators (*i.e.*, high exposure, medium exposures, or low exposure areas); mortality rather than morbidity as a study objective; the lack of historical data on exposures; and confounding from exposures to chemicals other than PCBs within the plant. A brief summary of the studies and their conclusions regarding the carcinogenicity of PCBs is provided below by type of cancer and population studied.

Breast Cancer

Recent studies have investigated PCB exposures and breast cancer. EPA has evaluated these studies and concluded that it is not possible to attribute a cause and effect association between PCB exposure and breast cancer given the sparse data available (USEPA, 1997).

Study results suggested that PCBs increase the risk of breast cancer after menopause (Moysich *et al.*, 1998) and research has suggested a mechanism by which PCBs can contribute to cancer, including breast cancer (Oakley *et al.*, 1996). Other studies have failed to show an association between PCB exposure and breast cancer (*e.g.*, Hoyer *et al.*, 1998, see studies reviewed in USEPA, 1997 and Table D-1 of USEPA, 2000a).

Researchers have suggested the need to consider PCB levels in women prior to the time of breast cancer diagnosis (*e.g.*, Adami *et al.*, 1995). The critical or sensitive period of exposure for the developing breast tissue may be as an infant or during puberty, in which case the current procedure of measuring blood PCB levels at the time of diagnosis may not be an appropriate biomarker of exposure.

Organ Sites Excluding Breast Cancer

EPA has also evaluated studies on PCB exposures and cancers other than breast cancer. Based on the available epidemiological evidence, EPA believes that the data are inconclusive with respect to the association of PCBs and cancer in humans, including hepatobiliary, hematological, malignant melanoma, rectal, gastrointestinal tract, pancreatic, and endometrial cancers based on the limitations of the epidemiological studies (USEPA, 1999b).

Kimbrough et al. (1999a) Occupational Study

In 1999, Dr. Kimbrough and colleagues published a study of cancer mortality in workers exposed to PCBs (Kimbrough *et al.*, 1999a). The paper describes a study of workers from two GE capacitor manufacturing plants in New York State. In this study, mortality (deaths) from all cancers was determined for 7,075 females and males who worked at the GE facilities for at least 90 days between 1946 and 1977. The total number of deaths from all causes was 1,195 people, and the total number of deaths caused by cancer was 353 people. No significant elevations in mortality for any site-specific cause were found in the hourly worker cohort (*i.e.*, group). No significant elevations were seen in the most highly exposed workers. Mortality from all cancers was significantly below expected in hourly male workers and comparable to expected for hourly female workers. Several researchers submitted Letters to the Editor identifying limitations of the Kimbrough *et al.* (1999a) study, which were published in the Journal of Occupational and Environmental Medicine (Bove *et al.*, 1999; Frumkin and Orris, 1999). The response to these letters was also published (Kimbrough *et al.* (1999b).

EPA performed a preliminary review of the Kimbrough *et al.* (1999a) study and identified aspects of the study that suggest that the study will not change the Agency's conclusions regarding the carcinogenicity of PCBs (USEPA, 2000a-c). The primary limitation, which is shared by other similar epidemiological studies, is that the degree of exposure is not well characterized.

As part of its review, EPA sent copies of the Kimbrough *et al.* (1999a) paper to several researchers requesting an evaluation regarding whether this new paper would change the Weight of Evidence classification of PCBs as probable human carcinogens. The findings from these letters are summarized below:

Dr. D. Ozonoff of the Boston University School of Public Health concluded (Ozonoff, 1999):

> "In short, we have here another "data point". It should be judiciously interpreted and used with the caution appropriate to studies of this type. In particular, this means not giving undue weight to its failure to show associations previously revealed, since there are too many factors that would mitigate against being able to show them in this study."

Dr. M. Harnois of the Massachusetts Department of Environmental Protection concluded (Harnois, 1999):

> "A subgroup that is masked in this study is the one containing hourly male workers exposed to Aroclor 1254 by dermal contact, incidental ingestion, and inhalation for at least 5 years and followed for at least 20 years. This group could have different cancer frequencies from those presented in the report, being definitely exposed to a known carcinogenic mixture for a prolonged interval and observed for an interval that could allow development of tumors.
>
> This report deals mostly with deaths due to cancer effects, but we know that reproductive, nervous and immunological effects can also occur. These are beyond the scope of the research report, but may be ignored by readers who assume that cancer is the only effect of PCBs."

Dr. T. Mack of the University of Southern California, Norris Comprehensive Cancer Center concluded (Mack, 1999):

> "I guess my bottom line is that the summary statements ("lack of any significant elevations adds important information" and "lack of consistent findings --- would suggest a lack of an association") in the paper are appropriate. I think that it is appropriate to downgrade the priority given to PCB's. However, based on the animal studies (and recognizing a. the possibility limited relevance to man and b. the absence of any confirmation of liver cancer in humans) and on this very small amount of information pointing to colorectal tumors, I don't think that this potential carcinogenicity of PCB's can be completely dismissed. I recognize the flimsiness of the evidence, and that a less conservative person could persuasively argue the other way."

The ATSDR Toxicological Profile for PCBs (ATSDR, 2000) summarizes the limitations of the exposure information from Kimbrough *et al.*, (1999a) as follows:

> "PCB exposures were predominantly to Aroclor 1254 from 1946 to 1954, Aroclor 1242 from 1954 to 1971, and Aroclor 1016 from 1971 to 1977. Exposures were qualitatively classified as high, low, or undefinable based on types and locations of jobs and some area measurements. No personal exposure monitoring was performed, although previously reported data on 290 self-selected workers from one of the plants had serum PCBs levels in ranges of 6 to 2,530 and 1 to 546 ppb for lower and higher chlorinated homologs, respectively (Wolff *et al.*, 1982). Workers with high exposure jobs had direct PCB contact (dermal and/or inhalation), workers with lower exposure jobs primarily had inhalation exposure to background levels of PCBs in the plant, and workers with undefinable exposures had exposures that varied depending on whether tasks were performed. Exposure-specific analysis was limited to workers with the greatest potential for exposure (*i.e.*, hourly workers who ever worked in a high exposure job, worked for at least 6 months in a high-exposure job, worked for at least 1 year in a high-exposure job). Workers who exclusively worked in high-exposure jobs could not be analyzed as a separate group due to small numbers (112 males, 12 females)."

The Toxicological Profile for PCBs concluded (ATSDR, 2000):

> "Interpretation of the Kimbrough *et al.* (1999a) findings is complicated by a few study limitations and biases, including some exposure misclassifications related to use of length of employment alone as a surrogate of exposure, potentially insufficient dosage differences between exposed and comparison groups, a degree of selection bias due to the healthy worker effect that may have resulted in an under estimate of SMRs, concern for low statistical power due to the small number of deaths from site-specific cancers in some of the group (*e.g.*, female hourly workers with high exposure and $\geq$ 20 years latency), relatively young age at follow-up, and use of the general population for comparison rather than an internal control group or a group of workers from another company. These issues are discussed by Bove *et al.* (1999), Frumkin and Orris (1999), and Kimbrough *et al.*, (1999b). Some of the limitations are typical of occupational cohort mortality studies, and strengths of the study include its size (the largest cohort of PCB workers ever studied) and essentially complete follow-up of long duration. Unresolved are the puzzling Kimbrough *et al.* (1999a) findings of significantly lower than expected mortality from all cancers among males and the lower number of observed cases of liver and biliary tract cancers among females compared to the smaller cohort studies by Brown *et al.* (1987), a subset of the same study population. These unresolved findings suggest that ascertainment of cancer mortality was not completed in this study. Overall, the study limitations are sufficient to cast doubt on the negative findings for liver and biliary tract cancer and other site-specific cancers."

In light of the information summarized above regarding the limitations of the Kimbrough *et al.* (1999a) study, which are similar to the limitations of other human epidemiological studies, EPA has not changed its Weight of Evidence classification of PCBs as probable human carcinogens.

EPA'S PCB RESEARCH

EPA has conducted significant research on PCBs and the mechanisms of PCB action. Following is a partial list of research conducted by EPA's Office of Research and Development from 1996 to 2000. In addition, EPA has worked with other federal agencies through programs such as the Superfund Basic Research Program (part of the National Institute of Environmental Health Sciences) to fund research on PCB toxicity through grants to a number of Universities (Massachusetts Institute of Technology, State University of New York-Albany, University of Kentucky, etc.) that are evaluating PCB toxicity.

Brouwer, A., M.P. Longnecker, L.S. Birnbaum, J. Cogliano, P. Kostyniak, J. Moore, S. Schantz, and G. Winneke. 1999. Characterization of potential endocrine-related health effects at low-dose levels of exposure to PCBs. Environ. Health Perspect. Aug: 107, Suppl. 4:639-649, 1999. PMID: 10421775 [PubMed - indexed for MEDLINE].

Chauhan, K.R., P.R. Kodavanti, and J.D. McKinney. 2000. Assessing the role of ortho-substitution on polychlorinated biphenyl binding to transthyretin, a thyroxine transport protein. Toxicol. Appl. Pharmacol. 162(1):10-21. January 1. PMID: 10631123 [PubMed - indexed for MEDLINE].

Choksi, N.Y., P.R. Kodavanti, H.A. Tilson, and R.G. Booth. 1997. Effects of polychlorinated biphenyls (PCBs) on brain tyrosine hydroxylase activity and dopamine synthesis in rats. Fundam. Appl. Toxicol. 39(1):76-80. September.

Crofton, K.M., D. Ding, R. Padich, M. Taylor, and D. Henderson. 2000. Hearing loss following exposure during development to polychlorinated biphenyls: a cochlear site of action. Hear Res. 144(1-2):196-204. June. PMID: 10831878 [PubMed - indexed for MEDLINE].

Crofton, K.M., P.R. Kodavanti, E.C. Derr-Yellin, A.C. Casey, and L.S. Kehn. 2000. PCBs, thyroid hormones, and ototoxicity in rats: cross-fostering experiments demonstrate the impact of postnatal lactation exposure. Toxicol. Sci. 57(1):131-40. September. PMID: 10966519 [PubMed - indexed for MEDLINE]

Crofton, K.M. and D.C. Rice. 1999. Low-frequency hearing loss following perinatal exposure to 3,3',4,4',5-pentachlorobiphenyl (PCB 126) in rats. Neurotoxicol. Teratol. 21(3):299-301. May-June. PMID: 10386834 [PubMed - indexed for MEDLINE].

DeVito, M.J., M.G. Menache, J.J. Diliberto, D.G. Ross, and L.S. Birnbaum. 2000. Dose-response relationships for induction of CYP1A1 and CYP1A2 enzyme activity in liver, lung, and skin in female mice. Toxicol. Appl. Pharmacol. 167(3):157-72. September 15. PMID: 10986007 [PubMed - indexed for MEDLINE].

DeVito, M.J., D.G. Ross, A.E. Dupuy Jr., J. Ferrario, D. McDaniel, and L.S. Birnbaum. 1998. Dose-response relationships for disposition and hepatic sequestration of polyhalogenated dibenzo-p-dioxins, dibenzofurans, and biphenyls following subchronic treatment in mice. Toxicol. Sci. 46(2):223-34. December.

Fischer, L.J., R.F. Seegal, P.E. Ganey, I.N. Pessah, and P.R. Kodavanti. 1998. Symposium overview: toxicity of non-coplanar PCBs. Toxicol. Sci. 41(1):49-61. Review. January. PMID: 9520341 [PubMed - indexed for MEDLINE].

Geller, A.M., W.M. Oshiro, N. Haykal-Coates, P.R. Kodavanti, and P.J. Bushnell. 2001. Gender-dependent behavioral and sensory effects of a commercial mixture of polychlorinated biphenyls (Aroclor 1254) in rats. Toxicol. Sci. 59(2):268-77. February. PMID: 11158720 [PubMed - indexed for MEDLINE].

Gilbert, M.E. and K.M. Crofton. 1999. Developmental exposure to a commercial PCB mixture (Aroclor 1254) produces a persistent impairment in long-term potentiation in the rat dentate gyrus in vivo. Brain Res. 850(1-2):87-95. December 11. PMID: 10629752 [PubMed - indexed for MEDLINE].

Gilbert, M.E., W.R. Mundy, and K.M. Crofton. 2000. Spatial learning and long-term potentiation in the dentate gyrus of the hippocampus in animals developmentally exposed to Aroclor 1254. Toxicol. Sci. 57(1):102-11. September. PMID: 10966516 [PubMed - indexed for MEDLINE].

Goldey, E.S. and K.M. Crofton. 1998. Thyroxine replacement attenuates hypothyroxinemia, hearing loss, and motor deficits following developmental exposure to Aroclor 1254 in rats. Toxicol. Sci. 45(1):94-105. September.

Johnson, C.W., W.C. Williams, C.B. Copeland, M.J. DeVito, and R.J. Smialowicz. 2000. Sensitivity of the SRBC PFC assay versus ELISA for detection of immunosuppression by TCDD and TCDD-like congeners. Toxicology 156(1):1-11. December 7.

Johnson, K.L., A.M. Cummings, and L.S. Birnbaum. 1997. Promotion of endometriosis in mice by polychlorinated dibenzo-p-dioxins, dibenzofurans, and biphenyls. Environ. Health Perspect. 105(7):750-5. July.

Kodavanti, P.R., E.C. Derr-Yellin, W.R. Mundy, T.J. Shafer, D.W. Herr, S. Barone, N.Y. Choksi, R.C. MacPhail, and H.A. Tilson. 1998. Repeated exposure of adult rats to Aroclor 1254 causes brain region-specific changes in intracellular Ca2+ buffering and protein kinase C activity in the absence of changes in tyrosine hydroxylase. Toxicol. Appl. Pharmacol. 153(2):186-98. December. PMID: 9878590 [PubMed - indexed for MEDLINE].

Kodavanti, P.R. and T.R. Ward. 1998. Interactive effects of environmentally relevant polychlorinated biphenyls and dioxins on [3H]phorbol ester binding in rat cerebellar granule cells. Environ. Health Perspect. 106(8):479-86. August. PMID: 9681975 [PubMed - indexed for MEDLINE].

Kodavanti, P.R., T.R. Ward, E.C. Derr-Yellin, W.R. Mundy, A.C. Casey, B. Bush, and H.A. Tilson. 1998. Congener-specific distribution of polychlorinated biphenyls in brain regions, blood, liver, and fat of adult rats following repeated exposure to Aroclor 1254. Toxicol. Appl. Pharmacol. 153(2):199-210. December. PMID: 9878591 [PubMed - indexed for MEDLINE].

Mundy, W.R., T.J. Shafer, H.A. Tilson, and P.R. Kodavanti. 1999. Extracellular calcium is required for the polychlorinated biphenyl-induced increase of intracellular free calcium levels in cerebellar granule cell culture. Toxicology 136(1):27-39. August 13. PMID: 10499848 [PubMed - indexed for MEDLINE].

Nishida, N., J.D. Farmer, P.R. Kodavanti, H.A. Tilson, and R.C. MacPhail. 1997. Effects of acute and repeated exposures to Aroclor 1254 in adult rats: motor activity and flavor aversion conditioning. Fundam. Appl. Toxicol. 40(1):68-74. November.

Roegge, C.S., B.W. Seo, K.M. Crofton, and S.L. Schantz. 2000. Gestational-lactational exposure to Aroclor 1254 impairs radial-arm maze performance in male rats. Toxicol. Sci. 57(1):121-30. September. PMID: 10966518 [PubMed - indexed for MEDLINE].

Saghir, S.A., L.G. Hansen, K.R. Holmes, and P.R. Kodavanti. 2000. Differential and non-uniform tissue and brain distribution of two distinct 14C-hexachlorobiphenyls in weanling rats. Toxicol. Sci. 54(1):60-70. March. PMID: 10746932 [PubMed - indexed for MEDLINE].

Sharma, R., E.C. Derr-Yellin, D.E. House, and P.R. Kodavanti. 2000. Age-dependent effects of Aroclor 1254R on calcium uptake by subcellular organelles in selected brain regions of rats. Toxicology 156(1):13-25. December 7.

Smialowicz, R.J., M.J. DeVito, M.M. Riddle, W.C. Williams, and L.S. Birnbaum. 1997. Opposite effects of 2,2',4,4',5,5'-hexachlorobiphenyl and 2,3,7,8-tetrachlorodibenzo-p-dioxin on the antibody response to sheep erythrocytes in mice. Fundam. Appl. Toxicol. 37(2):141-9. June.

Svendsgaard, D.J., T.R. Ward, H.A. Tilson, and P.R. Kodavanti. 1997. Empirical modeling of an in vitro activity of polychlorinated biphenyl congeners and mixtures. Environ. Health Perspect. 105(10):1106-15. October. PMID: 9349838 [PubMed - indexed for MEDLINE].

Tiffany-Castiglioni, E., M. Ehrich, L. Dees, L.G. Costa, P.R. Kodavanti, S.M. Lasley, M. Oortgiesen, and H.D. Durham. 1999. Related articles bridging the gap between in vitro and in vivo models for neurotoxicology. Toxicol. Sci. 51(2):178-83. Review. October. PMID: 10543019 [PubMed - indexed for MEDLINE].

Tilson, H.A. and P.R. Kodavanti. 1998. The neurotoxicity of polychlorinated biphenyls. Neurotoxicology 19(4-5):517-25. Review. August-October. PMID: 9745906 [PubMed - indexed for MEDLINE].

Yang, J.H. and P.R. Kodavanti. 2001. Possible molecular targets of halogenated aromatic hydrocarbons in neuronal cells. Biochem. Biophys. Res. Commun. 280(5):1372-7. February 9. PMID: 11162682 [PubMed - indexed for MEDLINE].

van Birgelen, A.P., M.J. DeVito, J.M. Akins, D.G. Ross, J.J. Diliberto, and L.S. Birnbaum. 1996. Relative potencies of polychlorinated dibenzo-p-dioxins, dibenzofurans, and biphenyls derived from hepatic porphyrin accumulation in mice. Toxicol. Appl. Pharmacol. 138(1):98-109. May.

van Birgelen, A.P., D.G. Ross, M.J. DeVito, and L.S. Birnbaum. 1996. Interactive effects between 2,3,7,8-tetrachlorodibenzo-p-dioxin and 2,2',4,4',5,5'-hexachlorobiphenyl in female B6C3F1 mice: tissue distribution and tissue-specific enzyme induction. Fundam. Appl. Toxicol. 34(1):118-131. November.

HUDSON RIVER PCBS SITE

IRIS toxicity values undergo an extensive internal and external peer review process (USEPA, 1996b,c and 1999b) and are thus the preferred toxicity values for use in Superfund risk assessments (USEPA, 1989, 1993, 1996b,c). The use of IRIS data in the evaluation of the toxicity of chemicals at Superfund sites addresses EPA's goal of using consistent toxicity information in risk assessments at Superfund sites across the country.

Consistent with EPA's risk assessment guidance (USEPA, 1989, 1990, 1993), in the HHRA for the Hudson River PCBs Site, EPA evaluated newer studies of PCB toxicity (USEPA, 2000a,b). Based on this review, EPA determined that these newer studies would not change the conclusions of the 1996 PCB Cancer Reassessment (*i.e.*, that PCBs are probable human carcinogens) and that it was appropriate to use the toxicity information and CSFs in IRIS in the Site-specific risk assessment (USEPA, 1996b,c; 2000a-d).

The peer reviewers for the HHRA agreed with EPA's use of the toxicity information in IRIS, but recommended that EPA provide an update of the data to identify recently published studies (ERG, 2000). In response, EPA updated the list of human epidemiology studies in Appendix D of the Revised HHRA (USEPA, 2000a). EPA identified a number of limitations with these newer human epidemiological studies similar to those identified in the IRIS file for PCBs (USEPA, 1999a), including lack of sufficient exposure information, failure to adequately account for co-exposure to other compounds, and inconsistency between study results.

EPA recognizes that environmental processes can alter the congener composition of a PCB mixture in the environment. The CSFs in IRIS are based on studies using a number of different Aroclor mixtures (*i.e.*, the commercial formulation of PCBs including Aroclor 1016, 1242, 1254, and 1260), which together span the range of congeners most frequently found in environmental mixtures (USEPA, 1996b). IRIS provides for using a lower CSFs for risk calculations when congener analysis demonstrates a predominance of the lower chlorinated congeners (*i.e.*, when congener or isomer analysis verifies that congeners with more than four chlorine atoms comprise less than 1/2 percent of the total PCBs). This lower CSF was not used in the HHRA based on congener analysis of Hudson River fish.

Dioxin-like PCBs

Consistent with EPA guidance and procedures (USEPA, 1996b), the revised HHRA (USEPA, 2000a) evaluated cancer risks from exposure to dioxin-like PCBs using the latest scientific consensus on TEFs for dioxin-like PCBs (USEPA, 1996b), as an additional consideration for the risk manager. Risks from dioxin-like PCBs were not combined with non-dioxin-like PCBs, based on EPA's ongoing effort to develop a procedure for combining these cancer risks to avoid potential double counting.

Effect of PCB Exposure on Blood Levels

EPA followed risk assessment guidance and procedures (USEPA, 1989, 1990, 1993, 1996b) to quantify cancer risks to individuals exposed to PCBs at the Hudson River PCBs Site in the HHRA (USEPA, 2000a). The approach used in the HHRA is different than measurement of blood PCB levels in former capacitor workers. First, the HHRA evaluates current and future exposures, while the data on PCB levels in blood integrates past exposure. Second, capacitor workers were primarily exposed through dermal contact and inhalation of PCBs, whereas anglers, which had the highest cancer risks evaluated in the HHRA, would be exposed to PCBs through ingestion of contaminated fish caught in the Hudson River. Third, in the HHRA EPA evaluated cancer risks to the RME individual, whereas for capacitor workers the level of exposure is generally not known. Fourth, the PCB congener profile in the capacitor plant is likely to be different from the congener profile of PCBs that are bioaccumulated in the fish. Lastly, EPA is concerned with potential exposures to the human population including sensitive groups that may include the fetus exposed from mothers who consumed PCB-contaminated fish, infants exposed to PCBs through breast milk, young children, adolescents, adults, and individuals with pre-existing medical conditions (USEPA, 2000a); many of these sensitive groups may not be represented in a healthy worker population. As stated in EPA's 1996 PCB Cancer Reassessment (USEPA, 1996b):

> "people with decreased liver function, including inefficient glucuronidative mechanism in infants, can have less capacity to metabolize and eliminate PCBs (Calabrese and Sorenson, 1977). Additionally, approximately 5% of nursing infants receive a steroid in human milk that inhibits the activity of glucuronyl transferase, further reducing PCB metabolism and elimination (Calabrese and Sorenson, 1977)."

Differences between occupational exposures and exposure through ingestion of contaminated fish were discussed in the 1996 PCB Cancer Reassessment (USEPA, 1996b). Notably, a study of people exposed through eating contaminated fish (Hovinga *et al.*, 1993) suggests that the PCB mixtures in fish can be more persistent than those to which the workers were exposed. From 1977 to 1985, mean PCB serum levels (quantified using Aroclor 1260 as a reference standard) from 111 Great Lakes fish eaters decreased only slightly from 20.5 to 19.0 ppb. This indicates that the rate of decline in the fish eating populations will be slower than that for the workers.

ATSDR's Toxicological Profile (ATSDR, 2000) states that there are no known treatment methods for reducing body burdens of PCBs, concluding that limiting or preventing further exposures appears to be the most practical method for reducing PCB body burdens.

REFERENCES

Adami, H.O., I. Persson, A. Ekbom, A. Wolk, J. Ponten, and D. Trichopoulos. 1995. The aetiology and pathogenesis of human breast cancer. Mutat. Res. 333(1-2):29-35. December.

Agency for Toxic Substances and Disease Registry (ATSDR). 1993. Toxicological Profile for Polychlorinated Biphenyls. ATSDR, Atlanta. TP–92/16, update.

Agency for Toxic Substances and Disease Registry (ATSDR). 2000. Toxicological Profile for Polychlorinated Biphenyls (Update). U. S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substance sand Disease Registry. Atlanta, Georgia.

Bertazzi, P.A., L. Riboldi, A. Pesatori, L. Radice, and C. Zocchetti. 1987. Cancer mortality of capacitor manufacturing workers. Am. J. Ind. Med. 11:165–176.

Bove, F.J., B.A. Slade, and R.A. Canady. 1999. Evidence of excess cancer mortality in a cohort of workers exposed to polychlorinated biphenyls. J. Occup. Environ. Med. 41(9):739-740.

Brown, D.P. 1987. Mortality of workers exposed to polychlorinated biphenyls - An update. Arch. Environ. Health 42(6): 333-339.

Brown, J. F. Jr. 1994. Determination of PCB metabolic excretion and accumulation rates for use as indicators of biological response and relative risk. Environ. Sci. Technol. 28(13):2295-2305.

Brown, J.F., Jr., R.W. Wagner, H. Feng, D.L. Bedard, M.J. Brennan, J.C. Carnahan, and R.J. May. 1987. Environmental dechlorination of PCBs. Environ. Toxicol. Chem. 6:579-593.

Brunner, M.J., T.M. Sullivan, N.W. Singer, M.J. Ryan, J.D. Toft, II, R.S. Menton, S.W. Graves, and A.C. Peters. 1996. An Assessment of the Chronic Toxicity and Oncogenicity of Aroclor 1016, Aroclor 1242, Aroclors 1254, and Aroclor 1260 Administered in Diet to Rats. Columbus, Ohio. Battelle Study #SC920192. Chronic toxicity and oncogenicity report.

Calabrese, E.J. and A.J. Sorenson. 1977. The health effects of PCBs with particular emphasis on human high risk groups. Rev. Environ. Health 2:285-304.

Cogliano, V.J. 1998. Assessing the cancer risk from environmental PCBs. Environ. Health Perspect. 106(6):317-323.

Eastern Research Group, Inc. (ERG). 2000. Report on the Peer Review of the Hudson River PCBs Human Health Risk Assessment. Prepared for U. S. Environmental Protection Agency, Region II. September, 2000. Final Report.

Frumkin, H. and P. Orris. 1999. Evidence of excess cancer mortality in a cohort of workers exposed to polychlorinated biphenyls. J. Occup. Environ. Med. 41(9):739-745.

Gustavsson, P., C. Hogstedt, and C. Rappe. 1986. Short-term mortality and cancer incidence in capacitor manufacturing workers exposed to polychlorinated biphenyls (PCBs). Am. J. Ind. Med. 10:341-344.

Gustavsson, P. and C. Hogstedt. 1997. A cohort study of Swedish capacitor manufacturing workers exposed to polychlorinated biphenyls (PCBs). Am. J. Ind. Med. 32(3):234-239.

Hardell, L., B. Van Bavel, G. Lindstrom, *et al.* 1996. Higher concentrations of specific polychlorinated biphenyl congeners in adipose tissue from non-Hodgkin's lymphoma patients compared with controls without a malignant disease. Int. J. Oncol. 9(4):603-608.

Harnois, M. 1999. Personal Communication to Dr. V. J. Cogliano of the USEPA National Center for Environmental Assessment, Office of Research and Development, Washington, D.C. Letter dated March 23, 1999.

Hovinga, M.E., M. Sowers, and H.E.B. Humphrey. 1993. Historical changes in serum PCB and DDT levels in an environmentally exposed cohort. Arch. Environ. Contam. Toxicol. 22(4):362-366.

Hoyer, A.P., P. Grandjean, T., Jorgensen, J.W., Brock, and H. B. Hartvig. 1998. Organochlorine exposure and risk of breast cancer. Lancet 352:1816-1820.

Interagency Regulatory Liaison Group (IRLG). 1979. Scientific basis for identification of potential carcinogens and estimation of risks. J. Natl. Cancer Inst. 63:245-267.

International Agency for Research on Cancer (IARC). 1978. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Volume 18: Polychlorinated Biphenyls and Polybrominated Biphenyls: World Health Organization, Lyon, France.

International Agency for Research on Cancer (IARC). 1982. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Supplement 4. Lyon, France.

International Agency for Research on Cancer (IARC). 1987. IARC Monographs on the Evaluation of the Carcinogenic Risks to Humans, Supplement 7, Overall Evaluations of Carcinogenicity: An Updating of IARC Monographs Volumes 1-42." Lyon, France.

Ito, N., H. Nagasaki, M. Arai, S. Makiura, S. Sugihara, and K. Hirao. 1973. Histopathologic studies on liver tumorigenesis induced in mice by technical polychlorinated biphenyls and its promoting effect on liver tumors induced by benzene hexachloride. J. Natl. Cancer Inst. 51(5): 1637-1646.

Ito, N., H. Nagasaki, S. Makiura, and M. Arai. 1974. Histopathological studies on liver tumorigenesis in rats treated with polychlorinated biphenyls. Gann 65:545-549.

Kimbrough, R.D., M.L. Doemland, and M.E. LeVois. 1999a. Mortality in male and female capacitor workers exposed to polychlorinated biphenyls. J. Occup. Environ. Med. 41(3):161-171.

Kimbrough, R.D., M.L. Doemland, and M.E. LeVois. 1999b. Author's reply to letter to the editor re: Evidence of excess cancer mortality in a cohort of workers exposed to polychlorinated biphenyls". J. Occup. Environ. Med. 41(9):739-745.

Kimbrough, R.D. and R.E. Linder. 1974. Induction of adenofibrosis and hepatomas in the liver of BALB/cJ mice by polychlorinated biphenyls (Aroclor 1254). J. Natl. Cancer Inst. 53(2): 547-552.

Kimbrough, R.D., R.E. Linder, and T.B. Gaines. 1972. Morphological changes in livers of rats fed polychlorinated biphenyls: Light microscopy and ultrastructure. Arch. Environ. Health 25:354-364.

Kimbrough, R.D., R.A. Squire, R.E. Linder, J.D. Strandberg, R.J. Montali and V.W. Burse. 1975. Induction of liver tumors in Sherman strain female rats by polychlorinated biphenyl Aroclor 1260. J. Natl. Cancer Inst. 55(6):1453-1459.

Kimura, N.T. and T. Baba. 1973. Neoplastic changes in the rat liver induced by polychlorinated biphenyl. Gann 64:105-108.

Koller, L.D. 1996. Letter dated July 3 to Dr. E.V. Ohanian, U.S. EPA, Office of Water, Washington, D.C.

Loomis, D., S.R. Browning, A.P. Schenck, E. Gregory, and D.A. Savitz. 1997. Cancer mortality among electric utility workers exposed to polychlorinated biphenyls. Occup. Environ. Med. 54(10):720-728.

Mack, T. 1999. Personal Communication to Dr. V. J. Cogliano of USEPA's National Center for Environmental Assessment, Office of Research and Development, Washington, D.C. Undated letter.

Mayes, B.A., E.E. McConnell, B.H. Neal, M.J. Brunner, S.B. Hamilton, T.M. Sullivan, A.C. Peters, M.J. Ryan, J.D. Toft, A.W. Singer, J.F. Brown Jr., R.G. Menton, and J.A. Moore. 1998. Comparative carcinogenicity in Sprague-Dawley rats of the polychlorinated biphenyl mixtures Aroclors 1016, 1242, 1254, and 1260. Toxicol. Sci. 41(1):62-76. January.

Moore, J.A., J.F. Hardsty, D.A. Banas, and M.A. Smith. 1994. A comparison of liver tumor diagnosis from seven PCB studies in rats. Regul. Toxicol. Pharmacol. 20:362-370.

Moysich, K.B., C.B. Ambrosone, J.E. Vena, P.G. Shields, P. Mendola, P. Kostyniak, H. Greizerstein, S. Graham, J.R. Marshall, E.F. Schisterman, and J.L. Freudenheim. 1998. Environmental organochlorine exposure and postmenopausal breast cancer risk. Cancer Epidemiol. Biomarkers Prev. 7(3):181-8.

National Cancer Institute (NCI). 1978. Bioassay of Aroclor 1254 for Possible Carcinogenicity. Carcinogenesis Tech. Rep. Ser. No. 38.

National Institute of Occupational Safety and Health (NIOSH). 1977. NIOSH Criteria Document for a Recommended Standard. Occupational Exposure to Polychlorinated Biphenyls (PCBs). Rockville, MD. U.S. Department of Health, Education and Welfare, Public Health Service, Centers for Disease Control, National Institute of Occupational Safety and Health. DHEW (NIOSH) Publication No. 77-225. September.

National Toxicology Program (NTP). 1981. Second Annual Report on Carcinogens: Summary 1981. Research Triangle Park, N.C.: U.S. Department of Health and Human Service, Public Health Service, National Toxicology Program.

National Toxicology Program (NTP). 1984. Report of the Ad Hoc Panel on Chemical Carcinogenesis Testing and Evaluation of the National Toxicology Program, Board of Scientific Counselors. Available from: U.S. Government Printing Office, Washington, D.C. 1984-421-132:4726.

National Toxicology Program (NTP). 2000. Ninth Annual Report on Carcinogens: Summary 1981. Research Triangle Park, N.C.: U.S. Department of Health and Human Service, Public Health Service, National Toxicology Program.

Norback, D.H. and R.H. Weltman. 1985. Polychlorinated biphenyl induction of hepatocellular carcinoma in the Sprague-Dawley rat. Environ. Health Perspect. 60:97-105.

Oakley, G.G., U. Devanaboyina, L.W. Robertson, and R.C. Gupta. 1996. Oxidative DNA damage induced by activation of polychlorinated biphenyls (PCBs): Implications for PCB-induced oxidative stress in breast cancer. Chem. Res. Toxicol. 9(8):1285-92. December.

Office of Science and Technology Policy (OSTP). 1985. Chemical carcinogens: review of the science and its associated principles. *Federal Register* 50:10372-10442.

Ozonoff, D. 1999. Personal Communication to Dr. V. J. Cogliano of USEPA National Center for Environmental Assessment, Office of Research and Development, Washington, D.C. Letter dated June 6, 1999.

Rao, C.V. and A.S. Banerji. 1988. Induction of liver tumors in male Wistar rats by feeding polychlorinated biphenyls (Aroclor 1260). Cancer Lett. 39:59-67.

Rothman, N., K.P. Cantor, A. Blair, D. Bush, J.W. Brock, K. Helzlsouer, S.H. Zahm, L.L. Needham, G.R. Pearson, R.N. Hoover, G.W. Comstock, and P.T. Strickland. 1997. A nested case-control study of non-Hodgkin lymphoma and serum organochlorine residues. Lancet 350(9073):240-244.

Safe, S. 1994. Polychlorinated biphenyls (PCBs): environmental impact, biochemical and toxic responses, and implications for risk assessment. Crit. Rev. Toxicol. 24(2):87–149.

Schaeffer, E., H. Greim, and W. Goessner. 1984. Pathology of chronic polychlorinated biphenyl (PCB) feeding in rats. Toxicol. Appl. Pharmacol. 75:278-288.

Shalat, S.L., L.D. True, L.E. Fleming, and P.E. Pace. 1989. Kidney cancer in utility workers exposed to polychlorinated biphenyls (PCBs). Br. J. Ind. Med. 46(11):823-824.

Sinks, T., G. Steele, A.B. Smith, K. Watkins, and R.A. Shults. 1992. Mortality among workers exposed to polychlorinated biphenyls. Am. J. Epidemiol. 136(4):389-398.

Steele, G.; Stehr-Green, P.; and Welty, E. 1986. Estimates of the biologic half-life of polychlorinated biphenyls in human serum. New Engl. J. Med. 314(14):926–927.

Tironi, A., A. Pesatori, D. Consonni, C. Zocchetti, and P.A. Bertazzi. 1996. Mortality among women workers exposed to PCBs. Epidemiol. Prev. 20:200-202.

U.S. Environmental Protection Agency (USEPA). 1976. Interim procedures and guidelines for health risk and economic impact assessments of suspected carcinogens. *Federal Register* 41:21402-21405.

USEPA. 1983a. Hazard Evaluations: Humans and Domestic Animals. Subdivision F. Available from NTIS, Springfield, Virginia. PB 83-153916.

USEPA. 1983b. Health Effects Test Guidelines. Available from: NTIS, Springfield, VA. PB 83-232984.

USEPA. 1984. Proposed guidelines for carcinogen risk assessment. *Federal Register* 49:46294. November 23.

USEPA. 1986. Guidelines for carcinogen risk assessment. *Federal Register* 51:33992-34003.

USEPA. 1988. Drinking Water Criteria Document for Polychlorinated Biphenyls (PCBs). Environmental Criteria and Assessment Office, Office of Research and Development, Cincinnati, Ohio. ECAO-CIN-414.

USEPA. 1989. Risk Assessment Guidance for Superfund (RAGS), Volume I. Human Health Evaluation Manual (Part A). USEPA, Office of Emergency and Remedial Response, Washington, D.C. USEPA/540/I-89/002, December.

USEPA. 1990. National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule, codified as amended at 40 C.F.R Part 300.

USEPA. 1992. Draft Report. A Cross-Species Scaling Factor for Carcinogen Risk Assessment Based on Equivalence of $mg/kg^{3/4}$-day. Notice. Federal Registry 57(109):24152-24173.

USEPA. 1993. Memorandum from William H. Farland, Director of the Office of Health and Environmental Assessment and Henry L. Longest, II, Director of the Office of Emergency and Remedial Response to: Directors of the Waste Management Divisions, Emergency and Remedial Response Divisions, Hazardous Waste Management Division and Hazards Waste Division. Subject: Use of IRIS Values in Superfund Risk Assessment. OSWER Directive #9285.7-16. December 21.

USEPA. 1994. Report on the Workshop on Cancer Risk Assessment Guidelines Issues. Office of Research and Development, Risk Assessment Forum, Washington, D.C. EPA/630/R-94/005a.

USEPA. 1996a. Proposed guidelines for carcinogen risk assessment. *Federal Register* 61 (79) 17960-18011. April 23.

USEPA. 1996b. PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures. National Center for Environmental Assessment, Washington, D.C. USEPA/600/P-96/001F. September.

USEPA. 1996c. Report on Peer-Review Workshop on PCBs: Cancer-Dose Response Assessment and Application to Environmental Mixtures. National Center for Environmental Assessment, Office of Research and Development, Washington, D.C.

USEPA. 1997. Special Report on Environmental Endocrine Disruption. An Effects Assessment and Analysis Risk Assessment Forum, Office of Research and Development, Washington, D.C. EPA/630/R-96/012.

USEPA. 1999a. Guidelines for Carcinogen Risk Assessment. SAB Review Draft, July, 1999. NCEA-F-0644.

USEPA. 1999b. Integrated Risk Information System (IRIS) Chemical File for PCBs. National Center for Environmental Assessment, Office of Research and Development, Cincinnati, Ohio.

USEPA. 2000a. Hudson River PCBs Reassessment RI/FS. Revised Human Health Risk Assessment. Prepared for the U.S. EPA and U.S. Army Corps of Engineers by TAMS Consultants, Inc. and Gradient Corporation. USEPA, Region 2, New York, New York. November.

USEPA. 2000b. Hudson River PCBs Reassessment RI/FS Response to Peer Review Comments on the Human Health Risk Assessment. Prepared for the U.S. EPA and U.S. Army Corps of Engineers by TAMS Consultants, Inc. and Gradient Corporation. USEPA, Region II, New York, New York. November.

USEPA. 2000c. Hudson River PCBs Reassessment RI/FS. Responsiveness Summary for Volume 2F. Human Health Risk Assessment. Prepared for the U.S. EPA and U.S. Army Corps of Engineers by TAMS Consultants, Inc. and Gradient Corporation. USEPA, Region II, New York, New York. March.

USEPA. 2000d. Hudson River PCBs Reassessment RI/FS. Responsiveness Summary for Volume 2F-A Human Health Risk Assessment for the Mid-Hudson River. Prepared for the U.S. EPA and U.S. Army Corps of Engineers by TAMS Consultants, Inc. and Gradient Corporation. USEPA, Region II, New York, New York. August.

USEPA. 2001. Notice of Opportunity to Provide Additional Information and Comment on draft revised Guidelines for Carcinogen Risk Assessment (July 1999). *Federal Register* 66:59593-59594.

Wolf, M.S., J. Thornton, A. Fischbein, R. Lilis, and I.J. Selikoff. 1982. Disposition of polychlorinated biphenyl congeners in occupationally exposed persons. Toxicol. Appl. Pharmacol. 62:294-306.

Yassi, A., R. Tate, and D. Fish. 1994. Cancer mortality in workers employed at a transformer manufacturing plant. Am. J. Ind. Med. 25(3):425-437.

PCB Non-Cancer Health Effects
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WHITE PAPER – PCB NON-CANCER HEALTH EFFECTS

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ABSTRACT

Non-cancer health effects associated with exposure to PCBs include reduced birth weight, learning problems, and reduced ability to fight infection. The quantification of non-cancer health effects is a Reference Dose, which is a dose below which non-cancer health effects are not expected to occur over a lifetime. EPA has established guidelines for evaluating non-cancer health effects and developing Reference Doses for chemicals. These guidelines were externally peer reviewed. Using these guidelines and associated documents, EPA developed a Reference Dose for Aroclor 1016, which was externally peer reviewed. EPA used the same methodology to develop a Reference Dose for Aroclor 1254, which was internally peer reviewed. EPA's Reference Dose for Aroclor 1254 is consistent with the chronic Minimal Risk Level for PCBs developed by the Agency for Toxic Substances and Disease Registry. EPA is currently updating the non-cancer toxicity information for PCBs contained in the Integrated Risk Information System, which is the Agency's consensus database of toxicity information.

In the Human Health Risk Assessment for the Hudson River PCBs Site, EPA summarized recent studies published since 1994, including studies on developmental/neurotoxic effects, thyroid and immunological effects, reproductive effects, and neurological effects in adults. Based on a review of these studies, EPA determined that it was appropriate to use the current Reference Doses for PCBs in the Human Health Risk Assessment. EPA submitted the Human Health Risk Assessment for external peer review, and the peer reviewers agreed with the toxicity values used in the Human Health Risk Assessment.

INTRODUCTION

The purpose of this paper is to provide an overview of EPA's process for evaluating the non-cancer toxicity of a chemical, development of non-cancer Reference Doses (RfDs) for PCBs, and the application of this toxicity information in the Human Health Risk Assessment for the Hudson River PCBs Site.

This paper is divided into three parts. The first part describes EPA's non-cancer guidelines and background documents for developing reference doses (RfDs) (USEPA, 1986a-b, 1991, 1992, 1993a,b, 1996a, 1998). These documents set forth principles and procedures for evaluating non-cancer toxicity information.

The second part of this paper describes the Agency's evaluation of the non-cancer toxicity of PCBs. It summarizes the important studies regarding PCB non-cancer toxicity, including the critical studies identified for development of the Reference Doses in the Integrated Risk Information System (IRIS), the Agency's consensus database of toxicity information.

The third part describes the non-cancer toxicity information used in the Human Health Risk Assessment for the Hudson River PCBs Site and addresses the Averaging Times and blood PCB levels from occupational studies.

EPA'S NON-CANCER GUIDELINES AND REFERENCE DOSE DEVELOPMENT

EPA's process for evaluating human epidemiological and animal evidence to determine the non-cancer toxicity of chemicals, including PCBs, is set forth in the Agency's guidelines (USEPA, 1986a-b, 1991, 1992, 1993a, 1996a, 1998) and supporting information (USEPA, 1993b; Barnes and Dourson, 1988; Dourson and Stara, 1983). The guidelines cover a variety of health endpoints including developmental toxicity (USEPA, 1991), reproductive toxicity (USEPA, 1996a), neurotoxicity (USEPA, 1998), female reproductive risk (USEPA, 1986a) and male reproductive risk (USEPA, 1986a).

The non-cancer toxicity guidelines were developed within the Agency and published in the *Federal Register* for comment. Periodically, the guidelines have been updated to reflect new scientific understanding regarding toxicity. Prior to being finalized, the guidelines, as updated, are externally peer reviewed by a panel of expert scientists in the various fields associated with non-cancer toxicity including developmental toxicity, neurological toxicity, endocrine effects, who work in universities, environmental groups, industry, labor, and other governmental agencies. EPA responds to comments on the draft guidelines and makes changes based on a review of the comments submitted by these groups or individuals. The guidelines are also submitted for review to EPA's Science Advisory Board, an external scientific review panel.

Reference Dose Development

The quantification of chronic non-cancer health effects is a chronic Reference Dose (RfD), which is defined as an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of an exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime (USEPA, 1989, 1993b).

The procedures used by EPA to develop RfDs are provided in the Background Document on RfD Development available on EPA's IRIS database (USEPA, 1993b; see also www.epa.gov/iris). In general, exposure to a given chemical, depending on the dose, may result in a variety of toxic effects ranging from death to subtle biochemical, physiologic, or pathologic changes. The process for RfD development includes:

- Critical evaluation of the available scientific literature, including human epidemiological and animal toxicity studies. Human data are often useful in qualitatively establishing the presence of an adverse effect in exposed human populations. Human epidemiological studies may be limited in their ability to establish a dose-response relationship between level of exposure and observed health effects, by the degree to which confounders (*e.g.*, other chemicals and lifestyle factors) are controlled.

- For many chemicals, the principal studies are drawn from experiments conducted on non-human mammals, such as the rat, mouse, rabbit, guinea pig, hamster or monkey. These

animal studies typically reflect situations in which exposure to the chemical has been carefully controlled and the problems of heterogeneity of the exposed population and concurrent exposures to other chemicals have been minimized.

- EPA uses a weight-of-evidence approach in evaluating the non-cancer toxicity of a chemical, with emphasis on the results from the principal and supportive studies.

- Identification of the critical study(s), critical effect(s) and a dose level (*i.e.*, no observed adverse effect level [NOAEL] or lowest observed adverse effect level [LOAEL]) based on the study(s). The dose level is then divided by uncertainty factors to calculate an RfD. In general, the values used for each uncertainty factor are either 1, 3, or 10 (USEPA, 1993b). The value of 3 is used as a "half" factor and represents the square root (rounded to one significant digit) of the full uncertainty factor of 10, so that two "half" factors yield a full factor of 10 when multiplied together (USEPA, 1994b).

- There are four standard uncertainty factors (ranging from 1 to 10) that can be used when calculating an RfD. These factors account for 1) the variation in sensitivity among members of the human population, 2) extrapolation from animal data to humans, 3) extrapolation from less than chronic NOAELs to chronic NOAELs, and 4) extrapolation from LOAELs to NOAELs. An additional modifying factor (MF), also ranging from 1 to 10, can be applied to the calculation of the RfD. The magnitude of the MF depends upon an assessment of the scientific uncertainties of the study and the database used in deriving the RfD that are not explicitly treated above, such as completeness of the overall database and the number of species tested.

The equation used in the calculation is:

$$RfD = NOAEL / (UF \times MF).$$

NON-CANCER TOXICITY OF PCBs

Based on a weight of the evidence, EPA concluded that PCBs pose a non-cancer health hazard. Non-cancer health effects associated with exposure to PCBs include dermal effects (*e.g.*, chloracne), developmental neurotoxic effects (*e.g.*, learning problems), ocular effects (eye problems), reduced birth weight, and immunotoxic effects (*e.g.*, reduced ability to fight infection). This conclusion is based primarily on animal studies, including monkey studies. Human evidence was also considered.

EPA is not alone in its concern regarding the non-cancer toxicity of PCBs and in using data from studies in monkeys to develop health protective toxicity values. In a joint publication with EPA, ATSDR stated (ATSDR and USEPA, 1996):

> "The findings of elevated PCB levels in human populations, together with findings of developmental deficits and neurologic problems in children whose mothers ate PCB-contaminated fish, have compelling implications. The weight of evidence clearly indicates that populations continue to eat fish containing PCBs

> and that significant health consequences are associated with consumption of large amounts of some fish…Human health studies…indicate that: 1) reproductive function may be disrupted by exposure to PCBs; 2) neurobehavioral and developmental deficits occur in newborns and continue through school-aged children who had in utero exposure to PCBs; 3) other systemic effects (e.g., self-reported liver disease and diabetes, and effects on the thyroid and immune systems) are associated with elevated serum levels of PCBs; and 4) increased cancer risks, e.g., non-Hodgkin's lymphoma, are associated with PCB exposures."

The National Research Council (NAP, 2000) concluded:

> "The Committee's review of recent scientific information supports the conclusion that exposure to PCBs may result in chronic effects (e.g., cancer, immunological, developmental, reproductive, and neurological effects) in humans and/or wildlife. Therefore, the committee considers that the presence of PCBs in sediments may pose long-term public health and ecosystem risks."

Dermal Effects

Several studies document dermal effects in workers exposed to PCBs (Fischbein *et al.*, 1979, 1982, 1985; Maroni *et al.*, 1981a,b; Ouw *et al.*, 1976; Smith *et al.*, 1982). Dermal effects include skin rashes, pigmentation disturbances of skin and nails, thickening of the skin, burning sensations, and chloracne, a severe form of acne that results from exposure to PCBs. Variability in response in more highly exposed individuals suggests that susceptibility varies greatly among individuals (ATSDR, 2000).

Studies in Rhesus monkeys fed diets containing Aroclors for intermediate durations of exposure found effects including facial edema (swelling), acne, folliculitis (inflammation of the hair follicle) and alopecia (hair loss) (Allen and Norback, 1973, 1976; Allen *et al.* 1973, 1974a,b; Barsotti *et al.*, 1976; Becker *et al.*, 1979; Ohnishi and Kohno, 1979; Thomas and Hinsdill, 1978).

Developmental/Neurotoxic Effects

Developmental/neurotoxic effects associated with PCB exposure in animals and identified in human epidemiological studies include reduced birth weight, learning problems, and memory problems.

On September 14 and 15, 1992, EPA convened a Risk Assessment Forum (RAF) Colloquium of expert scientists to evaluate the developmental/ neurotoxic effects of PCB exposure. The Workshop papers discuss the principles and methods for evaluating data from animal and human epidemiological studies (USEPA, 1993a). The report concluded:

> "The sense of the meeting seemed to be that, at least in qualitative terms, the available data are sufficient. In other words, based on an evaluation of the strengths and weaknesses in the data and on the consistency of effects seen in all species tested, including humans, there is sufficient information to indicate that PCBs cause developmental neurotoxicity. Interestingly, the data suggest that

> prenatal exposure to PCBs may be more detrimental than postnatal exposure, even though the level of exposure via breast milk is much greater than that occurring via placental transfer."

Similarly, ATSDRs Toxicological Profile for PCBs (ATSDR, 2000) stated:

> "Studies in humans who consumed high amounts of Great Lakes fish contaminated with environmentally persistent chemicals, including PCBs, have provided evidence that PCBs are important contributors to subtle neurobehavioral alterations observed in newborn children and that some of these alterations persist during childhood…Neurobehavioral alterations have been also observed in rats and monkeys following pre- and/or postnatal exposure to commercial Aroclor mixtures, defined experimental congener mixtures, single PCB congeners, and Great Lakes contaminated fish. In addition, monkeys exposed postnatally to PCB mixtures of congeneric composition and concentration similar to that found in human breast milk showed learning deficits long after exposure had ceased."

Immunotoxic Effects

The immune system is the body's primary defense against infection. Immune effects associated with PCBs include a reduced ability to fight infections.

Several human epidemiological studies evaluated the effects of PCBs on workers and found transient effects on total and differential white blood cell counts (Chase *et al.*, 1982; Lawton *et al.*, 1985; Maroni *et al.*, 1981b; Smith *et al.*, 1982). A number of studies have evaluated the effects of PCBs in specific population groups (*i.e.*, infants, children of mothers who consumed fish, and fish consumers). Immunotoxic effects reported in the Great Lakes populations include increased middle ear and respiratory tract infections in children of exposed mothers (Smith, 1984).

ATSDR (2000) concluded:

> "Findings include increased susceptibility to respiratory tract infections in adults and their children, increased prevalence of ear infections in infants, decreased total serum Immunoglobulin A and Immunoglobulin M antibody levels, and/or changes in T lymphocyte subsets. Overall there is a consistent of effects among the human studies suggesting sensitivity of the immune system to PCBs, particularly in infants expose in utero and/or via beast feeding. However, due to the mixed chemical nature of the exposures and generally insufficient information on exposure-response relationship, the human studies provide only limited evidence of PCB immunotoxicity."

Decreased antibody responses (Immunoglobulin G and Immunoglobulin M) were detected in studies on monkeys (Tryphonas *et al.*, 1989, 1991a,b).

Ocular Effects

Occupational studies have shown eye irritation, tearing and burning among workers exposed to airborne PCBs (Emmett *et al.*, 1988, Ouw *et al.*, 1976; and Smith *et al.*, 1982). Fischbein *et al.* (1979, 1985) found that some capacitor workers had edema of the upper eyelid, congestion of the conjunctiva, eye discharge and enlargement of the Meibomian glands following exposures to various Aroclors in a range of concentrations.

The monkey studies noted ocular exudate (discharge) and inflamed and enlarged Meibomian glands (Arnold *et al.*, 1993a, b).

Reference Doses for Aroclors 1016 and 1254

Using the process summarized above, EPA evaluated both human epidemiological evidence and animal toxicity studies in developing quantitative RfDs for Aroclors 1016 and 1254 (USEPA, 1999a,b).

EPA determined that the human data available for risk assessments of Aroclor 1016 and Aroclor 1254 are useful only in a qualitative manner, noting, "Studies of the general population exposed to PCBs by consumption of contaminated food, particularly neurobehavioral evaluations of infants exposed in utero and/or through lactation, have been reported, but the original PCB mixtures, exposure levels and other details of exposure are not known (Kreiss *et al.*, 1981; Humphrey, 1983; Fein *et al.*, 1984a,b; Jacobson *et al.*, 1984a,b, 1985, 1990a,b; Rogan *et al.*, 1986; Gladen *et al.*, 1988). Most of the information on health effects of PCB mixtures in humans is available from studies of occupational exposure. Some of these studies examined workers who had some occupational exposure, but in these studies concurrent exposure to other Aroclor mixtures nearly always occurred, exposure involved dermal as well as inhalation routes (the relative contribution by each route was not known), and monitoring data were lacking or inadequate (Fischbein *et al.*, 1979, 1982, 1985; Fischbein, 1985; Warshaw *et al.*, 1979; Smith *et al.*, 1982; Lawton *et al.*, 1985)."

A brief summary of EPA's development of the RfDs is provided below.

Aroclor 1016

EPA identified the monkey reproductive studies by Barsotti and van Miller (1984) and neurological studies by Levin *et al.* (1988), and Schantz *et al.* (1989, 1991) as critical studies. The critical effect identified was reduced birth weights. A NOAEL of 0.25 ppm in feed (or 0.007 mg/kg-day) was identified. The IRIS chemical file for Aroclor 1016 summarizes the critical study and effect and describes EPA's evaluation of a number of other studies that provide supporting information for the selection of these studies (USEPA, 1999a; see also www.epa.gov/iris).

As part of EPA's peer review process, on May 24 and 25, 1994, EPA convened an RAF Workshop to assess whether the Reference Dose (RfD) for Aroclor 1016 (USEPA, 1994a) represents a full consideration of the available scientific data and whether that analysis is clearly articulated in the RfD entry on IRIS. The results from this Workshop were used in finalizing the

RfD for Aroclor 1016 (USEPA, 1999a) currently listed on IRIS. The IRIS chemical files for both Aroclor 1016 (USEPA, 1999a) and Aroclor 1254 (USEPA, 1999b) represent the consensus of the Reference Dose/Reference Concentration Workgroup, responsible for reaching consensus on non-cancer toxicity values, which was in existence when the files were completed.

USEPA's applied uncertainty/modifying factors totaling 100 (3 x 3 x 3 x 3 and rounded) to be protective of sensitive human populations that may be exposed *i.e.*, the NOAEL of 0.007 mg/kg-day was divided by a factor of 100 to yield a RfD of 0.00007 mg/kg-day. A summary of the UFs and their basis is provided below:

- A factor of 3 is applied to account for sensitive individuals. The results of these studies, as well as data for human exposure to PCBs, indicate that infants exposed transplacentally represent a sensitive subpopulation.

- A factor of 3 is applied for extrapolation from Rhesus monkeys to human. A full 10-fold factor for interspecies extrapolation is not considered necessary because of similarities in toxic responses and metabolism of PCBs between monkeys and humans and the general physiologic similarity between these species. In addition, the Rhesus monkey data are predictive of other changes noted in human studies such as chloracne, hepatic changes, and effects on reproductive function.

- A factor of 3 is applied because the study duration was considered as somewhat greater than subchronic, but less than chronic; a partial factor of 3 is used to account for extrapolation from a subchronic exposure to a chronic RfD.

- A factor of 3 is applied because of limitations in the database. Despite the extensive amount of animal laboratory data and human epidemiologic information regarding PCBs, the issue of male reproductive effects is not directly addressed and two-generation reproductive studies are not available.

Aroclor 1254

EPA identified the monkey studies by Arnold *et al.* (1993a,b), Tryphonas *et al.* (1989, 1991a,b) as the critical studies. The critical effects were ocular exudate, inflammation and prominent Meibomian glands in the eye, distorted growth of finger- and toenails, and decreased antibody responses (Immunoglobulin G and Immunoglobulin M) based on responses to sheep erythrocytes (USEPA, 1999b). A NOAEL could not be identified so a LOAEL of 0.005 mg/kg-day was identified.

EPA applied uncertainty factors totaling 300 (*i.e.*, 10 x 3 x 3 x 3 and rounded) to the LOAEL of 0.005 mg/kg and calculated an RfD of 0.00002 mg/kg-day. The basis for the UFs are provided below:

- A factor of 10 is applied to account for sensitive individuals such as children, elderly, and others.

- A factor of 3 is applied to extrapolation from Rhesus monkeys to humans. A full 10-fold factor for interspecies extrapolation is not considered necessary because of similarities in toxic responses and metabolism of PCBs between monkeys and humans and the general physiologic similarity between these species. Tilson *et al.* (1990) reported that humans appear to be more sensitive than monkeys or rodents. EPA noted that the differences in species sensitivity may be related to variations in the sensitivity of the testing paradigms used in different species, and/or differences in the toxicity of the various commercial mixtures, or environmental exposures used in various studies" (USEPA, 1993a). Based on similarity in types of effects but dissimilarity in effective doses and NOAELs across test species, EPA concluded that monkeys are not less sensitive than humans with respect to developmental/neurotoxic effects of PCBs (USEPA, 1993a).

- A factor of 3 is applied for the use of a minimal LOAEL since the changes in the periocular tissues and nail bed seen at the 0.05 mg/kg-day are not considered to be of marked severity. The duration of the critical study continued for approximately 25% of the lifespan of Rhesus monkeys, so a factor of 3 is appropriate for extrapolation from subchronic exposure to a chronic RfD.

- A factor of 3 is applied based on the immunologic and clinical changes that were observed but did not appear to be dependent upon duration, which further justifies using a factor of 3 rather than 10 for extrapolation from subchronic to chronic, lifetime exposure.

The Agency for Toxic Substances and Disease Registry issued an updated Toxicological Profile for Polychlorinated Biphenyls following external peer review (ATSDR, 2000). ATSDR (2000) includes Minimal Risk Levels (MRL). The MRL is defined as "an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure" (ATSDR, 2000). The chronic MRL is developed to be protective over a one-year period or more, and is similar to EPA's RfD, which is developed to be protective over a lifetime. The intermediate MRL is developed to be protective from 15 to 364 days.

ATSDR's chronic MRL is 0.00002 mg/kg/day, based on the study by Tryphonas *et al.* (1989, 1991a,b), which also was used as the critical study for EPA's RfD for Aroclor 1254. The intermediate oral MRL level developed by ATSDR based on monkey studies by Rice (1997, 1998, 1999b) and Rice and Hayward (1997 and 1998) is 0.00003 mg/kg-day, which is slightly higher than the MRL for chronic exposure (ATSDR, 2000). Similar to EPA, ATSDR used a factor of 3 for extrapolating from the monkey studies to humans in developing its MRLs.

HUDSON RIVER PCBs SITE

Consistent with EPA guidance and CERCLA and NCP policies, the PCB non-cancer toxicity information and RfDs that are in IRIS were used in the HHRA (USEPA, 2000a,b). The use of IRIS data in the evaluation of chemical toxicity at Superfund sites addresses EPA's goal of using consistent toxicity information at Superfund sites across the country.

EPA submitted the HHRA (USEPA, 1999c) for external peer review. EPA specifically charged the peer reviewers to evaluate whether use of the IRIS values was appropriate. The peer

reviewers for the HHRA agreed with USEPA's use of non-cancer toxicity information from IRIS.

In the HHRA, EPA applied an Averaging Time that is equivalent to the Exposure Duration multiplied by 365 days/year, consistent with USEPA (1989). The peer reviewers of the HHRA agreed with EPA's selection of Averaging Times (USEPA, 2000b) and recommended that EPA evaluate the effects of PCBs to pregnant and nursing women using a shorter exposure duration. The non-cancer hazards to the fetus and infant were addressed qualitatively in the HHRA (USEPA, 2000a), due to the lack of an approved methodology for modeling the effects of PCBs on the fetus and calculating the PCB levels in breast milk based on the mother's body burden.

The HHRA peer reviewers also recommended that EPA also provide a discussion of the more recently published studies on non-cancer endpoints to determine what effect these studies might have on risk estimates. In response, in the Revised HHRA, EPA summarized a number of newly published human epidemiological studies on the non-cancer effects of PCBs (including updates of the neuro-developmental studies in cohorts of children and adults) identified in the IRIS files for Aroclors 1016 and 1254 (USEPA, 2000a). Based on an evaluation of this data, EPA concluded that the toxicity values in IRIS are still appropriate for the HHRA (USEPA, 2000b).

Since 1994, a number of new animal studies and human epidemiological studies and updated studies of the cohorts originally described in 1993-1994 have been published (*e.g.*, Rice 1997, 1998, 1999b, Rice and Hayward, 1997, 1998; Schantz, 1996, Schantz *et al.*, 2001; Jacobson and Jacobson, 1996a,b; 1997; Lanting *et al.*, 1998a,b,c; Patandin *et al.*, 1998, 1999a,b; Koopman-Esseboom *et al.*, 1996; Weisglas-Kuperus *et al.*, 1995, 2000; and Fitzgerald *et al.*, 1995, 1996, 1998, 1999). The studies have been published in a variety of peer-reviewed journals (*e.g.*, Neurotoxicology, New England Journal of Medicine, Science, Lancet, Environmental Health Perspective, Journal of Pediatrics), including a number of public health and epidemiological journals (American Journal of Public Health, Annals of Epidemiology, Epidemiology, American Journal of Epidemiology). In general, as the studies progressed through time, the list of confounders were expanded or reduced as appropriate based on *a priori* information regarding previous studies, consistent with epidemiological practices. A summary of these studies is provided the HHRA (USEPA, 2000a).

Some of these studies found reductions in IQ points (*i.e.*, 3 to 5 points across the various studies) based on prospective studies in children exposed to various sources of PCBs, including fish consumption. At a population level, as well as at an individual level, the potential impacts of the loss of IQ points may be significant, especially among children at the low end of the IQ distribution.

As part of EPA's reassessment of PCB non-cancer toxicity, EPA will critically evaluate this new information (*e.g.*, from human epidemiological studies, animal studies, and mechanistic data) to determine the critical study, critical effect, and appropriate Uncertainty/Modifying Factors necessary to develop a new RfD or reaffirm the current RfD. Documents summarizing the non-cancer toxicology of PCBs will be reviewed within the Agency, and submitted for external peer review. Based on the results of this review, an IRIS chemical file will be developed and undergo internal EPA consensus IRIS review, and will be made available on the IRIS database at the completion of this process.

Effects of PCB Exposure on Blood Levels

EPA followed risk assessment guidance and procedures (see National Contingency Plan; see also USEPA, 1989, 1993c, 1995, 1997) to quantify non-cancer health hazards to individuals exposed to PCBs at the Hudson River PCBs Site in the HHRA (USEPA, 2000a). The approach used in the HHRA is different than measurement of PCB levels in blood of former capacitor workers. First, the HHRA evaluates current and future exposures, while the blood PCB level data integrates past exposure.

Second, capacitor workers were primarily exposed through dermal contact and inhalation of PCBs, whereas anglers, which had the highest cancer risks evaluated in the HHRA, would be exposed to PCBs through ingestion of contaminated fish caught in the Hudson River.

Third, in the HHRA EPA evaluated non-cancer health hazards to the RME individual, whereas for capacitor workers the level of exposure is generally not known. Fourth, the PCB congener profile in the capacitor plant is likely to be different from the congener profile of PCBs that are bioaccumulated in the fish. Lastly, EPA is concerned with potential exposures to the human population including sensitive groups that may include the fetus exposed from mothers who consumed PCB-contaminated fish, infants exposed to PCBs through breast milk, young children, adolescents, adults, and individuals with pre-existing medical conditions (USEPA, 2000a); many of these sensitive groups may not be represented in a healthy worker population. EPA has stated that (USEPA, 1996b):

> "People with decreased liver function, including inefficient glucuronidative mechanism in infants, can have less capacity to metabolize and eliminate PCBs (Calabrese and Sorenson, 1977). Additionally, approximately 5% of nursing infants receive a steroid in human milk that inhibits the activity of glucuronyl transferase, further reducing PCB metabolism and elimination (Calabrese and Sorenson, 1977)."

A study of people exposed through eating contaminated fish (Hovinga *et al.*, 1992) suggests that the PCB mixtures in fish can be more persistent than those to which the workers were exposed. From 1977 to 1985, mean PCB serum levels (quantified using Aroclor 1260 as a reference standard) from 111 Great Lakes fish eaters decreased only slightly from 20.5 to 19.0 ppb (see USEPA, 1996b). Half-life estimates for a mixture can underestimate its long-term persistence (USEPA, 1996b), especially from consumption of fish where changes in PCB blood levels may take longer (Hovinga *et al.*, 1992). This indicates that the rate of decline in the fish eating populations will be slower than that for the workers.

ATSDR's Toxicological Profile (ATSDR, 2000) states that there are no known treatment methods for reducing body burdens of PCBs, concluding that limiting or preventing further exposure appears to be the most practical method for reducing PCB body burdens.

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 2000. Toxicological Profile for Polychlorinated Biphenyls (Update). ATSDR, Atlanta, Georgia, November.

ATSDR and USEPA. 1996. Public Health Implications of Exposure to Polychlorinated Biphenyls (PCBs). US Public Health Service, the Agency for Toxic Substances and Disease Registry, US Department of Health and Human Services and the U.S. Environmental Protection Agency, Washington, D.C. Available at: www.epa.gov/OST/fish/pcb99.html

Allen, J.R., L.J. Abrahamson and D.H. Norback. 1973. Biological effects of polychlorinated biphenyls and triphenyls on the subhuman primate. Environ. Res. 6: 344-354.

Allen, J.R., Carstens, L.A., and Barsotti, D.A. 1974a. Residual effects of short-term, low level exposure to non-human primates to polychlorinated biphenyls. Toxicol. Appl. Pharmacol. 30:440-451.

Allen, J.R. and Norback, D.H. 1973. Polychlorinated biphenyl - and triphenyl-induced gastric mucosal hyperplasia in primates. Science 179:498-499.

Allen, J.R. and D.H. Norback. 1976. Pathobiological responses of primates to polychlorinated biphenyl exposure. In: Proceedings of the National Conference on Polychlorinated Biphenyls. EPA 560/6-75-004. p. 43-49.

Allen, J.R., D.H. Norback and I.C. Hsu. 1974b. Tissue modifications in monkeys as related to absorption, distribution, and excretion of polychlorinated biphenyls. Arch. Environ. Contam. Toxicol. 2(1): 86-95.

Arnold, D.L., F. Bryce, R. Stapley *et al.* 1993a. Toxicological consequences of Aroclor 1254 ingestion by female Rhesus (Macaca mulatta) monkeys, Part 1A: Prebreeding phase - clinical health findings. Food Chem. Toxicol. 31: 799-810.

Arnold, D.L., F. Bryce, K. Karpinski *et al.* 1993b. Toxicological consequences of Aroclor 1254 ingestion by female Rhesus (Macaca mulatta) monkeys, Part 1B: Prebreeding phase -clinical and analytical laboratory findings. Food Chem. Toxicol. 31: 811-824.

Barnes, D.G., and M. L. Dourson, 1988. Reference Dose (RfD): Description and use in health risk assessment. Regul. Toxicol. Pharmacol. 8:471-486.

Barsotti, D.A., R.J. Marlar and J.R. Allen. 1976. Reproductive dysfunction in rhesus monkeys exposed to low levels of polychlorinated biphenyls (Aroclor 1248). Food Cosmet. Toxicol. 14: 99-103.

Barsotti, D.A. and J.P. van Miller. 1984. Accumulation of a commercial polychlorinated biphenyl mixture (Aroclor 1016) in adult rhesus monkeys and their nursing infants. Toxicology. 30: 31-44.

Becker, G.M., W.P. McNulty and M. Bell. 1979. Polychlorinated biphenyls-induced morphologic changes in the gastric mucosa of the rhesus monkey. Lab. Invest. 40: 373-383.

Calabrese, E.J. and A.J. Sorenson. 1977. The health effects of PCBs with particular emphasis on human high risk groups. Rev. Environ. Health 2:285-304.

Chase, K.H., Wong, O., Thomas, D. *et al.* 1982. Chemical and metabolic abnormalities associated with occupational exposure to polychlorinated biphenyls (PCBs). J. Occup. Med. 24:109-114.

Dourson, M.L. and S. F. Stara. 1983. Regulatory history and experimental support of uncertainty (safety) factors. Regul. Toxicol. Pharmacol. 3:224-238.

Emmett, E.A., Maroni, M., Jeffrey, J.S. *et al.* 1988. Studies of transfer repair workers exposed to PCBs. II. Results of Clinical Laboratory Investigations. Am. J. Ind. Med. 14:47-62.

Fein, G.G., J.L. Jacobson, S.W. Jacobson *et al.* 1984a. Intrauterine exposure of humans to PCBs: Newborn effects. U.S. EPA, Duluth, MN. EPA 600/53-84-060.

Fein, G.G., J.L. Jacobson, S.W. Jacobson *et al.* 1984b. Prenatal exposure to polychlorinated biphenyls: Effects on birth size and gestation age. J. Pediatr. 105: 315-320.

Fischbein, A. 1985. Liver function tests in workers with occupational exposure to polychlorinated biphenyls (PCBs): Comparison with Yusho and Yu-Cheng. Environ. Health Perspect. 60: 145-150.

Fischbein, A., M.S. Wolff, R. Lilis *et al.* 1979. Clinical findings among PCB-exposed capacitor manufacturing workers. Ann. NY Acad. Sci. 320: 703-715.

Fischbein, A., M.S. Wolff, J. Bernstein *et al.* 1982. Dermatological findings in capacitor manufacturing workers exposed to dielectric fluids containing polychlorinated biphenyls (PCBs). Arch. Environ. Health. 37(2): 69-74.

Fischbein, A., J.N. Rizzo, S.J. Solomon *et al.* 1985. Oculodermatological findings in workers with occupational exposure to polychlorinated biphenyls (PCBs). Br. J. Ind. Med. 42: 426-430.

Fitzgerald, E.F., Brix, K.A., Deres, D.A. *et al.* 1996. Polychlorinated biphenyl (PCB) and dichlorodiphenyl dichloroethylene (DDE) exposure among Native American men from contaminated Great Lakes fish and wildlife. Toxicol. Ind. Health 12(3-4):361-368.

Fitzgerald, E.F., Deres, D.A., Hwang, S.A., Bush, B., Yang, B.Z., Tarbell, A., and Jacobs, A. 1999. Local fish consumption and serum PCB concentrations among Mohawk men at Akwesasne. Environ. Res. 80(2 Pt. 2):S97-S103.

Fitzgerald, E.F., S. A. Hwang, K. A. Brix, B. Bush, K. Cook, and P. Worswick. 1995. Fish PCB concentrations and consumption patterns among Mohawk women at Akwesasne. J. Exposure Anal. Environ. Epidemiol. 5(1):1-19.

Fitzgerald, E.F., S. A. Hwang, B. Bush, K. Cook and P. Worswick. 1998. Fish consumption and breast milk PCB concentrations among Mohawk women at Akwesasne. Am. J. Epidemiology 148(2):164-172.

Gladen, B.C., W.J. Rogan, P. Hardy *et al.* 1988. Development after exposure to polychlorinated biphenyls and dichlorodiphenyl dichloroethene transplacentally and through human milk. J. Pediatr. 113: 991-995.

Hovinga, M.E., Sowers, M., Humphrey, H.E.B. (1992). Historical changes in serum PCB and DDT levels in an environmentally exposed cohort. Arch. Environ. Contam. Toxicol. 27:362-366.

Humphrey, H.E.B. 1983. Population studies of PCBs in Michigan residents. In: PCBs: Human and Environmental Hazards, F.M. D'Itri and M. Kamrin, Ed. Butterworth, Boston, MA. p. 299-310.

Jacobson, J.L., S.W. Jacobson, P.M. Schwartz *et al.* 1984a. Prenatal exposure to an environmental toxin: A test of the multiple effects model. Develop. Psychobiol. 20(4): 523-532.

Jacobson, J.L., G.G. Fein, S.W. Jacobson *et al.* 1984b. The transfer of polychlorinated biphenyls (PCBs) and polybrominated biphenyls (PBBs) across the human placenta and into maternal milk. Am. J. Public Health. 74(4): 378-379.

Jacobson, S.W., G.G. Fein, J.L. Jacobson *et al.* 1985. The effect of intrauterine PCB exposure on visual recognition memory. Child Develop. 56:856-860.

Jacobson, J.L., S.W. Jacobson and H.E.B. Humphrey. 1990a. Effects of in utero exposure to polychlorinated-biphenyls and related contaminants on cognitive-functioning in young children. J. Pediatr. 116: 38-45.

Jacobson, J.L., S.W. Jacobson and H.E.B. Humphrey. 1990b. Effects of exposure to PCBs and related compounds on growth and activity in children. Neurotoxicol. Teratol. 12: 319-326.

Jacobson, J.L. and Jacobson, S.W. 1996a. Prospective, longitudinal assessment of developmental neurotoxicity. Environ. Hlth. Perspect. 104(Suppl. 2):275-283.

Jacobson, J.S. and Jacobson, S.W. 1996b. Dose-response in perinatal exposure to polychlorinated biphenyls (PCBs): the Michigan and North Carolina cohort studies. Toxcol. Indu. Health 12(3-4):435-445.

Jacobson, J.L. and S.W. Jacobson. 1997. Evidence of PCBs as neurodevelopmental toxicants in humans. Neurotoxicol. 18(2):415-424.

Koopman-Esseboom, C., N. Weisglas-Kuperus, M.A.J., De Ridder, C.G., van der Paauw, L.G.M.Th, Tuinstra, and P. J.J. Sauer. 1996. Effects of polychlorinated biphenyl/dioxin

exposure and feeding type on infants' mental and psychomotor development. Pediatrics 97(5):70-706.

Kreiss, K., M.M. Zack, R.D. Kimbrough *et al.* 1981. Association of blood pressure and polychlorinated biphenyl levels. J. Am. Med. Assoc. 245(24):2505-2509.

Lanting, C.I., V. Fidler, M. Huisman, and E. R. Boersma. 1998a. Determinants of polychlorinated biphenyl levels in plasma from 42-month old children. Arch. Environ. Contam. Toxicol. 35:135-139.

Lanting, C.I., S. Pantandin, V. Fidler, N. Weislas-Kuperus, P.J.J., Sauer, E.R., Boersma, and B.C.L. Touwen. 1998b. Neurological condition in 42-month old children in relation to pre- and postnatal exposure to polychlorinated biphenyls and dioxins. Early Human Develop. 59:283-292.

Lanting, C.I., S. Pantandin, N. Weisglas-Kuperus, B.C. Touwer, and E.R. Boersma. 1998c. Breastfeeding and neurological outcome at 42 months. Acta. Paediatr. 87(12):1224-1229.

Lawton, R.W., M.R. Ross, J. Feingold *et al.* 1985. Effects of PCB exposure on biochemical and hematological findings in capacitor workers. Environ. Health Perspect. 60: 165-184.

Levin, E.D., S.L. Schantz and R.E Bowman. 1988. Delayed spatial alternation deficits resulting from perinatal PCB exposure in monkeys. Arch. Toxicol. 62: 267-273.

Maroni, M., A. Colombi, G. Arbosti *et al.* 1981a. Occupational exposure to polychlorinated biphenyls in electrical workers. II. Health effects. Br. J. Ind. Med. 38: 55-60.

Maroni, M., A. Colombi, G. Arbosti *et al.* 1981b. Occupational exposure to polychlorinated biphenyls in electrical workers. I. Environmental and blood polychlorinated biphenyls concentrations. Br. J. Ind. Med. 38: 49-54. NCI (National Cancer Institute). 1978. Bioassay of Aroclor 1254 for possible carcinogenicity. NCI-GC-TR-38. NCI, Bethesda, MD. NTIS PB279624.

National Academy Press (NAP). 2000. A Risk-Management Strategy for PCB-Contaminated Sediments. National Academy of Science, National Research Council of the Academy of Sciences, Washington, D.C., December.

Ohnishi, Y. and Kohno, T. 1979. Polychlorinated biphenyl poisoning in monkey eye. Invest. Ophthalmol. Vis. Sci. 18(9):981-984.

Ouw, H.K., Simpson, G.R., and Siyali, D.T. 1976. Use and health effects of Aroclor 1242, a polychlorinated biphenyl, in an electrical industry. Arch. Environ. Health 31:189-194.

Pantandin, S., C. Koopman-Esseboom, J. A. J., DeRidder, N. Weisglas-Kuperus and P. J. J. Sauer. 1998. Effects of environemtnal epxousre to polychlorinated biphenyls and dioxin on birth size and growth in Dutch children. Pediatr. Res. 44:538-545.

Pantandin, S., P.C. Dagnelie, P.G.H. Mulder, E.O. de Coul, J.E. van der veen, N. Weisglas-Kuperus, and P.J.J. Sauer. 1999a. Dietary exposure to polychlorinated biphenyls and dioxins from infancy until adulthood: A comparison between breast-feeding, toddler and long-term exposure. Environ. Health Perspect. 107(1):45-51.

Pantandin, S. 1999b. Effects of Environmental Exposure to Polychlorinated Biphenyls and Dioxins on Growth and Development in Young Children. A Prospective Follow-Up Study of Breast-Fed and Formula-Fed Infants from Birth Until 42 Months of Age. Thesis.

Rice, D.C. 1997. Effect of postnatal exposure to a PCB mixture in monkeys on multiple fixed interval-fixed ratio performance. Neurotox. Teratol. 19(6):429-434.

Rice, D.C. 1998. Effects of postnatal exposure of monkeys to a PCB mixture on spatial discrimination reversal and DRL performance. Neurotox. Teratol. 20(4):391-400.

Rice, D.C. 1999b. Behavioral impairment produced by low-level postnatal PCB exposure in monkeys. Environ. Res. Section A 80:S113-S121.

Rice, D.C. and S. H. Hayward, 1997. Effects of postnatal exposure to a PCB mixture in monkeys on nonspatial discrimination reversal and delayed alternation performance. Neurotoxicology 18(2):479-494.

Rice, D.C. and S. H. Hayward, 1998. Effects of postnatal exposure of monkeys to a PCB mixture on concurrent random interval-random interval and progressive ratio performance. Neurotox. Teratol. 21(1):47-58.

Rogan, W.J., B.C. Gladen, J.D. McKinney *et al.* 1986. Neonatal effects of transplacental exposure to PCBs and DDE. J. Pediatr. 109: 335-341.

Schantz, S.L. 1996. Developmental Neurotoxicity of PCBs in humans: What do we know and where do we go from here? Neurotoxicol. Teratol. 18(3):217-227.

Schantz, S.L., E.D. Levin and R.E. Bowman. 1991. Long-term neurobehavioral effects of perinatal polychlorinated biphenyl (PCB) exposure in monkeys. Environ. Toxicol. Chem. 10: 747-756.

Schantz, S.L., Gasior, D.M., Polverejan, E., McCaffrey, R.J., Sweeney, A.M., Humphrey, H.Z., and Gardiner, J.C. 2001. Impairments of memory and learning in older adults exposed to polychlorinated biphenyls via consumption of Great Lakes fish. Environ. Health Perspect. 109(6):605-611, 2001.

Schantz, S.L., E.D. Levin, R.E. Bowman *et al.* 1989. Effects of perinatal PCB exposure on discrimination-reversal learning in monkeys. Neurotoxicol. Teratol. 11: 243-250.

Smith, A.B., J. Schloemer, L.K. Lowry *et al.* 1982. Metabolic and health consequences of occupational exposure to polychlorinated biphenyls. Br. J. Ind. Med. 39: 361-369.

Smith, B.J. 1984. PCB levels in human fluids; Sheboygan Case Study. University of Wisconsin Sea Grant Institute, Madison, WI. Technical Report. WIS-SG-83-240.

Taylor, P.R., C.E. Lawrence, H.L. Hwang *et al.* 1984. Polychlorinated biphenyls: Influence on birth weight and gestation. Am. J. Public Health. 74(10): 1153-1154.

Thomas, P.T. and Hinsdill, R.D. 1978. Effect of PCBs on the immune response of rhesus monkeys and mice. Toxicol. Appl. Pharmacol. 44(1):41-51, 1978.

Tilson, H., Jacobson, J., and Rogan, W. 1990. Polychlorinated biphenyls and the developing nervous system: cross-species comparisons. Neurotox. Teratol. 12:239-248.

Tryphonas, H., S. Hayward, L. O'Grady *et al.* 1989. Immunotoxicity studies of PCB (Aroclor 1254) in the adult rhesus (Macaca mulatta) monkey -- preliminary report. Int. J. Immunopharmacol. 11: 199-206.

Tryphonas, H., M.I. Luster, G. Schiffman *et al.* 1991a. Effect of chronic exposure of PCB (Aroclor 1254) on specific and nonspecific immune parameters in the rhesus (Macaca mulatta) monkey. Fund. Appl. Toxicol. 16(4): 773-786.

Tryphonas, H., M.I. Luster, K.L. White *et al.* 1991b. Effects of PCB (Aroclor 254) on non-specific immune parameters in Rhesus (Macaca mulatta) monkeys. Int. J. Immunopharmacol. 13: 639-648.

US Environmental Protection Agency (USEPA). 1986a. The Risk Assessment Guidelines for 1986. Office of Health and Environmental Assessment, Washington, D.C. EPA/600/8-89/043, July.

USEPA. 1986b. Guidelines for the Health Assessment of Suspect Developmental Toxicants. Federal Register 51 (185) 34028-34040, 24 September.

USEPA. 1989. Risk Assessment Guidance for Superfund (RAGS), Volume I. Human Health Evaluation Manual (Part A). USEPA, Office of Emergency and Remedial Response, Washington, D.C. USEPA/540/I-89/002, December.

USEPA. 1991. Guidelines for Developmental Toxicity Risk Assessment. Federal Register 56 (234) 63798-63826, 5 December.

USEPA. 1992. Guidelines for Exposure Assessment. Federal Register 57 (104) 22888-22938, 29 May.

USEPA. 1993a. Workshop Report on Developmental Neurotoxic Effects Associated with Exposure to PCBs. U. S. EPA, Risk Assessment Forum, Office of Research and Development, Washington, D.C. EPA/630/R-92/004, May.

USEPA. 1993b. Reference Dose (RfD): Description and Use in Health Risk Assessments. Background Document 1A. USEPA, National Center for Environmental Assessment (NCEA), Office of Research and Development, Washington, D.C. March 15.

USEPA. 1993c. Memorandum from William H. Farland, Director of the Office of Health and Environmental Assessment and Henry L. Longest, II, Director of the Office of Emergency and Remedial Response to: Directors of the Waste Management Divisions, Emergency and Remedial Response Divisions, Hazardous Waste Management Division and Hazards Waste Division. Subject: Use of IRIS Values in Superfund Risk Assessment. OSWER Directive #9285.7-16. December 21.

USEPA. 1994a. Report on the Technical Review Workshop on the Reference Dose for Aroclor 1016. USEPA, Risk Assessment Forum, Office of Research and Development, Washington, D.C. EPA/630/R-94/006, November.

USEPA. 1994b. Methods for development of inhalation reference concentrations and application of inhalation dosimetry. USEPA, Environmental Criteria and Assessment Office, Research Triangle Park, NC. EPA-600/8-90/066F, October.

USEPA. 1995. "USEPA Risk Characterization Program". Memorandum from Administrator Carol Browner to Assistance Administrators, Associate Administrators, Regional Administrators, General Counsel, and Inspector General on March 21, 1995. Washington, D.C.

USEPA. 1996a. Guidelines for Reproductive Toxicity Risk Assessment. Federal Register 61 (212) 56274-56322, 31 October.

USEPA. 1996b. PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures. National Center for Environmental Assessment, Washington, D.C. USEPA/600/P-96/001F. September.

USEPA. 1997. Risk Assessment Guidance for Superfund (RAGS) Volume I - Human Health Evaluation Manual (Part D, Standardized Planning, Reporting and Review of Superfund Risk Assessments." Office of Solid Waste and Emergency Response, Washington, D.C. SWER Publication #9285.7-01D-1.

USEPA. 1998. "Guidelines for Neurotoxicity Risk Assessment. Federal Register 63 (93) 26926-26954, 14 May.

USEPA. 1999a. Integrated Risk Information System Chemical File for Aroclor 1016. USEPA, National Center for Environmental Assessment, Office of Research and Development, Cincinnati, Ohio.

USEPA. 1999b. Integrated Risk Information System Chemical File for Aroclor 1254. USEPA, National Center for Environmental Assessment, Office of Research and Development, Cincinnati, Ohio.

USEPA. 1999c. Phase 2 Report, Further Site Characterization and Analysis: Volume 2F-Human Health Risk Assessment for the Upper Hudson River, Hudson River PCB Reassessment RI/FS. Prepared for the USEPA and U. S. Army Corps of Engineers by TAMS Consultants, Inc. and Gradient Corporation. USEPA, Region II, New York, New York, August.

USEPA. 2000a. Phase 2 Report, Further Site Characterization and Analysis: Volume 2F-Human Health Risk Assessment Hudson River PCB Reassessment RI/FS. Prepared for the USEPA and U. S. Army Corps of Engineers by TAMS Consultants, Inc. and Gradient Corporation. USEPA, Region II, New York, New York, November.

USEPA. 2000b. Hudson River PCBs Reassessment RI/FS: Peer Review Responsiveness Summary for Volume 2F - Human Health Risk Assessment. Prepared for the USEPA and U.S. Army Corps of Engineers by TAMS consultants, Inc. and Gradient Corporation. USEPA, Region II, New York, New York. March.

Warshaw, R., A. Fischbein, J. Thornton *et al.* 1979. Decrease in vital capacity in PCB-exposed workers in a capacitor manufacturing facility. Ann. NY Acad. Sci. 320: 277-283

Weisglas-Kuperus, N., T.C.J. Sas, C. Koopman-Esseboom, C.W. van der Zwan, M. A. J. DeRidder, A. Beishuizen, H. Hooijkaas, and P.J.J. Sauer. 1995. Immunological effects background prenatal and postnatal exposure to dioxins and polychlorinated biphenyls in Dutch infants. Pediatr. Res. 38:404-410.

Weisglas-Kuperus, N., Patandin, S., Berbers, G.A., Sas, T.C., Mulder, P.G., Sauer, P.J., and Hooijkaas, H. 2000. Immunological effects of background exposure to polychlorinated biphenyls and dioxins in Dutch preschool children. Environ. Health Perspect. 108(12):1203-1207.

Relationship Between Tri + and Total PCBs
424694

WHITE PAPER – RELATIONSHIP BETWEEN TRI+ AND TOTAL PCBs

(ID 424694)

ABSTRACT

The historical database of water column, sediment, and fish data generally represent the Tri+ fraction of PCB contamination. In order to estimate the total mass of PCB in these media, a correction factor, the Total PCB to Tri+ ratio, is required. To estimate this ratio, more recent data on sediments, water and fish were examined where all, or nearly all, PCB congeners were represented. This white paper discusses the basis for estimating these ratios in various regions of the river. Data obtained by EPA and GE form the basis for these revised ratios. On the basis of the revised ratios, EPA's estimates of sediment Total PCB inventory, the Total PCB mass remediated and the fraction of the sediment Total PCB inventory remediated will all require adjustment upward. Conversely, Total PCB transport past Waterford actually decreases compared to the previous estimate. The Total PCB release due to dredging increases as well but still remains a minor release relative to the "naturally" occurring sediment releases. However, because PCB contamination in fish tissue is shown to contain almost exclusively Tri+ (98 percent or higher), EPA's forecasts and modeling analyses, which are based on Tri+, require no revision.

INTRODUCTION

EPA has examined the PCB contamination of the Hudson River using two basic measures of concentration, Total PCBs and Tri+ PCBs. Total PCBs represents the entire sum of reported PCB congeners present in a sample. While not including all PCB congeners, this measurement generally represents the major congeners present in the sample and typically includes congeners from all homologue groups. Tri+ PCBs (generally referred to simply as "Tri+") represents only a portion of the PCBs present in the sample. Specifically, this measurement represents the sum of the reported trichloro- to decachloro-homologue groups. As discussed below, many of the historical measurements can be readily transformed into an estimate of the Tri+ concentration.

Both Total PCB and Tri+ PCB values have been used in the assessment of Hudson River PCB contamination. The choice of PCB measure has depended, to a large extent, on the available data. While estimates of Total PCBs are generally preferable, Tri+ represents a measure of PCB contamination that is more accurately represented by historical measurements. That is, historical analytical techniques frequently did not or could not represent the entire spectrum of PCB contamination present in the sample.

The primary means of PCB analysis prior to 1990 involved gas chromatography using a packed column[1] and analytical standards based on commercial Aroclors. These techniques were largely

[1] A packed column typically consisted of a narrow tube packed with a sorbant material to permit the separation of PCBs from other compounds in the samples. This technology permitted the separation of PCBs into groups of congeners for later identification and quantitation. Current technology uses a capillary tube coated with a sorbant material. Current technology is able to separate PCBs into individual congeners. Application of a capillary tube along with analytical standards for the individual congeners has permitted a much more accurate and complete

incapable of detecting and quantifying many of the monochloro and dichloro PCB congeners present in the environment. In most studies of the Hudson, historical analytical techniques focused on the main Aroclors thought to be discharged by GE; specifically, Aroclors 1242 and 1254. As a result, many analytical programs did not even attempt to examine the less-chlorinated congeners, based in part on the incorrect assumption that a mixture of PCBs in the environment would remain similar to the original mixture discharged to the environment. As extensively documented in the EPA's Phase 2 reports, the original mixtures of Aroclors 1242, 1016, and 1254 have been modified to varying degrees by processes such as dissolution, degradation, dechlorination, bioaccumulation, and partitioning. Thus, in many cases, the mixtures in the Hudson do not closely resemble the GE source from which they were derived. (As shown in the DEIR [USEPA, 1997] and the Ecological Risk Assessment for the Lower Hudson [USEPA, 1999b], sediment mixtures are readily traced to the GE sources when geochemical and dechlorination processes are considered. PCB patterns in the biota were shown to correlate with the GE contamination in the sediments.) Both the lack of analytical technology and the lack of a thorough understanding of PCB geochemistry contributed to the limitations of the historical data.

Early on in the reassessment, EPA recognized the need for the data obtained in Phase 2 to be understood in the context of historical data. In order to accomplish this, it was necessary to convert both the historical and current data sets to a consistent basis so as to permit accurate and meaningful comparisons. As noted above, many of the historical data sets did not represent the entire spectrum of PCB congeners present in the samples. Based on a review of the data available, including data from NYSDEC, USGS, and GE, among others, it became clear that most of the historical data represented analytical techniques that could be translated into a measure of the trichloro and higher homologue fraction. This portion of the PCB mass in a sample, that is, the sum of trichloro to decachloro homologues (or Tri+), became the basis on which historical data could be compared to more recent analyses. Because the more sophisticated techniques employed by EPA and others after 1990 represented the entire (or almost the entire) spectrum of PCBs, the more recent data could be readily converted to a Tri+ basis. Thus, many of the data interpretations performed in Phase 2 were based on the Tri+ parameter. Discussions of the development and application of the Tri+ conversions can be found in the DEIR (USEPA, 1997), the Baseline Modeling Report Responsiveness Summary (USEPA, 2000b) and Butcher *et al.*, 1997.

In particular, the sophisticated computer models developed by EPA required a consistent measure of PCBs across sediments, water, and biota in order to simulate PCB contamination in the Hudson over a long period of time. The extended period of simulation (*i.e.*, the long period of data) provided additional insights into the nature of PCB transport and strengthened the calibration of the model. The Tri+ parameter represents essentially the only metric available that is consistent across all three media and can be derived from nearly all environmental data sets available for the Hudson.

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quantitation of PCBs in environmental samples. This approach was used for the entire set of Phase 2 samples collected by EPA.

Among the more important data sets that required consideration of the Total PCB to Tri+ ratio were the following:

- NYSDEC 1976-1978 Sediment Survey of the Upper Hudson.
- NYSDEC 1984 Sediment Survey of the Thompson Island Pool.
- USGS 1977-1999 Water Samples from the Upper Hudson.
- NYSDEC 1977-2000 Fish Collection from the Upper Hudson.

These data sets, along with the conversion of the EPA Phase 2 and GE data sets, formed the basis for the calibration of the EPA's HUDTOX and FISHRAND models.

As discussed later in this white paper, as well as in the ecological risk assessment reports (USEPA, 1999a, 1999b, 2000c), PCB contamination in fish is almost exclusively comprised of congeners represented by the Tri+ summation. Thus, for the purposes of forecasting future exposures to humans and wildlife via fish, it is only necessary to model the Tri+ parameter. The Tri+ parameter is the main output variable for the EPA's models.

Nonetheless, Total PCBs (*i.e.*, the sum of the entire spectrum of congeners) remains EPA's primary focus for the purposes of remediation, since PCB toxicity is not limited to the Tri+ fraction. Exposure to PCB-contaminated sediments and water results in exposure to the entire spectrum of PCBs, not just Tri+. Additionally, Total PCBs, and not Tri+, form the basis for assessing sediment treatment, shipping, and landfilling. As a result, EPA's analyses have considered both measures of PCB. Tri+ was principally used for modeling, while Total PCBs were considered when dealing with engineering considerations.

Since much of the historical data can only provide an estimate of the Tri+ concentration and since EPA needed estimates of Total PCB in the environmental media, a basis was needed for each medium to translate the measured or forecast Tri+ concentration into an estimate of the Total PCB concentration. The basis for these conversions is described in the next section of this white paper.

CONVERSION OF TRI+ TO TOTAL PCB

The ratio of Total PCB to Tri+ is well defined for Aroclor 1242, based on the analysis of an available standard. Once released into the environment, processes such as dechlorination, partitioning, and bioaccumulation will modify the ratio. The ratio of Total PCB to Tri+ in the analytical standard for Aroclor 1242 is approximately 1.17. Depending upon the media, various factors can work to change this ratio substantially, yielding a different ratio for each media type. In fact, the ratio varies across the Upper Hudson as well, since the factors affecting the ratio are not equal everywhere.

Water

The need for a standard set of factors to convert Tri+ to Total PCB in the water column was recognized early in the model simulation process. Although EPA and GE data are available to quantitate Total PCB and Tri+ through the 1990s in the Upper Hudson, the models employ the Tri+ parameter only, as discussed above; thus, a conversion factor is needed to estimate future

Total PCB loads and concentrations in the Upper Hudson on the basis of the Tri+ forecasts. An examination of the Total PCB to Tri+ ratio at the various Phase 2 monitoring stations showed that the ratio varied with distance downstream from the GE facilities. Thus, station-specific ratios were developed for each of the major water-column monitoring stations. These ratios were applied in the FS in order to forecast Total PCB loads in the Upper Hudson

Ratios for Total PCB to Tri+ were required at two main stations, Thompson Island Dam (TI Dam) and Waterford. The ratio was examined at other stations as well, however, to provide additional support for the analysis. The Phase 2 data set represents the only data set available that can provide an estimate of the Total PCB to Tri+ ratio throughout the Upper Hudson (*i.e.*, from Bakers Falls to Troy). Although the GE data cover a greater period of time, that data set is more limited spatially, extending only to Schuylerville[2]. The GE data are also limited to some degree by a significantly higher detection limit. As a result, the EPA data are used for the ratio estimate of 1.4 at the Waterford station, while the GE values for TI Dam (TID West and PRW2) and Schuylerville were all considered in deriving the value for the TI Dam (2.2). The three stations are considered together in estimating the ratio for the TI Dam, due to the significant variability in water column conditions in this area. The EPA ratios, as well as those developed from the GE data, are given on a station-specific basis in Table 424694-1.

Recognizing the limited number of samples, the Phase 2 results for several stations have been combined to yield the estimated ratios. As shown in Table 424694-1, the GE data yield ratios similar to those developed from the EPA data. Notably, the ratio at TI Dam and Schuylerville obtained from the GE data is about 10 percent higher than that obtained from the Phase 2 data.

Note that the ratio for the GE Rogers Island station is based on the entire period of monitoring. This was appropriate, given the general consistency of the PCB source to this location over time. The ratio at the TI Dam was derived from data limited to the post-1996 period, when the upstream source was better controlled. Prior to this period, the TI Dam sample was subject to fairly large variability, due to the variation in contributions from above Rogers Island relative to those of the sediments of the pool itself. The Phase 2 sampling program was able to avoid some of this variability due to the sampling techniques employed.

As is evident in Table 424694-1, the biggest increase in ratio occurs across the Thompson Island Pool (TI Pool), as the release of PCBs from the sediments greatly increases the total PCB load and changes the proportions among the PCB congeners in the water column. Downstream of Schuylerville, the value declines, possibly as a result of interactions between the water column and the less-dechlorinated PCBs found in the sediments downstream. Preferential losses of the less-chlorinated congeners due to degradation or gas exchange may occur as well (USEPA, 2000d).

The Total PCB to Tri+ ratio developed for the Waterford station was used to estimate the total mass of PCBs delivered to the Lower Hudson under each of the various model runs. Tri+ is directly forecast by the model and is unaffected by the analysis presented here. Conversely, the

[2] Although GE did collect samples downstream of Schuylerville, these samples were collected during the Allen Mill event and ensuing large PCB releases (Sept 1991 to 1992). These samples represented an unusual condition in the Upper Hudson and thus could not be used to characterize the Total PCB to Tri+ ratio for the predominantly sediment-derived releases post-1993.

Total PCB delivered to the Lower Hudson is estimated as the product of the Tri+ load at Waterford and the Total PCB to Tri+ ratio. In the original estimates given in the FS, the Total PCB to Tri+ ratio at Schuylerville of 2.2 (developed from the GE data collected at Schuylerville) was used as the ratio at Waterford. Thus the application of the value estimated for Waterford (1.4) yields load estimates of Total PCB that are one-third lower than originally calculated. Although both the Tri+ and Total PCB loads are estimated, it is important to note that the values estimated for Total PCBs include a higher degree of uncertainty due to this additional step in the estimation process.

Sediments

The estimation of a Total PCB to Tri+ ratio for the sediments of the Upper Hudson was made difficult by the heterogeneous nature of sediment contamination in the Upper Hudson and the lack of a Total PCB data set that could be considered spatially representative of the entire area. The heterogeneity was due to several factors including variable rates of deposition and scour, as well as dechlorination of PCB in the sediments. Dechlorination directly increases the ratio since it produces monochloro and dichloro congeners by converting heavier congeners to lighter ones. As noted in the DEIR (USEPA, 1997), the degree of dechlorination in the sediments of the Upper Hudson is dependent on the concentration of PCBs. In general, the most contaminated sediments typically exhibit the greatest degree of dechlorination. In addition, extensive dechlorination in the Hudson River appears largely limited to sediments above an initial concentration of 30 ppm Total PCB. Thus, sediments with low levels of contamination are expected to have relatively low ratios of Total PCB to Tri+, as compared to highly contaminated sediments[3].

The need for an estimate of the Total PCB to Tri+ ratio for each river section of the Upper Hudson was dependent on the available data and the engineering data requirements. Thus the ratio was estimated for each river section for each sediment subclass on an as-needed basis. The data sets available to provide this information were different in each river section. The derivation of the necessary information for each river section is described below.

River Section 1 (TI Pool)

During the preparation of the FS, it was recognized that no study existed in River Section 1 that could provide a complete description of the Total PCB inventory in the sediments. A ratio was needed to describe Total PCBs for the entire TI Pool. The 1984 data set represented the best coverage for an estimate of the Tri+ concentrations and inventory but was not well suited for the estimate of Total PCB. In the FS, as well as prior EPA reports, the estimate of Total PCB mass for the TI Pool was based on the sum of Aroclors as originally reported by Brown *et al.*, 1988. This approach was considered a low-end estimate since it was recognized that the 1984 results did not capture the monochloro and dichloro fractions well. Upon subsequent review of the most recent GE data (1999 coring data) in conjunction with the existing set of Phase 2 low-resolution cores, Phase 2 high-resolution cores, the 1991 GE composite samples, and the 1998 GE

[3] Evidence suggests that most dechlorination in the Upper Hudson River occurs rapidly after sediment deposition, and subsequent dechlorination is limited. As discussed at length in the DEIR (USEPA, 1997), it is unlikely that historically deposited sediments will undergo further, substantial dechlorination.

composite samples, it was decided that a sufficient amount of data were available to support an independent estimate of the Total PCB to Tri+ ratio for the TI Pool.

To best estimate the Total PCBs to Tri+ ratio, it is important to recognize that this ratio varies almost directly with the degree of dechlorination. This is because the mono- and di-homologue fractions increase and the Tri+ fractions decrease in response to the dechlorination process. Thus, highly dechlorinated mixtures have a high ratio, and vice versa. As extensively documented in the DEIR (USEPA, 1997), the extent of dechlorination in the sediment varies logarithmically with the concentration in the sediment. Thus, the Total PCB to Tri+ ratio should also vary with concentration.

This correlation was best demonstrated by the Phase 2 high-resolution cores (as shown in the first diagram of Figure 424694-1). These core samples represent relatively thin core segments (2- to 4-cm thick), a scale at which sediment concentrations are expected to be relatively homogeneous within the sediment. Thus, the relationship between sediment concentration and dechlorination should be clearest for these samples. The Total PCBs to Tri+ ratio clearly increases with concentration. A weighted curve has been fit to the data to suggest how the mean ratio varies with concentration. The initial value of 1.25, which applies below 10 mg/kg of Tri+, is quite close to the theoretical starting value of 1.17 for Aroclor 1242. This is consistent with the findings of the DEIR, which stated that little dechlorination occurs at low concentrations. As sediment concentrations rise above 10 mg/kg Tri+, the Total PCB to Tri+ ratio increases substantially, reaching a value around 4 above 100 mg/kg Tri+. Clearly, the Total PCB to Tri+ ratio is dependent on the sediment concentration.

This can also be seen in the GE coring data from 1998 and 1999. These data also represent relatively thin core segments and would be expected to yield a similar relationship between the sediment concentration and the Total PCB to Tri+ ratio. This is illustrated in the second diagram of Figure 424694-1. Again a weighted curve has been fit to the data to track the mean ratio. A few outliers were excluded from the weighted curved determination, based on a statistical Mahalanobis analysis (SAS, 1997).

This diagram also shows an initial low value for the Total PCB to Tri+ ratio, rising to a much higher value at higher concentrations. The absolute value of the mean ratio is higher than that obtained from the high-resolution cores. This is attributed to the differences in analytical technique between the two data sets. Part of the difference may lie in the quantitation techniques used by GE. Essentially, the mono and di congeners are analyzed on a congener-specific basis, whereas the Tri+ fraction is tied to an Aroclor standard (Hydroqual, 1997). Thus, the absolute value of the Total PCB to Tri+ ratio for the GE data is strongly dependent on the internal calibration of the two analytical bases. Nonetheless, both the Phase 2 and the GE data sets suggest about a threefold increase in the ratio at high concentrations. In both sets, individual samples can attain ratios nearly double the mean high-end value.

Both data sets demonstrate a strong relationship between Tri+ concentration and the Total PCB to Tri+ ratio. However, both data sets represent small sampling intervals (less than or equal to five cm), much shallower than the 1984 NYSDEC coring data set (nominally 30 cm). As documented in the LRC (USEPA, 1998), the process of collecting thick segments serves to confound ratio-to-concentration relationships, since layers of many different properties are

blended into a single analysis. This is evident in the third diagram of Figure 424694-1, where the low-resolution core results are presented. As was seen for the molar dechlorination product ratio (USEPA, 1998), the relationship for the Total PCB to Tri+ ratio to Tri+ concentration is much noisier than that for the high-resolution cores.

However, these samples are closest in collection technique to the 1984 survey, and so are best suited to describe the Total PCB to Tri+ ratio for the 1984 data. Additionally, the conversion of the 1984 data set to a Tri+ basis is founded on the EPA's congener-specific analytical technique. Thus, for both sampling technique and analytical approach, the curve developed for the low-resolution cores is most applicable to the 1984 data set.

A review of the third diagram would not, of itself, suggest a strong relationship. However, the strength of the Total PCB to Tri+ ratio relationship is already well established by the high-resolution core and GE core data sets. As a result, a relationship was developed that parallels the relationship seen in the high-resolution cores (Figure 424694-2).

The upper diagram of the figure shows the weighted mean curves from each of the data sets. Notably, the low-resolution core curve is similar to the GE curve at low concentrations (less than 10 mg/kg), and converges to approximately the same value as the high-resolution cores at high concentrations (greater than 100 mg/kg). The weighted curve developed for the low-resolution curve was then approximated as three segments, as follows:

Tri+ Concentration	**Total PCB to Tri+ Ratio**
Less than 10 mg/kg	2.2
Between 10 and 100 mg/kg	2.2 + log (Tri+Conc / 10)
Greater than 100 mg/kg	3.8

This approximation is shown in the second diagram of Figure 424694-2.

As explained in White Paper – Sediment PCB Inventory Estimates, this curve was applied to the length-weighted average Tri+ concentrations of the TI Pool to estimate the Total PCB concentrations in the sediments. Each individual 1984 core or grab was corrected to estimate the local Total PCB concentration. These results were then integrated over the area of the pool and the volume of sediment to be removed. Based on this integration, the mass-integrated Total PCB to Tri+ ratio for the TI Pool was estimated at 3.1. For the sediments to be remediated under the selected remedy, the ratio was estimated at 3.4. These ratios are summarized in Table 424694-2.

The relationship between Total PCB and Tri+ is such that the most contaminated sediments have the highest ratios. These are also the sediments that are preferentially targeted for removal under the selected remedy. As a result, the estimates for Total PCBs in the areas slated for removal under the selected remedy increased more than the areas to be left untouched. This modification has the effect of increasing the estimate of the fraction of Total PCBs to be removed under the selected remedy. As discussed in Whiter Paper – Sediment PCB Inventory Estimates, the estimate for the *in situ* Total PCB inventory of the TI Pool increased 3-fold to 45 metric tons. Of this inventory, approximately 80 percent, or 36 metric tons, will be removed. The result of the increase in the Total PCB inventory estimate for the TI Pool serves to increase the overall

importance of the TI Pool to the PCB inventories of the Upper Hudson. Correspondingly, the mass of PCBs removed for this river section has increased as well. Ultimately, since both estimates increase, this leads to an overall increase in the fraction of PCB removed from the Upper Hudson for the selected remedy.

River Sections 2 and 3 (TI Dam to Waterford)

In these river sections, there is no single synoptic data set of sufficient quality and recent age that can be used to estimate Tri+ or Total PCB concentrations or inventories on a section-wide basis. However, as the data available contain estimates for both Total PCB and for Tri+, there is no need to independently estimate their ratio, as was done for River Section 1. As discussed in White Paper – Sediment PCB Inventory Estimates, the low-resolution coring data set provided a basis for assessing both Total PCB and Tri+ in the areas to be remediated, effectively equivalent to the cohesive sediment areas. For noncohesive sediments, the 1991 GE composite samples were used. The application of these data is discussed in detail in White Paper – Sediment PCB Inventory Estimates. This discussion will focus on the Total PCB to Tri+ ratio for these areas.

Because the relatively recent low-resolution cores and 1991 GE composites samples could be used to estimate inventories and concentrations and because these samples provide direct estimates of Tri+ and Total PCBs, the data could be used to estimate the Tri+ and Total PCB values for the river sections independently. However, it is useful to compute the Total PCB to Tri+ ratio simply for comparative purposes, providing further support for the approach used in River Section 1. These results are summarized in Table 424694-2.

The ratios given in the table agree well with the values found for the TI Pool. Specifically, the values obtained for the sediments targeted for remediation in River Sections 2 and 3 (3.4 and 2.7, respectively) compare well with the value obtained for the sediments targeted for remediation in the TI Pool (3.4). These data support the derivation of a ratio for the TI Pool, as was described above.

Fish

Results for fish samples collected by EPA were used to examine the Total PCB to Tri+ ratio in Hudson River fish. This data set, like the other Phase 2 results, is able to provide an independent estimate of the Total PCB and Tri+ concentration for each sample. The ratio is, therefore, not needed for calculations, but rather to support the modeling and risk-calculation assumptions. In the presentations of the BERA and RBMR, the observation that PCBs in fish are nearly entirely represented by the Tri+ summation has been stated many times but not quantitated. This examination will briefly summarize the results.

The 207 fish samples collected in Phase 2 and analyzed via EPA's congener-specific methodology form the basis for this calculation. Sample replicates of the same species from the same station were averaged prior to inclusion in the region-wide calculation; *e.g.*, five white perch samples from the station were averaged together prior to inclusion in the calculation. In this manner, stations and species were more evenly represented. After this summation, 60 unique species/station samples were available. These were arithmetically averaged together on a

regional basis to determine the mean Total PCB to Tri+ ratio. These results are presented in Table 424694-3.

Evident in the table is the very high mass fraction of Tri+, regardless of region. The average value ranges from 98 to nearly 100 percent Tri+. These values translate to a Total PCB to Tri+ ratio of 1.02 to 1, respectively. From these results, it is clear that the assumption used in the RI and FS (*i.e.,* Total PCB in fish is equal to Tri+) is a valid assumption and introduces little additional uncertainty. This has important ramifications for the use of the historical fish data from NYSDEC. As noted in the RBMR (USEPA, 2000a), the NYSDEC fish data can be converted to a Tri+ basis by a relatively small correction factor. The analysis above demonstrates that no further correction is needed to use these data as an estimate of Total PCB in fish tissue.

IMPLICATIONS AND CONCLUSIONS

A focus on the Tri+ fraction of PCBs permitted the use of historic data in the detailed study of PCB contamination in the Hudson. The results and conclusions of the FS are largely based on the Tri+ results due, in large part, to the fact that fish body burdens are almost exclusively Tri+. Thus, future improvements in fish tissue concentrations are inherently tied to declines in the Tri+ PCB concentrations. EPA's selected remedy is specifically designed to reduce Tri+ concentrations.

Improved estimates of the Total PCB to Tri+ ratio were made for the sediments of the TI Pool and the water column at Waterford. Other calculations presented provide further support for these revisions, as well as supporting the assumptions used in the reassessment. The improved estimates for the Total PCB to Tri+ ratio presented here affect only the estimates of Total PCBs. The revised estimates for the ratio specifically affect the following:

- The estimate of Total PCB inventory for the TI Pool will be substantially increased compared to the estimate in the FS. This will increase the estimates of Total PCB removed as well as the increase the fraction of PCB remediated by the selected remedy. (White Paper—Sediment PCB Inventory Estimates).

- The estimated Total PCB load to the Lower Hudson will be decreased from the estimate in the FS. This will apply to all alternatives. (See Chapter 11, Master Comment 337780.)

- The estimate for the amount of Total PCB resuspended by dredging will increase, as more PCB mass will be removed. (See Chapter 10, Master Comment 583 and White Paper – Resuspension of PCBs During Dredging.) This increase will not affect the forecasts for fish tissue concentrations downstream, however, since the increase is strictly limited to the mono- and di-homologue fractions.

- The increase in Total PCB concentrations for the TI Pool will serve to increase the estimate for material requiring TSCA handling. However, the FS estimate also did not account for several important factors that serve to reduce the volume of material requiring TSCA handling. Consideration of these factors yields an estimate for TSCA materials that is similar to that presented in the FS (White Paper – Estimate of Dredged Material Exceeding TSCA Criteria).

REFERENCES

Brown, M.P., M.B. Werner, C.R. Carusone and M. Klein. 1988. Distribution of PCBs in the Thompson Island Pool of the Hudson River: Final Report of the Hudson River PCB Reclamation Demonstration Project Sediment Survey. Prepared for NYSDEC. Albany, NY.

Butcher, J.B., T.D. Gauthier and E.A. Garvey. 1997. Use of historical PCB Aroclor measurements: Hudson River fish data. Environ. Toxicol. Chem. 16 (8): 1618-1623.

HydroQual. 1997. Development of Corrections for Analytical Biases in the 1991-1997 GE Hudson River PCB Database. Report to General Electric Company, Albany, NY. HydroQual, Inc., Camillus, NY, June.

SAS, 1997. JMP Statistical Software, Version 3.2.1 SAS Institute, Inc. Cary, NC.

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

USEPA. 1998. Further Site Characterization and Analysis. Volume 2C-A Low Resolution Sediment Coring Report (LRC), Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Gradient Corporation, and TetraTech, Inc. July.

USEPA. 1999a. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E - Baseline Ecological Risk Assessment, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS Consultants, Inc. and Menzie-Cura Associates, Inc. August.

USEPA. 1999b. Phase 2 Report - Review Copy. Further Site Characterization and Analysis, Volume 2E-A Baseline Ecological Risk Assessment for Future Risks in the Lower Hudson River, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc. and Menzie-Cura & Associates, Inc. December.

USEPA. 1999c. Responsiveness Summary for Volume 2C-A Low Resolution Sediment Coring Report, Addendum to the Data Evaluation and Interpretation Report. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS Consultants, Inc. and TetraTech, Inc. February.

USEPA. 2000a. Further Site Characterization and Analysis, Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS Volume 2D. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, Inc., and Tetra-Tech, Inc. January 2000.

USEPA. 2000b. Responsiveness Summary for Volume 2D - Baseline Modeling Report. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, Inc. and TetraTech, Inc. February.

USEPA. 2000c. Phase 2 Report, Further Site Characterization and Analysis. Volume 2E-Revised Baseline Ecological Risk Assessment, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS Consultants, Inc. and Menzie-Cura Associates, Inc. November.

USEPA. 2000d. Response to Peer Review Comments on Volume 2C-(DEIR) and 2C-A-(LRC), Hudson River PCBs Reassessment RI/FS. Prepared for the USEPA, Region 2 and USACE by TAMS Consultants, Inc. November.

Relationship Between PCB Concentrations in Surface Sediments and Upstream Sources
255353

WHITE PAPER – RELATIONSHIP BETWEEN PCB CONCENTRATIONS IN SURFACE SEDIMENTS AND UPSTREAM SOURCES

(ID 255353)

ABSTRACT

The relative age of the Thompson Island Pool (TI Pool) surface sediments and their associated PCB concentrations is important in determining the fate and transport histories of Upper Hudson River PCBs. Surface PCB concentrations within sediments of the TI Pool have been sampled since 1977. Water column samples have been collected at Rogers Island since 1977 as well. However, for both matrices, the frequency of sampling increased markedly in 1991 shortly after GE began its federally mandated water column monitoring of the Upper Hudson and also began sediment sampling. As discussed elsewhere in the Hudson River PCBs Reassessment reports, the PCB contamination of the sediments of the Upper Hudson is predominantly attributable to releases from the GE facilities at Fort Edward and Hudson Falls. This white paper addresses the relationship between the most recent (post-1990) releases and the sediment contamination of the Upper Hudson.

This analysis presented below finds that the surface concentrations in 1998-1999 sediment samples are far too high to represent PCBs that were deposited after 1996. The finding indicates that surface sediment contamination must be derived from historical PCB stores at least older than 1996. Similarly, an examination of high-resolution cores collected in 1992 and 1998, as well as shallow cores collected in 1998-1999, indicates the absence of a significant increase in surface concentrations over the last 10 years of deposition, despite the occurrence of the Allen Mill event in 1991 to 1993. These two findings collectively lead to the conclusion that surface sediment concentrations have been largely independent of the upstream load for the last 10 years.

By inference, it is the historical deposits of PCBs that control the PCB concentrations in the surface sediments because the concentrations at the surface could only have been derived from older, more-contaminated releases, such as the Fort Edward Dam removal. The corollary to this is that the historical, highly contaminated sediments of the Upper Hudson are not being consistently buried by cleaner sediments with less-concentrated amounts of PCBs. Furthermore, because current and anticipated future loads from the upstream sources are already low and expected to decline further, Total PCB concentrations in future deposition resulting from the upstream sources will be at or below the target residual PCB concentrations. Thus the implementation of the selected remedy does not need to be closely linked to further reductions in PCB releases from the GE facilities. Rather, these remedial efforts can proceed in parallel.

INTRODUCTION

A comparison of the geochemical character of the suspended matter and sediments of the Upper Hudson has the potential to associate or disassociate the upstream water column loads from the surficial sediments. The basic premise is: If current suspended solids, which are relatively clean as compared to historical sediment and suspended solids, are burying the existing contaminated

sediments of the Upper Hudson, then the mean surficial sediment PCB concentrations should be comparable to those on the suspended matter. This calculation is limited to the period 1996 to 1999, when the Hudson Falls discharges were largely controlled and concentrations at Rogers Island were consistently low.

For the period prior to 1996, water column loads and suspended-matter concentrations were frequently impacted by discharges from the Hudson Falls facility. Commenters have claimed that these discharges were of sufficient magnitude to recharge the surface concentrations of the TI Pool, thus causing the increases in water column PCB load as the water passes over the sediments of TI Pool. If this is the case, then evidence of this sediment recharge should be visible in the high-resolution cores obtained by EPA and GE in the Upper Hudson. To the extent that no "recharge," expressed as higher sediment concentrations, is evident in the most recently deposited sediments, then little or no recharge has occurred, and the releases from Hudson Falls have been transported through the Upper Hudson with little impact on the sediments there. In turn, this implies that the annual sediment releases are the result of historical discharges, most likely the large release event associated with the Fort Edward Dam removal.

ESTIMATION OF SUSPENDED MATTER CONCENTRATIONS AT ROGERS ISLAND, 1996-1999

Suspended-matter concentrations at Rogers Island can be estimated using the two equilibrium-based partitioning models developed in the DEIR (USEPA, 1997). These models have been applied throughout EPA's modeling analysis. In the DEIR, it was shown that the PCB concentrations in the Upper Hudson are well described by the effective partition coefficients calculated from the transect samples from EPA's Phase 2 investigation. These constants are applied here to estimate the concentrations of PCBs on the suspended matter in the water column at Rogers Island over the period 1996-1999. Both three-phase and two-phase equilibria are examined here, although the two-phase model is used as the primary reference for the concentration on suspended matter.

Three-Phase Equilibrium

PCB equilibrium calculations were performed using both three-phase and two-phase representations of sediment-PCB partitioning. The composite partition coefficients for total PCBs were derived from a mass-weighted average of the available partition coefficients for individual congeners using the total PCB concentration in the water column. Specifically, the entire congener spectrum obtained in EPA's April 1993 (Transect 4) water column sampling was used to weight the congener values. This transect was chosen because it is considered representative of the freshly released PCBs from Hudson Falls and is at a sufficiently high concentration that all important congeners are readily detected.

The recent GE water-column samples collected from 1996-1999 were not used because many of these samples were extremely low in concentration and many congeners were not detected. Because only a small number of congener-specific partition coefficients are available for the three-phase calculations, the entire spectrum was not used in deriving the three-phase coefficient. The three-phase partition coefficient was derived from the two greatest (by weight) congener contributors (BZ#28 – 8.5 percent and BZ#31 – 7.0 percent; TPCB) to the overall PCB signature.

Thus, the three-phase partition coefficient for total PCBs was the average of coefficients estimated for BZ#28 and BZ#31. The three-phase equilibrium assumes total PCB concentration in the water column is equal to the sum of PCBs contained within the dissolved fraction, the suspended solids fraction, and the fraction bound to dissolved organic carbon, such that:

$$\text{TPCB Mass/L} = (C_{SS} * TSS) + (C_{DISS}) + (C_{DOC} * DOC)$$

$$= C_{DISS} (K_{OC} * f_{OC} * TSS + 1 + K_{DOC} * DOC)$$

Where:

TPCB	=	Total PCBs Mass/L
C_{SS}	=	Concentration of suspended solids fraction (ng/L)
TSS	=	Total suspended solids (mg/L)
C_{DISS}	=	Concentration of dissolved fraction (ng/L)
C_{DOC}	=	Concentration bound to dissolved organic carbon fraction (ng/L)
DOC	=	Dissolved organic carbon (mg/L)
K_{OC}	=	Partition coefficient to organic carbon (L/kg)
f_{OC}	=	Fraction of organic carbon in the solid phase
K_{DOC}	=	Partition coefficient to dissolved organic carbon (L/kg)

Two-Phase Equilibrium

The two-phase equilibrium analysis assumes that the PCBs bound to the DOC concentration are small or that the DOC is approximately constant (which is suggested by historical data); therefore, the total PCB concentration in the water column is equal to the sum of an apparent dissolved fraction (truly dissolved and DOC-sorbed PCBs) and the suspended solids fraction, such that:

$$\text{TPCB Mass/L} = (C_{SS} * TSS) + (C_{DISS})$$

$$= C_{DISS} (K_{OC} * f_{OC} * TSS + 1)$$

The following water-quality parameters were used in the equilibrium calculations:

TPCB	=	13.5 ng/L flow-weighted average concentration (at Fort Edward [1/19/96 to 9/30/99]; GE Database)
log K_{OC} (three-phase)	=	5.82 (Optimized with temperature correction to 20 degrees C) (DEIR, USEPA, 1997)
log K_{OC} (two-phase)	=	5.90 (DEIR, USEPA, 1997)
f_{OC}	=	0.175 at avg. discharge (Q) = 4,000 cfs; (RBMR, USEPA, 2000b).
TSS	=	3.23 mg/L (RBMR, Equation 6-13a, USEPA, 2000b)
log K_{DOC}	=	4.28 (Optimized with temp. correction to 20 degrees C) (DEIR, USEPA, 1997).
DOC	=	4.72 mg/L average at Fort Edward (RBMR, Table 6-30, USEPA, 2000b)

The results of the three-phase calculation indicate that the C_{SS} = 1.06 mg/kg; C_{DISS} = 9.22 ng/L; and C_{DOC} = 1.7 ng/L, on average, in response to recent loading from the upstream source. The results of the two-phase calculation indicate that the C_{SS} = 1.30 mg/kg; and C_{DISS} = 9.30 ng/L.

DISCUSSION OF RESULTS

The equilibrium-based calculations yield flow-weighted concentrations of one to two ppm on suspended matter. These values represent the mean concentration expected in sediments derived from the suspended matter. However, as can be seen in the GE core profiles presented in the FS (Appendix D1, Figure 13), the surface concentrations at these locations are substantially higher than these values. Values in the top few centimeters of these cores are frequently more than an order of magnitude higher than the one to two ppm produced at Rogers Island. From the coring results collected in 1998 and 1999, it is clear that at the vast majority of locations studied by GE, principally in *Hot Spots 14 and 16*, little to no recent deposition occurred. Surface concentrations remain well above the concentrations that would be produced within the water column of the river, indicating that, despite the passage of three to four years of relatively low suspended matter concentrations, surface concentrations were largely unaffected.

Among the most recent samples, the 1998 GE sediment sampling (O'Brien & Gere, 1999) shows 129 ppm total PCBs in 0-2 cm sediment at *Hot Spot 14* in the TI Pool (sample BS-14F-200), 90 ppm total PCBs in 0-2 cm sediment at *Hot Spot 10* in the TI Pool (sample BS-10T-100), and 53 and 56 ppm total PCBs in 0-1 cm sediment at *Hot Spot 28* below Lock 6 (samples FS-28-3 and FS-28-3). Among 18 cores collected by GE in 1999, two samples at *Hot Spot 5* showed concentrations of 275 and 586 ppm in the 0-5 cm sediment interval (samples P14-03 and P14-05). These results indicate the absence of any substantial deposition or burial of PCBs in these locations during this period.

Discussion Of High-Resolution Coring Results And The Allen Mill Event

The high-resolution cores obtained by EPA and GE provide a means to examine the degree of "recharge," or replenishment, of surface PCB concentrations by the Allen Mill event. This event delivered high PCB concentrations to the Upper Hudson over the period from September 1991 to late 1995. During this period, water column concentrations were occasionally above 500 ng/L at Rogers Island. These concentrations have the potential to generate high sediment concentrations if deposition occurs. It was noted during this time, however, that water column loads appeared to pass through the Upper Hudson with very little loss, implying little to no deposition of suspended PCBs to the river bottom.

If these loads were responsible for recharging the surface sediments, then evidence for this should be found in the high-resolution cores obtained by GE and EPA. These cores record the levels of PCB contamination in recently deposited sediments. Thus, if the Allen Mill event represented a significant addition to the sediment inventories of the Upper Hudson, this should be evident as an increase in the concentrations of PCBs in the sediments deposited in these cores during this period. That is, if this event was important, the concentrations of deposited sediments should increase during this period and decline afterwards.

Five cores are available to examine this event. The results are presented in Figures 255353-1 and 255353-2. The latter figure is an expanded-scale version of the first figure. Evident in both figures is the absence of any significant increase in sediment concentrations in the most recently deposited sediments, generally the upper 10 to 15 centimeters of the core. These cores indicate that depositing sediments did not respond to the Allen Mill event. Instead, the depositing concentrations were controlled by other processes.

In view of the huge existing inventory of PCBs within the TI Pool and the apparent conservative behavior of the water-column loads during this period, it is likely that the Allen Mill event caused little or no significant recharge. Rather, it is the production and release of PCBs from the sediments of the TI Pool itself that is responsible for the PCB concentration in recent deposition at these coring locations. By the absence of a response in these cores to the Allen Mill event, these cores also indicate that this event was of minor importance relative to the catastrophic release of PCBs that occurred in 1974-1976 after the Fort Edward Dam was removed. The releases associated with the Allen Mill event were also small relative to the direct GE discharges, prior to 1974, as the sediment PCB concentrations from the mid-1990s are much lower than those of the 1960s.

Implications for the Selected Remedy

The current loads from sources above Rogers Island yield surface sediment Total PCB concentrations of about 1 to 2 mg/kg, as discussed above. These values are quite close to the anticipated residual PCB concentrations for the selected remedy prior to backfill. As a result of the on-going and planned remedial efforts at the GE facilities, it is also expected that further reductions in the upstream load will continue to occur over time, with the upstream load declining to a level of 0.0256 kg/day at or around 2005. A load at this level would be expected to yield Total PCB surface concentrations of about 0.25 mg/kg, the target residual concentration after backfill. Thus, the current and anticipated future loads from the upstream sources do not represent significant sources for the maintenance of surface sediment Total PCB concentrations. Additionally, these sources should not be a significant source for the recontamination of surface sediments during or after dredging. They are both low relative to current surface concentrations and at or near the target concentrations for remediation.

As a result, the implementation of the selected remedy will not be directly linked to further control of the upstream sources. While upstream source control is important, the river sediments are the predominant source of PCBs in the fish. Remediation of the sediments is therefore necessary, regardless of when additional upstream source control measures are implemented. As noted in the modeling analyses presented in the RBMR and the FS, the current and anticipated future upstream loads do not control riverine concentrations of Total PCB until 25 to 30 years after the dredging operations begin. Thus, the remediation of the sediments and the continued remediation of the GE facilities can proceed in parallel.

CONCLUSIONS

The data from cores collected in 1998 and 1999 demonstrate that in many locations within the TIP, PCB concentrations in the surface sediments have maintained consistently high

concentrations of total PCBs, with concentrations in excess of 50 ppm in the top two cm, despite the occurrence of low PCB concentration on suspended-matter concentrations at Rogers Island. Based on either the two-phase equilibrium or three-phase equilibrium calculations, water-column PCBs bound to suspended solids at Rogers Island are expected to exhibit average PCB concentrations of one to two ppm. These concentrations are well below those seen at the tops of high-resolution sediment cores at several locations in the TI Pool. If significant deposition were occurring on a consistent basis through the TI Pool, the 1 to 2-mg/kg suspended solids that settle out would leave significantly lower concentrations in surface sediments. Based on the sediment-water interface concentrations obtained in 1998-1999, it appears that little to no deposition is occurring within some of the highly contaminated sediment *hot spot* areas of the TI Pool.

Thus, the ongoing release of PCBs to the water column in the Upper Hudson River, documented by both EPA and GE data, is primarily attributable to historical PCB deposits. These deposits remain at the surface in many locations, as shown by both EPA and GE cores, despite the recent low levels of load from upstream. These sediments are not being rapidly sequestered, but instead continue to contaminate the water and fish of the Upper Hudson. As a result, the upstream source controls implemented by GE have had little effect on the net release of PCBs to the water column from the sediments, which has continued relatively unabated for the past 10 years (Master Responses 577 and 633 in Chapter 2 of this RS).

Additionally, the Total PCB concentrations in future deposition resulting from the upstream sources will be at or below the target residual PCB concentrations. Thus the implementation of the selected remedy does not need to be closely linked to further reductions in PCB releases from the GE facilities. Rather, these remedial efforts can proceed in parallel.

REFERENCES

Bopp, Richard F., and Simpson, H. James. 1988. Sources and Trends of Persistent Contaminants in the New York Harbor Complex. Final Report for Grant Nos. 015/85B and 015/86B, Hudson River Foundation. August 1988. 54 p.

O'Brien & Gere. 1999. Final Report - 1998 Upper Hudson River Sediment Coring Program. Prepared for General Electric Company Corporate Environmental Programs, Albany, NY by O'Brien & Gere Engineers, Inc., East Syracuse, NY. January 1999.

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

USEPA. 2000a. Database for the Hudson River PCBs Reassessment RI/FS. Release 5.0 (Compact Disc). Prepared for USEPA, Region II and the US Army Corps of Engineers, Kansas City District. Prepared by TAMS Consultants, Inc. October 2000.

USEPA. 2000b. Further Site Characterization and Analysis, Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Volume 2D. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, Inc., and Tetra-Tech, Inc. January 2000.

Sediment PCB Inventory Estimates
363334

WHITE PAPER – SEDIMENT PCB INVENTORY ESTIMATES

(ID 363334)

ABSTRACT

Estimates of the PCB inventories in Upper Hudson sediments were revised based on additional data and a subsequent analysis of the relationship between Total and Tri+ PCBs. The amounts of Total and Tri+ PCBs were estimated for each river section based on section-specific data. The major change in the inventories of the Upper Hudson involved the Total PCB inventory of the Thompson Island Pool (TI Pool). Relative to the value given in the FS and previous Reassessment reports, the inventory estimate is three times greater (*i.e.,* 45 metric tons vs. the 15 metric tons given in the FS due to the incorporation of additional data on the ratio of Total PCBs to Tri+ PCBs in sediment samples). Estimates of Tri+ PCB inventories changed only a few percent, resulting from subtle refinements in the data sets used for the estimate. Due to these revisions, the estimate for the percentage of Total PCBs remediated by the selected remedy has increased from about 50 percent to 65 percent of the inventory of the Upper Hudson. Above Schuylerville, the selected remedy will address approximately 80 percent of the in-place Total PCB inventory.

Other Total and Tri+ PCB values were also obtained, including an estimate of surface concentration in the TI Pool and estimates of concentration in the dredged materials. The dredged material estimates account for the overcut in clean material. Therefore, the concentration of Total PCB and Tri+ in the dredged material is up to three times less than *in situ* concentrations.

INTRODUCTION

PCB inventories and average surface concentrations presented for the selected remedy (3/10/Select) in the FS were calculated using various data sets collected from 1977 through 1994. The various data sets provide different perspectives on sediment PCB concentrations due to the various sample collection techniques and subsequent analytical procedures performed during the different investigations. These issues were extensively documented in the Phase 2 reports, *i.e*., the Data Evaluation and Interpretation Report, or DEIR (USEPA, 1997); the Low Resolution Sediment Coring Report, or LRC (USEPA, 1998); and the Revised Baseline Modeling Report, or RBMR (USEPA, 2000). In addition, the reconciliation of the data sets was summarized in the FS.

In delineating remedial areas, various metrics were employed to determine the extent of PCB contamination. These included surface concentrations; mass per unit area (MPA); length-weighted average (LWA); and maximum concentration. In addition to these PCB-based parameters, physical characteristics of the Upper Hudson River sediments were also considered. Definitions and derivations of the various PCB metrics are presented within the FS.

Since the issuance of the FS, the EPA has continued its review of available data. In particular, new GE data have become available, which permitted a review of the Total PCB to Tri+

relationship in Hudson River sediments. Using this new information, EPA has revised its estimate of the mass of Total PCB in several areas of the TI Pool. The calculations of the Total PCB to Tri+ relationship are described in detail in White Paper – Relationship Between Tri+ and Total PCBs. In this White Paper – Sediment PCB Inventory Estimates, the revisions in the relationship between these parameters are reflected in the revised estimates of the Total PCB sediment inventory.

Additionally, this white paper will serve to clarify some of the concerns about the "correct" estimate of the PCB inventory presented in the FS. Due to the focus of the modeling analysis on the Tri+ PCB (generally referred to simply as “Tri+” in this White Paper) parameter as opposed to Total PCB contamination, the FS was unclear as to the total amount of PCB mass contained in the sediments as well as the fraction of that mass to be remediated. This white paper presents a set of revised inventory estimates for both Tri+ and Total PCBs, as well as revised values for the PCB mass remediated under the selected remedy. In particular, this white paper will reflect the new information concerning the current best estimate of the Total PCB to Tri+ ratio developed for the sediments of the TI Pool. This revision has resulted in a significantly higher estimate of the Total PCB mass in the pool.

The discussion below is organized as follows:

- Calculation Methodology
- PCB Inventory in River Section 1
- PCB Inventory in River Sections 2 and 3
- Comparison of the Extent of Remediation for the Selected Remedy and Full Section Removal
- Surface Sediment Concentrations in the TI Pool
- Estimation of PCB Concentrations in Dredged Sediments
- Uncertainty
- Summary

CALCULATION METHODOLOGY

The process of calculating the PCB inventories for various areas of the Upper Hudson has been discussed at length in several Phase 2 reports, including the DEIR (USEPA, 1997), the LRC Responsiveness Summary (USEPA, 1999), the RBMR (USEPA, 2000) and the FS. In each of these documents, historical and current data were examined to estimate PCB concentrations and inventories that were applicable to the analyses being performed. These calculations used various means to integrate the data. Among the more important of these was the area-weighted and length-weighted averaging calculations, as well as the calculation of mass-per-unit-area, or MPA. These formulas are repeated here as an aid to the reader in the subsequent discussions.

The area-weighted average PCB concentration over the entire thickness of contaminated sediment was determined using the following equation:

$$Area-Weighted\ Average\ Concentration = \sum_{i=1}^{n}(Area_i \times LWA_i)/TotalArea \qquad (1)$$

where: $Area_i$ = Area of polygon *i* [based on polygonal declustering (4.2.3, DEIR, USEPA, 1997)].

LWA_i = mean concentration of core *i* as a function of core length (see equation below)

n = number of polygons which represent the entire area (effectively equal to the number of samples contained in the area)

$$LWA_i = \frac{\sum_{j=1}^{no.\,core\ segments} Conc_j * l_j}{\sum_{j=1}^{no.\,core\ segments} l_j} \qquad (2)$$

where: $Conc_j$ = PCB concentration in core segment *j*

l_j = length of core segment *j*

no. core segments = number of core segments in the core at location *i.*

In this calculation, the LWA is used as a means to estimate the average concentration at a given location. The area of the polygons comes from a polygonal declustering analysis (Thiessen polygons), as described in USEPA, 1999. Effectively, it is a nearest-neighbor mapping wherein each location on the map is assigned the properties of the sample nearest to it. This approach avoids over-counting those areas with many samples, since the samples are weighted by the amount of area closest to them. Thus, samples close together are weighted by small polygons whereas samples far apart have large polygons. Further discussion of this technique can be found in Chapter 4 of the DEIR (USEPA, 1997).

For calculation of mean surface-sediment concentrations, equation 1 above is modified as follows:

$$Area-Weighted\ Surface\ Concentration = \sum_{i=1}^{n}(Area_i \times Conc_i)/TotalArea \qquad (3)$$

where: $Area_i$ = Area of polygon *i* [based on polygonal declustering (see Appendix B of the LRC Responsiveness Summary, USEPA, 1999).

$Conc_i$ = surface concentration of core *i* (*i.e.*, the concentration in the topmost segment)

n = number of polygons which represent the entire area (effectively equal to the number of samples contained in the area)

The Mass-Per-unit-Area (MPA) of PCBs was determined from the following equation:

$$MPA_i = \sum_{j=1}^{no.\,core\ segments} Conc_j * r_j * l_j \qquad (4)$$

where:

	MPA_i	= PCB mass at location *i*
	$Conc_j$	= PCB concentration in core segment *j*
	ρ_j	= solids-specific weight of core segment *j* (mass of dry solids per unit volume of *in situ* sediment
	l_j	= length of core segment *j*

Thus, the MPA represents the integration of the PCB content of the core over its length by summing the mass of PCB found in each core segment. To integrate the mass of PCB in an area, each MPA estimate is multiplied by an associated area, based on the polygonal declustering analysis mentioned previously. This is shown in equation 5:

$$Total\ Mass = \sum_{i=1}^{no.\,polygons} MPA_i * Area_i \qquad (5)$$

where:

	$Area_i$	=	Area of polygon *i* [based on polygonal declustering (see Appendix B of the LRC Responsiveness Summary, USEPA, 1999).
	MPA_i	=	PCB mass at location *i*

Equation 5 can be applied on a pool-wide basis as well as on a sediment-type basis to obtain estimates of inventory for a whole river section or for a more limited area. These five equations form the basis for the inventory estimates to be provided in the remainder of this white paper.

PCB INVENTORY IN RIVER SECTION 1

The original estimates of PCB mass and concentrations were based on the 1984 survey of the TI Pool conducted by NYSDEC (Brown *et al.*, 1988). As discussed in the DEIR, the measure of PCBs represented the sum of Aroclors but neglected the lightest congeners, particularly the mono- and di- homologues. These data provided a good basis for estimating the Tri+ inventory of the TI Pool but were inadequate for estimating the Total PCB inventory. At the time of the preparation of the FS, the estimate for Total PCB was made based on the 1984 data alone, knowing that the value (approximately 15 metric tons) was a significant underestimate. The effective ratio of Total PCB to Tri+ assumed in the DEIR was 1.06. Since the issuance of the FS, EPA has reviewed the original analysis as well as some additional data collected by GE.

There are several data sets collected after 1984 that describe Total PCB and Tri+ concentrations in the Upper Hudson and in particular, the TI Pool. These include the following:

- 1991 GE Sediment Composite Survey (maximum depth 10 in. [25 cm])
- 1992 EPA Phase 2 High Resolution Sediment Coring Program (maximum depth about 3 ft [91 cm])

- 1994 EPA Phase 2 Low Resolution Sediment Coring Program (maximum depth about 4 ft [122 cm])
- 1998 GE Sediment Composite Survey (maximum depth 2 in. [5 cm])
- 1998-1999 GE Sediment Core Collection (maximum depth 3 ft [91 cm], but most limited to 6 in. [15cm])

None of these data sets presented alone are sufficient to describe the inventory of the TI Pool, but taken together they can provide insight as to the relationship between Total PCBs and Tri+. This is discussed at length in White Paper – Relationship Between Tri+ and Total PCBs. For the data sets presented this analysis provided a basis for converting the 1984 Tri+ data to estimates of Total PCBs, which could then be averaged and/or integrated as needed.
In preparing this estimate, several approximations were made that simplified the calculation process but should not significantly impact the estimate, given the age of the 1984 data set and the limitations and uncertainty associated with the Total PCB to Tri+ correction. Specifically, for the estimation of the LWA Total PCB concentration, the relationship between Total PCB and Tri+ was developed on a core-section basis. However, to avoid a lengthy recalculation process, the relationship was applied to the length-weighted Tri+ values directly. This approximation introduces some uncertainty to the calculation, since the ratio developed for the core based on the LWA may differ from the effective one resulting from the correction of the individual core segments. However, this uncertainty is expected to be small relative to the other uncertainties in the calculation.[1]

A second approximation was made in the calculation of the individual MPA values. In this instance, the Total PCB values were obtained as follows:

$$MPA_{TPCB\ i} = \frac{MPA_{Tri+\ i}}{LWA_{Tri+\ i}} * LWA_{TPCB\ i} \tag{6}$$

where:

	$MPA_{TPCB\ i}$	= Total PCB mass-per-unit-area at location *i*
	$LWA_{TPCB\ i}$	= Total PCB concentration at location *i*
	$MPA_{Tri+\ i}$	= Tri+ mass-per-unit-area at location *i*
	$LWA_{Tri+\ i}$	= Tri+ concentration at location *i*

The estimation of the Total PCB values for the MPA, like the LWA, is most accurately calculated from the individual core segments. However, the approximation in equation 6 assumes a constant specific weight for the sediment solid throughout the core. As was shown in the LRC (USEPA, 1998), the solid specific weight was correlated with Total PCBs but the relationship was not very strong (correlation coefficient of 0.55). Therefore, this approximation will add some uncertainty, but should not introduce a significant bias in the integration of the MPA values to estimate the Total PCB inventory in the TI Pool. Given the other sources of uncertainty in the calculation, this approximation should not increase the uncertainty significantly[1].

[1] The other sources of uncertainty to the calculation include (among others) the age of the 1984 data set, the accuracy of the conversion factor from the original sum of Aroclors to Tri+, the uncertainty in the Total PCB to Tri+ ratio for thickly sliced sediments, and the failure to obtain the complete inventory of contaminated sediments in many 1984 sampling locations.

Total PCB inventory and concentrations were estimated for the TI Pool using the 1984 data set, the Total PCB to Tri+ ratio relationship developed in this Responsiveness Summary, and the approximations given above. Inventory and concentration estimates were also obtained for the remediated and unremediated sediments and the cohesive and non-cohesive areas of the pool. Equation 5 was used to integrate PCB mass over area. These values are presented in Tables 363334-1 and 363334-2 for Total PCB inventory and Total PCB concentration, respectively. The remediated and unremediated sediment inventories and concentrations are based on the selected remedy for the TI Pool (*i.e.*, greater than 10 mg/kg or 3 g/m^2). In addition to these values, EPA's estimates of Tri+ PCB are also presented. Note that the Tri+ values were developed as described in Appendix B of the LRC Responsiveness Summary. A minor correction has been made to the values originally presented. As a result, the estimate of the Tri+ PCB inventory of the TI Pool was increased by three percent, from 14.1 to 14.5 metric tons.
The revised estimates for the TI Pool Total PCB inventory represent a major change relative to the previous value. The new value (45 metric tons) is over three times greater than the prior estimate, because the calculations in the DEIR underestimated the correct ratio of Total PCBs to Tri+ PCBs. This estimate brings the TI Pool sediment inventory in line with the inventory estimates of River Section 2, discussed below. Although they are both derived independently, the effective Total PCB to Tri+ ratio for remediated sediments in both river sections is 3.4, indicating that dechlorination levels in the sections are comparable, as might be expected. This also places the TI Pool more prominently in the Total PCB inventory of the Upper Hudson, as might be anticipated given its proximity to the GE source areas.

The inventory of Total PCBs in the TI Pool represents 40 percent of the Total PCB mass in all three river sections. The percentage increased from a previous estimate of 20 percent, due to improved estimates of the mono- and di-homologue fractions of PCBs in the sediments. Finally, these revised estimates show the selected remedy to be more effective in removing PCB mass from the river than originally thought. Based on the revised inventory estimate, the selected remedy will remove approximately 80 percent of the Total PCB mass in the TI Pool and about two-thirds (65 percent) of the inventory in the entire Upper Hudson. The basis for the latter conclusion is further discussed below.

Similar levels of change are noted for concentration estimates of Total PCBs in the TI Pool. The overall estimate of the mean Total PCB concentration for this river section also increased threefold, from about 20 to 63 mg/kg, again reflecting the previously uncounted mono- and di-homologue fractions. Total PCB concentration estimates in the cohesive sediments are most dramatically affected, increasing 3.3 fold from about 44 to 145 mg/kg, while non-cohesive sediments increased 2.6 fold from 11 to 29 mg/kg. The difference in the degree of increase is a direct reflection of the dependence of Total PCB to Tri+ ratio on concentration and the lower levels of contamination in non-cohesive sediments relative to cohesive sediments, as described in the White Paper – Relationship Between Tri+ and Total PCBs.

PCB INVENTORY IN RIVER SECTIONS 2 AND 3

In River Sections 2 and 3, the difficulty in estimating the PCB inventories and concentrations does not arise from the lack of Total PCB data in general but, rather, the lack of a completely descriptive data set. Unlike the TI Pool, there has been no synoptic study of the sediment inventory in this area since 1978. The 1978 study is not considered to be useful for current

inventory estimates because the river was still undergoing major sediment bed changes due to the removal of the Fort Edward Dam. Additionally, there are significant analytical uncertainties associated with the data, as noted by the peer-review panel (USEPA, 1999b). Subsequent studies have been more limited either vertically (*e.g.*, GE's 1991 composite cores) or horizontally (*e.g.*, EPA's 1994 low-resolution cores).

As a result, it was necessary to combine data sets to estimate the inventories for these areas. To accomplish this, the data were applied as follows. For the most contaminated, generally cohesive sediment areas, the EPA 1994 low-resolution cores were used to estimate PCB inventory and concentration. In River Sections 2 and 3, the LRC program design was to sample the largest, most extensive *hot spots* with the intention of estimating their inventories. These areas generally have vertically extensive inventories as well as high concentrations, which are best represented by these cores.

Estimation of the areas outside the *hot spots* was more problematic. GE's composite cores had two significant limitations for this purpose. First, the cores only penetrated to 25 cm (10 in.); thus, in many instances, the core composites did not capture the entire in-place inventory. Second, the composite samples frequently composited sediments from inside and outside the *hot spots*; thus, the samples did not exclusively represent those areas outside the *hot spots*. More importantly, the samples did not appear to be limited to a single sediment type or general level of contamination. As a result, the estimates of PCB mass outside the cohesive or selected remediation areas would appear relatively uncertain. As will be shown later in this white paper, the overall range in the GE composite data is rather small so that the actual degree of uncertainty is acceptable for the purpose of this analysis.

Both the EPA and the GE data sets provide independent measures of Total PCB and Tri+. Thus, it was not necessary to develop a relationship between the parameters as was done for the TI Pool. In order to obtain a best estimate of PCB mass in the sediments as well as concentration, the inventories of Total PCB and Tri+ in each area were first estimated separately. Mean concentrations were developed later based on these inventories.

In River Sections 2 and 3, the data are not sufficient to prepare separate estimates of cohesive and non-cohesive sediment inventories. In River Section 2, the remediated sediments are predominately cohesive and, therefore, conditions in the remediated sediments that were sampled were assumed to be representative of the unsampled cohesive sediments being remediated; a similar assumption was used for non-remediated and non-cohesive sediments. In River Section 3, cohesive sediments were assumed to be represented by the *hot spot* areas.

Cohesive Sediment/*Hot Spot* Inventories

The mass estimation for both Tri+ and Total PCB in the *hot spots* of River Sections 2 and 3 has been performed based on the MVUE, *i.e.*, a minimum variance unbiased estimator of the arithmetic mean. The MVUE represents the best estimate of the arithmetic mean, given that the underlying data distribution is lognormal. The lognormal distribution of the PCB MPA values is documented in the LRC (USEPA, 1998), and therefore not repeated here. The formula for the MVUE is given by Gilbert (1987). The particular formula used here is based on the Psi function

(Gilbert, 1987, equation 13.3), and not the statistically less-rigorous approximation used in the LRC.

Equation 3, given previously, was used to calculate the individual MPA values for Total PCB and Tri+ at each of the low-resolution coring locations. The inventory for each *hot spot* or dredge zone was then estimated by calculating the MVUE based on all the coring locations contained within the zone. This calculation is similar to that performed in the LRC (USEPA, 1998), although a more rigorous approximation is used in these current calculations. The values for the MVUE estimate of the MPA were then multiplied by the total area of the *hot spot* to estimate the Total PCB or Tri+ mass for the area. In this manner an estimate of mass for each of the studied *hot spots* (*i.e., Hot Spots 25, 28, 31, 34, 35, 37* and *39*) was obtained. In the first five *hot spots,* the areas themselves were defined from the side-scan sonar results, which identified cohesive sediments. Areas for *Hot Spots 37* and *39* were based on the original NYSDEC boundaries (Tofflemire and Quinn, 1979).

Since the LRC program in River Sections 2 and 3 focused on *hot spot* areas and, therefore, predominately cohesive sediments, areas consisting of cohesive sediments that were not sampled as part of the program were considered to be similar to those areas that were sampled. Thus, the samples collected from the study areas were considered generally representative of unsampled cohesive sediments. An MVUE of the Total PCB and Tri+ was calculated for the unsampled cohesive sediments using all the samples collected in the river section. Thus samples from *Hot Spots 25* through *35* were used to estimate the MPA for River Section 2 ,and samples from *Hot Spots 37* and *39* were used to estimate the MPA for River Section 3. In River Section 2, the MPA value was multiplied by the area of the additional cohesive sediments in the section, which did not have PCB data, to obtain an estimate of their PCB mass. In River Section 3, the areas of the *hot spots* defined by NYSDEC and the River Section 3 MPA value were used to estimate the PCB mass. Both Total PCB and Tri+ were done in this manner.

In River Section 2, the unsampled areas added approximately 25 percent to the Total PCB and Tri+ inventories. In River Section 3, the unsampled areas were approximately equal to the studied areas in mass.

Non-Cohesive Sediment Inventories

In River Sections 2 and 3, the PCB mass in non-cohesive areas was estimated using GE's 1991 composite samples. In both sections, only those GE composites falling entirely outside the remediation zones were used in the estimate. In River Section 2, this criterion eliminated all but one of the ten GE composites. In River Section 3, 15 of the 60 composites were excluded by this criterion. The main reason for the higher number of samples accepted in River Section 3 is the proportionately smaller area targeted for remediation in this section.

The identified GE composite samples were then used to create MPA values for each composite line for each parameter. The lines were then arithmetically averaged to obtain the MPA for the section. For River Section 2, four composites were identified as coarse-grained; however, they all included locations within the dredge zones. Despite this concern, these four coarse samples should be characteristic of the unremediated sediments, since it was the fine-grained sediments that were targeted. As it turned out, the one composite entirely outside of the remediation areas

in River Section 2 had a LWA value (14.8 mg/kg) that was quite close to the average of the four separate coarse-grained composites in the section (12.1 mg/kg). Thus, the limited data set did not appear to introduce a large amount of uncertainty, since the range is relatively small.

Using the MPA from composite lines entirely outside of remediation areas, the Total PCB and Tri+ inventory in each section for non-remediated areas was then calculated as follows:

$$\text{MASS} = \text{total area (not remediated)} \times \text{average MPA (not remediated)} \qquad (7)$$

For River Section 2, composite rocky areas were excluded from the calculation. For River Section 3, no exclusion for rocky areas could be made due to the lack of data to define these areas. A solid specific weight of 1 g/cm^3, which is close to the average of the cohesive and non-cohesive solid-specific weight values, was used in the MPA calculation. This introduces some potential bias in the calculation since the contaminant mass in non-cohesive areas will be underestimated and the contaminant mass will be overestimated in cohesive sediments. However, given the larger sources of uncertainty involving the extrapolation of the data in general, this correction is not worth further pursuit.

Summary of PCB Inventories in River Sections 2 and 3

Using the approaches described above, the Total PCB and Tri+ inventories were estimated for each river section. These results are summarized in Table 36334-1. The Total PCB inventories given here are the same as those given in Chapter 3, Table 3-4 of the FS, with the addition of the channel dredging. Thus, the 23,600 kg for the *hot spot* remediation in River Section 2 given in Table 3-4 of the FS is 24,300, with the added channel area. Similarly, the previous estimate of 6,700 kg in River Section 3 under the selected *hot spot* removal is replaced with 7,100 kg. The Tri+ calculation presented in Table 363334-1 represents additional inventory estimates for the sections.

River Section 2 is most like the TI Pool in that 80 percent or more of its PCB contamination will be remediated under the selected remedy. As noted in the White Paper – Relationship Between Tri+ and Total PCBs, the relationship between Total PCBs and Tri+ is also similar, with a ratio of 3.4 in the remediated areas. The ratio in River Section 3 is slightly lower, at 2.7, reflecting a lower level of dechlorination due to lower levels of contamination in the section.

In River Section 3, a much more limited PCB removal is anticipated. Thus, its percent removal is only 22 percent. Part of this results from the fact that the section is quite large and much of the area in this section has relatively low levels of contamination, which are, in general, too impractical to consider for remediation.

Estimation of Total PCB and Tri+ Concentrations in River Sections 2 and 3

The section-wide average concentrations of Total PCB and Tri+ were calculated from the mass estimates rather than an independent statistical analysis or via polygonal declustering. Since both the mass of PCB contamination in the sediments and the mass of contaminated sediments were known (the mass of contaminated sediments was known based on the reported length of contaminated core sections and the measured or estimated sediment densities), calculation of the

average *in situ* concentration was simply the quotient of these two values converted to mg/kg. These values are given in Table 363334-2. Again, the values for River Section 2 are more similar to River Section 1 than River Section 3, as would be expected.

COMPARISON OF THE EXTENT OF REMEDIATION FOR THE SELECTED REMEDY AND FULL SECTION REMOVAL

There have been several comments that indicate that the PCB mass anticipated to be removed under the selected remedy is not sufficient, and that further remediation is warranted. After modifying the inventories in the sediments and reviewing the areas for remediation, the results indicate that the mass of Total PCBs to be removed represents about 65 percent of the Upper Hudson inventory, a larger fraction than originally reported. Above Lock 5 (*i.e.*, River Sections 1 and 2), the anticipated removal is about 80 percent as measured by Total PCBs or Tri+. Further, for cohesive sediment in the TI Pool, the selected remedy is estimated to remove about 94 percent of the Total PCB and Tri+ inventories.

It is useful to compare these values to those estimated for the most extensive removal alternative (*i.e.*, REM 0/0/3). The estimated masses of Total PCBs and Tri+ remediated under the full-section removal are presented in Table 363334-3. The mean *in situ* concentrations for both Total PCBs and Tri+ for the TI Pool were also estimated for comparison. These values are presented in Table 363334-4. *In situ* concentration is examined in this section to serve as an example of the types of concentration differences between the two alternatives.

As can be seen by comparing Tables 363334-1 and 363334-3, the full-section removal addresses a larger fraction of the PCB inventories. For the entire Upper Hudson the REM 0/0/3 alternative would address 78 percent of the PCB inventory, as opposed to the 65 percent addressed under the selected remedy. For the region above Lock 5, the percent of Total PCBs remediated under the REM 0/0/3 alternative is 96 percent as opposed to 82 percent for the selected remedy. The gain in the fraction of Total PCBs and Tri+ removed comes as the result of a great expansion in the areas affected. Specifically, the number of acres affected under the REM 0/0/3 alternative (964 acres) is nearly double that affected under the selected remedy (493 acres) while the mass of PCBs removed increases by only 20 percent (from 70,000 to 84,000 kg).

The extended areas affected under the REM 0/0/3 alternative are not evenly distributed among the sediment types. For example, in Section 1 the percentage of Total PCB mass removed increases from 82 percent for the selected remedy to 94 percent for the full-section treatment. However, nearly all of this change is due to the addition of a large amount of non-cohesive sediment and associated PCBs. The change in percent remediated for the cohesive sediments is only 3 percent, from 95 to 98 percent. Thus the additional PCB mass in the full-section alternative is the result of the addition of many acres of low PCB concentration, coarse-grained sediment. Similarly, the percentage of remediated Tri+ inventory for cohesive sediments increases from 94 to 99 percent as a result of the more-extensive remediation. Given the extensive volume of cohesive sediments to be removed under either alternative, these differences are only minor.

Changes in the non-cohesive percentage remediated are much more dramatic – the percentage remediated increases from 55 to 88 percent for Total PCBs, and the Tri+ increase is similar.

Thus, the net effect of the full-section alternative for the TI Pool is the addition of extensive areas of non-cohesive sediments. A similar increase between the alternatives would be expected for River Section 2, which achieves an even higher percentage PCB mass removal with a smaller affected area under the selected remedy.

The changes in the mean concentration of the dredged material can be seen by comparing Tables 363334-2 and 363334-4. Essentially, as the level of remediation increases, the PCB concentrations on the material removed approach the PCB concentrations of the material left behind undisturbed. Both values converge to that of the mean *in situ* condition. This is a result of several factors, the most important of which is that for such high removal fractions (better than 80 percent), the conditions of the material removed must approach those of the *in situ* material, since the remediation would remove nearly the entire inventory.

The estimated concentrations of the residual sediments left undisturbed also approach the mean. The cause of this is less clear, as there is no *a priori* reason for it. However, a closer examination reveals that the PCB concentration estimates for much of the unremediated areas are based on the extrapolation of data points over relatively long distances. Few data points are actually in the undisturbed area, in part because much of it is rocky or adjacent to rocky areas and difficult to sample. Thus, as the area left undisturbed gets smaller, the amount of site-specific data pertinent to that area declines and instead the estimates of PCB mass and concentration rely on data points that are outside of the undisturbed area. This is believed to be the cause of the converging sediment concentrations.

SURFACE SEDIMENT CONCENTRATIONS IN THE TI POOL

Estimates of cohesive sediment surface concentrations were required for the revision of the Depth-of-Scour Model (DOSM) calculations. At the request of the State of New York, the impacts of a higher flow rate at Fort Edward were examined (White Paper – Application of the Depth-of-Scour Model [DOSM] in the Thompson Island Pool for Additional Flooding Assumptions). Additionally, the estimate of Total PCB released by a 100-year flood was reassessed using the revised estimates for the TI Pool inventory.

To this end, both (1) the surface core segments and grabs samples obtained by the 1984 NYSDEC survey, and (2) the 1991 GE composite samples were used to estimate Total PCB and Tri+ concentrations in the uppermost sediment layers. The estimate based on the 1984 data provides a reasonable upper bound on the PCB concentration in resuspended sediments during dredging. The depths of the 1984 NYSDEC cores (generally 30 cm or 12 in.) are substantially greater than the predicted depths-of-scour (mean depth is less than 1 cm), and since PCB levels generally increase with depth, the average value obtained from the 1984 data should represent a high-end estimate for resuspension.

The mean surface concentration for cohesive sediment was estimated based on a polygonal declustering analysis using the 1984 data set and the side-scan sonar definitions of sediment texture (USEPA, 1997). The mean surface concentration in the TI Pool was calculated using the Tri+ surface concentrations and Equation 3 (given previously). This yielded a value of 51 mg/kg for cohesive surface sediments. Given that the Total PCB to Tri+ ratio for the TI Pool is approximately 3.4, Total PCBs were not calculated as an area-weighted average but rather by

simply multiplying the Tri+ value by the ratio, yielding 170 mg/kg for Total PCB. These values are given in Table 363334-5.

The 1991 GE composite samples were also used to estimate surface concentrations for the DOSM model analysis. These samples are believed to represent a low-end value for several reasons. First, the GE composites appear to contain both cohesive and non-cohesive sediments, thus diluting the more-contaminated cohesive sediment values with the non-cohesive samples. Similarly, they represent a mechanically averaged sediment concentration (via compositing), which tends to suppress higher values. Lastly, since the set of composites represent all areas of the pool (cohesive and non-cohesive), they cannot be easily separated or classified according to sediment type. Because the composites extend across sediments types they generally cannot be classified based on the sediment texture of the sampling location as the cores were.

The concentrations in the 0-5 cm layers of the 1991 GE composite cores were arithmetically averaged to yield mean values for both Total PCB and Tri+. These are also given in Table 363334-5. Notably, the range between the GE- and NYSDEC-based estimates is close to a factor of three for Tri+ and more than a factor of five for Total PCBs. This partially reflects the sensitivity of the Total PCBs estimate to the Tri+ value. The ratio of Total PCB to Tri+ is only 2 for the GE sediments, as opposed to 3.4 for the 1984 samples.

ESTIMATION OF PCB CONCENTRATIONS IN DREDGED SEDIMENTS

In addition to characterizing the PCB contamination in place on the river bottom, estimates of PCB concentration on the dredged materials themselves were also needed as part of several engineering analyses. The nature of the dredging process is such that a significant amount of uncontaminated sediment is expected to be incorporated with the target material. This material will effectively dilute the PCB concentrations on the dredged material, resulting in lower PCB concentrations in the materials undergoing the handling process than in the in-river sediment. In estimating the impacts of the dredging process, it is important to recognize this dilution step, since uncontaminated sediments do not generally pose a risk or dramatically affect the environment.

The estimates of sediment mass and volume to be removed were discussed extensively in the FS as well as in Chapter 4, Master Comments 313219 and 313224, in this RS. The estimation of the mean concentration of Total PCBs and Tri+ on the dredged sediments is given as follows:

$$Conc_{TPCB} = \frac{Mass_{TPCB}}{Vol_{Sed} * r_{Sed}} \tag{8}$$

where:

$Conc_{TPCB}$	=	Concentration of Total PCB in the dredged material for the river section
$Mass_{TPCB}$	=	Mass of Total PCB contained within the sediments to be dredged
Vol_{Sed}	=	Volume of sediments to be dredged
ρ_{Sed}	=	Solid-specific weight of the sediments to be dredged (*i.e.*, the mass of dry solids per unit volume of wet sediment

Using this calculation, the concentration of the dredged material was estimated for each section of the Upper Hudson. Additionally, in the TI Pool it was possible to further separate the calculation by sediment type. These results are presented in Table 363334-6. Both Total PCB and Tri+ concentrations were estimated for each section, as well as for the entire removal operation.

The results show a slightly greater than threefold decline in the Total PCB concentrations of dredged material when compared to *in situ* values for River Sections 1 and 2, which reflects the significant amount of overcut and dredging of low-level contamination from the channel. These sections had extensive data on the depth of sediment contamination and its horizontal extent, as well as bathymetric data. These data provided input for the selection of overcut depth.

Since these data were not available in River Section 3, the actual volume of dredged material and the extent of overcut have much greater uncertainties. Therefore, the overcut in River Section 3 was estimated on a more limited basis and not as rigorously as River Sections 1 and 2. As a result, the concentration estimates for the dredged material in River Section 3 declined from the *in situ* values by only 30 percent. It is important to note that these estimates will undergo extensive refinement as part of the remedial design, when a sampling program will be implemented. The estimates of concentration calculated here are simply intended to provide a basis for estimations involving the transport and processing of the materials and potential hazards or concerns related to dredging. Specifically, the values provided in Table 363334-6 were used as a basis for estimating resuspension losses, gas-exchange losses, and other material transport and processing issues. The issue of TSCA material is discussed separately in White Paper – Estimate of Dredged Material Exceeding TSCA Criteria.

UNCERTAINTY

The nature of the mass estimates provided here does not lend itself easily to quantitative estimates of uncertainty. Although the various data sets could be used to create statistical estimates of uncertainty, there is no simple statistical technique to account for the differing ages of the data, the geochemical changes in the river since the date of collection, the differences in analytical and sampling techniques, and the correction factor (*i.e.*, ratio) between the Tri+ and Total PCB estimates. As a result, there are no presentations of statistical uncertainty. Rather, a professional judgment of uncertainty indicates that most of the inventory estimates probably have an uncertainty of at least $\pm$ 25 percent.

CONCLUSIONS

The reassessment of Total PCB and Tri+ concentrations yielded improved estimates of concentration and total mass for each parameter in each river section. For Tri+, the changes were minor. However, for Total PCBs, the revised inventory of the TI Pool was found to be three times greater than the previous estimate given in the FS. This revision resulted from analysis of the Total PCBs to Tri+ ratio described elsewhere in the White Paper – Relationship Between Tri+ and Total PCBs. As a result of the revisions, the estimate for the TI Pool is in closer agreement to the conditions measured in River Section 2. The revisions also indicate that the TI Pool contains the largest fraction of PCB mass in the Upper Hudson. This follows intuitively, since the TI Pool is closest to the GE facilities and the former Fort Edward dam site. The Total

PCB inventory of the Upper Hudson was estimated to be 110,000 kg (240,000 lbs). Of this, 70,000 kg (150,000 lbs) will be removed as part of the selected remedy.

Estimates were also provided for the percentage of PCB inventory remediated by the selected remedy. Approximately 65 percent of the Total PCB inventory in the Upper Hudson will be remediated under this remedy. This represents an upward revision from the original estimate of approximately half, as a result of a revised estimate of the mono- and di-homologue inventories for the sediments based on recent and earlier data. The estimate of percent PCB inventory removed increases from the previous estimate because the selected remedy targets cohesive sediments. Cohesive sediments in general have higher PCB concentrations and, accordingly, have a higher ratio of mono- and di-homologues than the non-cohesive sediments. The Tri+ inventory estimates presented in the FS were essentially unchanged.

In the TI Pool the selected remedy is estimated to remove 80 percent of the Total PCB inventory. This was contrasted with the 94 percent remediated by the full-section alternative (>0g/m^2) in River Section 1. However, most of this difference results from the addition of low-PCB level, coarse-grained sediment to the remediation volume. The selected remedy addresses about 95 percent of the fine-grained-sediment PCB inventory, as compared to 98 percent under the full-section removal.

Estimates for surface concentrations and concentrations on dredged materials were also derived. Concentrations for surface sediments were obtained from the 1984 NYSDEC sediment survey for cohesive sediment and from the 1991 GE composite samples for the entire TI Pool. These values differed by approximately a factor of five. This range reflects the difference in sampling depths as well as other sampling artifacts, such as compositing. Estimates of concentrations in material targeted for dredging were obtained by integrating the PCB mass and sediment mass slated for removal. In this manner, the impact of the removal of clean sediments along with the contaminated sediments was taken into account. This approach yielded dredged material concentrations that were about three times lower than the *in situ* concentrations.

REFERENCES

Gilbert, R.O. 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold, New York. p 158-159.

Tofflemire, T.J., and S. O. Quinn. 1979. PCB in the Upper Hudson River: Mapping and Sediment Relationships. NYSDEC Technical Paper No. 56. March 1979. NYSDEC, Albany, New York.

USEPA. 1999a. Responsiveness Summary for Volume 2C-A Low Resolution Sediment Coring Report, Addendum to the Data Evaluation and Interpretation Report. Prepared for USEPA Region 2 and the USACE, Kansas City District by TAMS Consultants, Inc. and TetraTech, Inc. February 1999.

USEPA. 1999b. Report on the Peer Review of the Data Evaluation and Interpretation Report and Low Resolution Sediment Coring Report for the Hudson River PCBs Superfund Site. Prepared by Eastern Research Group, Inc., June 1999.

USEPA. 2000. Phase 2 Report, Further Site Characterization and Analysis, Volume 2D, Revised Baseline Modeling Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA and US Army Corps of Engineers Kansas City District by Limno-Tech, Inc., Menzie-Cura and Associates, Inc. and TetraTech, Inc. January 2000.

Metals Contamination
253002

WHITE PAPER – METALS CONTAMINATION

(ID 253002)

ABSTRACT

Comments included concerns about unacceptable levels of residual heavy metals in river sediments when the selected remedy is implemented. Based on multiple data sets spanning 16 years, the evidence suggests that the historical release of heavy metals found in the Upper Hudson River sediments coincides with the input of PCBs. This co-depositional pattern is clearly evident in Figure 253002-1, which shows the coincidence of maximum metals and PCB concentrations in the early- to mid-1970s (early- to mid-1960s for nickel and zinc) and then a downward trend in concentration in recently deposited sediments. The data indicate that when the selected remedy (REM 3/10/Select) is implemented, not only significant amounts of PCBs will be removed from this river environment, but also much of the heavy metals that were deposited coincidentally with the PCBs. Therefore, residual metals in newly exposed sediments would be at or near background levels. A sampling and evaluation plan for metals will be implemented during remedial design in order to ensure there is no problem with sediment residuals or dredged sediment disposal.

INTRODUCTION

Throughout the course of PCB-related data collection and analyses in the Upper Hudson River, it became apparent that other contaminants were also associated with the same sediments. The first reported data set with respect to heavy-metal concentrations in Upper Hudson sediments is from the 1977 sediment survey (as reported by Tofflemire and Quinn, 1979, and Brown, *et al.*, 1988). Selected samples from this survey were submitted to the NYSDOH for metals analyses. The metals analyzed for included: calcium, chromium, copper, iron, lead, manganese, nickel, potassium, rubidium, strontium, titanium, and zinc. The results of these analyses indicated elevated levels of chromium, copper, lead, manganese, nickel, and zinc, and are summarized in Table 253002-1. For purposes of this report, the term 'elevated levels' refers to concentrations of various metals detected above background levels (Tables 253002-1 through 253002-11) observed in this region. Subsequent data sets, as outlined within the metals data inventory below, were also compiled with respect to Upper Hudson River sediments and metals concentrations. These data have shown that in addition to elevated PCBs concentrations within the sediments, there also are elevated metals concentrations.

The concern was raised that dredging would expose the biota to deeper sediments with elevated metals concentrations. Indeed, removing one contaminant but leaving another would be unacceptable. Another concern focused on the potential mobility of these metals through the process of leaching during the dredging and sediment handling/processing requirements. However, the extraction procedure (EP) toxicity analyses (comparable to Toxicity Characteristic Leaching Procedure [TCLP]) performed on the 1984 and 1986 data indicated that these sediments and their associated metals did not exceed any of the TCLP criteria. In fact, all of the

results were at least one order of magnitude below the criteria, and thus, the metals should not be redistributed as a result of leaching.

The data clearly indicate that there is a direct correlation between concentrations of PCBs and metals within these sediments. Furthermore, the removal of PCB-contaminated sediments in target areas will effectively remove much of the metals contamination, and the residual metal levels will be at or near background levels. Therefore, even prior to the placement of clean backfill over dredged areas, the concentrations and availability of metals to the biota will be within acceptable levels.

METALS DATA INVENTORY

Metals data used in this analysis include results contained in the Hudson River PCBs database as well as in other Hudson River reports. These data sets represent sediment, biota, and sediment EP toxicity results, and include the following sources:

- 1977 – Sediment grab data from 1977 and analyzed by NYSDOH, obtained from Tofflemire and Quinn, 1979 (Table 253002-1).

- 1984 – Sediment core data (avg. 80-cm depth) from the 1984 sediment survey, obtained from Brown *et al.*, 1988 (Table 253002-2).

- 1986 and 1987 – Sediment core data (generally one- to two-foot depth) from *Hot Spots 3, 8,* and *20* collected in 1986 and 1987, obtained from Brown *et al.*, 1988 (Table 253002-3).

- 1983 and 1991 – Sediment core data from *Hot Spot 20* (0- to 44-cm depth) collected at RM 188.5 in 1983 and RM 188.6 in 1991 by Dr. Richard Bopp (Rensselaer Polytechnic Institute [RPI] and Lamont-Doherty Earth Observatory [LDEO] [Tables 253002-4 and 253002-5]).

- 1993 – Sediment data from 0-5 cm collected at RMs 203.3 (baseline station), 194.1, 191.5, 189.5, 189.0, 188.7, and 188.5 for the Ecological Risk Assessment (ERA) by EPA in 1993 (Tables 253002-6, 253002-7, and 253002-8).

- 1984 and 1986 –EP toxicity analysis (comparable to EPA test Method 1311, TCLP) of nine sediment samples from the 1984 survey and six samples from the 1986 survey, obtained from Brown *et al.*, 1988 (Table 253002-9).

- Fish data collected by NYSDEC in 1988 (Table 253002-10).

- Fish data collected in 1997 and 1998, as reported by Sloan, 1999.

The entire sediment data set is summarized in Table 253002-11.

DISCUSSION OF SEDIMENT METALS DATA

Each of the data sets described above provides a slightly different perspective on the levels of inorganic contaminants in Upper Hudson River sediments. No one data set is completely descriptive but combined they provide a fairly complete picture. In this section, the results are combined to describe the likely set of conditions to be encountered under the selected remedy.

The core data obtained by Dr. Richard Bopp provide an important historical perspective (Tables 253002-4 and 253002-5; Figure 253002-1). By the use of radionuclide dating procedures (such as those in Bopp and Simpson, 1988, and USEPA, 1997), it is possible to establish a chronology of sediment deposition and transport. The sediment cores collected by Bopp provide data on both PCBs and metal transport and deposition over the period from 1954 to 1991. These data show that the occurrence of elevated metal concentrations in the sediments is coincident with the highest PCB concentrations. Metal concentrations in the deepest core segments are close to those seen in the baseline samples at RM 203.3. Thus, the removal of PCB-contaminated sediments will also achieve near-baseline levels of metals within the residual sediments.

A second important feature of Dr. Bopp's core data is the decline in metals concentrations in the shallowest core layers. These data indicate levels approaching those seen at the baseline site at RM 203.3 for all metals but chromium. However, even chromium is reduced by an order of magnitude from its peak concentration. These results indicate that areas dredged as a part of the selected remedy will not become recontaminated with elevated metal concentrations after the dredging is complete. That is, since the most recently deposited sediments, represented by the shallowest sediment layers, are at or close to background levels, the river is currently depositing metal concentrations that do not present a contamination problem. Thus, once an area has been cleaned of its metal contamination, the river's depositional processes should not recontaminate it with elevated metals levels. This would not be the case if metals were currently being released to the river or otherwise being re-released from the sediments at a significant rate.

While the Bopp data provide information on the history of metal deposition in the Upper Hudson, the samples are not considered to be spatially representative of the river bottom. To assess the likely metal levels in the sediments to be dredged, the data from all available sources was combined to estimate the mean metals concentrations as well as likely maximums. These results are summarized in Table 253002-11.

The 1977 grab samples analyzed by the NYSDOH (Table 253002-1) were collected at 20 stations within the Thompson Island Pool (TI Pool). The analytical results indicate that chromium, copper, lead, manganese, nickel, titanium, and zinc were detected above background levels (Note: Titanium did not have any detectable background level; however, all reported samples from within the TI Pool had detected concentrations).

The 1984 sediment survey produced over 400 cores for analysis (Table 253002-2). The cores averaged 80 cm (32 inches) in depth from stations within the TI Pool. A subset of these samples was sent for analytical testing of metals based on the results of PCB analyses. The primary purpose of the metals analyses was to characterize sediments within proposed PCB dredging areas with respect to metals concentrations and potential residual levels after remediation. A summary of the results is provided in Table 253002-2. The results indicate elevated levels of

arsenic, cadmium, chromium, copper, lead, mercury, and nickel, relative to background. The chromium and lead levels are on the same order as the data from the 1977 samples.

NYSDEC collected six cores at *Hot Spots 3, 8,* and *20* (two from each *hot spot*) in 1986 and again in 1987. A summary of the analytical results is provided in Table 253002-3. The results indicate elevated levels of antimony, arsenic, barium, cadmium, chromium, copper, lead, mercury, selenium, vanadium, and zinc ,relative to background levels.

The 1983 and 1991 cores collected by Dr. Bopp were located at RM 188.5 and RM 188.6, respectively. These cores were on the eastern side of the river within *Hot Spot 20*. The 1983 core was collected to a depth of 40 cm and the 1991 core to a depth of 44 cm. A summary of the analytical results is provided in Tables 253002-4 and 253002-5, as well as Figure 253002-1. Each of the two cores was dated using ^{137}Cs to trace chronological deposition of sediments and their respective contaminants. The analytical results indicate elevated levels of cadmium, chromium, copper, lead, nickel, and zinc, relative to background levels.

As discussed above, the significance of the metals-PCB relationship over time obtained from the Bopp cores is of great importance. Note that the two cores were separated by one-tenth of a mile and collected eight years apart, yet each of the cores depicts a good correlation between metals and PCB concentrations. This observation is relevant when discussing residual metals based on the selected PCB remedy.

Removing PCB-contaminated sediments will also remove nearly all of the harmful metals from the same system (with no additional dredging). Residual concentrations of metals will be at or near background levels. The evidence for this is provided in Table 253002-4. The 1983 Bopp core indicates that a PCB concentration of 1.2 mg/kg is observed at a depth of 36 to 40 cm, which approximately corresponds to the year 1954. If sediment removal occurred to this depth, the residual metal concentrations would be: cadmium (0.2 mg/kg), chromium (11 mg/kg), copper (6 mg/kg), lead (5 mg/kg), nickel (5 mg/kg), and zinc (288 (mg/kg). These residual metal levels, when compared to both surface and background concentrations (Table 253002-4a), indicate that they would be considerably less than current surface concentrations within the TI Pool. All but cadmium would be less than background levels.

However, these concentrations are based on removal to 40 cm (16 inches) (year: 1954), whereas the *hot spot* associated with this core (*i.e., Hot Spot 20*) is targeted for sediment removal to 122 cm (4 feet). Since the targeted depth is set below the zone discussed above, and significantly pre-dates the 1954 sediments and their respective contaminant inputs, it is safe to infer that the PCBs and metal levels will also be significantly less. Thus, the amount of metals removed from this environment is nearly 100 percent, with only trace amounts in the dredging residual.

The 1993 sediment survey for the ERA obtained metals data in sediment. There were five stations in the lower TI Pool (RMs 191.5 – 188.5), one Rogers Island station (RM 194.1), and one background station (RM 203.3). The background station at RM 203.3 was used to determine a baseline level for metals and PCBs concentrations, since its location was sufficiently upgradient of the two GE facilities. Summaries of the results are provided in Tables 253002-6, 253002-7, and 253002-8. The analytical results indicate elevated levels of arsenic, barium,

beryllium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, thallium, and vanadium, relative to background levels observed at the RM 203.3 sampling location.

Extraction Procedure Toxicity Analyses Results

The samples described previously document the level of metals contamination in Upper Hudson River sediments. These data do not provide information on the suitability of the sediments for disposal in a landfill. The test for suitability is the TCLP test. Nine sediment samples from the 1984 survey and six samples from the 1986 survey were analyzed for PCBs and also analyzed using EP toxicity testing, which is comparable to EPA test Method 1311 (the TCLP test). This procedure was done to provide analytical results on the leachability of metals (such as arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) within Upper Hudson River sediments. A summary of the analytical results is provided in Table 253002-9. No exceedances of TCLP criteria were found in any sample for any metal. The results indicate that the TCLP results are at least one order of magnitude below the Leaching Toxicity Characteristic Standards (40 CFR § 261.3). Therefore, the potential risks associated with residual metals (post-remedy, in-river) and metals within sediments during processing/transfer will be minimal, due to the low leaching characteristics. The data indicate that disposal of the sediments will not require special restrictions due to leachable metal levels.

NYSDEC FISH DATA

In addition to metals data for sediments, NYSDEC also collected data for fish tissue. In 1988 NYSDEC sampled fish above (RM 201.3) and at two locations (RMs 198.3 and 198.2) adjacent to the Hercules/Ciba-Geigy paint factory to determine concentrations of selected metals in fish. Carp, smallmouth bass, and bass were sampled. Standard fillets for analyses were prepared from all fish; however, liver samples were analyzed from carp only. A total of 14 RM 201.3 background samples (9 fillet, 5 liver), 22 samples from RM 198.3 Hercules/Ciba-Geigy Station 5 (12 fillet, 10 liver), and 19 samples from RM 198.2 Hercules/Ciba-Geigy Station 5 (12 fillet, 7 liver) were analyzed. Samples were analyzed for cadmium, chromium, mercury, nickel, lead, strontium, and vanadium (Table 253002-10).

At RM 201.3, the background fillets had elevated concentrations of mercury, with an average concentration of 0.8 ppm in fillets and 0.6 ppm in liver (Table 253002-10 and Figure 253002-2). Liver samples had an average of 5 ppm cadmium, 0.6 ppm mercury, and 0.2 ppm strontium and vanadium.

At RM 198.3, the fillets had lower concentrations of mercury, with an average concentration of 0.3 ppm in fillets and none detected in liver samples. Strontium was detected at 0.2 ppm in the fillets and at 0.1 ppm in the liver samples. Liver samples also had average concentrations of 11 ppm cadmium, 2 ppm chromium, 1 ppm lead, 0.1 ppm strontium, and 0.2 ppm vanadium.

Just downstream, at RM 198.2, the fillets also had an average concentration of 0.3 ppm mercury, with no mercury detected in liver samples. Liver samples had average concentrations similar to those at RM 198.3, with 16 ppm cadmium, 1 ppm chromium, and 0.3 ppm strontium. The elevated concentrations of cadmium and chromium detected in fish livers at these locations may be due to releases from the paint factory, as these contaminants are used in paint manufacturing.

Contaminants other than PCBs were also analyzed in Hudson River fish collected in 1997 and 1998 (Sloan, 1999). The only metals included as additional contaminants by Sloan were mercury and cadmium. Cadmium concentrations in fish (*i.e.*, yellow perch [3 samples] and pumpkinseed [5 samples]) at all stations within the vicinity of the Hercules/Ciba-Geigy paint station (RMs 201 and 189) were below 0.01 ppm. No livers were analyzed separately in 1997. One of the conclusions of the briefing on 1997 striped-bass results prepared by NYSDEC (Sloan, 1999) was that other contaminants (*e.g.*, DDT, mercury, PAHs, dioxins, and dibenzofurans) are present in the Hudson River, but do not represent as great a problem as PCBs.

RESIDUAL CONCENTRATIONS AND OVERALL CONCLUSIONS

The two cores collected by Dr. Bopp (1983 and 1991) illustrate key aspects of the spatial and chronological relationship between PCBs and metals in the TI Pool sediments (Tables 253002-4 and 253002-5; Figure 253002-1). Table 253002-4 suggests that the maximum levels of PCBs are contained within the same sediment depth horizon as the maximum metals concentrations, or just below (1983 core) the metals maximum concentrations. That is, in the 1991 core, maximum values for Total PCBs and metals occurred at 28-32 cm, while in the 1983 core, maximum metals levels occurred in the sediment layer just below the maximum Total PCBs level. Based on the good correlation between PCBs and metals concentrations, the removal of PCB-contaminated sediments will also achieve near-baseline levels of metals within the residual sediments.

The data from Table 253002-4 suggest that the maximum metals concentrations occur at a maximum depth of 32 cm (12.6 inches). These data generally represent cohesive sediments, where metals contamination is greatest. The minimum depth of removal in cohesive sediments in the TI Pool under the selected remedy is 2 feet (61 cm). The proposed depth of removal in *Hot Spot 20*, where the Bopp cores were collected, is 4 ft. (122 cm). A comparison of the 1983 Bopp core to the 1993 background sample indicates that levels at a depth of 40 cm within the Bopp core are near or below the actual baseline levels (Table 253002-12). Thus, the planned depth of sediment removal in cohesive sediments is at least double the mean depth of metals contamination, as well as more than double the measured depth of contamination in *Hot Spot 20*.

The sediment data from the TI Pool undeniably suggest that the metals were deposited coincident with the PCBs. Based on the depth of removal proposed in the selected remedy, the removal of PCB-contaminated sediments will also remove nearly 100 percent of the metals contamination above background levels. The residual traces within the sediments will be either near or below the baseline metals concentrations. Furthermore, clean backfill placed above dredged areas will reduce aquatic exposure to metals and hence will further minimize the ecological impact.

Based on the fish data, cadmium and chromium may be passed on in the food chain, although tissue concentrations are lower than sediment concentrations (*i.e.*, biomagnification is not occurring). Cadmium has been implicated as the cause of severe deleterious effects on fish and wildlife (Eisler, 1985). Concentrations of cadmium in freshwater above 10 ug/L are associated with higher mortality, reduced growth, inhibited reproduction, and other effects. Effects are most pronounced in waters of comparatively low alkalinity. Adsorption and desorption rates of cadmium are rapid on mud solids and particles of clay, silica, humic material, and other naturally occurring solids.

Chromium toxicity is dependent on speciation, with the hexavalent form considered the most toxic. Although chromium is an essential trace element in many species, at high environmental concentrations it is a health concern (Eisler, 1986).

Cleanup of contaminants to lowest effect levels (LEL) (Persaud *et al.*, 1993; Long and Morgan, 1990) of 0.6 mg/kg cadmium, 26 mg/kg chromium, and 31 mg/kg lead would be protective of aquatic organisms. However, these levels are generally at or close to background levels and would be difficult to achieve. Cleanup based on severe effect levels (SEL) (Persaud *et al.*, 1993; Long and Morgan, 1990) of 9 mg/kg cadmium, 110 mg/kg chromium, and 110 mg/kg lead is unlikely to be adequately protective of aquatic organisms and would be required at only a few areas, as most locations are below these levels. Other sediment quality targets that may be considered for metals are the threshold effects concentration (TEC) (below which adverse effects are not expected to occur), and the probable effects concentration (PEC) (above which adverse effects in sediments are expected to frequently occur), which are consensus-based sediment quality guidelines (SQGs) developed by MacDonald *et al*. (2000). TECs and PECs are 0.99 and 4.98 mg/kg for cadmium, 43 and 111 mg/kg for chromium, and 36 and 128 mg/kg for lead, respectively. A realistic cleanup goal can be considered to fall within the range of these sediment-quality targets, which is likely to be achieved (based on the correlation between PCBs and metals) by the remediation performed for PCBs under the selected remedy (*i.e.*, REM-3/10/Select).

In sum, heavy-metal contamination within the Upper Hudson River sediments will be removed at the same time as the PCBs are removed, based on the dredging plan for the selected remedy. The concentrations of residual metals (post-remedial) are expected to be at or near the baseline (Table 253002-12). No exceedances of TCLP criteria were found in the historical data. The leachability of metals has been found to be at least one order of magnitude below the TCLP criteria (Table 253002-9). A sampling plan for metals will be implemented during the remedial design in order to confirm the conclusion that metal contamination does not pose a significant concern for sediment residuals or dredged sediment disposal.

REFERENCES

Bopp, Richard F., and Simpson, H. James. 1988. Sources and Trends of Persistent Contaminants in the New York Harbor Complex. Final report for grant nos. 015/85B and 015/86B, Hudson River Foundation. August. 54 p.

Brown, Mark P., Mary B. Werner, Cynthia R. Carusone, and Michael Klein. 1988. Distribution of PCBs in the Thompson Island Pool of the Hudson River, Final Report of the Hudson River PCB Reclamation Demonstration Project Sediment Survey. Bureau of Technical Services and Research, Division of Water, NYSDEC. Albany, NY. May.

Eisler, R. 1985. Cadmium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Fish and Wildlife Service, U.S. Department of the Interior. Biological Report 85(1.2) 46 pp.

Eisler, R. 1986. Chromium Hazards to Fish, Wildlife, and Invertebrates: A synoptic Review. Fish and Wildlife Service, U.S. Department of the Interior. Biological Report 85(1.6) 60 pp.

Long, E.R., D.D. MacDonald, S.L. Smith, F.D. Calder 1995. Incidence of Adverse Biological Effects Within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. *Environmental Management*. 19(1):8197.

Long, E.R. and L.G. Morgan. 1990. The potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. National Oceanic Atmospheric Administration (NOAA) Technical Memorandum NOS OMA 52. Seattle, Washington.

MacDonald, D.D., Ingersoll, C.G., and T. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Archives of Environmental Toxicology and Chemistry* 17:972-974.

Malcolm Pirnie. 1986. Hudson River PCB Dredging Reclamation Project. Prepared for NYSDEC. Albany, NY. August.

McNulty, A. K. 1997. *In-Situ* Anaerobic Dechlorination of Polychlorinated Biphenyls in Hudson River Sediments. Rensselaer Polytechnic Institute (RPI). Troy, NY. August.

New York State Department of Environmental Conservation (NYSDEC). 1999. Technical Guidance for Screening Contaminated Sediments, NYSDEC, Division of Fish and Wildlife, Division of Marine Resources. January 25.

NYSDEC. 2000. DEC: Cleanup of Former Hercules/CIBA-GEIGY Plant to Begin. NYSDEC Press Release, June, 9, 2000, (http://www.dec.state.ny.us/website/press/pressrel/2000-74.html).

NYSDEC. 2001a. NYSDEC Memorandum from Frank Estabrooks regarding heavy metals in Hudson River sediment cores dated July 17, 1995 sent to Ed Garvey (TAMS) on January 29, 2001 from William Ports (NYSDEC).

NYSDEC, 2001b. Personal communication from Michael Kane (NYSDEC) to Ed Garvey (TAMS) via electronic mail. NYSDEC Hudson River Biota Database. February 12, 2001.

Persaud, D., R. Jaagumagi, and A. Hayton. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. Ontario Ministry of the Environment and Energy. August.

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

Tofflemire, T.J. and S.O. Quinn. 1979. Technical Paper No. 56, PCB in the Upper Hudson River: Mapping and Sediment Relationships. Bureau of Water Research, NYSDEC. Albany, NY. April.

US Environmental Protection Agency (USEPA). 1997. Phase 2 Report, Further Site Characterization and Analysis, Volume 2C – Data Evaluation and Interpretation Report (DEIR),

Hudson River PCBs RI/FS. Prepared for USEPA Region 2 and USACE by TAMS Consultants, Inc., the Cadmus Group, Inc., and Gradient Corporation. February.

USEPA. 1999. Hudson River PCBs Reassessment RI/FS; Volume 2E- Baseline Ecological Risk Assessment. Prepared for USEPA, Region 2 and the US Army Corps of Engineers, Kansas City District. Prepared by TAMS/MCA. August.

USEPA. 2000. Database for the Hudson River PCBs Reassessment RI/FS. Release 5.0 (Compact Disc). Prepared for USEPA, Region II and the US Army Corps of Engineers, Kansas City District. Prepared by TAMS Consultants, Inc. October.

Dioxin Contamination
860

WHITE PAPER – DIOXIN CONTAMINATION

(ID 860)

ABSTRACT

Chlorinated dibenzodioxins and dibenzofurans (hereafter simply referred to as dioxins) are present in the sediments of the Upper Hudson River. To the extent that levels exceed regulatory criteria, dioxins may present additional concerns with respect to the handling and disposal of PCB-bearing sediments. Dioxins were detected in four samples from a sediment core collected by Dr. Richard Bopp in 1991 at RM 188.6 in the vicinity of *Hot Spot 20* (Table 860-1). This data set is the most useful set of available data because it was obtained as part of a dated sediment core. Dioxins were also detected in samples collected in 1983 and 1987 (Brown *et al.*, 1988) (Tables 860-2 and 860-3). However, the available dioxin data are not sufficient to determine the full extent of contamination in the Upper Hudson. In order to better understand the spatial and chronological distribution of dioxins within these sediments, more sampling and analyses for dioxins will be conducted as part of the remedial design phase.

INTRODUCTION

Upper Hudson River dioxin data are very limited. The most useful data set is from the Bopp 1991 core at RM 188.6, which was analyzed by the New York State Department of Health (NYSDOH) and the New York State Department of Environmental Conservation (NYSDEC, 2001a). This core was analyzed for PCBs, metals, radiometric dates (^{137}Cs), and, subsequently, dioxins, as well as physical characteristics. A summary of the analytical results for dioxins, furans, and total PCBs is provided in Table 860-1. This core was collected from sediments located at the southern end of the Thompson Island Pool (TI Pool) in the vicinity of *Hot Spot 20*. It was analyzed in a manner similar to the EPA's high-resolution cores (USEPA, 1997). For a more thorough discussion of the core results and coring location, refer to Brown *et al.*, 1988 and McNulty, 1997.

Other dioxin data associated with Upper Hudson River sediments are from Brown *et al.*, 1988. There are two data sets reported – one from 1983, which consists of two cores (one located at RM 188.5 and one located at RM 191.1 [Table 860-2]), and the other from 1987, which consists of composite samples from *Hot Spots 20, 8,* and *3*.

Based on the limited dioxin data from the Upper Hudson River, relatively little can be asserted about dioxins and their correlation to PCBs within the river. In order to better understand the spatial and chronological distribution of dioxins within these sediments, more sampling and analyses for dioxins will be conducted as part of the remedial design. This sampling can occur prior to as well as during dredging operations, in order to best assess the dioxin concentration of the *in situ* sediments as well as the cumulative concentrations of dredged sediments. The dioxin concentrations of the cumulative dredged sediments are necessary in order to determine the processing and landfill requirements. The dioxin criterion for disposal in a non-TSCA-permitted landfill is less than 0.001 mg/kg.

DISCUSSION OF SEDIMENT DATA

The 1991 Bopp core used for analyses was located near the eastern shore of the Hudson River, at RM 188.6 within *Hot Spot 20*. The core was segmented and analyzed for dioxins in the following depth intervals: 0-2 cm, 20-24 cm, 28-32 cm, and 40-44 cm. The maximum concentration of the sum of tetra-, penta-, hexa-, and hepta- dioxins and furans was found in the 20- to 24-cm depth interval at a level of 180,000 pg/g, or 0.18 ppm (Table 860-1).

Note that this peak concentration lies just slightly above the peak concentration in the core corresponding to total PCBs, and cadmium, chromium, copper, and lead at 28 to 32 cm. Also note that the dioxin peak appears to decrease steadily with depth below the maximum. These data suggest that dioxin levels are largely coincident with PCB levels and that dioxin levels will attain background levels at the same depth as PCBs. However, the number of dioxin samples is not sufficient to confirm this since the core segments were not analyzed all the way to the bottom of the core.

In this core, the measured dioxin maximum lies close to the PCB maximum, suggesting similar discharge and transport histories for the two contaminants. However, the lack of deeper samples or a complete core leaves open the issue of how deep the dioxin contamination extends and its correlation with PCBs. Further sampling as part of the design will be required to clarify these issues. Note that the data set for metals contamination was able to address the depth of contamination issue, since samples are available from the deeper core segments (White Paper – Metals Contamination).

The results from the NYSDEC 1983 data set as reported by Brown *et al.*, 1988, indicate a slight increase in concentration going from 8 – 12 cm to 24 – 28 cm in depth (RM 188.5) with respect to 2,3,7,8 tetrachloro dibenzodioxin (TCDD); total TCDD; and 2,3,7,8 tetrachloro dibenzofurans (TCDF). There was a slight decrease in concentration in total TCDF. The sample recovery was poor for the surface samples at RM 188.5; thus, no samples were analyzed. Based on the limited data from Table 860-2, it is difficult to make any inferences about correlations between dioxins and PCBs. However, all samples fell below the TSCA threshold of 0.001 ppm, or 1 ng/g.

Composite sediment samples were collected by NYSDEC in 1987 from *Hot Spots 20*, *8*, and *3* (two from each *hot spot*). The average core length for the individual samples in the composite was 19.2 inches. All of the samples from *Hot Spots 20* and *3* were non-detections (Table 860-3). The composite samples from *Hot Spot 8* had concentrations of 0.17 ng/g and 0.1 ng/g of total TCDF. Again, all samples fell below the TSCA threshold.

LANDFILL CRITERIA

The criterion for dioxin levels in material for disposal in a TSCA-permitted landfill is 0.001 ppm (1 ng/g) per homologue (tetra-, penta-, hexa-, and hepta-). For this determination, dioxins and furans are counted separately. The concentrations of dioxin and furan homologues from the 1991 Bopp core (RM 188.6) can be found in Table 860-1. Surface concentrations (0-2 cm) suggest that surface sediments would not require a TSCA-permitted landfill. However, based on the three other samples at depth (20-24 cm, 28-32 cm, and 40-44 cm), 62.5 percent of the homologue values exceeded the criteria.

By contrast, the results for the NYSDEC 1983 and 1987 samples showed no exceedances. One of the major differences between the Bopp and the NYSDEC samples is the thickness of the sample. Bopp's segments are substantially thinner than those obtained by NYSDEC. The NYSDEC samples can be considered closer to the integrating effects of the dredging process; that is, the dredge operations will remove and homogenize sediments over a one- to two-foot thickness. Thus, the dredged material will tend to have lower concentrations than those obtained from thin core slices.

Combining the results of the three investigations suggests that much of the material to be dredged will not require special disposal based on dioxin levels. It is anticipated that, since PCBs and dioxins have similar geochemistries, high levels of dioxin will tend to be coincident with high levels of PCBs. The Bopp core data suggest such a relationship. It is likely then that any sediments requiring special disposal because of dioxin levels will also require this treatment due to PCB levels. As a result, no additional volume of TSCA material beyond that estimated for PCBs is anticipated at this time. However, the limited data set for dioxins is not sufficient to completely support this conclusion.

Since a well-defined spatial distribution of dioxins cannot be determined from the limited data available, sampling will be required during the remedial design. Once further analyses have been concluded, an estimation of the dioxin concentrations with respect to the cumulative volume of sediments can be made. Thus, after further sampling and evaluation, the necessary processing and landfill requirements can be reassessed.

FISH DATA

Data on dioxin levels in Hudson River fish were obtained by NYSDEC on several occasions. In all, there are 50 Lower Hudson River dioxin samples in the NYSDEC fish database and 25 Upper Hudson River samples. This data set includes two samples from RM 201, above the GE facilities (Table 860-4). Most of the samples were obtained during 1997, but a few were obtained from 1987 to 1991.

Samples were typically analyzed as standard fillets, with a few liver analyses. These fish results have been summarized by homologue in Table 860-4.

In the Upper Hudson River, dioxins were detected in less than 45 percent of the samples for each of the homologue groups (tetra-, penta-, hexa-, and hepta-), except for tetrachlorodibenzofurans, which were detected in about 90 percent of the samples (Table 860-4). In the Lower Hudson River, dioxins were detected in about 50 to 94 percent of the samples for each of the homologue groups.

The highest detected concentrations were for the tetrachlorodibenzofurans. The highest observed concentration for this homologue group in the Upper Hudson River was obtained from a white sucker standard fillet sample at RM 185 at 30 µg/kg. In the Lower Hudson, the maximum value, 26 µg/kg, occurred in a striped bass standard fillet sample from RM 73. In general, average observed concentrations are lower in the Upper Hudson River samples as compared to the Lower

Hudson River. Specifically, for six of the eight homologue groups reported, the Lower Hudson had higher average values.

The fact that dioxin levels in fish were generally higher for the Lower Hudson relative to the Upper Hudson indicates that there are substantive additional sources of dioxin in the Lower Hudson. This is unlike PCBs in the Hudson, which are dominated by the GE source. The fact that the Upper Hudson is not the highest in dioxin levels indicates that any remediation of the Upper Hudson is unlikely to have a substantive impact on dioxin levels in fish in the Lower Hudson.

CONCLUSIONS

Elevated levels of dioxins within the Upper Hudson River sediments appear to be generally coincident with elevated levels of PCBs and metals. Since, geochemically, dioxins behave similar to PCBs within the environment, it is anticipated that the removal of PCB-contaminated sediments will also remove other contaminants, such as metals (White Paper – Metals Contamination) and dioxins, thereby eliminating multiple environmental threats by a single process. The concentrations of dioxins in fish indicate the influence of independent contaminant sources in the lower river; therefore, sediment removal in the upper river is likely to reduce dioxin levels in upper river fish only. However, the limited dioxin data hamper the ability to make inferences over large spatial extents. Since a better data set is necessary to assess the extent of dioxin contamination within these sediments, a sampling and evaluation plan will be implemented during remedial design.

REFERENCES

Brown, Mark P., Mary B. Werner, Cynthia R. Carusone, and Michael Klein. 1988. Distribution of PCBs in the Thompson Island Pool of the Hudson River, Final Report of the Hudson River PCB Reclamation Demonstration Project Sediment Survey. Bureau of Technical Services and Research, Division of Water, New York State Department of Environmental Conservation (NYSDEC). Albany, NY. May.

McNulty, Anne K. 1997. *In-Situ* Anaerobic Dechlorination of Polychlorinated Biphenyls in Hudson River Sediments. Rensselaer Polytechnic Institute (RPI). Troy, NY. August.

New York State Department of Environmental Conservation (NYSDEC). 2001a. Personal communication from William Ports (NYSDEC) to Ed Garvey (TAMS) on January 29, 2001 regarding dioxin and furan isomer specific data in Hudson River cores.

NYSDEC, 2001b. Personal communication from Michael Kane (NYSDEC) to Ed Garvey (TAMS) via electronic mail. NYSDEC Hudson River Biota Database. February 12, 2001.

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

Model Forecasts for Additional Simulations in the Upper Hudson River
363150

WHITE PAPER – MODEL FORECASTS FOR ADDITIONAL SIMULATIONS IN THE UPPER HUDSON RIVER

(ID 363150)

ABSTRACT

Concerns were expressed that some of the assumptions used to conduct model forecast simulations with EPA's fate and transport (HUDTOX) and bioaccumulation (FISHRAND) models may affect comparisons between various remedial scenarios (*e.g.*, the selected remedy [REM-3/10/Select] versus monitored natural attenuation [MNA]). This paper presents results from additional forecast simulations with the HUDTOX and FISHRAND models that were designed to address these concerns.

The new model forecast simulations examine three specific factors and their effects on long-term predictions of Tri+ PCBs in the water column, surficial sediments, and fish of the Upper Hudson River: a phased implementation of the remedial dredging, with the first year at less than full-scale production, extending the schedule for the selected remedy by one year; reduction of upstream PCB loads to zero as a lower-bound estimate for external source control; and inclusion of sediment Tri+ PCB resuspension losses due to dredging. The results of these additional HUDTOX and FISHRAND forecast simulations:

- Demonstrated that phasing of the implementation schedule for the selected remedy (REM-3/10/Select) by extending it one year does not significantly affect the predicted long-term trajectories for Tri+ PCB levels in the water, sediments, and fish of the Upper Hudson River.

- Demonstrated that elimination of upstream Tri+ PCB loading does not diminish the relative separation between predictions for the selected remedy and MNA scenarios in the water column, surficial sediments, or fish.

- Clarified the significance of sediment-mixing processes and sediment-water interactions in controlling long-term Tri+ PCB levels in surficial sediments, water, and fish as external sources of PCBs entering the river are reduced or perhaps even eliminated.

- Showed that by reducing the upstream Tri+ PCB load to zero, the Remediation Goal of 0.05 ppm PCB in fish tissue (wet weight) will be reached in all river sections during the modeling time frame. The Remediation Goal will be reached much sooner for the selected remedy than for Monitored Natural Attenuation.

- Demonstrated that while dredging-induced resuspension of sediment will likely increase Tri+ PCB levels in the water column (as measured by either concentration or load passing a given location) and in fish, the impacts will largely be confined to the years during which the selected remedy is implemented, regardless of whether a 0.13-percent or a 2.5-percent loss rate is applied. Impacts from dredging-induced resuspension (at either rate) are also predicted to occur in downstream surficial sediments, but the increases in concentration are generally small relative to existing Tri+ PCB contamination levels.

- Showed that application of the 2.5-percent dredging-induced loss rate results in much greater increases in Tri+ PCB levels in water and fish during the active remedy period than does EPA's loss rate estimate of 0.13 percent. However, EPA believes that the 2.5-percent loss rate is unrealistically high and that the 0.13-percent loss rate is a justifiably conservative estimate (Appendix E.6 of the FS report; White Paper –Resuspension of PCBs during Dredging).

These findings are not unexpected, but they do serve to provide a further quantitative assessment of important technical issues raised through comments on the analyses presented in the FS.

INTRODUCTION

Additional model runs were conducted to evaluate issues raised after the release of the Proposed Plan and FS. These additional model runs considered the implications of upstream source-control measures reducing future PCB loading at the upstream boundary to zero, dredging-induced resuspension of PCBs, and a revised schedule of contaminated-sediment removal for the selected remedy (REM-3/10/Select) based on a phased approach.

Descriptions of the assumptions used for the additional modeling runs and the basic results of the HUDTOX and FISHRAND models are examined in this paper. Note that additional discussion of the predicted fish concentrations and associated human health and ecological risks are found in White Paper – Human Health and Ecological Risk Reduction under Phased Implementation.

A lower-bound calculation was conducted for the selected remedy in which it was assumed that future upstream source control completely eliminates Tri+ PCB loading to the river. The comparison of results between this lower-bound calculation and the post-source-control upstream PCB load predicted in the FS better clarifies the influence of the assumed upstream source on the selected remedy, as well as the effectiveness of the selected remedy.

Possible impacts of PCBs being resuspended during dredging have also been incorporated into model simulations for the revised remedy schedule. This was accomplished through inclusion of two different estimates of downstream transport of Tri+ PCB due to dredging-induced resuspension during the dredging season each year. The resuspension loss rates assumed for these simulations were 0.13 percent (from Appendix E.6 of the FS and White Paper – Resuspension of PCBs during Dredging) and 2.5 percent and were taken to represent sediment mass loss to the water column. As discussed in the White Paper – Resuspension of PCBs during Dredging, the 0.13 percent resuspension loss rate is based on the 0.3 percent resuspension rate at the dredge head. The value of 0.13 percent represents a resuspended-mass-weighted average over River Sections 1, 2, and 3 and is a conservative estimate, based on the assumptions employed in determining this value (presented in detail in Appendix E.6 of the FS). These conservative assumptions include:

- No dredging-related settling of resuspended sediment (or PCB mass) beyond 10 meters downstream of the dredge head.

- No use of silt curtains that would reduce downstream sediment transport.

Although EPA believes that 2.5 percent resuspension loss rate is unrealistically high for the dredging equipment and methods that are expected to be used at the site, the Agency decided to run its model using the 2.5 percent loss rate in view of, among other things, the large number of public comments received on the dredging resuspension issue.

The revised schedule extends the remediation effort over six years, versus the five-year schedule originally proposed in the FS, to allow for a phased implementation. The first phase will be the first construction season of remedial dredging. The dredging during that year will be implemented initially at less than full-scale operation and will include an extensive monitoring program of all operations. These monitoring data will be compared to performance standards identified in the Record of Decision or developed during the remedial design with input from the public and in consultation with the State and federal natural resource trustees.

In the ROD, EPA has identified performance standards that address air and noise emissions from the dredging operations and the sediment processing/transfer facilities. Performance standards that will be developed during the remedial design phase will address (but may not be limited to) dredging resuspension, production rates, PCB residuals after dredging (or dredging with backfill, as appropriate), PCB air emissions, and community impacts (*e.g.*, odor). The information and experience gained during the first phase of dredging will be used to evaluate and determine compliance with the performance standards. Further, the data gathered will enable EPA to determine if adjustments are needed to operations in the succeeding phase of dredging or if performance standards need to be reevaluated.

DESCRIPTION OF REVISED SCENARIOS UNDER THE SELECTED REMEDY

As described in Section 6.4.2.2 of the FS, the selected remedy includes expanded *hot spot* removal (nominal mass-per-unit-area (MPA) targets are 3 g/m^2 Tri+ PCBs or greater) in River Section 1, *hot spot* removal (nominal MPA targets are 10 g/m^2 Tri+ PCBs or greater) in River Section 2, and removal of selected areas containing high PCB concentrations that are potentially subject to scour in River Section 3.

The selected remedy also includes sediment removal in the navigation channel as necessary to implement the remediation and to accommodate normal boat traffic on the river. Isolation of residual PCBs in sediments that may remain after dredging is completed through addition of a layer of clean backfill material suitable for replacement of the fish and benthic habitat. No backfill will be placed in the navigation channel. After construction is completed, MNA will be implemented in each section of the river until the remedial action objectives (RAOs) are achieved. The areas to be remediated under the selected remedy are shown in Plate 17 of the FS. The total area of sediments targeted for removal is approximately 493 acres, and the estimated volume of sediments to be removed is 2.65 million cubic yards.

Several HUDTOX model forecasts were conducted to examine various alternative assumptions that could be applied in simulating the selected remedy. Table 363150-1 describes eight HUDTOX model forecast scenarios that are presented in this paper. Three of these scenarios have already been presented in the FS report: No Action, MNA, and REM-3/10/Select (5 years –

no resuspension). The other five scenarios address various alternative assumptions, including an extended implementation schedule, upstream PCB source loading conditions, and possible effects of dredging-induced PCB resuspension.

The REM-3/10/Select alternative (the selected remedy), as presented in the FS, incorporates a five-year dredging schedule with remediation commencing in 2004[1] and being completed by 2008. It has been decided to extend the schedule from five to six years to allow for the phased implementation of the selected remedy. Table 363150-2 contains the percent of each HUDTOX sediment segment that is not dredged and the Tri+ PCB concentration in the portion of each segment that is dredged. It also contains the timing for changing the value (sequencing) and also compares the sequence for the six-year phased-implementation schedule to the five-year schedule.

The removal, capping, and MNA alternatives evaluated in the FS all specify that sediment remediation activity will be performed in conjunction with a separate source-control action in the vicinity of the GE Hudson Falls plant. At this time, it is expected that GE will implement the upstream source control under NYSDEC authority. The upstream source control is characterized in the HUDTOX model by assuming an upstream boundary water column Tri+ PCB load of 0.16 kg/day from 1998 through 2004, followed by a step-down reduction to 0.0256 kg/day on January 1, 2005. In order to further clarify the effect of the upstream boundary conditions on long-term surficial sediment and water column Tri+ PCB predictions, model forecasts for REM-3/10/Select (five-year schedule) and MNA were conducted with a step-down upstream load reduction on January 1, 2005 to zero (*i.e.*, complete elimination of upstream PCB sources).

An evaluation of dredging-induced resuspension effects on model-forecasted water column and sediment Tri+ PCB concentrations for the selected remedy was also conducted in order to address questions regarding this issue in a more comprehensive fashion. Estimated dredging-induced Tri+ loads resuspended to the water column on a daily basis during the active dredging season (May 1 – November 30) for the five-year and six-year scenarios were included in HUDTOX model forecasts for the selected remedy according to the schedules presented in Tables 363150-3 and 363150-4.

Two rates of dredging-induced PCB resuspension were simulated under the six-year remediation schedule: A river section-specific estimate of 0.13 percent mass loss and a public-requested 2.5 percent mass loss. The river section-specific suspension rate estimate is the time-weighted average of the three sections of the river (The resuspension rate for each river section of the river is described in the White Paper –Resuspension of PCBs during Dredging). In addition, the original five-year dredging schedule for the selected remedy was simulated using section-specific estimates for dredging-induced resuspension losses. The estimates of dredging-induced contaminant resuspension were simulated as additional Tri+ PCB loads to specific water column segments in the HUDTOX model. The loading to the HUDTOX water column segments was done in a north-to-south approach. (Note that the north-to-south approach has been assumed for this exercise and that it is expected that such an approach will generally be used. However, the actual location of the first phase of work will not be determined until the remedial design stage.)

[1] EPA now expects dredging to commence in 2005. Initiating dredging in 2005 would not be expected to significantly affect modeling projections or the comparative analysis of alternatives.

As with all of the remedial alternatives presented in the FS, the scenarios evaluated in this paper, excluding No Action, also rely on institutional controls (such as the fish consumption advisories), and naturally occurring attenuation processes to reduce the toxicity, mobility, or volume of the remaining PCBs in the Upper Hudson River sediments after the construction is completed.

For the selected remedy, target areas in River Section 1 with an MPA target of greater than 3 g/m^2 Tri+ PCBs sediments (cohesive and non-cohesive) are removed. For River Section 2, an MPA target of greater than 10 g/m^2 Tri+ PCBs was selected as the minimum target area criterion, and all target areas with cohesive and non-cohesive sediments in this section are removed. For River Section 3, NYSDEC-defined *Hot Spots 36, 37,* and part of *39* are targeted for removal. This scenario also includes removal of navigational channel sediments as required to implement the remedy. The percent Tri+ PCB mass removed from the sediment is calculated using the polygonal-weighted average method (instead of point-averaged) for River Section 1. For River Sections 2 and 3, the point-averaged method is used to calculate percent Tri+ PCB mass removed.

HUDTOX Implementation for the Selected Remedy

As presented in Appendix D.2 of the FS, the refined engineering sediment-removal remedies are implemented within the HUDTOX model, as follows.

For River Sections 2 and 3, initial average MPA conditions were calculated for a given segment by averaging the MPA of each point within the segment. This approach assumes that each point contributes equally to the initial conditions of the segment; none is more heavily weighted than the others. The average MPA was then recalculated for the segment (assuming removal of those points that fall within the target MPA area) by averaging the MPA of each remaining point. The average calculated MPA was multiplied by the associated area to determine the mass of Tri+ PCBs. One minus the ratio of the recalculated MPA to the initial-condition MPA represents the percent mass removed for the segment during remediation. This calculated percent mass removed is assumed to be representative of the sediment segment. A Tri+ PCB percent mass removed associated with the removal was provided for each sediment segment.

For River Section 1 (TI Pool), Tri+ PCB percent mass removal was calculated as described above (for River Sections 2 and 3) for 15 of the refined engineering model runs. For the remaining model runs, Tri+ PCB mass, mass removed (*i.e.*, Tri+ PCB mass in areas targeted for removal), and mass remaining (*i.e.*, Tri+ PCB mass in areas not targeted for removal) were calculated for each segment by using the Thiessen polygon area-weighted MPAs. The Tri+ PCB mass values were used to calculate the percent mass removed for each sediment segment.

HUDTOX Forecast Simulations for Revised Scenarios under the Selected Remedy

Figures 363150-1 through 363150-14 present comparisons over the 70-year forecast period of predicted HUDTOX Tri+ PCB concentrations in the surficial sediments (cohesive and non-cohesive) and in the water column at various locations throughout the Upper Hudson River for the scenarios presented in Table 363150-1.

The effect of the revised implementation schedule and inclusion of a dredging-induced resuspension load on predicted surficial sediment and water column Tri+ PCB concentrations is largely confined to the six-year active dredging period (2004 to 2009) for the river section-specific estimate (0.13 percent) of dredging-induced Tri+ PCB resuspension (R20RS). Outside of the period of scheduled dredging, impacts on water column Tri+ PCB concentrations are minimal. Inclusion of 2.5 percent for resuspension losses (R20RX) results in significantly higher water-column concentrations during the dredging period and slightly elevated water-column concentrations for five to 10 years in river sections downstream of the TI Pool (Schuylerville to Federal Dam).

Surficial sediment concentrations in sections of the river below the TI Pool are slightly impacted for a number of years beyond the completion of dredging, due to the inclusion of the river section-specific estimate (0.13 percent) of dredging-induced Tri+ PCB resuspension in either the 5-year or 6-year scenarios (R14RS and R20RS). These impacts are not large when compared to selected remedy predictions that do not include resuspension (R14S2). The inclusion of 2.5 percent for resuspension losses (R20RX) results in predictions that show a negligible impact on surficial sediment concentrations in the TI Pool after dredging is completed, but somewhat greater and longer lasting impacts on surficial sediment concentrations downstream. For example, Tri+ PCB concentrations in surficial cohesive sediments at Stillwater remain slightly elevated for approximately 15 to 20 years compared to simulations that included either no resuspension (R14S2) or the river section-specific resuspension loss rate of 0.13 percent (R20RS and R14RS).

The effect of assuming that future upstream source control reduces Tri+ PCB loads to zero is clearly seen in both the water column and surficial sediment predictions (R14S0). This assumption eliminates the upstream boundary as a factor in controlling predicted long-term water column and surficial sediment Tri+ PCB levels. Under this assumption, the interactions between the sediments and water column (*i.e.*, solids dynamics, sediment-to-water PCB fluxes, etc.) largely control the predicted future trajectories. The implications of this result are readily apparent. First, upstream source control to levels below those that are anticipated to occur slightly accelerate the predicted decline of Tri+ PCB concentrations in the surficial sediments as a result of the dilution effect from cleaner solids entering the river. Second, predicted sediment Tri+ PCB concentrations under MNA remain well above levels predicted for the selected remedy, even assuming source control could eliminate upstream PCB loading to the river. Simply put, the degree of separation between the MNA and selected remedy predictions for Tri+ PCBs in the sediments is not diminished when an assumption of complete upstream source control is applied.

The predicted annual Tri+ PCB loads over the Thompson Island Dam, the Northumberland Dam, and the Federal Dam (to the Lower Hudson River) for each of the seven HUDTOX forecast scenarios are shown in Tables 363150-5 through 363150-7. In general, the annual loads for the five- and six-year scenarios (R14RS and R20RS) that incorporate the river section-specific resuspension loss rate of 0.13 percent are not appreciably different from the annual loads for the REM-3/10/Select alternative (the selected remedy) with no resuspension. Differences in the predicted loads to the lower river are largely confined to the five- and six-year active dredging periods, and are largely due to the inclusion of dredging-induced resuspension losses. Application of a 2.5 percent estimate for resuspension losses (R20RX) results in significantly

greater predicted Tri+ PCB water column loading during the active dredging period, and continued slightly higher annual loading rates at locations downstream of the Thompson Island Dam for approximately 15 to 20 years after dredging is completed in comparison to other selected remedy scenarios with lower resuspension losses.

The effect of assuming complete control of upstream PCB sources is also seen in the predicted loads entering the Lower Hudson River. Under the assumption of stepping down to zero upstream load, both MNA and the selected remedy (R14S0) predict continued declines in loading to the lower river throughout the 70-year forecast period. However, the load difference between MNA and the selected remedy remains approximately the same, regardless of whether upstream Tri+ PCB loads are reduced to zero or to the 0.0256 kg/day rate applied for the forecast scenarios presented in the FS. The predicted annual Tri+ PCB loads to the lower river for all of the other scenarios, whether assuming a constant upstream load (*i.e.*, No Action) or a reduced load, eventually reach approximately constant values controlled by the upstream boundary load and annual variations in the specified hydrologic conditions.

FISHRAND Forecast Simulations for Revised Scenarios under the Selected Remedy

The FISHRAND model requires surface sediment and dissolved water Tri+ PCB concentrations corresponding to the three river sections as described in the FS. All FISHRAND model parameters were the same as those used in the Revised Baseline Modeling Report (USEPA, 2000); the only differences were the predicted sediment and water concentrations passed from the HUDTOX model to the FISHRAND model.

FISHRAND modeling results show, similar to the HUDTOX modeling, that the revised implementation schedule and inclusion of a dredging-induced resuspension load is largely confined to approximately a 10-year period (2004 to 2014). Results are provided as follows:

- Figure 363150-15 presents a graph of the results for largemouth bass, brown bullhead, and yellow perch just for the period 2004 through 2010 (2015 at RM 154) to highlight the differences in predicted concentrations.

- Figure 363150-16 presents the results for these species through the end of the modeling period (2067).

- Figure 363150-17 presents the results for white perch. This species was only modeled at RM 154, as they are typically not found in the Upper Hudson River above that location.

- Figure 363150-18 presents the species-weighted results for the four different selected remedy model forecasts.

- Figure 363150-19 presents the species-weighted results for the four different selected remedy model forecasts shown in Figure 363150-18, with the addition of the No Action (P3NACW), MNA (P3NAS0), MNA with upstream load decreasing to zero (P3NAS0), and the five-year selected remedy with upstream load decreasing to zero (R14S0).

- Figure 363150-20 presents the species-weighted results shown in Figure 363150-19, with an expanded scale to show only those years during and immediately following dredging.

Predicted fish tissue concentrations for the selected remedy scenarios are within less than 1 percent of each other by approximately 2015 for all species and locations in the Upper Hudson River.

A comparison was conducted of the five-year implementation of the selected remedy without dredging-induced Tri+ PCB resuspension (R14S2), as presented in the FS, with the selected remedy including the section-specific loss estimate (0.13 percent) for dredging-induced Tri+ PCB resuspension (R14RS). The comparison found that the difference in predicted fish body burdens is no more than approximately 15 percent and typically less than 10 percent, for all species and locations in the Upper Hudson River. As stated above, by 2015 the difference between these scenarios is less than 1 percent.

A comparison of predicted body burdens under the five-year versus six-year implementation schedule, both assuming the section-specific loss rate (0.13 percent) for dredging-induced Tri+ PCB resuspension (R14RS and R20RS, respectively), shows slightly higher concentrations during the time frame that dredging is occurring for the six-year scenario. The differences last until approximately 2008 – 2010 at RMs 189 and 184, and until approximately 2015 at RM 154.

Predicted fish body burdens for the six-year implementation schedule with the dredging-induced Tri+ PCB resuspension loss rate of 2.5 percent (R20RX) are higher than all the scenarios (including No Action) at the beginning of the period of dredging, but quickly drop to levels commensurate with the other REM–3/10/Select scenarios by the end of the dredging period.

The differences among predicted fish concentrations are typically greatest for the species more closely associated with the water column. At RM 189, the predicted difference between the five-year and six-year implementation schedules are greater than the predicted difference between the two resuspension assumptions for brown bullhead, a predominantly sediment-associated fish. For largemouth bass, the 2.5 percent resuspension assumption has a greater effect than the difference between the implementation schedules. Yellow perch tend to follow the largemouth bass pattern, although absolute concentrations are slightly lower. At RM 154, the effects of resuspension last slightly longer than at locations further upstream.

The impact of reducing the upstream Tri+ load to zero is seen in the results for the selected remedy (R14S0) and the Monitored Natural Attenuation alternative (P3NAS0). Under the selected remedy (R20RS) (6-years, 0.13 % dredging-induced resuspension, 0.0256 kg/d upstream Tri+ PCB load), the Remediation Goal of 0.05 ppm PCBs (wet weight) in fish tissue is reached only in River Section 3, in 2050. If upstream source control can reduce the Tri+ load to zero, then the selected remedy implemented in 5 years, with no resuspension (RS14S0) is predicted to reach the Remediation Goal of 0.05 ppm PCBs (wet weight) in fish tissue by 2039 in River Section 1, by 2041 in River Section 2, and by 2025 in River Section 3. Under MNA with an upstream load of zero Tri+ PCBs, it would take until 2063 in River Section 1, 2061 in River Section 2, and 2032 in River Section 3. This emphasizes the impact of reducing the upstream PCB load to the greatest extent possible, as well as the need for remediation.

Calculations of human health and ecological risk corresponding to the model simulations discussed in this paper are found in the White Paper – Human Health and Ecological Risk Reduction under Phased Implementation. The human health risk calculations used species-weighted concentrations in the estimates of exposure-point concentrations. The species-weighted predicted fish body burdens (47 percent largemouth bass, 44 percent brown bullhead, and 9 percent yellow perch) are presented in Figures 363150-18 through 363150-20. These figures show that the differences in predicted species-weighted concentrations are comparable to the differences in the individual species.

A comparison of short-term risk between the selected remedy scenarios found essentially no differences between the selected-remedy scenarios. See White Paper – Human Health and Ecological Risk Reduction under Phased Implementation.

CONCLUSIONS

Comments received expressed concerns that some of the assumptions used to conduct forecast simulations with the EPA fate and transport (HUDTOX) and bioaccumulation (FISHRAND) models may affect comparisons among various remedial scenarios. Several additional HUDTOX and FISHRAND forecast simulations were conducted to address these concerns, the results of which:

- Demonstrated that phasing of the implementation schedule for the selected remedy (REM-3/10/Select) by extending it one year does not significantly affect the predicted long-term trajectories for Tri+ PCB levels in the water, sediments, and fish of the Upper Hudson River.

- Demonstrated that elimination of upstream Tri+ PCB loading does not diminish the relative separation between predictions for the selected remedy and MNA scenarios in the water column, surficial sediments, or fish.

- Clarified the significance of sediment mixing processes and sediment-water interactions in controlling long-term Tri+ PCB levels in surficial sediments, water, and fish as external sources of PCBs entering the river are reduced or perhaps even eliminated.

- Showed that by reducing the upstream Tri+ PCB load to zero, the Remediation Goal of 0.05 ppm PCB in fish tissue (wet weight) will be reached in all river sections during the modeling time frame. The Remediation Goal will be reached much sooner for the selected remedy than for Monitored Natural Attenuation.

- Demonstrated that while dredging-induced resuspension of sediment will likely increase Tri+ PCB levels in the water column (as measured by either concentration or load passing a given location) and in fish, the impacts will largely be confined to the years during which the selected remedy is implemented, regardless of whether a 0.13 percent or a 2.5 percent loss rate is applied. Impacts from dredging-induced resuspension (at either rate) are also predicted to occur in downstream surficial sediments, but the increases in concentration are generally small relative to existing Tri+ PCB contamination levels.

- Showed that application of the 2.5 percent dredging-induced loss rate results in much greater increases in Tri+ PCB levels in water and fish during the selected remedy period than does EPA's loss rate estimate of 0.13 percent. However, EPA believes that the 2.5 percent loss rate is unrealistically high and that the 0.13 percent loss rate is a justifiably conservative estimate (Appendix E.6 of the FS; White Paper – Resuspension of PCBs during Dredging).

The additional HUDTOX and FISHRAND model forecast simulations presented in this paper provide a quantitative assessment of important technical issues raised through comments on the analyses presented in the FS.

REFERENCES

USEPA. 2000. Phase 2 Report, Further Site Characterization and Analysis, Volume 2D, Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Prepared for USEPA and US Army Corps of Engineers Kansas City District by Limno-Tech, Inc., Menzie-Cura and Associates, Inc. and TetraTech, Inc. January.

Application of the Depth of Scour Model (DOSM) in the Thompson Island Pool for Alternative Flooding Assumptions
407426

WHITE PAPER – APPLICATION OF THE DEPTH-OF-SCOUR MODEL (DOSM) IN THE THOMPSON ISLAND POOL FOR ALTERNATIVE FLOODING ASSUMPTIONS

(ID 407426)

ABSTRACT

An important question in the Hudson River PCBs Reassessment was whether there are contaminated sediments now buried that are likely to become "reactivated" following a major flood, possibly resulting in an increase in contamination of the fish population. To address this question, a Depth-of-Scour Model (DOSM) was developed to provide estimates of sediment erodibility in response to large floods. In the Revised Baseline Modeling Report (RBMR) (USEPA, 2000a), the DOSM was applied to a 100-year flood peak flow estimated to be 47,330 cubic feet per second (cfs), based on available historical data. Concern was expressed that this flow estimate could be too low and that a more appropriate value for a 100-year peak flow was 61,835 cfs. To address this concern, the DOSM application was repeated for this new estimated upper-limit peak flow.

The results of the DOSM reapplication indicate that the average flow and bottom shear stress for the upper-limit flood peak is greater than for the previous flow estimate. The resulting average erosion depth in cohesive sediments for the upper-limit flood peak is more than twice the estimate for the lower flow, but is still less than 1 cm (0.719 cm versus 0.317 cm). Although a flow of 61,835 cfs could erode between 120 to 650 kg of Total PCBs, this mass represents only 0.2 to 3 percent of the mass inventory estimated to reside in the cohesive sediments of the Thompson Island Pool (TI Pool).

The re-application of the DOSM for the upper-limit estimate of 61,835 cfs for the 100-year flood peak flow found that a major flood would not scour a large portion of the PCB inventory in the sediment of the TI Pool. The upper-limit flood peak would result in a mass of PCBs resuspended that is only slightly higher than the amount expected during typical annual high flow events.

INTRODUCTION

One of the principal questions in the RBMR (USEPA 2000a) was whether there are contaminated sediments now buried that are likely to become "reactivated" following a major flood, possibly resulting in an increase in contamination of the fish population. To address this question, the Depth of Scour Model (DOSM) was developed to provide spatially refined information on sediment erodibility in response to high-flow events, such as a 100-year flood. The DOSM is a two-dimensional, sediment-erosion model that was applied to the TI Pool. The DOSM is linked with a hydrodynamic model (RMA-2V) that predicts the two-dimension pattern of flow velocities and water depths within the TI Pool, providing the information necessary to compute bottom-shear stress (force of the water acting on the sediment surface) during high flows. In the RBMR, the DOSM was applied for a 100-year flood peak-flow value estimated to be 47,330 cfs at Fort Edward. This estimate was based on an analysis of available historical flow

records and operational practices for the Sacandaga Reservoir, as presented in the Appendix of the Baseline Modeling Report Responsiveness Summary (USEPA, 2000b).

The New York State Department of Environmental Conservation (NYSDEC) raised questions regarding uncertainties in development of the 100-year flood peak-flow value used in the RBMR. Concern was also expressed regarding the potential for the NYSDEC relicensing agreement with Orion Power in operating the Sacandaga Reservoir to increase maximum Hudson River flood flows. In order to evaluate these concerns, an estimated upper limit for the 100-year flood peak flow of 61,835 cfs was developed for NYSDEC (NYSDEC, 2001). To estimate potential "reactivation" of buried sediments under this new condition, the RMA-2V and DOSM were reapplied for a peak flow of 61,835 cfs, and results were compared with the application of these same models for the peak flow of 47,330 cfs in the RBMR.

The following sections in this paper present the results of:

- Reapplication of the RMA-2V model for a flow of 61,835 cfs.
- Reapplication of the DOSM for cohesive sediment areas at bottom-shear stresses corresponding to a flow of 61,835 cfs.
- Comparison of RMA-2V and DOSM results for the RBMR flow of 47,330 cfs and the alternate flow of 61,835 cfs for all TI Pool cohesive sediment areas and at the locations of five USEPA high-resolution core sites.

HYDRODYNAMIC MODEL REAPPLICATION

The development and application of the RMA-2V hydrodynamic model is fully described in Chapter 3 of the RBMR (USEPA, 2000a). The RMA-2V model is a two-dimensional finite-element model capable of simulating dynamic fluid flow in the horizontal plane. The version of the model that was applied was RMA-2 Version 4.35, developed in August 1995 by the US Army Corps of Engineers.

The upper limit estimate of the 100-year flood flow evaluated in this paper is based on the assumption that the Sacandaga Reservoir is full during an extreme flood and will not act as an effective flood-control structure (NYSDEC, 2001). In effect, this assumption infers that the Sacandaga drainage basin will behave similarly to the Upper Hudson River during an extreme event, and that Hudson River flows at Hadley may be prorated (based on drainage area differences) to estimate an upper limit for the 100-year flood flow at Fort Edward.

Using Hudson River at Hadley flow data collected from 1922 to 1998, Bopp (NYSDEC, 2001) estimated an upper limit 100-year flood flow of 61,835 cfs (assuming a log-Pearson Type III distribution). EPA does not endorse this estimated upper-limit flow as being appropriate for evaluating the potential effects of PCB remobilization from the sediments due to a 100-year flood event, since the probability of maximum releases from Sacandaga Reservoir coinciding with a 100-year flood flow in the mainstem Hudson River is less than one. Thus, the actual recurrence interval for the assumptions that were applied to generate the upper limit flow is greater than 100 years. However, EPA concurs that it is reasonable and appropriate to examine the estimated sediment scour and PCB remobilization response for this event, since there is

significant uncertainty in estimating maximum flood flows based on data for a period of record that is significantly less than the recurrence interval.

The two principal boundary conditions for the model are the upstream flow, designated as 61,835 cfs for the upper limit 100-year flood peak flow, and a downstream water surface elevation. The downstream water surface elevation was estimated based on water surface elevation and flow data from NYSDOT barge canal data for Gage 118, along with the FEMA-estimated 100-year flow of 52,400 cfs and downstream elevation of 126.5 feet (Zimmie, 1985; FEMA, 1982). A second-order polynomial curve was fit to this data and extrapolated out to a flow of 61,835 cfs to estimate the corresponding water surface elevation of 127.6 feet.

Comparative results from application of the RMA-2V hydrodynamic model for average velocity, depth, and shear stress for cohesive and non-cohesive sediment areas are presented in Table 407426-1. As illustrated in the table, the average velocities and water depths are higher for the 61,835 cfs peak flow. Even with the increased water depth, the velocities are elevated such that the resulting average shear stresses for the 61,835 cfs flow are also higher than for the 47,330 cfs flow. Also, for both peak flows, the average values of all three parameters are higher for the non-cohesive areas than for the cohesive areas.

DEPTH-OF-SCOUR MODEL REAPPLICATION

The development and application of the DOSM is fully described in the RBMR (USEPA, 2000a). The DOSM calculates cohesive sediment scour on the basis of site-specific measurements of resuspension properties for TI Pool cohesive sediments. Model inputs include sediment dry-bulk density (*i.e.*, grams of dry solids per cm^3 of sediment) and flow-induced bottom-shear stress. The model outputs mass of solids eroded by the shear stress and the depth of erosion. Given a concentration of PCBs in the sediment solids, the mass of PCBs eroded can also be calculated. The DOSM was used to estimate an average poolwide depth-of-scour and to estimate sediment erosion at five locations where EPA collected high-resolution sediment cores in 1992.

The DOSM results are given in terms of probabilistic estimates. These probabilities range from 0 to 100 percent, and represent the likelihood that less than or equal to a given amount of solids will be eroded by a given shear stress. From these calculated probabilities, values corresponding to the 5th percentile, the 50th percentile (median), and the 95th percentile erosion depths are reported, as well as the mean (arithmetic average) erosion depth. DOSM probabilities of erosion reflect the range of variability actually observed in site-specific measurements of erosion made using annular flume and shaker devices (HydroQual, 1995).

Reapplication of the DOSM was done in the same manner as the RBMR application, with the only change being the new bottom-shear stresses corresponding to the upper-limit peak flow of 61,835 cfs. The same map of cohesive sediment areas in TI Pool was used for both applications. For poolwide estimates, these cohesive sediment areas were subdivided into polygons of constant shear stress and dry-bulk density by intersecting coverages (maps) for these properties in a Geographical Information System (GIS). The Monte Carlo technique was employed to calculate the depth of scour and the solids-mass scoured for each such polygon, as a function of randomly varied parameters in the resuspension equation. The extent of random variation was set

to reflect the underlying variability in the observed data upon which the resuspension equation is based.

Poolwide results for total mass scoured were obtained by summing the results at all locations, while an area-weighted average was calculated as the mean depth-of-scour. The calculation was repeated 3,000 times to get a valid statistical distribution of results. Monte Carlo calculations were performed with the Crystal Ball 2000® computer program (Decisioneering, Inc., 2001). Results at specific high-resolution coring sites made direct use of the DOSM output, without Monte Carlo analysis. Depths of scour at these sites made use of estimates of dry-bulk density interpolated from the reported core densities at depth.

In addition to the assumptions in the RBMR for application of the DOSM to the original peak flow of 47,330 cfs, the following factors must be given consideration when interpreting the predictions generated by the DOSM to the upper-limit peak flow of 61,835 cfs. First, the 61,835 cfs flow extends the hydrodynamic model application further beyond the available calibration data, resulting in increased uncertainty of computed bottom-shear stress values used to drive the DOSM.

Second, the higher shear-stress values predicted in this model reapplication increase the degree of extrapolation from the site-specific experimental measurements used to derive the sediment resuspension relationships in the DOSM, resulting in additional uncertainty beyond that associated with the hydrodynamic model application.

Finally, the passage of time between the RBMR application and this reapplication results in increased uncertainty about TI Pool physical and chemical properties.

Apart from the above factors, a new source of uncertainty has been discovered that affects the DOSM application to both the original peak flow of 47,330 cfs in the RBMR and the upper-limit peak flow of 61,835 cfs. The sediment resuspension measurements conducted by GE with Upper Hudson River sediments used a shaker device and an annular flume (HydroQual, Inc., 1995). Experimental artifacts have been discovered with these techniques (Lick *et al.*, 1998; Jones and Lick, 1999), and it is now believed that resuspension data acquired with these devices may underestimate the potential for sediment scour, especially under high-shear stresses. In recent years, newer techniques have been developed to measure sediment resuspension (McNeil *et al.*, 1996; Jepsen *et al.*, 1997; Lick *et al.*, 1998; Jones and Lick, 1999; Ravens and Gschwend, 1999); however, transport and fate models capable of using experimental data from these techniques remain the subject of ongoing research (*e.g.*, Jones, 2000) and have not yet been fully tested. Furthermore, no measurements using these newer techniques have been conducted with TI Pool sediments. Consequently, given the absence of additional site-specific data and a compatible modeling framework, it is currently not possible to accurately assess the significance of these new findings with regard to predicting flood-driven erosion of TI Pool cohesive sediments.

COMPARISON OF MODEL RESULTS

At the high-resolution core locations, model results are compared on the basis of predicted erosion depth, which in turn depends on predicted flow-induced bottom shear stress. For the poolwide Monte Carlo modeling, the applications are compared on the basis of erosion depth and

mass of solids scoured. Using the same approach as in the original DOSM application, PCB erosion is estimated using an assumed constant cohesive sediment PCB concentration. Two different PCB concentrations for the surface sediment are used, based on different sets of data. The first one is based on 1984 data, using Thiessen polygons and side-scan sonar results. On this basis, the area-weighted average Tri+ PCB concentration is 51.49 mg/kg (White Paper – Sediment PCB Inventory Estimates). For purposes of the calculations presented in this paper, this Tri+ PCB sediment concentration has been rounded off to two significant digits, or 51 mg/kg, in acknowledgment of the uncertainty associated in determining this value. This number (51 mg/kg) is about 17 percent higher than the number used in previous calculations (43.7 mg/kg) that were presented in the Baseline Modeling Responsiveness Summary Report [RBMR RS] (USEPA, 2000b). The new value is based on a revised analysis of the 1984 data (White Paper – Sediment PCB Inventory Estimates). The estimates of PCB mass eroded using the 1984 data are thought to be conservative – that is, the poolwide average PCB concentration in the cohesive surface sediments is now lower than in 1984, thus the present estimates of PCB mass eroded are higher than would actually occur for a given mass of solids eroded.

The second PCB concentration is based on the more recent data collected in 1991 by GE. Using these data, the TI Pool surface sediment Tri+ PCB concentration is 16 mg/kg and the Total PCB concentration is 32 mg/kg. A summary of the cohesive surficial sediment concentrations for Tri+ and Total PCBs is listed in Table 407426-2.

Table 407426-3 lists estimated shear stresses at the high-resolution core locations being compared. Despite the higher flow in the model reapplication, estimated shear stresses decreased at two of the five locations, HR-25 and HR-26. The reason for this relates to greater submergence of the floodplain in the vicinity of these near-shore core locations for the higher flow. In effect, a significant portion of the increased flow is predicted to move over the floodplain, resulting in lower local velocities and, subsequently, lower bottom-shear stresses in some areas.

In addition, the side channel and floodplain along the eastern portion of Rogers Island are predicted to have increases in storage under this higher flow condition, resulting in greater depths and somewhat lower velocities within the channel as compared to the lower flow of 47,330 cfs in the RBMR. Bottom-shear stress depends on both depth and velocity, and it decreases for greater depths and smaller velocities. Given the hydraulic behavior in this region of the TI Pool, the decreases in predicted bottom-shear stresses for cores HR-25 and HR-26 under a higher flow condition are plausible. However, as noted above, the uncertainty in the hydrodynamic model predictions likely increases with the further extrapolation beyond available data for the downstream boundary condition and for model calibration.

Table 407426-4 compares depth to peak PCB concentration at the high-resolution core locations with low (5th percentile), median (50th percentile), and high (95th percentile) estimates of erosion depth for the original RBMR application (47,330 cfs) and the upper-limit peak flow (61,835 cfs).

Table 407426-5 compares expected values (*i.e.*, arithmetic averages of the 3,000 Monte Carlo iterations) for the original RBMR application (47,330 cfs) and the upper-limit peak flow (61,835 cfs). Tables 407426-6 and 407426-7 list the expected values of Tri+ and Total PCBs eroded in comparison to the existing PCB inventory in the cohesive sediment of the TI Pool.

Although the estimated mass of Tri+ PCB resuspended for the upper-limit peak flow (60 and 190 kg based on 1991 and 1984 data, respectively) is greater than that resuspended for the lower flow used in the RBMR analysis (30 and 89 kg based on 1991 and 1984 data, respectively), these values are small relative to the estimated Tri+ PCB mass reservoir in the TI Pool. The resuspended Tri+ PCB mass due to the 100-year peak flow is only 0.3 to 2.4 percent of the Tri+ PCB inventory in the cohesive sediment of the TI Pool. The previous estimated mass of Tri+ PCB resuspended reported in the RBMR RS – 76 kg – falls in the range of the revised estimated mass of 30 to 89 kg.

The estimated mass of Total PCB for the upper-limit peak flow ranges from 120 to 650 kg based on 1991 and 1984 data, respectively. The estimated mass of Total PCB for the lower 100-year flood peak flow (47,330 cfs) ranges from 60 kg (using 1991 sediment data) to 300 kg (using 1984 sediment data). Similar to the Tri+ PCB, the estimated mass of Total PCBs resuspended during the 100-year flood is small (0.3 to 3 percent) relative to the estimated Total PCB mass inventory in the cohesive sediment of the TI Pool.

Two factors suggest that use of 1984 sediment PCB concentrations would overestimate Total PCB mass scour. First, a poolwide average of less than one cm of surface sediment is predicted to scour in the TI Pool. Application of a sediment PCB concentration that represents the upper 30 cm of sediment would include highly contaminated subsurface layers that are not predicted to scour during a 100-year peak flow.

Second, surface-sediment PCB concentrations have declined substantially since 1984 (USEPA, 2000a; Appendix D.1 of the FS report) and do not represent present conditions. Therefore, PCB mass scour calculations based on the 1984 sediment data should be considered high-end estimates. The 1991 sediment data are likely more representative for estimating PCB remobilization based on DOSM-predicted scour depths, since these data are more recent and represent conditions in the top five cm of sediment. However, the average PCB concentrations based on these data incorporate composite samples that represent both cohesive and non-cohesive sediment areas. Non-cohesive sediment areas generally have lower levels of PCB contamination than cohesive areas; therefore, PCB mass scour calculations based on an average of the 1991 sediment data may be characterized as low-end estimates. In summary, the 1984-based PCB mass scour estimates are larger than the 1991-based estimates due both to likely declines in concentration and the substantial difference in the vertical resolution of surficial sediment that each of these datasets are capable of representing (*i.e.*, 5 cm for 1991 versus 30 cm for 1984).

Although the DOSM predicts substantially greater scour of solids mass from cohesive sediments within the TI Pool for the upper-limit peak flow of 61,835 cfs, the poolwide average scour depth is still less than one cm. Additionally, the 95th percentile maximum scour depth is less than the depth of peak PCB concentrations at four of the five high-resolution core locations that were analyzed for the RBMR. The fifth location, HR-25, has a predicted 95th percentile scour depth that is below the measured peak PCB concentration for both the upper-limit peak flow (61,835 cfs) and the lower peak flow (47,330 cfs) used for the RBMR analysis of the 100-year flood. It should be noted that the peak PCB contamination in this core is just five cm below the sediment-water interface, suggesting that this location is subject to periodic scour, as predicted by the

DOSM in the RBMR analyses and for the reapplication of the model to an upper-limit 100-year peak flow.

The DOSM reapplication for the estimated upper-limit 100-year flood peak flow of 61,835 cfs does not alter the major findings that were presented in the RBMR. The major finding related to the 100-year flood analyses was that "results of the 100-year peak flow simulation show that a flood of this magnitude would result in only a small additional increase in sediment erosion beyond what might be expected for a reasonable range of annual peak flows."

CONCLUSION

The results of the DOSM reapplication indicate that:

- Average bottom shear stress on cohesive sediments increases by 27 percent for the upper-limit flood peak versus the lower flow analyzed in the RBMR (21.3 dynes/cm^2 versus 16.8 dynes/cm^2).

- Average erosion depth in cohesive sediments is approximately 2.27 times greater for the upper-limit flood peak flow than for the lower flow analyzed in the RBMR (0.719 cm versus 0.317 cm).

- The 95th percentile maximum scour depth for the upper-limit 100-year flood peak flow is less than the depth of peak PCB concentration at the same four out of five high-resolution sediment core locations in the TI Pool that were examined for the lower flow in the RBMR.

- Using 1991 surficial sediment data representing average PCB concentrations in the top five cm of the sediments across the entire TI Pool, a low-end estimate of PCB mass scour can be made. This estimate indicates that an additional 30 kg of Tri+ PCBs would be scoured for the upper-limit flood peak flow than for the lower flow analyzed in the RBMR (60 kg versus 30 kg). On a Total PCB-basis the increase in estimated scour for the upper-limit flood peak would be 60 kg (120 kg versus 60 kg).

- Using 1984 sediment data representing average PCB concentrations in the top 30 cm of the cohesive sediments in TI Pool, a high-end estimate of PCB mass scour can be made. This high end estimate indicates that an additional 101 kg of Tri+ PCBs would be scoured for the upper limit flood peak flow than for the lower flow analyzed in the RBMR (190 kg versus 89 kg). On a Total PCB-basis the increase in estimated scour for the upper limit flood peak would be 350 kg (650 kg versus 300 kg).

- The predicted mass of PCBs resuspended, on either a Tri+ or Total PCB basis, for the upper-limit peak flow is small, ranging from 0.2 to 3 percent of the mass inventory estimated to reside in the cohesive sediments of the TI Pool.

In summary, the major RBMR findings related to the assessment of flood-induced sediment PCB remobilization are not significantly altered based on the results from reapplication of the DOSM to the upper-limit estimate of 61,835 cfs for the 100-year flood peak flow in the TI Pool. Based

on a conservative estimate of the mass of PCBs resuspended under a 100-year peak flow, the 100-year flow will result in only a slightly larger amount of PCBs resuspended than may be expected during typical annual high-flow events.

REFERENCES

Decisioneering, Inc., 2001. *Crystal Ball*Ò *2000 Version 2000.2 User Manual*. Denver, CO.

Federal Emergency Management Agency (FEMA). 1982. *Flood Insurance Study for the Town of Fort Edward, New York, Washington County*. Washington, D.C.

HydroQual, Inc., 1995. "The Erosion Properties of Cohesive Sediments in the Upper Hudson River." General Electric Company.

Jepsen, R., J. Roberts, and W. Lick. 1997. Effects of Bulk Density on Sediment Erosion Rates. Water, Air and Soil Pollution, Vol. 99, pp. 21-31.

Jones, C. and W. Lick. Effects of Bed Coarsening on Sediment Transport. Estuarine and Coastal Modeling. Proceedings of the Sixth International Conference, held in New Orleans, Louisiana, November 3-5 1999. ASCE, Reston, Virginia. 1999.

Jones, C.A. 2000. An Accurate Model of Sediment Transport. Department of Mechanical and Environmental Engineering, University of California, Santa Barbara. Ph.D. Dissertation.

Lick, W., Z. Chroneer, C. Jones and R. Jepsen. 1998. A Predictive Model of Sediment Transport. Estuarine and Coastal Modeling, Volume 4, pp. 389-399.

McNeil, J., C. Taylor, and W. Lick. 1996. Measurement of Erosion of Undisturbed Bottom Sediments With Depth. Journal of Hydraulic Engineering, ASCE, 122:6, pp. 316-324.

New York State Department of Environmental Conservation (NYSDEC). 2001. Analysis of Hudson River Water Column PCB Data and 100-Year Flood Estimate. Prepared by Dr. Richard Bopp, Rensselaer Polytechnic Institute. September.

Ravens, T.M. and P.M. Gschwend. 1999. Flume Measurements of Sediment Erodibility in Boston Harbor. Journal of Hydraulic Engineering, ASCE, 125:10, pp. 998-1005.

US Environmental Protection Agency (USEPA). 2000a. Further Site Characterization and Analysis, Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS Volume 2D. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, Inc., and Tetra-Tech, Inc. January 2000.

USEPA. 2000b. Responsiveness Summary for Volume 2D – Baseline Modeling Report. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, Inc., and Tetra-Tech, Inc. February 2000.

Zimmie, 1985. "Assessment of erodibility of sediments in the Thompson Island Pool of the Hudson River." Final Report to the Office of Special Projects, New York State Department of Environmental Conservation. USEPA Grant No. C-36-1167-01.

Trends in PCB Concentrations in Fish in the Upper Hudson River
312627

WHITE PAPER – TRENDS IN PCB CONCENTRATIONS IN FISH IN THE UPPER HUDSON RIVER

(ID 312627)

ABSTRACT

EPA presented an analysis of trends in PCB concentrations in fish in the Upper Hudson River in Appendix D.1 of the FS. That analysis demonstrated that the decline in fish tissue concentrations observed in the 1970s and 1980s had tapered off, with a period of increase (accompanying the increased PCB releases at the GE Hudson Falls facility) followed by very slow rates of decline in the 1990s. Even after the releases at the Hudson Falls facility were largely controlled (*i.e.*, since 1995), fish tissue PCB concentrations in the Thompson Island Pool (TI Pool) and near Stillwater appeared to remain approximately constant, at levels well above acceptable concentrations.

In addition, the monitoring results suggest the possibility that the EPA and GE models predict too rapid a rate of decline in fish tissue PCB concentrations under current conditions. Since the FS was written, additional, more-recent fish monitoring data have become available, requiring an update of EPA's analysis.

This white paper contains two sections. The first section is a revised version of Appendix D.1, Section 3.1, of the FS, which presents EPA's analysis of trends in PCB concentrations in fish in the Upper Hudson River. This update is needed to incorporate the new data, most notably the year 2000 fish sampling results, which were not available at the time the FS was prepared. Including the newer data reinforces and confirms the conclusions presented in the FS.

GE has provided an alternative analysis of trends in PCB concentrations in fish, submitted as Appendix H to GE's comments. GE questioned a number of the assumptions used by EPA in its analysis, and presented conclusions regarding recent trends in PCB concentrations in fish that differ from those of EPA.

The second section of this white paper provides a detailed commentary on GE's alternative analysis of trends. The technical analyses conducted by GE are, in general, valid; however, the conclusions that are drawn from these analyses are not supported by the data. In fact, GE's reanalysis of fish concentration trends does not contradict EPA's analysis. Instead, the GE analysis confirms the observation of a lack of clear declining trends in PCB concentration in recent years for most of the fish species sampled.

INTRODUCTION

Data on PCB concentrations in fish are important for two reasons: First, PCB concentrations in fish tissue represent the primary route of exposure to humans in the Hudson River. Second, because PCBs accumulate in fatty tissue, observations of PCBs in fish integrate exposure over time and provide an important indicator of trends in river conditions that is not strongly influenced by transient water-column concentrations.

The FS examined PCB concentrations in fish through the 1998 data, which were the most recent analytical results available at the time. Since release of the FS, NYSDEC has provided the results of the 1999 and 2000 fish data collections. This white paper examines recent PCB trends in fish up through 2000. It also evaluates an alternative analysis of fish tissue concentration trends provided in comments by GE.

EPA'S ANALYSIS OF PCB CONCENTRATION TRENDS IN FISH

Concentration trends in fish potentially provide one of the most rigorous tests of the joint performance of the HUDTOX and FISHRAND models, as the fish response integrates over many geochemical and biological processes. Long time-series of concentrations in various species at multiple locations are available from NYSDEC, and these biotic concentrations should integrate or smooth out short-term or spatial variability seen in other media.

Several caveats should, however, be noted. Most importantly, changes in analytical methods over time may serve to introduce apparent step changes into the fish concentration record. This problem is reduced by attempts to convert the NYSDEC data to a consistent Tri+ PCB basis, although the conversions themselves are subject to uncertainty. In addition, concentrations in fish in a given year may be influenced by factors such as weather, food availability, and the distribution of age and sex in a given sample.

It is also important to remember that calibration of the FISHRAND model was conducted using environmental concentration estimates from HUDTOX as the forcing function. Thus, any shortcomings in HUDTOX will also propagate into the FISHRAND calibration. Trends in brown bullhead should generally follow HUDTOX-predicted trends in surface sediment concentration, while trends in pumpkinseed should generally follow predicted trends in water column concentration (particularly summer concentrations), and largemouth bass should depend on both sediment and water (Table 6-7 in the Revised Baseline Modeling Report, or RBMR; USEPA, 2000).

Concentration trends in fish are evaluated here as lipid-based concentrations, on the assumption that conversion to a lipid basis better reflects actual uptake processes and helps to smooth out some of the year-to-year and sample-to-sample variability.

A comparison of FISHRAND median predictions to observed (corrected) Tri+ PCB data in fish lipid is shown for three species in the lower TI Pool and the Stillwater reach in Figures 312627-1 and 312627-2. These results use actual (observed) upstream boundary conditions for the 1998–1999 validation period, while model results for 2000 are from the model forecast of future conditions conducted for the Revised Baseline Modeling Report (USEPA, 2000).

Figure 312627-1 shows results for fish collected by NYSDEC near Griffin Island at RM 189 in the TI Pool. While the general fit seems acceptable, there are some discrepancies between model and data. For largemouth bass, the model appears to under-predict recent concentrations (*i.e.*, 1998 through 2000). High concentrations observed in 1990–1991 were also not predicted by the model.

For brown bullhead in the TI Pool, the general model trend appears to be a better fit than that for largemouth bass. It is noted, however, that the model predicts a gradual decreasing trend from 1995–2000, while the data show what appear to be nearly constant concentrations, with a slight increase in 1999.

As EPA's FISHRAND bioaccumulation modeling indicates a strong relationship between brown bullhead tissue PCB concentrations and concentrations in surface sediment, this result suggests that the modeled trend in surface sediment concentrations for this period might differ from the trend in sediment-driven exposure experienced by the sampled fish. This could occur either because the modeled trend is incorrect or because the fish's exposure occurs at a local spatial scale that is smaller than that simulated by the model, in which sediment concentration trends differ from the reach-averaged trend. Alternatively, the trend in the observed fish data may be obscured by random variability in the sample results.

Pumpkinseed body burdens should provide a diagnostic of model ability to reproduce summer water-column concentration trends. The FISHRAND model fits the general trend for pumpkinseed in the TI Pool. Notable here, however, is the failure to predict elevated concentrations in 1989 – which could, in turn, be a source of the elevated concentrations seen in largemouth bass in 1990 and 1991. The year 1989 is one in which data to characterize the upstream boundary loads are very sparse, which could indicate a failure to capture pulse loading from upstream and consequent underestimation of summer water-column concentrations.

The 1995–2000 data from the TI Pool suggest that the models could be predicting a rate of decline in fish tissue concentration that is more rapid than seen in the environment since the upstream source was largely controlled. Small changes in trend at this end of the distribution could have large effects on the rate of natural decline during the forecast period.

The interpretation of the TI Pool results must be made with caution, due to the locations used for sampling. The fall samples of yearling pumpkinseed are generally collected on the east side of the main channel, opposite Griffin Island and just south of *Hot Spot* 14. The spring samples of largemouth bass and brown bullhead are, however, collected in the backwater channel *behind* Griffin Island (because this is an area in which the bass congregate in the spring). Because this channel is somewhat isolated from the main river, the relevance of trends in these data to overall conditions in the lower TI Pool is uncertain. (During remedial design, EPA will work with the State and federal natural-resource trustees to design a comprehensive fish-monitoring program to evaluate the effectiveness of the remedy, and may modify the sites used in the existing fish-monitoring program.)

The model and data for the Stillwater reach (Figure 312627-2) are generally in closer agreement for brown bullhead and largemouth bass in the 1990s relative to the TI Pool. The pumpkinseed calibration misses the error bars on observed lipid-based concentrations in most years up through 1993, which could indicate that summer water-column concentrations are different than those predicted by HUDTOX.

More notable at this location is a divergence between the model and observations for the period between 1977 and 1982. For all three species, the data suggest that initial concentrations were higher, with a more rapid decline, than is indicated by the FISHRAND model. For this period,

the data to constrain water-column concentrations in the modeling are very sparse. There are also significant uncertainties regarding the interpretation of analytical methods for the earlier data.

Table 312627-1 summarizes half-life data for the three species discussed above, plus limited data for yellow perch. The consistent Tri+ data includes both Aroclor-based data reported by NYSDEC and direct estimates of Tri+ from homologue-based analyses conducted for GE by Northeast Analytical (NEA). For 1998 through 2000, only the homologue results from NEA are used, as provided in NYSDEC's database for 1998–1999, and in GE's database for 2000. For this period, an analysis for conversion of the Aroclor data to consistent Tri+ results is not available.

Across the period 1985-2000, trends in model and data (expressed as consistent Tri+ PCBs) are generally quite close. This reflects the fact that FISHRAND is calibrated to data that span this period, and the general fit of the model is quite good. For the 1985-1991 period of declining concentrations, model and data are again close in the Stillwater reach; however, the data-based trends in the TI Pool show both largemouth bass and pumpkinseed increasing, whereas the model predicts declines.

In general, the model does a good job of reproducing observed fish concentrations over the period of record when examined as an annualized lipid-based average concentration. However, the model does not seem to reproduce the trend in observed concentrations since 1995.

For the 1995-2000 period following substantial control of the upstream source, trends in the model and data appear to diverge. The model predicts continuing steady declines in fish concentrations in the TI Pool, but the data show either increasing or very slowly decreasing concentrations in the pool. For brown bullhead, the data show essentially no downward trend for the period 1995-2000, while the decline predicted by the model is approximated by a half-life of 3.8 years. The largemouth bass concentrations have a data-based half-life of 11.6 years versus a model estimate of 3.6 years. The rate of decline predicted by the model for the Stillwater reach also appears to be more rapid than that observed for brown bullhead and largemouth bass.

In evaluating these trends it is important to keep in mind that the observed data are variable and subject to uncertainty. Reported trends are based on annual means. The 95-percent confidence limits on the observed means in the TI Pool for 1995-2000 are consistent with half-lives as short as 5.4 years for brown bullhead and as short as 4.0 years for largemouth bass.

The FISHRAND output provides 1995-2000 half-lives that are outside (shorter than) the range estimated from observed data for both brown bullhead and largemouth bass, suggesting that the model did not accurately predict realized concentrations; however, the cause of this is uncertain at this time.

COMMENTARY ON GE'S APPENDIX H: TRENDS IN PCB LEVELS IN HUDSON RIVER FISH

Appendix H to GE's comments is a document entitled "Trends in PCB Levels in Hudson River Fish." This document presents conclusions that differ in some respects from EPA's analysis. Most importantly, the document contends that fish in the TI Pool and at Stillwater exhibit a continuing decline in concentration that is consistent with rates of decline in fish and water and

sediment exposure concentrations predicted by the GE model. This section of the white paper examines the reasons for the difference in conclusions between GE's and EPA's analyses, as revised to incorporate the year 2000 data.

GE's analysis is based on essentially the same data as used by EPA. The data have, however, been subjected to selective filtering by GE, some of which appears to be inappropriate. In addition, GE sets up a false comparison to EPA's effort that reflects a misunderstanding of the purpose of the analyses presented in Appendix D of the FS.

Introduction

In Section 1 of Appendix H, GE states that EPA "claims that the PCB concentrations in Upper Hudson River fish have not declined in recent years or are declining very slowly," and that "EPA's conclusions about these trends is based on an unsound analysis."

EPA neither contends nor believes that PCB concentrations in Hudson River fish have stopped declining – when viewed at the scale of reach averages. EPA's fate and transport and bioaccumulation models predict a continuing decline, as documented in the FS. However, reach-averaged trends do not necessarily hold across all individual locations and it is, therefore, essential to point out that fish concentrations have not exhibited a consistent decline in recent years for a number of species and at a number of the locations historically sampled by NYSDEC.

The fact that a decline is not verified in the monitoring data is reason for concern. As described in Appendix D.1 of the FS, this lack of decline may reflect localized sediment-exposure concentrations that are not declining at the reach-averaged rates predicted by the model.

The "bounding calculation" developed by EPA is intended to provide a reasonable estimate of elevated fish tissue concentrations in localized areas that exhibit continuing, slowly declining sediment-exposure concentrations. It is not a prediction of average biotic concentrations in the river as a whole. However, it should be noted that the NYSDEC sampling locations in the TI Pool and at Stillwater were selected because they are areas in which fish are plentiful. Thus, significant populations of fish are associated with areas of the Hudson River in which the rate of decline in PCB concentration is less than is predicted by the models at the reach-averaged scale. This is an important factor that should be taken into consideration as part of the remedial decision to use the model predictions alone, or to use several analytical tools and factual databases to evaluate the need for remediation of contaminated sediment.

Data Interpretation

Section 2 of GE's Appendix H contains a detailed discussion of "factors that affect interpretation of the data." GE's interpretation of these factors is reviewed in detail.

Fish Lipid Content

Because PCBs are more soluble in oils than in water, they are stored primarily within fats, or lipids, in fish. EPA agrees with GE's conclusion that the fish PCB concentration data should be evaluated on a lipid basis to remove potential bias and uncertainty in PCB concentrations due to

changes in lipid content. That is why EPA's analysis was conducted on a lipid basis. EPA also agrees that the relationship between PCB concentration and lipid content is likely to be somewhat nonlinear and may be due to the interaction between elimination rate and growth dilution.

Fish Weight and Age

EPA agrees that PCB concentrations in fish are likely to increase with age. Unfortunately, age estimates are not available for the vast majority of Hudson River fish samples. Available measures of length and weight are imprecise surrogates for age.

Potential dependence of fish PCB body burden on weight and/or length was evaluated in detail during the development of the bivariate BAF model (USEPA, 2000), but no statistically significant explanatory power was found for these variables. GE presents lipid-based PCB concentration versus weight in Appendix H, Figure 2.2-2, and claims to find a relationship between weight and PCB concentration. The figure does not support this statement. In fact, the large majority of the weight-class PCB concentrations have 95-percent confidence limits that overlap one another. There is possibly an increasing trend in lipid-normalized PCBs across the several lightest-weight classes in largemouth bass and brown bullhead, but no clear trend in other weight classes.

GE also claims that variance in PCB concentration increases with weight, but this does not seem to be correct: The larger uncertainty associated with the heavier weight classes instead seems to reflect smaller sample size.

In sum, the data do not support GE's assertion "that body weight impacts bioaccumulation" to an extent sufficient to require subsetting the data.

Nevertheless, GE chose to analyze trends in brown bullhead and largemouth bass based only on data from a restricted weight range. This excludes 24 percent of the data for largemouth bass and 20 percent of the data for brown bullhead. No pumpkinseed data were excluded, as NYSDEC samples almost exclusively yearling pumpkinseed. EPA believes that this paring of the data is not justified, based on available evidence in the monitoring.

Extreme Values

GE further limited the data set by excluding extreme value outliers that deviated from local mean conditions. Given the relatively small size of fish samples (typically 20 analyses per species/location/year), one should be extremely careful in rejecting outliers as anomalous or unrepresentative.

In fact, because the Hudson River is not a homogenous environment, and each individual fish sampled may have a somewhat different history of exposure, it can be argued that no outliers should be rejected unless there is strong evidence of analytical error. EPA concluded that there was not compelling evidence to reject any individual data points, and therefore worked with the complete data set.

Variation in Exposure Location

In Section 2.4 of Appendix H, GE states, "Fish may be exposed to sediment and water column PCB concentrations characteristic of some sub-reach-scale location…" This statement is worth highlighting, as, in direct comments, GE has stated that a focus on the sub-reach scale "lacks any basis in fact or reason."

GE's Appendix H also misrepresents the purposes of the bounding calculation, stating that "EPA inappropriately uses these brown bullhead data to estimate a rate of recovery for the cohesive sediments of the entire pool." This is incorrect: EPA uses the NYSDEC TI Pool brown bullhead data to make inferences about trends at fine-grained sediment locations similar to the NYSDEC sampling location, not over the whole TI Pool.

Laboratory Methods

GE provides an analysis of split-sample comparisons between NYSDEC contract-laboratory results and capillary-column analysis by NEA, including new results for the Year 2000 data. EPA generally agrees with GE's analysis regarding uncertainties in the interpretation of the later packed-column data to a consistent Tri+ basis. For this reason, the revised analysis presented in the previous section of this paper relies on NEA's capillary-column results.

As did GE, EPA used NYSDEC packed-column results in the trend analysis up through 1997, as few capillary-column results are available. The earlier version of EPA's analysis, presented in the FS, also used NEA capillary-column results preferentially, when these were available.

Interruptions to Ongoing Decline

EPA generally agrees with GE's analysis, presented in Section 2.6 of their Appendix H, of temporal interruptions to ongoing declines in the TI Pool.

Analysis of Temporal Trends

Section 3 of GE's Appendix H presents results of their temporal trend analysis. This section commences by setting out several incorrect characterizations of EPA's effort.

First, GE states that it presents trends for largemouth bass, pumpkinseed, and brown bullhead, which "contrasts with EPA's analysis." This is incorrect, as EPA also analyzed trends in all three species, as well as for yellow perch.

The introduction to GE's Section 3 also claims that "EPA did not include values measured by GE since 1998." This is incorrect: EPA used all the GE/NEA analyses that were available in the database provided by GE at the time the FS was written. For split samples where both NYSDEC packed-column and NEA capillary-column results were available, the GE/NEA capillary-column results were judged more reliable and were thus used to estimate Tri+ PCBs. GE's 2000 results were not available at the time the FS was written; however, they are now available and have been incorporated into the analysis (the previous section of this white paper), with little change in results.

GE presents trend results for a variety of time intervals, including, for the TI Pool, results from start of monitoring up through 1991 and results for 1994-2000, and, for Stillwater, results for 1984-1991, 1984-2000, and 1994-2000.

Of most interest are the recent trends. A key difference from EPA's approach is that GE chose 1994 as the starting point for the evaluation of recent trends. This is significant, because 1994 results were higher than 1995 results for all three species in the TI Pool; thus, starting with 1994 results in faster estimates of decline. EPA believes it is inadvisable to start the trend analysis in 1994, as fish samples were collected in the first half of the year and likely still showed the effects of 1993's high-concentration releases from the Hudson Falls facility.

In presenting results for the TI Pool, GE again mischaracterizes EPA's effort, stating that EPA "used data for one species, brown bullhead, in one location, Thompson Island Pool, over four years, 1995 to 1998." In fact, the analyses cover four species, in both the TI Pool and Stillwater, over a five-year period, 1995 to 1999. These results have now been extended through 2000, as shown in the previous section of this white paper.

It is true that EPA based its bounding calculation primarily on the brown bullhead results. This was done intentionally; of monitored species, bullhead are believed to be those most closely tied to sediment food-chain pathways. Therefore, it is the bullhead that are most likely to be affected by elevated localized sediment concentrations that are not declining at the reach-averaged rate, and the bullhead that are most appropriate to establish an upper-bounding calculation.

GE's results for the TI Pool for 1994 onward suggest that largemouth bass, brown bullhead, and pumpkinseed concentrations are all declining, at rates of from 7 to 16 percent per year. EPA finds slower rates of decline, with increases for pumpkinseed (Table 312627-1 and Figure 312627-1). The difference is due primarily to GE's choice of 1994 as a starting period for the trend analysis, with some additional impact due to the selective rejection of data.

As is clear from Figure 312627-1, strong decreases in brown bullhead and largemouth bass concentrations in the TI Pool occurred between 1994 and 1995, and inclusion of the 1994 data automatically results in a faster estimated rate of decline. However, no decrease in bullhead concentrations are evident from 1995 onward in either GE's or EPA's analysis of the data.

GE's analysis for Stillwater presents results for 1984-1991, 1994-2000, and 1984-2000. GE's focus on the 1984-2000 results is inappropriate, as fish at Stillwater clearly were affected by the Allen Mill event (see brown bullhead and pumpkinseed results for 1992 in Figure 312627-2), thus rendering the long-term trends crossing this event meaningless. As GE itself notes, observed trends are not reliable predictors of the future.

The fact that a strong decline occurred at Stillwater between 1984 and 1991 does not negate the lack of trend in recent data. GE results for 1994-2000 (with corrections for analytical differences) show increases in both largemouth bass and brown bullhead at Stillwater from 1994 on – results that are generally in agreement with EPA's analyses.

GE's text states that "EPA errs in its interpretation of these data, concluding that trends have flattened out in the 1990s" (p. 3-10 of Appendix H); however, GE had already made the same conclusion a page earlier: "For the period from the mid-1990s to 2000, levels exhibited no trend."

In sum, the re-analysis of fish concentration trends developed by GE does not contradict EPA's analysis that provides evidence for lack of strong declining trends in most species in the TI Pool and at Stillwater in recent years. Rather, it merely demonstrates that, for the TI Pool, faster declining trends can be obtained if earlier data in close proximity to the loading events at Hudson Falls are included, coupled with selective rejection of outliers.

For Stillwater, GE’s analysis shows essentially the same lack of trends as EPA’s analysis of recent data. Therefore, GE’s analysis is consistent with EPA’s finding that fish tissue PCB concentration data collected since 1995 do not demonstrate a continuing steady decline.

REFERENCES

US Environmental Protection Agency (USEPA). 2000. Further Site Characterization and Analysis, Revised Baseline Modeling Report (RBMR), Hudson River PCBs Reassessment RI/FS. Volume 2D. Prepared for USEPA Region 2 and USACE, Kansas City District by TAMS Consultants, Inc., Limno-Tech, Inc., Menzie-Cura & Associates, and Tetra Tech, Inc. January.

Relative Reduction of Human Health and Ecological Risks in the Mid- and Lower Hudson River

313699

WHITE PAPER – RELATIVE REDUCTION OF HUMAN HEALTH AND ECOLOGICAL RISKS IN THE MID- AND LOWER HUDSON RIVER

(ID 313699)

ABSTRACT

For the five remedial alternatives evaluated in detail in the Feasibility Study (No Action, Monitored Natural Attenuation, CAP-3/10/Select, REM-3/10/Select, and REM-0/0/3), cancer risks and non-cancer hazard indices were calculated for the Mid-Hudson River (Federal Dam at Troy to just south of Poughkeepsie) and ecological toxicity quotients were calculated for the Lower Hudson River (Federal Dam to River Mile 33.5)). The risks, hazards and toxicity quotients are greatest for the No Action and Monitored Natural Attenuation alternatives and are similarly reduced for the active alternatives, with the most extensive remedial alternative, REM-0/0/3, offering the greatest risk reduction. Thus, the cancer risks, non-cancer hazard indices and ecological toxicity quotients show the same pattern of relative risk reduction among the remedial alternatives as was shown for the Upper Hudson in the Feasibility Study. In addition, the modeling shows the same overall pattern among the five remedial alternatives with respect to meeting remediation goals and other target concentrations of PCBs in fish.

For the selected remedy, REM-3/10/Select, three scenarios were examined: 1) a five-year dredging schedule with no resuspension (same as Feasibility Study and Proposed Plan); 2) a six-year dredging schedule with 0.13 percent resuspension loss (base case); and 3) a six-year dredging schedule with 2.5 percent resuspension loss. Cancer risks, non-cancer health hazards, and ecological toxicity quotients for the three scenarios are essentially the same. In addition, the modeling shows essentially no difference among the scenarios of the selected remedy with respect to meeting remediation goals and other target concentrations of PCBs in fish. These results indicate that implementing the selected remedy in two phases over six years does not change the relative human health and ecological risk reductions of the selected remedy from the risk reductions presented in the Feasibility Study and Proposed Plan.

INTRODUCTION

This white paper presents the risks to human health (cancer and non-cancer) in the Mid-Hudson, modeled from Federal Dam (River Mile [RM] 153.5) south to the salt front (approximately RM 63.5), and ecological receptors (river otter and mink) in the Lower Hudson, modeled from RM 153.5 to RM 33.5. Risks are presented for the five remedial alternatives evaluated in detail in the Feasibility Study (No Action Alternative, Monitored Natural Attenuation, CAP-3/10/Select, REM-3/10/Select [selected remedy], and REM-0/0/3).

For the selected remedy, REM-3/10/Select, this paper presents the risks to human health (cancer and non-cancer) and ecological receptors (river otter and mink) under three scenarios. The three scenarios evaluate the effects on risk reduction in the Mid-and Lower Hudson of implementing the selected remedy in the Upper Hudson in two phases over six years rather than in a single phase over five years as described in the Feasibility Study and Proposed Plan. The scenarios

also show the effect of different rates of PCB loss due to resuspension on the calculated risk reductions. See White Paper – Resuspension of PCBs during Dredging for additional information on resuspension. Specifically, the three scenarios and their model run designations (e.g., R14S2) are as follows:

- Five-year dredging schedule, no resuspension, same as Feasibility Study and Proposed Plan (R14S2).
- Six-year dredging schedule, 0.13 percent resuspension, base case (R20RS).
- Six-year dredging schedule, 2.5 percent resuspension (R20RX).

Similar to the approach used for baseline conditions summarized in the Feasibility Study, output from HUDTOX, EPA's fate and transport model for PCBs in the Upper Hudson River, was used as an external input for modeling of the Mid- and Lower Hudson River. Future concentrations of PCBs in river water, sediment and white perch were derived from the Farley PCB fate, transport, and bioaccumulation model (Farley *et al*., 1999, as updated by Cooney, 1999). Future concentrations of PCBs in brown bullhead, largemouth bass, yellow perch, and spottail shiner were derived from FISHRAND, EPA's bioaccumulation model for the Upper Hudson River. The calculations for all remedial alternatives (No Action, Monitored Natural Attenuation, CAP-3/10/Select, REM-3/10/Select [the selected remedy; all three scenarios] and REM-0/0/3) are based on the top layer of sediment in the Farley model (i.e., 0-2.5 cm) rather than the top two layers (i.e., 0-5 cm) used in the Revised Human Health Risk Assessment and Revised Baseline Ecological Risk Assessment. The Farley model does not have a particle exchange process between sediments layers so that deeper layers are effectively isolated from the surface and any surface interactions with the biota. Additionally, the Farley bioaccumulation model was calibrated using only the 0-2.5 cm layer. Thus the use of the top layer only for the EPA forecasts yields the most representative forecast of surface concentrations for the Lower Hudson River. This is also consistent with the author's original model design (Farley, 2001).

Risks were calculated with exposure durations (*e.g*., 40 years for evaluating cancer risks to the reasonably maximally exposed (RME) adult angler, 7 years for evaluating non-cancer health hazards to the RME adult angler, and 25 years for river otter and mink) beginning one year after the year in which dredging will be completed in the Upper Hudson River. Thus, risks were calculated beginning in 2010 (five-year scenarios) and 2011 (six-year scenarios), the years in which dredging will be completed over the entire 40-mile stretch of the Upper Hudson River.

All other risk assumptions, locations, toxicity values, receptors and fate, transport and bioaccumulation models (i.e., HUDTOX, FISHRAND, and Farley) used in this White Paper are the same as those used for baseline conditions in the Revised Human Health Risk Assessment, the Revised Baseline Ecological Risk Assessment and the Feasibility Study.

See White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River for additional information regarding modeling of PCB concentrations in fish in the Upper Hudson. See White Paper – Human Health and Ecological Risk Reduction under Phased Implementation for risk calculations for the selected remedy and modeling of PCB concentrations in fish in the Upper Hudson.

HUMAN HEALTH RISK REDUCTION

The species-weighted annual average PCB concentrations in fish fillet used in the human health calculations are shown in Table 313699-1 averaged over the entire Mid-Hudson (*i.e.*, RMs 152, 113, and 90).

Cancer Risks

For the Mid-Hudson, the cancer risks for the RME adult angler for the five remedial alternatives follow the same overall pattern of relative risk reduction as was shown for the Upper Hudson in the Feasibility Study. The cancer risks are greatest for the No Action and Monitored Natural Attenuation alternatives and are similar for the active alternatives, with the most extensive remedial alternative, REM-0/0/3, offering the greatest risk reduction. Specifically, the cancer risks are 1.6E-04 for No Action, approximately 8E-05 for Monitored Natural Attenuation, and range from 5E-05 to 7E-05 for the active alternatives (CAP-3/10/Select, REM-3/10/Select, and REM-0/0/3) (see Table 313699-2). The cancer risks for the central tendency (CT), or average, adult angler are lower than those for the RME adult and also show a similar pattern among the remedial alternatives.

Cancer risks to the RME and CT adult for the three scenarios of the selected remedy are essentially the same (*i.e.*, 6 to 8E-5 for RME and approximately 2E-6 for CT), with the highest risks for the six-year, 2.5 percent resuspension scenario, as shown in Table 313699-2.

Non-Cancer Health Hazards

Similar to the cancer risks, the non-cancer Hazard Indices (HIs) for the RME adult angler for the five remedial alternatives follow the same overall pattern of relative reduction in HIs as was shown for the Upper Hudson in the Feasibility Study. The non-cancer HIs are greatest for the No Action and Monitored Natural Attenuation alternatives and are similar for the active alternatives, with the most extensive remedial alternative, REM-0/0/3, offering the greatest reduction. Specifically, the HIs are approximately 10 or 11 for No Action, approximately 6 to 8 for Monitored Natural Attenuation, and range from 4 to 6 for the active alternatives (see Table 313699-3). The HIs for the CT adult angler also show a similar pattern among the remedial alternatives, but are all less than an HI of 1.

Non-cancer HIs for the RME and CT adult for the three scenarios of the selected remedy are essentially the same (i.e., 6 to 8 for RME and 0.4 to 0.6 for CT), with the highest HIs for the six-year, 2.5 percent resuspension scenario).

Time to Reach Human Health Risk-Based Concentrations in Fish

The human health risk-based remediation goal (RG) and other target concentrations of PCBs in fish show the same overall pattern among the remedial alternatives with respect to the years in which such goals and target concentrations are met as was shown for the Upper Hudson in the Feasibility Study (see Table 313699-4).

Specifically, the RG of 0.05 mg/kg PCBs (wet weight) in species-weighted fish fillet is not met for the any of the remedial alternatives by 2046, which is the extent of the modeling period. The 0.2 mg/kg target concentration is not met for the No Action alternative, is met in 2017 for the Monitored Natural Attenuation alternative, is met in 2015 for CAP-3/10/Select and REM-3/10/Select, and is met in 2013 for REM-0/0/3. The 0.4 mg/kg target concentration is met in 2016 for the No Action alternative, is met in 2009 for the Monitored Natural Attenuation alternative, is met in 2008 for CAP-3/10/Select and REM-3/10/Select, and is met in 2007 for REM-0/0/3 (see Table 313699-4).

Among the three scenarios of the selected remedy, the years in which the human health risk-based RG and other target concentrations of PCBs in species-weighted fish fillet are met in the Mid-Hudson are essentially the same, with the longest times for the six-year, 2.5 percent resuspension scenario. Specifically, the 0.05 mg/kg RG is not met by 2046, the 0.2 mg/kg target concentration is met in 2015-2016, and the 0.4 mg/kg is met in 2008-2012 (see Table 313699-4).

ECOLOGICAL RISK REDUCTION

Annual PCB concentrations in largemouth bass, which were used in the ecological calculations of risk to the river otter, are shown in Table 313699-5 averaged over the Lower Hudson (i.e., RMs 152, 113, 90, and 50). Annual PCB concentrations in spottail shiner, which were used to calculate risk to the mink, are shown in Table 313699-6 averaged over the Lower Hudson.

Toxicity Quotients

The Toxicity Quotients (TQs) for the river otter in the Lower Hudson for the remedial alternatives follow the same overall pattern of relative reduction in TQs as was shown in the Feasibility Study for the Upper Hudson. The TQs are greatest for the No Action and Monitored Natural Attenuation alternatives and are similar among the active alternatives, with the most extensive remedial alternative, REM-0/0/3, offering the greatest reduction. Specifically, the TQs are about 5 (lowest-observed-adverse-effect [LOAEL] basis) to 50 (no-observed-adverse-effect [NOAEL] basis) for No Action, 3 (LOAEL basis) to 30 (NOAEL basis) for Monitored Natural Attenuation, and are approximately 2 (LOAEL basis) and 20 (NOAEL basis) for the active alternatives (see Table 313699-07). The TQs for the mink in the Lower Hudson also show a similar pattern among the remedial alternatives.

For the three scenarios of the selected remedy, ecological TQs for the river otter in the Lower Hudson are essentially the same (*i.e*, 2 or 3 [LOAEL basis] and 22 to 26 [NOAEL basis]), with the longest times for the six-year, 2.5 percent resuspension scenario (see Table 313699-7). The TQs for the mink are lower (*i.e*., less than one [LOAEL basis] and about 5 [NOAEL basis]) than those for the river otter and also show similar patterns for the three scenarios of the selected remedy (see Table 313699-7).

Time to Reach Ecological Risk-Based Concentrations in Fish

The ecological risk-based concentrations of PCBs in fish show the same overall pattern among the remedial alternatives with respect to the years in which risk-based concentrations are met as

was shown in the Feasibility Study (see Table 313699-8). Specifically, the risk-based NOAEL concentration of 0.03 mg/kg in largemouth bass based on the river otter is not met for the any of the remedial alternatives by 2046, which is the extent of the modeling period. The risk-based LOAEL concentration of 0.3 mg/kg target concentration is not met for the No Action alternative, is met in 2033 for the Monitored Natural Attenuation alternative, is met in 2023 for CAP-3/10/Select and REM-3/10/Select, and is met in 2019 for REM-0/0/3. The risk-based NOAEL concentration of 0.07 mg/kg in spottail shiner based on the mink is not met for the No Action alternative or the Monitored Natural Attenuation alternative, is met in 2030 for CAP-3/10/Select, is met in 2027 for REM-3/10/Select, and is met in 2023 for REM-0/0/3. The risk-based LOAEL concentration of 0.7 mg/kg in spottail shiner is met in 2004 for all alternatives.

As shown in Table 313699-8, there is little difference among the three scenarios of the selected remedy in the time to reach ecological risk-based concentrations in fish. In the Lower Hudson, the ecological remediation goal (RG) range of 0.03 to 0.3 mg/kg in largemouth bass (whole body), based on the river otter, is met between 2023 to 2026 for all scenarios, with the longest time for the six-year, 2.5 percent resuspension scenario.

The ecological RG is considered to be protective of all the ecological receptors evaluated because it was developed for the river otter, the piscivorous mammal calculated to be at greatest risk from PCBs. An additional range of 0.07 to 0.7 mg/kg PCBs in spottail shiner (whole fish) was developed based on the NOAEL and LOAEL for the mink, which is a species known to be sensitive to PCBs. As shown in Table 313699-8, there is no difference among the three scenarios in the time to reach the range developed for protection of the mink; all scenarios of the selected remedy meet the range in 2004.

CONCLUSIONS

Cancer risks, non-cancer hazard indices, and ecological toxicity quotients show the same overall pattern of risk reduction in the Mid-Hudson (human health) and Lower Hudson (ecological receptors) for the five remedial alternatives evaluated in detail in the Feasibility Study. The risks, hazard indices and toxicity quotients are greatest for the No Action and Monitored Natural Attenuation alternatives and are similarly reduced for the active alternatives, with the most extensive remedial alternative, REM-0/0/3, offering the greatest risk reduction. The modeling shows the same overall pattern among the five remedial alternatives with respect to meeting risk-based concentrations in fish.

For the three scenarios of the selected remedy, REM-3/10/Select, cancer risks and non-cancer hazard indices in the Mid-Hudson and ecological toxicity quotients for river otter and mink in the Lower Hudson are essentially the same. These results show that implementing the selected remedy in two phases over six years rather than in a single phase over five years does not materially change the risk reduction in the Mid- and Lower Hudson provided by the selected remedy.

REFERENCES

Cooney, T. 1999. Revised Lower Hudson Bioaccumulation Model Formulation, Personal Communication to C. Hunt, TAMS. December 8.

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

Farley, K. 2001. Application of Farley Model, Personal Communication to E. Garvey, TAMS. February 22.

Resuspension of PCBs During Dredging
336740

WHITE PAPER – RESUSPENSION OF PCBs DURING DREDGING

(ID 336740)

ABSTRACT

Numerous comments were received on the resuspension and contaminant transport estimates in Appendix E.6 of the Feasibility Study (FS). Some comments concurred with the estimates while others suggested the estimates are unrealistically low. Most of the comments suggesting higher resuspension rates based on their position on information from other environmental dredging projects. Dredging projects in the Fox River, Manistique River and Harbor, and Grasse River were presented as examples with data seemingly contrary to the FS estimates. GE comments also suggested inconsistency between the source strength models discussed in the FS and those recommended in other publications such as the recent NRC report (NRC, 2001). Several other questions related to the basis for the source strength estimates were raised.

This paper addresses these comments, focusing particularly on how the initial estimates were made, the use of models in the FS, and the applicability of data from these other dredging projects to the Hudson River. Careful analysis shows that the original estimates are still valid for the dredging operations proposed in the FS. Observed rates of resuspension at several sites are compared with model-based estimates for the Hudson.

After carefully considering the comments received on dredging, EPA concludes that the information contained in or referred to by those comments does not justify modifying the basis for the sediment resuspension estimates contained in Appendix E.6 of the FS. The estimates of resuspension at the dredgehead of 0.3 percent for mechanical dredges and 0.35 percent for cutterhead dredges are well supported by the above discussion. The associated downstream transport estimates of 0.13 and 0.065 percent, respectively, represent conservative estimates of the potential releases due to dredging and are consistent with direct observations made on several sites.

INTRODUCTION

Dredging is fundamentally a sub-aqueous earth moving action. Just as ground-based earth moving operations generate dust, dredging results in sediment particles being released into the water column. Just as air currents spread dust from a construction site, ambient water currents transport resuspended sediments downstream. And, resuspended sediments with particulate-associated PCBs increase water column PCB concentrations just as contaminated dust particles result in airborne contaminants. The key to estimating these impacts is an accurate estimate of the mass of sediment placed into the water column by the mechanical actions of the dredge itself. Even hydraulic dredges utilize mechanical actions to loose sediment and guide it into the hydraulic intake. Since each dredgehead and dredge type applies distinctly different mechanical forces to move sediment from the river bottom, the most important factor in estimating the rate of sediment resuspension is the type of equipment being used and its operation. Resuspension rates for one type of dredge are entirely irrelevant to resuspension that might be expected from another dredge type.

It is important to note that resuspension of sediments occurs as a result of the movements of the dredge head and its appendages along the river bottom (and in the case of the mechanical dredge, upward through the water column). These disturbances serve to suspend a portion of the sediment in the water column in the immediate vicinity of the dredge head. However, only those materials that can remain in the water column (i.e., silts and clays) represent potentially important releases to the water column and downstream areas. The process of moving the sediments from the river bottom to the water column is referred to in the following discussion as "resuspension." The downstream movement of resuspended material away from the dredge head is referred to in this discussion as "downstream transport." Notably, it is the amount of downstream transport and not simply the amount of resuspension which ultimately determines the impacts to areas downstream.

Because the processes of resuspension and downstream transport are so closely linked, the term "resuspension": is used throughout the main body of this responsiveness summary to refer to the entire process of resuspension and downstream transport.

A brief summary of related FS assessments is followed by a discussion of the relationship between suspended sediment concentrations and downstream contaminant transport. The role of silt curtains in this transport process is also addressed. Available field data including the data referenced in a number of FS comments are summarized. Existing resuspended sediment source strength models are addressed in light of these data.

RELATED FS ASSESSMENTS

Appendix E.6 provides a comprehensive assessment of sediment resuspension, PCB release, and downstream transport estimates for the proposed remedial dredging operations. This section summarizes the procedures followed and the resulting estimates.

The remedial dredging operations of the selected remedy are substantial in scope. Selecting dredging equipment capable of successfully completing the project is critical, particularly since not all dredges can satisfactorily accomplish the project goals under the given Site conditions and project constraints. In particular, some of the smaller hydraulic dredges have inadequate pumping capacity and removal effectiveness. Significantly higher water quality impacts have been observed around these dredge types (USACE 1990; FRRAT 2000; USGS 2000).

The FS identified a conventional hydraulic cutterhead dredge and environmental bucket dredges as the most appropriate existing equipment for the project. Further, the FS suggested that a hydraulically closed bucket such as the horizontal profiler might have advantages, especially in areas where debris could be a problem. Thus, Appendix E.6 provided estimates for a conventional 12-inch diameter cutterhead suction dredge and 4-cy and 2-cy environmental bucket dredges; although a brief discussion of horizontal profiler buckets was included, only estimates for environmental buckets were used since no data on the horizontal profiler bucket were available.

For the conditions expected in the Hudson River, suspended sediment loss estimates were 0.35 percent for a conventional cutterhead dredge and 0.3 percent for an "environmental bucket."

Since resuspension characteristics are so closely tied to equipment characteristics and operation, these estimates are applicable only to these two dredge types; similarly, one should not expect any relationship between observed sediment resuspension rates from other dredge types and the selected dredge types.

The suspended sediment loss rate of 0.35 percent[1] for a conventional cutterhead dredge reflects conditions in the immediate vicinity of the dredging operation (within a few meters). The estimate results from the combination of several analyses, but is primarily based upon available field data for similar dredging operations.

First, empirical near-field source strength models developed by Hayes *et al.* (2000b) and Wu and Hayes (2000) were used to estimate the sediment resuspension rate based upon anticipated operational conditions. These models were developed solely on available water quality data from hydraulic cutterhead suction dredging operations. Hayes *et al.* (2000b) includes ranges of applicability for all parameters and clearly states that these models should not be used outside of these ranges; the models are well behaved within these ranges. However, because the operational conditions are still uncertain, it was concluded that these estimates should be verified using field data from two conventional 12-inch hydraulic cutterhead suction dredging operations; these data are described in detail below. A statistical analysis showed the highest observed instantaneous rate for this dredge type and size was 0.35 percent. Most of the observed resuspension rates were less than 0.2 percent.

Source strength models are not available for environmental bucket dredging operations. Thus, data from more conventional bucket dredging operations were the basis for estimating a 0.3 percent sediment resuspension rate. Properly sealed and operated environmental buckets should result in lower resuspension rates.

The estimates above are for fine sediment particles at the point of dredging. Some silt resuspended by the dredging operation will resettle in the immediate vicinity of the dredging operation. Published transport models for dredging operations (Kuo *et al.* 1985; Kuo and Hayes 1991) were used to estimate downstream transport of the resuspended material. Settling rates and lateral dispersion coefficients from the literature were used in the modeling efforts as described in Appendix E.6 of the FS. These models were used to estimate the mass flux of suspended sediment particles at 10 meters from the dredging operation. The flux at 10 meters was conservatively assumed to remain in suspension in perpetuity[2] and used in all other estimates of downstream suspended sediment and PCB transport. Assuming 100 percent efficiency, the production rates are 95 cy/hr and 270 cy/hr for the environmental bucket and cutterhead dredges, respectively. The downstream TSS flux for different sections of the river can be found in Table 336740-1. The fluxes are summarized for both the conventional enclosed bucket and cutterhead dredge. Mass-weighted averages of these flux rates in the three reaches result in an estimated

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[1] All sediment resuspension loss values are of the fine-sediment fraction only. Sands and larger particles will resettle immediately, even if resuspended, and not be transported downstream

[2] In reality, reductions in PCBs in the water column will occur at greater distances downstream due to further settling of resuspended particles. For discrete load gain calculations, no further settling was assumed. For model calculations, no settling due to the dredging process was included. Some settling is inherent in the model algorithms.

downstream transport of 0.13 percent of the total sediment dredged for an environmental bucket dredge and 0.065 percent for a conventional hydraulic cutterhead dredge. The mass of PCB resuspended and transported downstream based on the revised estimate of total PCBs to be removed by the selected remedy (150,000 lbs) would be 200 lbs (91 kg) for environmental bucket dredges and about half that amount for a hydraulic cutterhead dredge.

TOXIC CONSTITUENT LOSSES AND TRANSPORT

Although the complexities of contaminant interactions and transformation of specific constituents are not completely understood, the basic theories associated with toxic constituent transport in surface waters are well developed. As described in Appendix A of the comments by GE (QEA *et al*., 2001), the area in the immediate vicinity of the dredging operation can likely be approximated as a well-mixed tank, often referred to as a continuous flow stirred tank reactor or (CFSTR). Suspended sediment and toxic constituent concentrations in the well-mixed water volume that can be approximated as a CFSTR can be approximated by:

Solids: $$V_{nf}\frac{dm}{dt} = qm_{in} - qm - v_s A_h m + \dot{M}_R$$

Toxics: $$V_{nf}\frac{dc}{dt} = qc_{in} - qc - kV_{NF}c - v_v A_{ws} F_d c - v_s A_h (1 - F_d)c + 10^{-6}\dot{M}_R c_{sed}$$

where:
V_{nf} = volume of the near-field area (m^3),
t = elapsed time (sec),
m_{in} = TSS concentration of flow entering the near-field volume (g/m^3),
m = TSS concentration in the near-field volume (g/m^3),
q = flow through the near-field volume (m^3/sec),
v_s = settling velocity of suspended particles in near-field volume (m/sec),
$\dot{M}_R$ = rate of mass resuspension into the near-field area due to dredging (g/sec),
c = toxic constituent concentration within the near-field volume (g/m^3),
c_{in} = toxic constituent concentration flowing into the near-field volume (g/m^3),
k = contaminant transformation rate (1/sec),
v_v = volatilization mass-transfer coefficient (m/sec),
A_{ws} = horizontal area of the near field exposed to the water surface (m^2),
A_h = horizontal area of the near field of the near-field volume (m^2),
F_d = fraction of contaminant mass in dissolved form (unitless), and
c_{sed} = contaminant concentration on bottom sediments (mg/kg).

Note that the term *qm* in the solids transport equation equates to the resuspension loss rate as defined by Hayes *et al* (2000b) as m_R. In most cases, some of these parameters can be neglected. For example, volatilization need be considered only when the near-field area extends to the water surface. Under steady-state conditions with minimal background concentrations and short retention times in the near-field zone allows the equations to be simplified to:

$$\dot{m}_R = \dot{M}_R - v_s A_h m \qquad \text{and} \qquad \dot{c}_R = 10^{-6} \dot{M}_R c_{sed} - v_s A_h F_p c_{sed}$$

Although the general approach is the same as described by QEA *et al.* (2001), Appendix A of the GE comments assumes that there is no suspended sediment transport out of the well-mixed volume. This is contrary to the basic assumption of a well-mixed water volume; if the energy is sufficiently low for all for the fine solids to settle, the volume is unlikely to be well-mixed. Observations of many dredging operations by Hayes have led to the conclusion that the well-mixed areas around active dredging operations are very small with correspondingly low detention times; flux out of this volume varies both temporally and spatially. Given a short retention time and the preferential association of toxic constituents with fine particles, it is reasonable to further assume that settling in this zone is not a major influence on contaminant water column concentrations. If so, these can be further simplified to:

$$\dot{m}_R \cong \dot{M}_R \qquad \text{and} \qquad \dot{c}_R = 10^{-6} \dot{m}_R c_{sed}$$

where $\dot{c}_R$ = mass flux of toxic constituent out of the near-field volume (g/sec).

Downstream transport is more complex, because spatial and temporal variability in current velocity and direction result in incompletely mixed transport. The general transport equations are:

$$\text{Solids: } \frac{\partial m}{\partial t} = -\nabla(um) + \nabla^2(Em) - \frac{m v_s}{h} + \dot{m}_R$$

$$\text{Toxics: } \frac{\partial c}{\partial t} = -\nabla(uc) + \nabla^2(Ec) - kc - \frac{v_v F_d c}{h} - \frac{v_s F_p c}{h} + \dot{c}_R$$

where: u = current velocity (m/sec), E = rate of diffusive transport (m^2/sec),
and $\dot{m}_R$ = mass flux of toxic constituent into the water column.

Common simplifications to this equation include steady-state conditions and neglecting either diffusive or advective transport, depending upon the value of the estuary number. Suspended solids transport models have been applied to dredging operations by several authors; Cundy and Bohlen (1980) is a classic example. Kuo *et al*. (1985) and Kuo and Hayes (1991) developed more general solutions for specific dredge types.

If concerns related to toxic transport are primarily associated with particulate concentrations, water column contaminant can be estimated from suspended solids concentrations by applying equilibrium partitioning. Given a water column TSS concentration of m, the contaminant

concentration associated with the sediment mass, c_{sed}, and an associated partitioning coefficient, K_d (m^3/g), the dissolved and particulate fractions can be estimated as:

$$F_d = \frac{1}{1+K_d m} \text{ and } \qquad F_P = \frac{K_d m}{1+K_d m}$$

or $c_d = F_d c_{sed}$ and $c_p = F_p c_{sed}$. Although this approach involves a number of simplifying assumptions, the particulate-associated concentrations should be reasonably accurate, albeit conservative. Recent observations of elevated dissolved constituent concentrations, however, suggest that a more rigorous analysis of contaminant transport, especially the dissolved component, may be needed. Dissolved constituents are of greater concern because silt curtains do not impede their transport and they are generally more bioavailable to fish and other aquatic organisms.

The approach described by QEA *et al.* (2001) assumes that no solids escape the well-mixed zone, thus downstream transport of suspended solids is unnecessary. The result, however, is that the PCBs in the water column are completely distributed in the dissolved phase since no suspended solids are available to adsorb hydrophobic PCBs.

The result of the modeling discussion in Appendix A of GE's comments proves that toxic constituent loss cannot exceed suspended sediment loss. This deduction is correct. Dissolved toxic constituent mass is of primary interest, however, since particulate-associated contaminants will predominantly resettle to the river bottom while dissolved contaminants are transported downstream and pose a much greater risk to fish and other aquatic biota. Low water-column TSS concentrations, as observed downstream of most dredging operations, result in a larger fraction of the toxic constituent mass being in the dissolved phase. Monitoring results from recent environmental dredging demonstration projects in the Fox River (WI) at Deposit N and SMU 56/57 seem to show substantial dissolved PCB loss downstream without corollary suspended sediment losses (USGS, 2000). In fact, USGS (2000) reports higher suspended sediment concentrations existed upstream from SMU 56/57 dredging operations than downstream. However, a review of the contaminant distribution equations in light of ambient suspended solids concentrations in the Fox River suggests this is quite unlikely.

It is useful, however, to review the conditions that might yield high dissolved toxic constituent losses to the water column. The basic dissolved constituent loss equation is:

$$R_{dissolved} = \frac{100R}{1+K_d Rh}$$

where

$$h = \frac{Q_d C_d}{q}$$

where: $R_{dissolved}$ = fraction of *in situ* toxic constituent mass loss to the water column in a dissolved form,

Q_d = dredge flowrate (m^3/sec), and

C_d = solids concentration of sediment during dredging (g/m^3).

It should be pointed out that this approach assumes the mass rate of sediment removal during dredging and the mass flow through the dredging operation are essentially equivalent. Since residuals certainly exist, the result is conservative. Figure 336740-1 shows that the highest dissolved releases occur when a combination of low production rates (resulting from low solids concentrations in the slurry and low-flow rates), significant flow through the area, and high resuspension rates. This probably explains, at least partially, the higher dissolved constituent observations during horizontal auger dredging operations. It also points to the need for caution in applying operational controls that substantially reduce dredge production rates.

Role of Silt Curtains

Silt curtains and silt screens are common appurtenances in environmental dredging operations. These consist of sections of either permeable or impermeable fabric hanging down into the water column from a floating boom. The fabric may extend into the water column as little as a meter or for the entire water depth. Sections can be connected together to form long, mostly continuous barriers. Under ideal conditions, silt curtains can contain much of the sediment resuspended by the dredging operation. QEA *et al.* (2001) imply that dissolved contaminants flow directly through the curtain, thus yielding an imbalanced contaminant distribution beyond the curtain. Although data have not been collected to prove the result, observations show that very little flow actually passes through the screen material. Instead, headloss associated with flow through small mesh results in redirection of most of the flow either around or underneath the curtain. Securing a silt curtain to the bottom is almost impossible, except in unusual circumstances. Headloss associated with flow through the curtain usually exceeds the maximum anchoring weights that can be dealt with in open water environments; as a result, the curtain lifts, redirecting much of the flow between the lifted curtain and bottom sediment. As illustrated in Figure 336740-2, even a slight current can generate enough force to lift the curtain above the bottom and allow the turbidity plume to escape.

NRC (2001) implies that when properly deployed under proper conditions, suspended sediments within the silt curtain can be considered to be at a uniform concentration and the toxic constituents at equilibrium much like a CFSTR. These conditions are mostly likely to exist when the volume within the silt curtain is small and the curtain is securely attached to the bottom sediments and completely encircles the dredging operation. However, such small enclosures require more intensive management and frequent repositioning. Thus, silt curtains are more frequently deployed in larger circles. Incomplete mixing and significant variations in suspended sediment concentrations within the curtain itself usually characterize these larger volumes.

EVALUATION OF FIELD STUDY DATA – HYDRAULIC DREDGES

Hydraulic dredges utilize mechanical action to feed sediment into a suction pipe that carries it to the surface and eventually some point of discharge. Most bottom sediments are too viscous to pump directly; thus, ambient water mixes with the sediment in the suction pipe to form a pumpable slurry.

Hydraulic dredges are quite distinguishable by the combination of mechanical actions used to guide sediment into the suction pipe. These include conventional basket-type cutterhead dredges, dustpan dredges, horizontal auger dredges, and a variety of specialized dredgeheads designed for specific purposes. For example, the dustpan dredge was designed for use in the lower Mississippi River where it could dredge a pit in the channel, then remove sediment from the pit as the river deposited it there. This minimizes dredge movement and is a very efficient sand-dredging operation in this environment. Horizontal auger dredges were initially designed for removing sewage sludge from lagoons.

These differences result in vastly different machinery and dictate that resuspension and production characteristics be considered independently for each hydraulic dredge type. This section attempts to summarize the available data by dredge type and draw conclusions related to the use of these data for estimating water quality impacts in the proposed Hudson River dredging operations.

CUTTERHEAD FIELD STUDIES

Resuspension data for cutterhead dredges have been presented by a number of authors. Hayes *et al.* (2000b) and Wu and Hayes (2000) present almost 400 observations of resuspension rates from five field studies. The characteristics of these studies are summarized in Table 336740-2.

Observed Resuspension Rates

Table 336740-2 summarizes the resulting resuspension rate values and their statistical characteristics for each field study. The results are consistent with expectations. The highest resuspension rate is from Lavaca Bay – Phase II. The combination of a small dredge with relatively low horsepower removing highly consolidated, sticky clay in a dynamic environment would be expected to be a poor combination. Small particle sizes and a relatively low production rate exacerbate the problem. New Bedford (Acushnet River) observations were also elevated (not accounting for background PCB levels) because of low dredge production, light sediments, and extensive debris. The DUBUQUE operated under almost ideal conditions in Calumet Harbor, and the resuspension rate reflects that the operation was quite effective.

The 18-inch cutterhead dredges used in the Back River (Savannah, GA) and James River (Norfolk, VA) are far larger vessels than one might deduce, based simply on their descriptive sizes. Generally, these larger dredges carry powerful hydraulic pumps capable of dredging much greater depths and transporting the sediments much larger distances. Thus, under normal conditions, the intake velocities are substantially greater; one would expect this fact alone to result in less resuspension, and these data generally support that conclusion.

Modest resuspension rates were observed, especially considering that the CLINTON (Back River) undercut a 20-foot bank (which often collapsed) using very aggressive operational tactics. As expected, the more cautious operation used by the ESSEX (James River) (McLellan, *et al.* 1989) yielded lower resuspension rates. James River sediments were likely more vulnerable to

resuspension because of their high *in situ* moisture content[3] (186 percent), especially considering that they are greater than the liquid limit (120 percent). Although sediment data are not available, the *in situ* moisture content of the Back River sediments were almost certainly between the plastic limit and liquid limit, or there probably would have a more significant difference.

Statistical Evaluation

Ideally, one would match site-specific conditions, dredging equipment, and operational methods with similar projects for which observed resuspension rates exist. The limited data currently available do not allow such a direct comparison. However, an adequate number of observations exist to draw general conclusions of observed resuspension rates for cutterhead dredging operations. Thus, it is useful to evaluate the range and frequency of observed resuspension rates.

Figure 336740-3 shows a frequency histogram of the 388 observations listed in Table 336740-2. Observed resuspension rates range from near 0 to 0.51 percent with the preponderance of values between 0 and 0.1 percent. The data have a mean of 0.11 percent with a standard deviation of 0.11 percent. Most of the observations, 282, are from the Phase II pilot study in Lavaca Bay, which has a strong influence over the data set. The data for all of the projects except Lavaca Bay have an average of 0.05 percent and standard deviation of 0.07 percent.

Observed resuspension rates used in this paper are from dredges ranging in size from 10-inch to 18-inch. The data imply that the average and range of sediment resuspension rates do not vary consistently with dredge size, except that both are lower for the larger dredge. This is probably due to higher vacuum pressures near the intake, due to large pump horsepower. Despite this seeming consistency between dredge sizes, care should be exercised in attempting to apply these resuspension values to dredge sizes outside of this range. In particular, the increase in resuspension rate for the smaller dredges is likely to be more exacerbated for other dredges. The Ellicott 370 used in the New Bedford study is more adequately powered than other types of similarly sized hydraulic dredges. For example, the Ellicott 370 has a 360 HP engine, as compared to the 175 HP engine used in the 8-inch horizontal auger dredge used later in the study. Many of the smaller specialty dredges were initially designed for dredging sewage sludge, which is much more fluid than sediments.

Water quality evaluations often focus on the possibility of exceeding regulatory criteria. These analyses require one to look at a cumulative probability distribution of observed resuspension rates. For the data presented here, a sediment resuspension rate of 0.31 percent is exceeded only 5 percent of the time ($R_{.05}$); a resuspension rate of 0.46 percent is exceeded only 1 percent of the time ($R_{.01}$). It would seem that these values should represent approximate maximums for similar cutterhead dredging operations.

It was also observed that the data fit a log-normal distribution quite well. While this is not utilized here, it provides the possibility to extend the current analysis to a risk-based assessment.

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[3] Moisture content is calculated here as the ratio of the mass of water per unit volume of wet sediments to the mass of solids per unit volume of wet sediment. Thus a sediment that was half water and half solids by weight would have a moisture content of 100 percent.

Summary of Cutterhead Data

Although more data would be helpful and the five field studies do not cover all possibilities, the presented values represent a reasonable range of sediment resuspension rates for different cutterhead dredge sizes and operating conditions. By matching dredging project characteristics with these field studies, one should be able to reliably estimate resuspension rates for similar dredging equipment.

OTHER FIELD STUDIES

Several other dredging resuspension studies provide additional information. This section examines four of them – the Fox River demonstration dredging operations at SMU 56/57 and Deposit N, the New Bedford *hot spot* dredging, and GE dredging at Hudson Falls.

Fox River Dredging Demonstration Studies

Many commenters mentioned the recent Fox River SMU 56/57 and Deposit N demonstration dredging operations as providing resuspension and contaminant transport data contrary to the FS estimates. 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 of the projects. Both studies were over three months long and generated impressive data sets. Composite suspended solids samples were taken at four to five stations across 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 show 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.

These results initially seem contrary to those estimated in Appendix E.6. Closer investigation, however, shows apparent limitations in the Fox River studies. These are listed below:

- 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 (see Figure 336740-4).

- 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 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.

- The method of PCB collection is not documented, but it appears that the method represents the dissolved and suspended matter fractions inaccurately, based on the lack of change in PCB pattern across the dredging area (see Figure 336740-5). 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 porewater displacement or sediment-water exchange, should yield a gain whose pattern is similar to the filter supernatant (see Figure 336740-6). 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.

- Similarly, the total PCB concentration of the suspended matter doubles, yet there is no change in the suspended matter loading (see Figures 336740-7 and 336740-8). 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.

- 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 (see Figure 336740-9). 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') 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 pre-dredging (*i.e.*, “natural”), and during dredging also contributes to the uncertainty evaluating dredging surface water contributions.

- 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.

Although substantial data sets resulted from the Fox River dredging demonstration projects, the sampling approach and compositing strategy 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 from any future dredging operations.

More importantly, however, the dredges used in the Fox River studies are entirely different from those proposed for the Hudson River remedial dredging. An 8-inch Moray Ultra dredge was used in the Deposit N demonstration project and for 7 to 14 days during the SMU 56/57 project. A horizontal auger dredge completed the SMU 56/57 dredging. The equipment characteristics and operation of both dredges are substantially different from those proposed for the Hudson River remedial dredging. There is no reason to believe that their resuspension characteristics are in any way related to those of either a conventional hydraulic cutterhead suction dredge or an environmental bucket dredge. In fact, the New Bedford pilot study compared the sediment resuspension characteristics of a horizontal auger dredge with a conventional hydraulic cutterhead suction dredge and found a disparity similar to that observed between the Fox River data and the estimates in the FS.

New Bedford Harbor Hot Spots

Under Superfund, the sediments of New Bedford Harbor were identified as a significant source of PCBs to the environment as such remediation via dredging was selected as the selected remedy. In 1994-1995, a portion of these sediments, identified as hot spots were removed from the harbor and stored in an upland facility (see Figure 336740-10). Approximately 14,000 cubic yards of sediment were removed. Waterborne PCB concentrations recorded during the outgoing tide at a downstream location (Coggeshall Bridge) served as a measure of the mass of PCBs released to the bay as a result of dredging. This location was sufficiently far away from the dredging area such that water column concentrations of re-released PCBs were probably homogeneous. Water column measurements were made throughout the dredging period. It was estimated that 57 kg of PCB escaped the inner harbor area. This included background PCB levels as well as any PCBs resuspended from the dredging. Measurements of the removed sediments themselves were also performed as part of treatability studies. These results indicate that the dredged sediments had an approximate PCB concentration of 5,000 mg/kg, or about 0.5 percent PCB by weight.

Using these results, it is possible to estimate a dredging “loss rate” by taking the ratio of PCBs lost to PCBs removed. The estimated PCB mass removed was 43,733 kg; thus, the estimated loss was 57/43,733 or 0.13 percent. This is substantially less than the 2.2 percent estimated from the Fox River work. It is also likely that this value is more representative of long-distance transport

since the monitoring location was sufficiently far from the dredge area that any rapidly settling particles were not captured by the monitoring samples.

The conditions at this location were also more extreme than those found on the Hudson, thus suggesting that the New Bedford Harbor results might represent an upper-bound estimate for dredging on the Hudson. Specifically, sediments were substantially finer than those of the Upper Hudson (silts and clays at New Bedford *vs.* fine sands in the Hudson). Additionally, the sediments of New Bedford were approximately two orders of magnitude more contaminated than those on the Hudson; thus, small spills or leaks at New Bedford have the potential to re-release substantially more PCBs than a similar-sized spill on the Hudson. In addition, it should be restated that the calculation for New Bedford did not account for background PCB flux.

The New Bedford Harbor resuspension rate coincidentally is identical to the resuspension calculations done for the FS. Therefore, based on the updated estimate of total PCBs removed by the selected alternative (150,000 lbs), approximately 91 kg (200 lbs) of Total PCB would be released. Table 336740-3 summarizes the calculations for this analysis of dredging losses.

GE Dredging at Hudson Falls

The last dredging study discussed here involves the removal of Hudson River sediments around the pump house near Hudson Falls. Sediments around this structure were shown to contain percent levels of PCBs, as well as pure PCB oil. Based on a series of cores collected from the area prior to dredging, the sediment concentration of PCB is estimated at 3,670 mg/kg, or 0.367 percent PCB by weight. Dredging was accomplished by diver-directed suction hoses over a total period of about seven months (Oct.-Dec. 1977 and Aug.-Nov. 1998).

During this period, GE conducted its regular monitoring at Bakers Falls and Rogers Island. A map of the area is given in Figure 336740-11. These data can serve to estimate the net release of PCBs from the dredging effort. The supporting calculations are outlined in Table 336740-4.

This effort resulted in the removal of 1,067 tons of sediment at 0.365 percent total PCB by weight. This yields approximately 3,900 kg (8,600 lbs) of total PCB removed. Monitoring data collected by GE at Rogers Island during this period shows little direct evidence of PCB additions to the water column. However, a net contribution from dredging was estimated by estimating the gain in PCB transport between Bakers falls and Rogers Island after correcting for the load gain seen prior to the start of dredging. Based on this, approximately 14 kg of PCBs were released as a result of GE's operations. Dividing this value by the total mass removed yields a PCB mass loss rate of about 0.36 percent. At this rate the removal of 150,000 lbs of PCB would re-release approximately 540 lbs. As noted above, the FS estimate is considered conservative, erring toward a higher value than is likely to occur.

While the dredging technique used by GE is different from that selected for the Hudson by EPA, it is unlikely that the technique was radically different (*i.e.*, substantially cleaner) than that proposed by EPA. Water column concentrations (see Figure 336740-12) inside the silt curtains were frequently higher than 1,000 ng/L and hit over 2,000 μg/L on several occasions (note unit change). Yet water column concentrations at Rogers Island increased little more than 15 ng/L relative to Bakers Falls during this period; thus, little impact was seen downstream despite

creating extremely high PCB concentrations within the dredging area. Similar levels of control are anticipated for the removal selected by EPA.

Like New Bedford Harbor, the material dredged by GE had a concentration nearly two orders of magnitude more contaminated than that in the selected remedy. This again suggests that future EPA releases will be substantially smaller, since the river sediment will be less contaminated. Additionally, the GE operation took place within the moving river, just above the dam at Bakers Falls, thus documenting the ability to use silt curtains in portions of the Hudson River.

Summary of Other Field Studies

These three recent dredging projects were examined to determine a dredging loss rate. While this approach is strictly empirical, it offers some potential bounds to the issue. Monitoring at one of the dredging operations (Fox River) was considered inappropriate (*i.e.*, too close to the source) for estimating the true re-release from the sediments. The latter two dredging operations yielded similar rates of PCB release that were also similar to those calculated from EPA's dredging resuspension model. In conclusion, the empirical results from two recent dredging projects provide evidence in support of EPA's FS estimates for PCB loss during dredging.

EVALUATION OF FIELD STUDY DATA – BUCKET DREDGES

Similar amounts of data are available from bucket dredging studies, but these data have not been as extensively evaluated as those from cutterhead dredges. The proximity of the data to the source is also not as convenient as for the cutterhead dredging operations; the operation of bucket dredges make it difficult to get data in the immediate vicinity of the source. There are, however, sufficient data to develop representative resuspension rate values for bucket dredging operations. Since all data are away from the immediate vicinity of the dredging operation, it is assumed that all particles larger than 74 μm have already settled (see equation (1), below). Thus, the resuspension rate was not adjusted for this fraction.

Standard (Open) Clamshell Buckets

A number of field studies have used standard clamshell buckets; these are often referred to as "open" buckets to distinguish them from buckets that are fully enclosed in an attempt to reduce turbidity. These data have been reported and analyzed by a number of authors. Table 336740-5 summarizes the studies used in this paper to estimate resuspension rate values.

Kuo and Hayes (1991) used average sediment-loss rates from the Thames River, St. Johns River, and Black Rock Harbor to calibrate their transport model for bucket dredging operations. Sediment loss rates for these studies are shown in Table 336740-5. Sediment loss rates for the Thames River and Black Rock Harbor are the same as those presented by Kuo and Hayes (1991). Sediment loss rates for the St. Johns River, however, were adjusted for what appears to be an error in the initial concentration used by Kuo and Hayes. Collins (1995) estimates the source strength to be 0.45 kg/sec rather than the 0.31 kg/sec published by Kuo and Hayes. Since an earlier version of Collins' report was the source of this value, it is assumed to be in error. This increases the sediment loss rate to 0.16 percent, more in line with the other studies.

A study of open clamshell dredging in the Calumet River (Hayes *et al.*, 1988) also included scow overflow. Collins (1995) calculated a sediment loss rate of 243 g/sec for the Calumet River field study. Although a production rate is not provided, assuming a full bucket and 50 cycles per hour, the production rate would be 380 m^3/hr. Assuming that the sediment characteristics are the same as those found in the Calumet Harbor field study (*in situ* concentration of 920 kg/m^3), the resulting loss is 0.25 percent.

All of these dredging operations included scow overflow; that is, the sediment scow was filled beyond the initial filling to displace supernatant liquid with sediment and increase the economic load. The supernatant overflows the barge and discharges solids into the water column, thus increasing TSS concentrations in the water column; once in the water column, these solids are not distinguishable from resuspension due to mechanical actions of the dredge.

Hayes *et al*. (2000a) present results from a dredging study in Boston Harbor conducted during 1999. Scow overflow was not allowed during these dredging operations; thus, measured sediment resuspension values result from dredging actions only. The conventional 26-cy bucket removed about two feet of silt plus a foot or so of virgin clay from the 38-ft bottom. The production rate is assumed to be about 1,530 m^3/hr, based upon the dredge operation and bucket capacity. TSS observations during dredging yield a depth-averaged TSS concentration above background of 201 mg/L. The width of the plume was not measured. Considering the short distance between the bucket and sampling location, it is unlikely to be more than twice the bucket width of about three m. Assuming that concentration occurs across a six-m width in a current velocity of 0.17 m/sec, the source strength is about 2.4 kg/sec. Assuming an *in situ* sediment concentration of 844 kg/m^3, the sediment lost to resuspension was 0.66 percent.

All of these studies show higher resuspension rates than the cutterhead dredge studies described previously. Resuspension rates range from 0.16 to 0.66. The results for the Boston Harbor field study are surprising in that they are among the highest value, even though barge overflow was not allowed. The other values seem to be in a reasonable range, particularly considering that barge overflow was included. If overflow accounts for 50 percent of the suspended sediments, the remaining resuspension rates are not substantially different from those for the cutterhead dredges.

The apparent increase in resuspension rate for Boston Harbor may result from the samples being collected much closer to the actual dredging location (within two to seven meters) than in the other studies. TSS concentrations at the source for the other studies were extrapolated from samples collected farther downstream. A substantial amount of the TSS in the Boston Harbor study was near the bottom; without that value, the average TSS concentration and source strength would have been reduced by 30 percent, yielding a resuspension rate of about 0.47. This is much more in line with the other studies. It is likely that these additional solids would have settled in the near vicinity of the dredging operation and not been measured in downstream samples as taken in the other studies.

Resuspension rate values from the open clamshell bucket dredges show a strong relationship with water depth (Figure 336740-13). This substantiates previous theories that sediment erosion from the top of the bucket as it moves upward is a primary resuspension mechanism for standard clamshell buckets.

Enclosed Clamshell Buckets

Data are available for two bucket dredging studies that used enclosed clamshell buckets. The first study was conducted in the St. Johns River at the same location and under the same conditions as the open bucket dredging study described above. Collins (1995) did not estimate source strength for the enclosed bucket operation in the St. Johns River, but did report an estimated TSS concentration at the bucket location of 150 mg/L. The estimated TSS concentration at the open bucket was 285 mg/L; since the conditions are the same, the resuspension rate is proportional. Thus, the representative resuspension rate for the enclosed bucket during the St. Johns River study was 0.27 kg/sec and a sediment loss rate of 0.10 percent. The resulting resuspension rate is 1,000 and includes bucket overflow.

The most recent data were collected in Boston Harbor in August 1999 (Hayes *et al.*, 2000a) during the operation of a 39-cy enclosed bucket. The enclosed bucket was a conventional 26-cy bucket converted to an enclosed bucket with a 39-cy capacity. The bucket removed about 2 feet of sediment from the 38-ft bottom with an observed depth-averaged TSS concentration of 50 mg/L. Assuming that concentration occurs across a six-m width in a current velocity of 0.17 m/sec the source strength is about 0.66 kg/sec. The dredge production was about 2,000 cy/hr. Assuming an *in situ* sediment concentration of 844 kg/m^3, the sediment lost to resuspension is 0.22 percent. The associated resuspension rate is 0.22.

EVALUATION OF SOURCE MODELS

Nakai's Source Models

Nakai (1978) proposed the popular TGU method. Nakai's initial formulation and variable definitions were:

$$TGU = \frac{KW_O}{Q_S} = \left(\frac{R_{74}}{R_O}\right)\frac{W_O}{Q_S} = KCg \qquad (1)$$

where:
W_o = total quantity of turbidity generated by dredging (tons),
C = coefficient depending upon dredge type, soil conditions, etc.,
W_s = total quantity of dredged materials (tons),
TGU = turbidity generation unit, tons/m^3,
Q_s = volume of dredged materials (m^3),
$\tilde{a}$ = specific weight of dredged materials (tons/m^3),
$K = R_{74}/R_O$,
R_{74} = fraction of particles with a diameter smaller than 74 m, and
R_O = fraction of particles with a diameter smaller than the diameter of a particle whose critical resuspension velocity equals the current velocity in the field.

Since the immediate interest is in using Nakai's approach to estimate the source strength, the appropriate equation form is:

$$W_O = \frac{TGU(Q_S)}{(R_{74} / R_0)} = TGU\left[\left(\frac{R_O}{R_{74}}\right)Q_S\right] \tag{2}$$

At this point, Nakai redefined W_O as the rate of turbidity generation in kg/sec rather than the units of tons as he did in the previous equation. This requires Q_s also be redefined as the volumetric rate of sediment removal (m^3/sec). Although easy to use, the R_0Q_S/R_{74} term has fundamental problems. First, there is the issue of incompatibility between the weight-based fractions R_0 and R_{74} and the volumetric flowrate Q_S. While troublesome, the gross nature of what is trying to be accomplished minimizes its impact. The term R_0Q_S, as defined by Nakai, represents the sediment mass (or volume) with a settling velocity sufficiently low that they will theoretically stay in suspension forever. While there are difficulties with the practicality of defining R_0, the concept is theoretically sound. However, the $1/R_{74}$ term increases as the average particle size increases (*i.e.* R_{74} decreases), thereby adjusting the rate of resuspension in the wrong direction.

Nakai determined W_O during dredging operations by measuring TSS along laterals normal to flow at 30 m and 50 m downstream from the dredging operation; the original manuscript describes the approach in detail, but does not provide details of the dredging projects investigated. He calculated the total mass of turbidity as:

$$W_O = C_{avg}BHU \tag{3}$$

where: C_{avg} = average concentration of TSS (kg/m^3),
B = width (m),
H = water depth (m), and
U = water velocity (m/sec).

Empirical Source Models

Several authors have developed empirical source strength models for cutterhead dredges that consider dredge-operating parameters (Hayes 1986; Crockett 1993; Hayes, *et al* 2000b; and Wu and Hayes 2000). The latest versions of these models, based upon 387 observations from a number of dredging sites, are:

$$DM: \qquad \hat{g}(\%) = \frac{(C_S t_C)^{0.676} V_S^{\ 2.008}}{10^{3.647} L_S^{\ 13.899}} \left(\frac{A_E}{d_C}\right)^{14.575} \left(\frac{Q}{D^2}\right)^{0.805} \tag{4}$$

$$NDM: \quad \hat{g}(\%) = 10^{-3.3293}\left(\frac{A_E}{L_S d_C}\right)^{13.503}\left(\frac{Q}{D^2 V_S}\right)^{0.388} \tag{5}$$

where: $\hat{g}$ = predicted rate of sediment suspended by the cutter and transported away from the dredging operation as a fraction of sediment mass dredged (%),
C_S = *in situ* sediment concentration (g/L),
t_C = thickness of cut (m),
A_E = cutter surface exposed to free water (m^2),
V_S = swing velocity at the tip of the cutter (m/sec),
d_C = diameter of cutter (m^2),
Q = volumetric flow rate through dredge (m^3/sec),
L_s = dredge stepping distance (m); and
D = sediment inlet pipe diameter (m).

The modified *DM* model, which is based upon the individual variables that affect dredging operations, resulted in an R^2 value of 0.588. An R^2 value of 0.470 was determined for the modified *NDM* model, which is based upon non-dimensional groups of the same variables. Although these models are empirically sound, they have several substantial drawbacks: a) they apply only to conventional cutterhead suction dredges, b) the forms of the empirical equations do not allow reliable extrapolation beyond the range of data used to develop them (12-inch to 20-inch dredges), and c) the equations require more knowledge of the dredging operation than is usually known prior to the initiation of dredging. Most readers trying to apply the models lack the knowledge of dredging operations to make reasonable estimates of the operating parameters.

Collins (1995) developed models to estimate the dredging-induced resuspended sediment concentrations near the dredge as a function of the dredge, dredge operation characteristics, and sediment properties. An approach similar to the empirical models shown in equations 4 and 5 was used to develop models for cutterhead and bucket dredging operations. However, these models also require considerable knowledge of the dredging operation and Collins described them as preliminary, unverified models.

OPERATIONAL CONTROLS

Operational controls are popular for environmental dredging projects. Hydraulic dredges, in particular, often have limits on swing speed, cutter rotation speed, and cutting depth imposed. Controls on mechanical dredges are often in the form of limits on bucket fall and raise velocities and total cycle speeds. Both types of restrictions result in lower production rates as a tradeoff in an attempt to reduce water quality impacts. Both are based upon research showing that these operational factors influence sediment resuspension and, probably, toxic constituent releases.

A closer look at the research shows that the concerns arise from extreme operating parameters and that normal operational ranges do not typically result in disproportionate increases in sediment resuspension. It is also not clear that such controls result in an overall decrease in toxic constituent release. For example, increasing the raising speed of a dredge bucket increases the acceleration force applied to sediments in the bucket. Leakage of sediment-laden water from the

bucket likely increases due to this acceleration. However, the leakage occurs for a shorter period and it is possible that a longer raising time could result in more mass release into the water column. In essence, an inappropriate operational control for bucket dredges could increase the total mass released during a removal operation. Operational controls for hydraulic dredges tend to reduce the concentration of sediment being pumped from the site. Reduced production rates decrease the productivity of the dredging operation, increase the water that must be treated, and, as shown in Figure 336740-1, may increase the dissolved contaminant release.

Operational controls are an effective means to ensure that careless dredge operation does not lead to excessive losses. Operational controls should focus on avoiding extreme conditions and encouraging "typical" operations that are more efficient.

SUMMARY

After carefully considering the comments received on dredging, EPA concludes that the information contained in or referred to by those comments does not justify increasing or decreasing the sediment resuspension estimates contained in Appendix E.6 of the FS. The estimates of resuspension at the dredgehead of 0.3 percent for mechanical dredges and 0.35 percent for cutterhead dredges are well supported by the above discussion. The associated downstream transport estimates of 0.13 and 0.065 percent, respectively, represent conservative estimates of the potential releases due to dredging and are consistent with direct observations made on several sites.

REFERENCES

Bohlen, W.F., Cundy, D.F., and Tramonano, J.M. 1979. "Suspended material distributions in the wake of estuarine channel dredging operations," *Estuarine and Coastal Marine Sci*., 9, pp. 699-711.

Collins, M.A. 1995. "Dredging-Induced Near-Field Resuspended Sediment Concentrations and Source Strengths," *Miscellaneous Paper D-95-2*, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Crockett, T.R. 1993. "Modeling Near Field Sediment Resuspension in Cutterhead Suction Dredging Operations," M.S. Thesis, University of Nebraska-Lincoln, Lincoln, NE.

Cundy, D.F. and Bohlen, W.F. 1980. "A Numerical Simulation of the Dispersion of Sediments Suspended by Estuarine Dredging Operations," *Estuarine and Wetland Processes*, Hamilton and McDonald, eds., Marine Science 11, Plenum Press, New York, pp 339-352.

Fox River Remediation Advisory Team (FRRAT). 2000. "Evaluation of the Effectiveness of Remediation Dredging: The Fox River Deposit N Demonstration Project; November 1998 – January 1999," Special Report WRI SR 00-01, Water Resources Institute, University of Wisconsin-Madison, Madison, WI.

Hayes, D. 1986. "Development of a Near Field Source Strength Model to Predict Sediment Resuspension from Cutter Suction Dredges," M.S. Thesis, Mississippi State University, Starkville, MS.

Hayes, D., McLellan, T., and Truitt, C. 1988. "Demonstrations of Innovative and Conventional Dredging Equipment at Calumet Harbor, Illinois", *Miscellaneous Paper EL-88-1*, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Hayes, D.F., Borrowman, T., and Welp, T. 2000a. "Near-Field Turbidity Observations During Boston Harbor Bucket Comparison Study," *Proceedings of WEDA XX*, Providence, RI, June 2000.

Hayes, D.F., Crockett, T.R., Ward, T.J., and Averett, D. 2000b. "Sediment Resuspension During Cutterhead Dredging Operations." *Journal of Waterway, Port, Coastal, and Ocean Engineering*, 126(3), May/June 2000, ASCE.

Kuo, A., Welch, C., and Lukens R. 1985. "Dredge Induced Turbidity Plume Model," *ASCE Journal of Waterway, Port, Coastal, and Ocean Engineering*, Vol. 111, No. 3.

Kuo, A.Y. and Hayes, D.F. 1991. "A Model for Turbidity Plume Induced by Bucket Dredge," *ASCE Journal of Waterways, Port, Coastal, and Ocean Engineering*, November 1991.

McLellan, T., Havis, R., Hayes, D., and Raymond, G. 1989. "Field Studies of Sediment Resuspension Characteristics of Selected Dredges," *Technical Report HL-89-9*, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Nakai, O. 1978. "Turbidity Generated by Dredging Projects," *Proceedings of the 3rd U.S./Japan Experts Meeting*, US Army Engineer Water Resources Support Center, Ft. Belvoir, VA.

National Research Council. 2001. *A Risk-Management Strategy for PCB-Contaminated Sediments*, National Academy Press, Washington, DC.

QEA, BBL, and Applied Environmental Management, Inc. 2001. "Assessment of Sediment Resuspension and PCB Release During Dredging Activities," Appendix A, Comments Of General Electric Company On The Feasibility Study And Proposed Plan For The Hudson River PCBs Superfund Site (December 2000). April.

USACE. 1990. "New Bedford Harbor Superfund Pilot Study: Evaluation of Dredging and Dredged Material Disposal," US Army Corps of Engineers, New England Division, May.

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

Wu, P.Y. and Hayes, D.F. 2000. "Verification and Enhancement of TSS Source Strength Models for Cutter Dredges," *World Dredging, Mining, and Construction*, August.

Human Health and Ecological Risk Reduction Under Phased Implementation

363176

WHITE PAPER – HUMAN HEALTH AND ECOLOGICAL RISK REDUCTION UNDER PHASED IMPLEMENTATION

(ID 363176)

ABSTRACT

Risks to human health (cancer and non-cancer) and ecological receptors (river otter and mink) were calculated for the selected remedy, REM-3/10/Select, assuming four scenarios: 1) a five-year dredging schedule with no resuspension (same as Feasibility Study and Proposed Plan); 2) a five-year dredging schedule with 0.13 percent loss of PCBs due to resuspension; 3) a six-year dredging schedule with 0.13 percent resuspension loss (base case); and 4) a six-year dredging schedule with 2.5 percent resuspension loss. Cancer risks, non-cancer health hazards, and ecological toxicity quotients are essentially the same for all four scenarios. In addition, the modeling shows essentially no difference among the four scenarios with respect to meeting risk-based remediation goals and other target concentrations of PCBs in fish are met. These results indicate that implementing the selected remedy in two phases over six years does not change the relative risk reduction of the selected remedy from that presented in the Feasibility Study and Proposed Plan. The modeling also shows that, for the remediation goals and other target concentrations that are achieved by 2067 (the extent of the modeling period), the concentrations in fish are reached one or two years later assuming 2.5 percent resuspension loss, compared to assuming no resuspension or 0.13 percent resuspension loss.

INTRODUCTION

This white paper presents the risks to human health (cancer and non-cancer) and ecological receptors (river otter and mink) for the selected remedy, REM-3/10/Select, under four different scenarios. These scenarios evaluate the effects of EPA's decision to implement the selected remedy in two phases over six years rather than in a single phase over five years as described in the Feasibility Study and Proposed Plan. The scenarios also show the effect of different rates of PCB loss due to resuspension on the calculated risk reductions. See White Paper – Resuspension of PCBs during Dredging for additional information on resuspension. Specifically, the four scenarios and their model run designations (e.g., R14S2) are as follows:

- Five-year dredging schedule, no resuspension, same as Feasibility Study and Proposed Plan (R14S2).
- Five-year dredging schedule, 0.13 percent loss of PCBs due to resuspension (R14RS).
- Six-year dredging schedule, 0.13 percent resuspension, base case (R20RS).
- Six-year dredging schedule, 2.5 percent resuspension (R20RX).

The risk assumptions, locations, toxicity values, and receptors used in this White Paper are the same as those used in the Feasibility Study. Risks were calculated with exposure durations (*e.g.*, 40 years for evaluating cancer risks to the reasonably maximally exposed (RME) adult angler, 7 years for evaluating non-cancer health hazards to the RME adult angler, and 25 years for river otter and mink) beginning one year after the year in which dredging will be completed in each

river section. Thus, under the modeling assumption that dredging would begin in 2004, risks were calculated beginning in 2008 (five-year scenarios) and 2009 (six-year scenarios) for River Section 1 (RM 189), beginning in 2009 (five-year scenarios) and 2010 (six-year scenarios) for River Section 2 (RM 184), and beginning in 2010 (five-year scenarios) and 2011 (six-year scenarios) for River Section 3 (RM 154). (Note: EPA now expects dredging to commence in 2005. Initiating dredging in 2005 would not be expected to significantly affect modeling projections or the comparative analysis of alternatives.) Exposure durations for the Upper Hudson River as a whole begin in 2009 (five-year scenario) and begin in 2010 (six-year scenario), the mean of the years in which dredging will be completed over the entire 40-mile stretch of the Upper Hudson River.

See White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River for additional information regarding modeling of PCB concentrations in fish in the Upper Hudson. See White Paper – Relative Reduction of Human Health and Ecological Risks in the Mid- and Lower Hudson River for relative risks below the Federal Dam at Troy.

Human Health

Table 363176-1 presents the annual average PCB concentration in species-weighted fish fillet for River Sections 1, 2 and 3 and for the Upper Hudson River (length-weighted) for the modeling period (i.e., 1998-2067). The exposure point concentrations for species-weighted fish fillet used in the human health calculations are shown in Table 363176-2 (Upper Hudson average and by river section).

Cancer Risks

As shown in Table 363176-3, there is essentially no difference among the four scenarios in the cancer risks for the RME adult angler. The cancer risks are either 2.0×10^{-4} or 2.3×10^{-4} in River Section 1 for all scenarios, are either 1.6×10^{-4} or 2.0×10^{-4} in River Section 2 for all scenarios, and range from 4.3×10^{-5} to 5.5×10^{-5} in River Section 3 for all scenarios. Cancer risks for the entire Upper Hudson River range from 8.2×10^{-5} to 9.9×10^{-5} for all scenarios.

The cancer risks for the central tendency (CT), or average, adult angler are lower than those for the RME adult and also show essentially no difference among the four scenarios (see Table 363176-3).

Non-Cancer Health Hazards

As shown in Table 363176-4, there is very little difference among the four scenarios in the non-cancer health hazards for the RME adult angler. The Hazard Indices (HIs) are either 13 or 15 in River Section 1 for all scenarios, range from 13 to 17 in River Section 2 for all scenarios, and range from 3 to 5 in River Section 3 for all scenarios. The HIs are either 6 or 8 averaged over the entire Upper Hudson for all scenarios.

The HIs for the CT adult angler are lower than those for the RME adult and also show essentially no difference among the four scenarios (see Table 363176-4).

Time to Reach Human Health Risk-Based Concentrations in Fish

As shown in Table 363176-5, there is essentially no difference among the four scenarios in the time to reach human health risk-based concentrations of PCBs in fish. In River Sections 1, 2, and averaged over the entire Upper Hudson, the remediation goal (RG) of 0.05 mg/kg PCBs (wet weight) in species-weighted fish fillet is not met by 2067, which is the extent of the modeling time period, for all scenarios due to the continuing upstream source of PCBs. In River Section 3, the RG of 0.05 mg/kg is met in 2051 for all scenarios. Note that the scenarios presented here and in the Feasibility Study all assume an upstream boundary water column Tri+ PCB load of 0.16 kg/day from 1998 to 2004, followed by a step-down reduction to 0.0256 kg/day on January 1, 2005. Should the upstream load be reduced to zero, the RG of 0.05 mg/kg PCBs in fish fillet would be met in each river section within the model forecast period (see White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River).

The 0.2 mg/kg target concentration is not met by 2067 in River Section 1 for all scenarios, is met in 2040 in River Section 2 for all scenarios, is met in either 2014 or 2015 in River Section 3 for all scenarios, and is met in 2024 averaged over the entire Upper Hudson for all scenarios. The 0.4 mg/kg target concentration is met in 2025 in River Section 1 for all scenarios, is met in 2024 in River Section 2 for all scenarios, is met in either 2010 or 2011 in River Section 3 for all scenarios, and is met in 2012 averaged over the entire Upper Hudson for all scenarios (see Table 363176-5).

Reduction in Short-Term Risks

Short-term risks to humans will be reduced through a Site-specific health and safety plan, appropriate monitoring, and institutional controls such as fish consumption advisories and fishing restrictions. A qualitative comparison among the four different scenarios of the selected remedy with respect to short-term cancer risks and non-cancer health hazards from ingestion of fish can be made based on the modeling of PCB concentrations in fish (species-weighted fish fillet) performed to estimate long-term effects. The short-term period begins in 2004 and ends one year after the year in which dredging will be completed in each river section. Specifically, the short-term period ends in 2008 (five-year scenarios) and 2009 (six-year scenarios) for River Section 1 (RM 189), ends in 2009 (five-year scenarios) and 2010 (six-year scenarios) for River Section 2 (RM 184), ends in 2010 (five-year scenarios) and 2011 (six-year scenarios) for River Section 3 (RM 154), and ends in 2009 (five-year scenarios) and 2010 (six-year scenarios) for the entire Upper Hudson.

As shown in Table 363176-5, the modeling predicts essentially no difference among the four scenarios in the short-term period. Only the 0.4 mg/kg target concentration in River Section 3 is met in the short term for all scenarios. The 0.2 mg/kg target concentration and the 0.05 mg/kg RG are not met in the short term for all the scenarios in each river section or averaged over the entire Upper Hudson.

Ecological Receptors

The PCB concentrations in largemouth bass (whole fish), which were used to calculate risk to the river otter, are shown in Table 363176-6 by river section and averaged over the Upper Hudson.

The PCB concentrations in spottail shiner that were used to calculate risk to the mink are shown in Table 363176-07 by river section and averaged over the Upper Hudson.

Ecological Toxicity Quotients

As shown in Table 363176-8, there is essentially no difference among the four scenarios in the ecological risks to the river otter and mink. The Toxicity Quotients (TQs) for the river otter are 5 (lowest-observed-adverse-effect-level [LOAEL] basis) and 50 or 52 (no-observed-adverse-effect-basis [NOAEL] basis) in River Section 1 for all scenarios; 3 (LOAEL basis) and range from 28 to 30 (NOAEL basis) in River Section 2 for all scenarios; and less than 1 (LOAEL basis) and range from 8 to 9 (NOAEL basis) in River Section 3 for all scenarios. The TQs for the river otter are 2 (LOAEL basis) and 17 or 18 (NOAEL basis) averaged over the entire Upper Hudson.

The TQs for the mink are lower than those for the river otter and also show essentially no difference among the four scenarios (see Table 363176-8).

Time to Reach Ecological Risk-Based Concentrations in Fish

As shown in Table 363176-9, the modeling predicts essentially no difference among the four scenarios in the time to reach ecological risk-based concentrations of PCBs in fish. In River Sections 1 and 2, PCB concentrations in largemouth bass (whole body) are not within the ecological remediation goal (RG) range of 0.03 to 0.3 mg/kg (based on the NOAEL and LOAEL for the river otter) by 2067, which is the extent of the modeling time period for all scenarios, due to the continuing upstream source of PCBs. In River Section 3, PCB concentrations in largemouth bass are within the RG range in 2019 or 2020 for all scenarios. Averaged over the entire Upper Hudson, all scenarios of the selected remedy are within the RG range of 0.03 to 0.3 mg/kg in 2035.

As noted above, the four scenarios of the selected remedy evaluated in this white paper assume that the upstream boundary water column Tri+ PCB load is reduced to 0.0256 kg/day on January 1, 2005. Should the upstream load be reduced to zero, the RG range of 0.03 to 0.3 mg/kg PCBs in whole fish would be met in each river section within the model forecast period (see White Paper – Model Forecasts for Additional Simulations in the Upper Hudson River).

The ecological RG of 0.03 to 0.3 mg/kg PCBs in largemouth bass (whole body) developed for the river otter, the piscivorous mammal calculated to be at greatest risk from PCBs, is considered to be protective of all the ecological receptors evaluated. In addition, a range of 0.07 to 0.7 mg/kg PCBs in spottail shiner (whole fish) was developed based on the NOAEL and LOAEL for the mink, which is a species known to be sensitive to PCBs. As shown in Table 363176-9, the modeling predicts essentially no difference among the four scenarios in the time to reach the range developed for protection of the mink.

Reduction in Short-Term Risks

Short-term, temporary impacts to aquatic species and wildlife habitat of the Upper Hudson will be reduced through appropriate mitigation measures and monitoring. A qualitative comparison

among the four scenarios of the selected remedy with respect to short-term ecological risks can be made based on the modeling of PCB concentrations in fish (largemouth bass and spottail shiner) performed to estimate long-term effects. The short-term period begins in 2004 and ends one year after the year in which dredging will be completed in each river section, as described above.

As shown in Table 363176-9, there is essentially no difference among the four scenarios in the short-term period. The RG range of 0.03 to 0.3 mg/kg in largemouth bass (whole body) based on the river otter is not met in the short term for all the scenarios in each river section and averaged over the entire Upper Hudson. The range of 0.07 to 0.7 mg/kg PCBs in spottail shiner (whole body) based on the mink is met in the short-term for all scenarios in River Sections 2 and 3 and averaged over the entire Upper Hudson.

CONCLUSIONS

Cancer risks, non-cancer hazard indices, and ecological toxicity quotients show very little or no difference among the four scenarios of the selected remedy. Similarly, the modeling shows essentially no difference among the four scenarios with respect to meeting remediation goals and other target concentrations of PCBs in fish. These results indicate that implementing the selected remedy in two phases over six years rather than in a single phase over five years does not change the relative risk reduction provided by the selected remedy from that presented in the Feasibility Study and Proposed Plan. The modeling also shows that, for the remediation goals and other target concentrations that are achieved by 2067 (the extent of the modeling period), the concentrations in fish are reached one or two years later assuming 2.5 percent resuspension loss, compared to assuming no resuspension or 0.13 percent resuspension.

ENGINEERING FEASIBILITY

Example Sediment Processing/Transfer Facilities
253216

WHITE PAPER – EXAMPLE SEDIMENT PROCESSING/TRANSFER FACILITIES

(ID 253216)

ABSTRACT

In order to reduce the transportation cost and meet the disposal requirement for moisture content, the construction of sediment processing/transfer facilities at suitable sites is necessary to process the dredged sediment.[1] In this white paper, conceptual facility layouts for processing the mechanically dredged sediment and the hydraulically dredged sediment are discussed.

For mechanically dredged sediment, processing will include barge unloading, treatment of excess water, removal of large debris, chemical stabilization, transfer to rail car loading area, and rail load-out. The water treatment would consist of coagulation/flocculation, filtration, and granular activated carbon (GAC) treatment.

For hydraulically dredged sediment, the slurry will be equalized before the dewatering process. Vibrating screens and hydrocyclones will remove the debris and large sandy particles, and the coagulation/flocculation process will remove the fine particles from the slurry stream. The settled solids will be dewatered and the supernatant will be treated in a water treatment unit before discharge to the river. All the solids would be loaded onto rail cars for off-site disposal. The preliminary design of unit processes is also included in this paper.

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[1] It is important to note that EPA has not yet determined the location(s) of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the Feasibility Study, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the Upper Hudson River valley and farther downstream, are possible.

The example facility locations presented in the Feasibility Study have also been used in the Responsiveness Summary in order to clarify material presented in the Feasibility Study and Proposed Plan and in connection with additional noise, odor and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after EPA performs additional analyses and holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, all information provided in this Responsiveness Summary relative to potential impacts of the sediment processing/transfer facilities on communities, residents, agriculture, the environment and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during design.

INTRODUCTION

The construction of sediment processing/transfer facilities is necessary to process the dredged sediments and ship them off-site for disposal. For the purpose of this study, two example locations were identified: a northern sediment processing/transfer facility (NTF) and a southern sediment processing/transfer facility (STF).

The NTF site is, for the sake of this analysis, assumed to be located in the vicinity of the Old Moreau Dredge Spoil Area. The existing site features are shown in Figure 253216-1. While this site has existing rail access, it may require access dredging for barge traffic. The site may be used for mechanical as well as hydraulic sediment processing/transfer operations. The nearest residential properties were identified using aerial photographs.

The STF is, for the sake of this analysis, assumed to be located in the industrial area near the Port of Albany. The site may only be considered for mechanical dredging because of its location (*i.e.*, about 40 miles from Thompson Island Pool [TI Pool]). The site has existing rail and barge access facilities. Site features are shown in Figure 253216-2. The nearest residential properties surrounding the site were identified using aerial photographs.

Both mechanical and hydraulic dredging were evaluated in the FS. Therefore, considering the different characteristics of dredged sediment, the layout of sediment processing/transfer facility will be discussed.

Mechanical Dredging Option

Hopper and/or deck barges will be used to transport the mechanically dredged sediments to the processing/transfer facilities. Barges delivering dredged sediments to the processing/transfer facilities will be secured at an existing or newly constructed wharf or dock. Material in the barges will be unloaded by an excavator. Prior to unloading barges, excess water that has accumulated above the incoming sediments will be pumped off, treated, and discharged back to the river. The water treatment process will include a series of filtration units for solids removal and activated carbon adsorption columns for dissolved PCB removal. It is expected that most of the excess water (*i.e.*, water entrained during dredging operations) will be recovered and treated by this means.

Once the dredged material has been off-loaded, it will be discharged into a hopper through a series of racks and screens that remove larger debris. The dredged material will then be blended with Portland cement (or other similar stabilizing agent) in a pug mill. Stabilized sediments will then be placed into a temporary staging area prior to being loaded into trucks (if necessary) by either conveyors or front-end loaders for delivery to the rail car loading area. At the rail car loading area, the sediment will be placed on the concrete pad and then loaded into the rail cars by front-end loader. It is possible that some in-storage residence time will be required before the sediment's handling properties improve sufficiently to allow rail load-out. Stabilized sediments will be hauled off-site in covered rail gondolas.

Preliminary Design of Unit Processes

Assuming mechanical dredging (*i.e.*, 20 percent water by volume) is utilized to remove all PCB-contaminated sediments, the necessary 120,000 gallon/day water treatment plant and the associated rail transfer facility will require about 10-15 acres of land area (Montgomery, 1985). The process layout at potential northern and southern sites are shown in Figures 253216-3 and 253216-4, respectively. Assuming a water flow rate of 85 gallons per minute (gpm), the proposed processing/transfer facility will consist of:

a. Filtration

Hydraulic Loading Rate = 2 to 10 gpm/ft^2 (Vesilind, 1997)
Assume 2 gpm/ft^2 for the units
Required filter area = 85/2 = 42.5 ft^2
Assume (5 ft X 10 ft) filter beds
Number = 1

(Additional units will be provided for reliability and backups)

b. Granular Activated Carbon Treatment (GAC)

Hydraulic loading 2 to 10 gpm/ft^2 (Vesilind, 1997)
Required filter area = 85/2 = 42.5 ft^2
Assuming 5-ft diameter columns, the resulting area
$= (\pi/4) * 5^2$
$= 19.63$ ft^2
Number of GAC columns = 42.5/19.63
= 3 units

(Additional units will be provided for reliability and backups)

Hydraulic Dredging Option

The PCB-contaminated dredged sediment will be pumped from the dredging site to the sediment processing/transfer facility, where it will arrive in slurry form. As noted in the FS, the solids content of the dredged slurry is typically 10 – 20 percent by *in-situ* (or, cut) volume. Hydraulic dredging operations produce highly variable slurry flow rates and solids concentrations; therefore, direct dewatering of dredged slurries may not be suitable and temporary storage in a tank or lagoon may be necessary to equalize the flow and the solids concentration prior to the dewatering process.

The primary goal of the processing/transfer facility is to improve the material's handling properties and to reduce shipping and disposal quantities by reducing water content and, hence, weight and volume. A schematic diagram of the slurry treatment process at the potential NTF is shown in Figure 253216-5. The slurry passes through a vibrating screen to remove cobbles, large rocks, and gravel. The slurry then enters a series of hydrocyclones at high velocity and pressure through the feed port and swirls downward toward the apex. The flow reverses near the apex into

an upward direction and leaves the hydrocyclone through the overflow. Coarse particles settle rapidly toward the walls and exit at the apex through a nozzle. Fine particles are carried with the fluid to the axial overflow port.

The slurry stream, which now contains mostly fine materials, is then pumped into a coagulation/flocculation process. Chemicals, such as alum, iron salts, or polymers are added to coagulate/flocculate the suspended particles. The settled solids from this process are then dewatered using mechanical dewatering systems. Mechanical dewatering systems have been used extensively to dewater hydraulically dredged materials. A high solids-removal efficiency is desired, because solids that escape from the process represent a route for contaminant loss. However, some solids loss is inevitable; therefore, the effluent stream must be treated for further solids removal. Generally, the mechanical systems can increase the solids content up to 70 percent by weight[2], which will be adequate for subsequent transport and disposal. Dewatered solids can then be loaded onto rail cars for off-site disposal. The supernatant from the coagulation/flocculation process will be pumped to treatment (filtration) units for treatment prior to discharge to the river.

Granular activated carbon columns will be used to remove dissolved PCBs from filtered water. The treatment plant will be sized to handle the entire incoming slurry flow, as well as any additional wastewater incidental to site operation.

Solids generated by the solids separation and water treatment systems will be hauled to off-site disposal facilities. Since Hudson River PCB contamination has been associated with fine-grained sediments (predominantly silts), the coarser fraction of the slurry materials, separated by physical methods as described above, is expected to be relatively free of contamination and may be suitable for beneficial use without further processing. The viability of beneficially using this fraction will be determined during the project's design phase.

Preliminary Design of Unit Processes

As indicated in the FS, assuming hydraulic dredging is utilized to remove PCB-contaminated sediments, the necessary 8.7 MGD sediment- and water-treatment plant (Montgomery, 1985) and the rail transfer facility will require about 15 to 20 acres of land area. The conceptual process layout at the NTF is shown in Figure 253216-5. The processing/transfer facility consists of:

a. Vibrating Screen

Three vibrating screens with a total area of 216 ft^2 are selected
Slurry flow rate = 9,000 gpm
Water velocity through the screen = 9,000/(60 x 7.48 x 216) = 0.1 ft/sec

b. Hydrocyclones

18-inch diameter cyclones: Approximately 700 gpm capacity

[2] It should be noted that reductions in solids water content are characterized on a percent weight basis in the materials-processing discipline. However, dredging productivity is characterized on the basis of *in-situ* (or, cut) volume, as shown elsewhere in the white paper.

80 percent overall solids removal

Slurry flow = 9,000 gpm
Number of hydrocyclones = 9,000/700 = 13 hydrocyclones

(Additional units will be provided for reliability and backups)

c. Coagulation/Flocculation

The flowrate, Q = 8.7 MGD = 362,500 gph.

Assuming a one-hour flocculation time, the flocculation tank volume:
= 362,500 gallons X ft^3/7.48gallons
= 48,462 ft^3

Assuming a six-foot depth, the area required:
= 48,462/6
= 8,077 ft^2

(Additional units will be provided for reliability and backups)

d. Filter Press

Belt filter system
Throughput = 75 *in situ* cy/hr = 1,800 cy/day

or, Daily throughput = 75 *in situ* cy/hr * 24 = 1800 cy/day
Required volume = 2.65 X 10^6 / (5 * 180)
= 2,944 cy/day
= 3,000 cy/day (approximately)
Required number of units = 3

(Additional units will be provided for reliability and backups)

e. Filtration

Hydraulic loading rate = 2 – 10 gpm/ft^2 (Vesilind, 1997)
Assume 2 gpm/ft^2 for the units
Required filter area = 9,000/2 = 4500 ft^2
Assume (20 ft X 20 ft) filter beds
Number = 12

(Additional units will be provided for reliability and backups)

f. Granular Activated Carbon Treatment (GAC)

Hydraulic loading 2 – 10 gpm/ft^2 (Vesilind, 1997)

Required filter area = 9,000/2 = 4500 ft^2
Assuming 12-ft diameter columns, the resulting area
= $(\pi/4) * 12^2$
= 113 ft^2
Number of GAC columns = 4,500/113
= 40 units

(Additional units will be provided for reliability and backups)

CONCLUSIONS

This paper presents the existing features of two example locations that may be considered as potential sites for the sediment processing/transfer facilities. Preliminary conceptual design and process layouts are presented for both mechanical and hydraulic dredging options at the NTF and for mechanical dredging at the STF.

REFERENCES

Eckenfelder, W.W.Jr. (1989) Industrial Water Pollution Control, McGraw-Hill, New York.

Granet, M. (1998) Hydrocyclone/Maximum Density Separator Demonstration Project at Ft. Myers Beach, Florida. U.S. Army Corps of Engineers, Jacksonville District.

LaGrega, M.D., Buckingham, P.L., Evans, J.C. and Environmental Resources Management (2nd ed.). (2001) Hazardous Waste Management, McGraw-Hill, New York.

Liu, D.H.F. and Liptak, B.G. (1997) Environmental Engineers' Handbook, Lewis Publishers, New York.

Montgomery, J.M. (1985) Water treatment Principles and Design, John Wiley & Sons, New York, NY.

Vesilind, P.A. (1997) Introduction to Environmental Engineering, PWS Publishing Company, New York.

Wentz, C.A. (1995) Hazardous Waste Management, McGraw-Hill, New York.

Dredging Productivity and Schedule
253090

WHITE PAPER – DREDGING PRODUCTIVITY AND SCHEDULE

(ID 253090)

ABSTRACT

In response to several comments, this white paper addresses the matters of project schedule and dredging productivity. Included in the discussion is a general description of the principal activities that will occur prior to remediation and, as well, an overview of the time frames available to accomplish those tasks. The activities addressed herein include project design, contracting for remedial services, and mobilization by the selected contracting team. It is concluded, that adequate time is available to accomplish the activities that precede remedial work.

Also addressed herein are questions that have arisen concerning production rates achievable by the selected dredging technologies. The commenters' principal criticism has been that production rates planned for the Hudson River have not been attained elsewhere. EPA has reviewed the projects referenced by commenters and has concluded either that production rates achieved at these other sites are consistent with those expected on the Hudson River or that site specific differences make comparisons inappropriate. In light of the assessment of other remedial projects, EPA concludes that production rates expected from the dredging technologies selected for the Hudson River are reasonable.

INTRODUCTION

Several commenters questioned the viability of the schedule on which EPA proposes to accomplish the selected remedy. Issues raised in this regard include the time needed to complete various pre-construction (pre-remedial) activities and the plausibility of achieving targeted dredging rates with the selected equipment technologies. Both pre-remedial activities and dredging productivity are discussed herein; related information may also be found in the White Paper –Delays and Downtime.

There are a number of factors that can influence implementation of the selected remedy, including resolving the matter of who will actually undertake the project. Once EPA issues a Record of Decision (ROD), it is possible for either a potentially responsible party (PRP) or the government to conduct the remedial work. At most Superfund sites, remedial work is accomplished by a PRP.

There can be schedule-related advantages to having the PRP undertake the work. In general, PRPs are able to minimize the complicated procedures that federal agencies must follow to secure construction services. Private parties need not follow the same competitive bidding procedures, labor regulations, and contractor-selection processes that are mandated for federal agencies. In addition, in some cases a PRP may have greater flexibility to divide the project into phases that allow for early initiation of some work, and for modifying contractual relationships as work proceeds through various phases.

Another advantage to the PRP handling the project is that a large corporate entity may have resources on-hand that are directly applicable to accomplishing the selected remedy. For instance, the PRP may have property available to set up processing/transfer facilities and may have staff knowledgeable in several aspects of the remedial work. In addition, a large corporate entity may have direct familiarity with transportation systems in the vicinity of the Superfund site, since it would have engaged those systems for its ongoing commercial needs.

It is not possible to elaborate, herein, on the approach that a PRP would take to implement the selected remedy. The resources and options available to the PRP are not publicly known and, therefore, it would be speculative to discuss a PRP scheduling strategy. Should a PRP conduct the work, EPA would monitor construction progress and assess the PRP's conformance with the agreement reached or order issued for conduct of the project. Among the matters over which EPA would maintain careful oversight is the PRP's adherence to the overall implementation schedule approved or ordered by EPA.

The discussion that follows is premised on the assumption that the government will implement the selected remedy. In that case, the US Army Corps of Engineers (USACE), acting on behalf of EPA, will develop a final design, contract for construction and disposal services, and manage the overall program. The following section presents an assessment of the interrelationships between various activities that must be accomplished before dredging of river sediments can begin. Also presented is an outline of the overall schedule for the principal pre-remedial activities. For purposes of this discussion, it is assumed that EPA issues a ROD on December 31, 2001.

PRE-REMEDIATION ACTIVITIES (AGENCY-MANAGED REMEDIATION)

Sediment Sampling and Analysis

It is assumed that actual in-river removal work will be initiated during the 2005 Champlain Canal operating season and that the work will be carried out over six successive seasons (2005 through 2010), with the first year being a phase-in period. In order to initiate remediation by 2005, a number of pre-construction activities will need to occur, including conducting various project investigations, establishing final sediment cut lines, preparing contract documents, selecting contractors, and contractor mobilization, among other matters. If removal is planned to start during the 2005 construction season, there will be over 36 months to accomplish these pre-remedial activities.

Perhaps the most extensive single investigation that would be accomplished before dredging begins is that associated with identifying removal or cut lines. As proposed in the design support section of the Hudson River Monitoring Plan in the FS, Appendix G, several thousand sediment samples will ultimately be collected for this purpose. However, a number of items should be noted with regard to this particular investigative program. The first is that EPA views the delineation of target removal areas presented in the FS (Plate 17) to be representative of final removal requirements, the reason being that fine-grained sediments (as mapped by side-scan sonar) are the principal source of PCBs to the water column and contain the highest PCB concentrations in the Upper Hudson. Thus, when additional sediment analysis becomes

available, it is expected that fine-grained materials will continue to be targeted as detailed in the FS, Appendix D.1.

Secondly, it is not necessary, in EPA's view, to complete the entire sediment-sampling program prior to either selecting a contractor or initiating remedial work. Dredging can be initiated on the basis of partial information from the program while the overall sampling effort is continued and completed. It is, of course, vital to have the latest information in-hand for those areas that are actually undergoing remediation. Finally, it may be possible to initiate some removal work without the benefit of up-to-date sediment chemical analysis. This circumstance would apply to areas being targeted only for navigational purposes and not because of their contribution to the river's PCB problem. Cut lines for these areas can be determined on the basis of bathymetric data. It should be noted that navigational dredging has been included in the project's volumetric removal estimates.

Other key elements of the design will include identification of backfill sources, development and implementation of a public involvement program, siting and design of dewatering facilities, establishment of performance standards and the attendant monitoring program, and development of contractor selection criteria including specifications for the work to be performed. It is expected that design will begin shortly after issuance of the Record of Decision. As mentioned in the following paragraphs, it is also likely that some design activities will continue past the first year of construction. This would be accomplished in a manner that design information specific to a construction season's work would always precede initiation of that work by a sufficient amount of time to ensure proper quality control and adequate time for mobilization.

Construction Contracting

Federal contracting for remedial work can follow any one of several processes. For purposes of this discussion, it is assumed that the government will pre-qualify contracting teams and then distribute bid documents to those found qualified. Of the approximate 30 months available to conduct pre-remedial activities, it is expected that at least half of that time will be expended on the process of selecting a contractor. EPA believes that there is sufficient time in the project schedule for EPA to prepare and issue Requests for Qualifications (RFQs), review contractor qualifications, to prepare and issue bid packages, review responses, and to then select a contractor.

While it is not yet certain as to how the RFQ will be structured, it is likely that EPA will request contracting teams to identify, among other matters, the specific dredging equipment they intend to use to implement the selected remedy, as well as their general requirements for processing facility sites. The bid package provided to qualified organizations will identify cut lines for those areas that are to be dredged during the initial phase of project work (*e.g.*, navigational and remedial dredging during the 2005 canal season). In addition, the bid package will specify performance requirements that must be met by the contractor, as well as various environmental and other constraints that will be imposed on contractor activities (*e.g.*, no trucking of backfill with the Upper Hudson River area). The bid documents will reflect the fact that final cut lines have not yet been established for the entire remedial program and that contract adjustments will, therefore, be necessary when final removal quantities and locations are established.

Dredging Technologies and Processing/Transfer Facility Siting

Selection of a preferred dredging method (mechanical or hydraulic) will depend on EPA's continuing evaluation of technologies, site conditions, and disposal options, as well as other information. The choice of technologies will be made before a contract is awarded. It is expected, however, that work in River Section 3 will be accomplished by mechanical methods irrespective of the dredging method chosen for River Sections 1 and 2, due to the potentially large distances between areas targeted for dredging in River Section 3 and a Southern Transfer Facility.

In order to begin dredging during the 2005 canal season, it will be necessary to have one functioning sediment processing/transfer facility on-line. The principal site development work needed to set up a processing/transfer operation is expected to include rail line improvements, construction of a stabilization facility, and the establishment of a water treatment plant.

Mobilization

In order to start phased dredging operations during the 2005 canal season, it will be necessary for the contractor to assemble a large array of equipment, design the materials handling operation, and arrange for sediment transportation and disposal. Given the scale and complexity of this project, it would be advantageous to provide up to 12 months for the mobilization phase. Assuming 12 months were available for mobilization, then EPA would have approximately 24 months (36 less 12) to select and enter into an agreement, via the USACE, with the preferred remedial contractor.

DREDGING PRODUCTIVITY

Some commenters suggested that actual dredging work, as required to implement EPA's selected remedy, cannot be accomplished in a five-year period. A concern has been expressed that removal will take twice as long – or longer – to accomplish, depending on the dredging technology employed. The response to such comments differs depending on whether mechanical or hydraulic dredging methods are selected for the bulk of the removal work in River Sections 1 and 2 (as already mentioned, it is anticipated that River Section 3 will be dredged mechanically irrespective of which dredging technology is selected for River Sections 1 and 2). Thus, the discussion that follows is specific to each potential dredging technology.

In addition, EPA has decided to pursue a phased approach for implementing the selected remedy. The phasing would involve removal of about 150,000 to 300,000 cubic yards of targeted sediments during the 2005 canal operating season. After this phase, full-scale removal operations would occur during the 2006 through 2009 canal season, then the remaining targeted sediment would be extracted during the 2010 canal season.

The information that follows concerning the productivity that is expected from the selected mechanical and hydraulic dredging technologies is directly relevant to removal rates during the 2005 to 2010 canal seasons. EPA's goal for these years is comparable to that presented in the FS.

Mechanical Dredging – General

EPA has identified a hydraulic excavator fitted with appropriate auxiliary equipment as the preferred technology, if mechanical dredging is utilized, for Upper Hudson River remediation. FS Section 5 details the principal attributes of the excavator-based system that led to its initial selection, and also describes various recent technical innovations that enhance that system's productivity and reduce its environmental impacts. It is recommended that the reader refer to FS Section 5.2.2.1 for additional information on the principal characteristics of excavators and recent advances in that technology.

Estimates of Productivity

Several principal factors that establish overall productivity of a mechanical dredging system have been presented in the FS and are summarized in the following table:

Bucket Capacity:	4 cubic yards	2 cubic yards
% filled per cycle:	80%	80%
Cycle time:	2 minutes	3 minutes
Production rate per hour:	82 cubic yards/hour	27 cubic yards/hour
Fraction of time productive work accomplished:	47 percent of available hours per week	47 percent of available hours per week
Hours of productive work per week:	78 hours	78 hours
Weeks of productive work each season:	30 weeks	30 weeks

The productivity information shown above reflects a range of site-specific factors such as sediment characteristics, river geometry, in-river transportation systems, and environmental constraints. It is worth noting that no commenters questioned the parameters in the above table but, rather, applied information obtained from other Superfund sites to critique the hourly and weekly production rates that were presented in the FS. It is EPA's view that productivity information obtained from one location needs to be fully evaluated before it is applied to another project. Minus that careful analysis of site specific circumstances, comparisons between sites can become an academic exercise and not a serious technical assessment.

In setting production rates for the Upper Hudson, EPA was aware that mechanical excavators are capable of significantly greater outputs than those presented in the FS, particularly in situations where there are few or no environmental constraints. For instance, excavators can readily attain one-minute cycle times, or less, if concerns over resuspension are not reflected in the work. The key point is that there are no inherent equipment-related, mechanical limitations that require cycle times of two or more minutes.

In addition, excavators are able to generate substantial digging force and thereby avoid some of the difficulties that have plagued some crane-mounted, bucket-on-rope systems at other locations. The force generated by these machines is expected to result in greater bucket utilization than has been achieved at several Superfund sites where conventional equipment was

employed. Furthermore, the precise positioning possible with excavator-based systems also leads to improved productivity, since less overlap is needed between bites to attain target removal elevations.

Another factor embedded in EPA's productivity estimates that supports the overall FS schedule is the fraction of the work week assumed available for productive work. For purposes of the FS it was assumed that mechanical dredges would function productively 78 hours per week, or about 47 percent of the time. Conversations with contractors have suggested that greater productive use of equipment may be possible with proper planning of work.

Productivity Comparisons with Other Sites

As mentioned above, one commenter compared EPA's productivity estimates to those actually attained at other Superfund sites. While such comparisons may be an interesting academic exercise, it must be noted that either site-specific conditions or the type of equipment actually employed at other sites will often render such comparisons without technical validity. For instance, for a project that entails removal of 50,000 cubic yards of sediment, there would be no purpose to attain the production levels specified for the Hudson River. Also, as has often happened in the past, productivity can be influenced by sediment in-river transport and processing systems, as well as by the dredging equipment itself. It is important that the actual causes of low productivity be identified when comparisons are made between dredging projects.

Saginaw River

Some effort has been expended, by one commenter, to reference productivity attained at the Saginaw River Superfund site in calendar year 2000 and superimpose that same value on the Upper Hudson. It appears that this commenter's entire conclusion on the productivity achievable on the Upper Hudson is based on the outcome of dredging work accomplished at Saginaw during calendar year 2000 and a somewhat narrowly focused assessment of that project.

By one estimate, the mechanical system employed at Saginaw (a conventional crane-mounted clamshell) was able to remove, on average, 981 cubic yards of sediment daily, or about 41 cubic yards per hour. Assuming this estimate is accurate, it should be noted that only one dredging unit was employed for all work at this site. This can be compared to the four excavators, with varying capacities and characteristics, proposed to work simultaneously on the Upper Hudson. In addition, beyond utilizing four excavators, debris removal on the Hudson would be accomplished by yet another piece of equipment, so that work by the main dredges will proceed unimpeded to the greatest extent possible. It is clear that productivity at Saginaw 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 (William Rito, pers. comm., June 2001).

Another inefficiency related to having one dredge on the Saginaw site was that apparently six different-sized buckets were employed there (4, 5, 8, and 10 cubic yard conventional buckets and 6 and 16 cubic yard cable-arm buckets). Thus, every bucket changeover that occurred resulted in a complete shutdown of in-river production. Under EPA's Hudson River approach, loss of a

single unit would not result in complete shutdown, since three other pieces of equipment would continue to function.

Finally, as mentioned above, the prediction by one commenter that Upper Hudson productivity (mechanical dredging) would be half that estimated by EPA appears to be largely based on averaging the production rate across all buckets used at the Saginaw site. If one were to perform the same calculation for the equipment EPA proposes to use on the Upper Hudson, the result would be an average production rate of 54.5 cubic yards per hour ([82+27]/2) – the 41 cubic yards per hour calculated for Saginaw. When one considers the lack of redundancy at Saginaw (one dredging machine) and the inefficiencies noted above, it is evident that EPA has not been optimistic in its estimates of Hudson River mechanical dredging productivity based on the outcome at Saginaw.

Early Action Assessment

One commenter compared EPA's productivity estimates in the FS to those presented in EPA's early action assessment (USEPA, 1999). The comparison is inappropriate for several reasons. The early action assessment was a relatively quick study that considered, among other alternatives, three dredging options (removal of 238,000 cubic yards, 120,000 cubic yards, and 59,000 cubic yards). To simplify comparisons, the same dredging- and material-management approach was presented for each alternative; *i.e*., use of a single, small mechanical dredge (two cubic yard) for all removal work, and transportation of dredged sediments in shipping containers to final disposal facilities.

It should be fairly evident that a system fashioned to handle 59,000 cubic yards would not be particularly efficient for removal of 238,000 cubic yards. The application of one dredge and shipping containers in the early action assessment is most applicable to the 59,000-cubic yard alternative, but is not considered efficient for larger removal programs.

Finally, it should be noted that the output of the small mechanical dredge described in the FS (the small dredge would be fitted with a two-cubic-yard bucket) was estimated to be 27 cubic yards per hour, which translates to somewhat over 60,000 cubic yards per dredging season, assuming 13 hours of production per working day and 180 working days per dredging season. Thus, from this perspective, the early action assessment and the FS are consistent.

New Bedford Harbor

Results of dredging programs at New Bedford Harbor, a Superfund site in Massachusetts, have also been used to draw conclusions with regard to Hudson River equipment productivity by at least one commenter. Until calendar year 2000, all demonstration and production work at New Bedford had been conducted with hydraulic dredges. However, in calendar year 2000, a mechanical system underwent testing to determine its viability for use during the next and largest phase of site cleanup. The mechanical system consisted of a hydraulic excavator fitted with a European-style profiling bucket that generates a relatively large, flat cutting profile. This technology is discussed in Chapter 5 of the FS and demonstrates that dredging equipment has evolved in reaction to environmental constraints imposed at Superfund sites.

Initial reports from the calendar year 2000 demonstration (Lally and Ikalainen, 2001) suggest that dredge performance was significantly improved over prior demonstrations at New Bedford. Production rates of 50-60 cubic yards per hour were achieved with the 4.5-cubic yard profiling bucket. In addition, it was concluded that with further pre-planning (*e.g.*, debris removal), the mechanical system could be expected to attain production levels of 75 cubic yards per hour or greater. The productivity estimates used in the FS are consistent with findings of the New Bedford mechanical demonstration program.

Hydraulic Dredging – General

EPA has proposed a hydraulic dredge system for the Hudson River remedy that is unique (FS, Appendix H). It will be built specifically for the work required under the selected remedy. Its hull dimensions, swing width, hoist speeds, spud and anchor handling, and cutter head arrangement will be fitted to the contours of the river and specific cut depths unique to the Upper Hudson River. Its subsystems will be designed and built to specification for this particular job.

Many dredging projects use off-the-shelf systems. This approach is taken largely because of economic realities and time constraints. Compromises are made on operating equipment that is not specifically designed for the task at hand. The equipment works well, but may not be absolutely ideal for project circumstances. Some systems are pieced together based on equipment availability rather than strictly on performance specifications.

Due to these compromises, the dredge must be adapted to work in the specific job environment. For example, a cutter head may be designed for use in a deep 20- to 45-foot channel, but may need to work in a shallower river environment. Dredges and pumps may also not be tailored to the specific project but rather be reflective of available equipment. Production efficiency may suffer somewhat as the project crew adapts their off-the-shelf system to the individual project. On the other hand, the system proposed for the selected remedy will be designed with actual Hudson River requirements in mind and, therefore, will operate with maximum design efficiency and minimal impact.

For work in the Hudson River, components of the hydraulic dredge, including a swing, ladder, and spud and anchor hoists, will be designed for optimal performance. Anchor booms will be provided to facilitate shifting of swing anchors in the Hudson's shallow water. The proposed cutter head design will allow the dredge to fit optimally to the contours of the Hudson River banks and to the relatively shallow river depth. This precise cutting technology maximizes the operating efficiency of the overall dredge. With minimal movement of the dredge to fit the river location, more production can result with each placement of the dredge head. The dredge can accomplish more in less time simply because it spends more time doing the actual work.

In addition, the hydraulic dredging processing subsystems will be designed for the unique requirements of this particular project. Inadequate materials-processing facilities can limit the productivity levels achieved by the overall project. Therefore, it is critical that the entire dredging/transport/processing system be designed to handle the operational requirements of the project.

Estimates of Productivity

Hydraulic dredging productivity is a function of the rate of dredge advance that is itself largely based on the swinging and stepping and anchoring characteristics of the dredge, and limited by its pumping capacity. Pumping capacity can be modeled using known theoretical values. These time-tested models use values that take into account many variables including friction loss, pump horsepower, material characteristics, and length of pipe.

These factors are analyzed against known historical data, and a theoretical pumping capacity value is found. This value produces a model for a particular project, in this case the Hudson River selected remedy, with a pumping capacity of 300-500 cy/hour. Even accounting for less-than-optimal conditions and for the uniqueness of the relatively shallow Upper Hudson River, the desired production rate of 275 cy/hour is achievable. This productivity estimate is described in greater detail in the FS, Appendix H.

Productivity Comparisons with other Sites

Commenters on EPA's proposed remedy indicated that the proposed dredging schedule would be unachievable. Commenters use a series of claims to support their argument based on dredging production at other sites. One commenter references four different environmental dredging projects as representative of hydraulic dredging projects and as proof of their argument that EPA's schedule is unachievable.

As stated previously for mechanical dredging, production rates at different sites can not simply be compared by the average production rate achieved at a site. It is necessary to take into consideration the type of dredging equipment employed at the site, quantity of equipment pieces, dredging pattern, and many site-specific conditions. Table 253090-1 illustrates missing essential data that was not presented in the commenter's analysis. The commenter's argument uses little information regarding the pipeline and only a smattering of information concerning the dredge and pump. There is no commonality in the hydraulic dredge type implemented at the various sites. Some are auger type; some are cutter head type. All of these variables are integral to an accurate assessment of dredge productivity and comparison to the proposed dredging rate suggested in the FS.

The same four environmental dredging projects noted earlier (Table 253090-1) are used by the commenter to make the argument that the EPA-proposed effective daily dredging hours are unachievable. The reality of dredge production is that certain days may have little or no production because of equipment delays due to maintenance and other operational constraints. At other times, production may continue unimpeded for days, weeks, or longer. EPA uses the concept of the average project day in its production analysis.

This average day analysis incorporates all sources of delay into a loss-of-production factor. In addition, the hydraulic dredge was not assumed to work full time or 24 hours per day, 7 days per week. Allowances were given in the typical dredge-operating week for downtime associated with equipment malfunctions, dredge repositioning, etc. For purposes of the FS, it was assumed that the hydraulic dredge would operate productively 102 hours per week, on average, or approximately 61 percent of the time.

REFERENCES

Lally, J. and A. Ikalainen. 2001. “Field Testing Advanced Remedial Dredging and Sediment Transport Technologies at the New Bedford Superfund Site.” Prepared for Foster Wheeler Corporation.

US Army Corps of Engineers (USACE). 2001. Personal communication, William Rito, Project Manager. June.

US Environmental Protection Agency and USACE. 1999. "Evaluation of Removal Action Alternatives – Thompson Island Pool – Early Action Assessment." Prepared by TAMS Consultants, Inc. March.

Delays and Downtime
313398

WHITE PAPER – DELAYS AND DOWNTIME

(ID 313398)

ABSTRACT

This white paper addresses comments regarding various factors that can cause dredging delays and thereby impact the planned remedial schedule. Comments related to delays and downtime can be placed into three categories:

- Constraints in canal operations.
- Adverse weather conditions.
- Equipment-related delays.

The implications of delay-inducing factors are discussed below. It is concluded that most of the conditions that can lead to project delays and downtime can be managed through proper planning of the remedial work. For instance, physical limitations associated with operating within the Champlain Canal system can be overcome by planning vessel movements for evening and other off-hour periods. In addition, the availability of spare equipment would reduce downtime associated with either canal constraints or mechanical malfunctions.

Finally, it does not appear that the potential for weather-related delays is significant and, in fact, based on EPA's review of historic data, it may be possible to extend the working season beyond the planned 30 weeks per year. Additional supporting information related to sources of potential delays and downtime may be found in the White Papers – Dredging Productivity and Schedule, River Traffic, and Rail Operations.

INTRODUCTION

Several commenters raised questions concerning constraints that the Champlain Canal will place on project operations. These canal-related matters include:

- The seasonal and daily operating schedule.
- Vessel navigation interferences.
- Lock-specific delays.
- Debris removal.

Information regarding these matters is presented below.

Canal Operating Schedule

The canal operates approximately 29 weeks per year; for purposes of the FS, it was assumed that the canal will operate 30 weeks per year. EPA plans to consult with the Canal Corporation throughout the term of remedial work and may request that the canal operating season be extended so that seasonal dredging productivity targets can be attained or exceeded. It is expected that the practical limits to dredging each season will be based on weather conditions

and the need for the Canal Corporation to conduct maintenance work on the system. These matters are discussed in following sections.

In addition to seasonal constraints, the Canal Corporation also imposes daily limits on passage through the system of locks that form the Champlain Canal. A typical daily lock schedule, over an entire season, is as follows:

7:00 am to 5:00 pm –	May 7 to May 23
7:00 am to 10:30 pm –	May 24 to October 3
8:00 am to 6:00 pm –	October 4 to October 27
7:00 a.m. to 5:00 pm –	October 28 to November 4

However, the Canal Corporation also provides around-the-clock access to commercial operators when adequate notice is given to the canal traffic agent. Since movements of loaded hopper barges to a potential southern transfer facility (STF) and return of empty hoppers to the dredging site may occur on a 24-hour-per-day basis, it will be necessary to request the Canal Corporation to operate the lock system on an extended daily schedule when dredging is occurring.

In-Transit Delays of Barges

One commenter suggested that project delays would be encountered when barges are not available for loading at the dredging site because of in-transit delays. Perhaps the most important project-related river movement is loaded hopper barges being towed to an STF and then returning empty to the work site for reloading. In the FS it was estimated that multiple hoppers would be needed to support operation of each large dredge under the mechanical dredging scenario. Under the hydraulic dredging scenario, hoppers would be used to haul dewatered sediments from a northern transfer facility (NTF) to an STF.

Should the contractor experience difficulty with hopper barge schedules, it would be possible to have additional equipment on-hand that could be placed into service whenever in-transit delays are being encountered. The additional barge(s) could be secured at an STF when not operating on the river. In this context, the availability of additional barges would not be for the purpose of increasing the daily output of dredged material but, rather, would be for the purpose of achieving the planned level of sediment removal for completing the remedial effort in six working seasons.

Delays Due to Lock Congestion

For information regarding congestion at the Champlain Canal System locks, refer to White Paper – River Traffic, which concludes that there is some potential for traffic congestion to occur at Locks 5 and 6 during the months of July and August when pleasure-craft traffic is highest. However, it is expected that a portion of the project's most time-critical movements of hopper barges can occur during off-peak periods (including nighttime hours when the canal locks do not operate for pleasure craft), and thereby limit or avoid congestion delays.

Delays Due to Canal System Maintenance and Other Activities

The Canal Corporation reports that navigation may be impeded by the need to conduct maintenance on canal locks and other facilities. Maintenance of locks is subdivided into several categories, including winter rehabs, navigation season repairs, and preventive maintenance. Major repairs and overhaul of canal systems (winter rehab) and preventive maintenance are performed outside the navigational season, and therefore outside the planned dredging season. Repairs during the operating season are performed on a maintenance cycle and are largely limited to above-water work. Occasionally, emergency maintenance (*e.g.*, removal of logs and debris resulting from high water) may occur during the operating season (USACE, 1990). Also, at times, events such as boat parades and land-based emergencies may impede navigation.

Delays Due to the Presence of Debris

As presented in the FS, the remedial concept calls for debris removal ahead of dredging work so as to limit the impact of debris on productivity. Results of a geophysical survey, conducted in November 1999 and presented in Appendix H of the FS, indicate that most debris that would interfere with dredging work can be detected by various electronic systems and removed prior to the start of dredging in any particular area.

ADVERSE WEATHER CONDITIONS

Commenters suggested that adverse weather may be the cause of delays in the dredging schedule. Adverse weather conditions could include low temperatures, high winds, and precipitation- or runoff-induced high river-flow rates and flooding.

Weather Delays – Temperature

Low temperatures leading to ice formation on both the river and canal locks place a practical constraint on the canal's operating season. From the perspective of dredging and sediment processing operations, low temperatures will primarily impede the transfer and processing of dredged sediments. Operations at the transfer facilities will become difficult as temperatures drop; also barges cannot transit the river when ice blockage occurs.

To evaluate the effect of temperature on seasonal work, data were obtained from the meteorological stations at the Albany and Glens Falls Airports for the years 1991 through 2000 (National Weather Service, 2001). The data are presented in Table 313398-1, which shows the dates of earliest daily average thaw and freeze for the 10-year period. Also presented in the table is the earliest seven consecutive day period when average daily temperatures were above freezing on the approach to spring and the earliest seven consecutive day period when average daily temperatures fell below freezing on the approach to winter.

These data support the possibility of extending dredging operations beyond the assumed 30-week dredging season. For instance, it would appear that, based on temperature, remedial work could occur throughout the entire month of April in most years (assuming other factors did not intervene). It may also be beneficial to the remedial effort to extend the canal's seasonal closing

by one or two weeks some years when moderate temperatures are occurring. EPA has had initial discussions with the Canal Corporation regarding this issue. From the perspective of weather limitations, it would appear that productive work could occur for 33 or 34 weeks each season. It should be noted, however, that the actual ability to extend the season will also depend on the Canal Corporation's plans for off-season maintenance.

High Winds

Although high winds cause turbulence and waves in open waters where there is a significant fetch, the Hudson River is relatively sheltered and is not prone to wave formation. Therefore, it is not expected that significant wind-related delays will be experienced during the remedial work.

Delays Due to High Water

The Canal Corporation reports, in published-memo form, instances wherein the system has been closed as a result of either flooding or high river flows. Between the years 1997 and 2001, the corporation issued one Memo to Mariners indicating that the canal system, between Lock C-1 and Lock C-4, would be closed for a few days until water receded to a safer level and debris could be removed (Canal Corporation, 2000a). A subsequent Memo to Mariners indicated that the canal had reopened for navigation (Canal Corporation, 2000b).

Delays Due to High River Flow Rate

To assess the possibility that high river flows (over 10,000 cfs) may halt dredging work, data from the USGS Fort Edward gauging station were examined. As illustrated in Table 313398-2 (data for the years 1978 to 2000), river flow rates in the range of 10,000 cfs are only encountered a fraction of time during the canal operating season. During the May through November season, river flows approach the level where delays could occur only seven times, on average, over the period of record.

As noted, the actual_number of delay days is about 5.3 percent of the total available and not 10 percent, as had been estimated by one commenter who had included data for the month of April in the analysis. It should also be noted that dredging work may be possible when flows exceed 10,000 cfs, but the precise flow constraint will need to be established during the project's design phase.

EQUIPMENT-RELATED DELAYS

Several commenters contend that significant downtime will occur from equipment failures. They cite projects such as the first year of the Saginaw River work, where major and minor repairs caused 12 percent downtime.

Saginaw River and other Dredging Projects

The Saginaw River project experienced delays associated with using a single dredge to conduct non-dredging tasks such as debris and pile removal. Considerable production time was lost each

time the dredge bucket was switched to accommodate a change in dredging conditions. The situation at Saginaw is further described in White Paper – Dredging Productivity and Schedule.

A summary of dredging projects relevant to the Hudson River project is presented in Appendix A of the FS. In addition to the Saginaw River project, two other dredging projects that are applicable, Bayou Bonfouca and Ford Outfall, have been reviewed. For these two mechanical dredging projects, delays associated with mechanical difficulties were reported to be minimal. During the Ford Outfall project, the reported site-specific difficulties included problems associated with the sediment processing equipment; the problems were quickly resolved when the contractor implemented design modifications to the processing facility. There were no delays associated with mechanical problems reported for the Bayou Bonfouca project.

With regard to hydraulic dredging, it can be noted that at the Fox River site, although only one hydraulic dredge was in use at any given time, three dredges were available to conduct the work. Redundancy will similarly be applied to the Hudson River remediation to minimize downtime due to equipment problems.

Silt Curtains

One respondent refers to problems associated with the use of silt curtains during the Saginaw River project (silt curtains are discussed in Appendix E.5 of the FS). For the Hudson River project, it is expected that use of silt curtains will be in shallower, low-velocity portions of the river where these systems are particularly effective. In addition, as presented in Appendix A of the FS, silt curtains were also used during the Bayou Bonfouca, Cherry Farm, Fox River, Grasse River, Manistique River/Harbor, Sheboygan River/Harbor, Sever Sound, Georgian Bay, Welland River, Thunder Bay, and Collingwood Harbor dredging projects. Few silt curtain-related problems were reported for these projects. The Ford Outfall project experienced silt curtain damage from a passing freighter traveling through a portion of the river that was closed to commercial traffic, with a resulting delay of approximately one to two dredging days.

Processing Bottlenecks

One commenter expressed concern that land-based bottlenecks will occur when dredged material arrives at the processing/transfer facility. Although problems encountered at other Superfund sites related to solids processing and water treatment have been documented, the main problems encountered at these other locations relate to selection of a less-than-optimal processing train and undersizing various processing-system components.

For the Hudson River project, EPA can avoid processing-related difficulties that have been encountered at other sites in several ways. Experiences at numerous other Superfund sites will be given substantial consideration during the design stage of the Hudson River project. Information is routinely shared for such purposes among EPA regional staff, so that experiences at one location can benefit projects occurring elsewhere. Qualified contractors will be expected to have operated similar materials processing/transfer facilities either at other Superfund sites or under conditions comparable to those occurring at Superfund sites.

Finally, all processing systems and components selected for use on the Hudson River PCBs Site will likely have been demonstrated at other locations. By using these and other methods, EPA will be able to avoid the principal processing-related difficulties encountered at other dredging sites.

CONCLUSIONS

Delays and downtime associated with weather, equipment problems, and/or canal constraints are not expected to significantly impact implementation of the selected remedy. Proper planning and design by a qualified team of designers and contractors, and taking maximum advantage of experiences and lessons learned at other Superfund sites, will be expected to minimize the impacts of factors that can cause delays.

REFERENCES

Canal Corporation (New York State Thruway Authority). 2000a. Memo to Mariners. June 7.

Canal Corporation (New York State Thruway Authority). 2000b. Memo to Mariners. June 8.

National Weather Service. 2001. Summary of Temperature and Precipitation data for the Albany and Glens Falls Stations, 1991-2000.

US Army Corps of Engineers (USACE). 1990. Champlain Canal of the New York State Barge Canal. September.

Post-Dredging PCB Residuals
312663

No Figures or Tables

WHITE PAPER – POST-DREDGING PCB RESIDUALS

(ID 312663)

ABSTRACT

Sediment removal depths for the selected remedy were calculated assuming removal of all sediment with Tri+ PCB concentrations of 1 mg/kg or more, plus an overcut into deeper sediment with less than 1 mg/kg (*i.e.*, "clean" sediment). Based on this approach, EPA expects that the residual PCB levels will be less than 1 mg/kg Tri+ PCBs. In addition, in areas that are backfilled with clean material, PCB concentrations are expected to approach non-detectable levels. Based on an evaluation of other environmental dredging projects (*i.e.*, Grasse River, GM Massena, Manistique, Fox River SMU 56/57, Cumberland Bay, New Bedford, Marathon Battery, Black River, Lake Jarnsjon), and an analysis of conditions within the Hudson River, EPA expects that the selected remedy will reduce PCB concentrations in targeted areas of the Upper Hudson by approximately 98 percent.

INTRODUCTION

This paper addresses expected residual PCB concentrations after completion of dredging. Commenters have questioned whether the 1 mg/kg Tri+ PCB residual for the selected remedy can be achieved, citing higher residual concentrations found at other sites. This white paper explains why EPA believes that a 1 mg/kg Tri+ PCB residual is achievable and discusses the site-specific conditions that may have led to higher residuals at some other projects.

As stated in the White Paper – Sediment PCB Inventory Estimates, the mean length –weighted average Tri+ PCB concentration in sediment in Section 1 is 27.2 mg/kg and in Section 2 is 43.1 mg/kg. Using the expected 1 mg/kg residual concentration of Tri+ PCBs, the selected remedy will leave a residual concentration in the target areas of between 96 and 98 percent less than the original concentration of PCBs.

Under the selected remedy, essentially all PCB-contaminated sediments within targeted areas will be removed. Although the goal is to remove all PCBs, EPA conservatively estimated that a sediment veneer containing 1 mg/kg of Tri+ PCBs would remain after dredging due to, for example, redeposition of sediments suspended by the dredge. To isolate these remaining PCBs and to provide a substrate suitable for benthic and fish habitat, clean backfill material will be placed in the dredged areas, as appropriate.

RESIDUAL SEDIMENT PCB CONCENTRATION

Sediment deposition rates in the Hudson River are relatively low and the majority of the PCB contamination occurs within a foot or so of the sediment surface. In most of the Upper Hudson, the PCB-contaminated sediment overlies older sediments that predate the deposition of PCBs. Therefore, by overcutting, it is possible to remove virtually all the PCBs in targeted areas.

The approach taken to estimate dredging depths, which is described in the FS, is conservative in that it overestimates the quantity of material to be removed based on contamination depth from individual Hudson River samples (complete and incomplete cores). If a sample core is complete (*i.e.*, it extends past the depth of 1 mg/kg Tri+ PCB concentration), the 1 mg/kg Tri+ PCB depth is assumed to be the depth of contamination for that area. If the core is not complete (PCB concentration greater than 1 mg/kg at the bottom of the core), one of two approaches is used. For cores with a peak PCB concentration of 100 mg/kg or more, the contamination depth is estimated as the length of the core plus 1.5 ft. For cores with a peak PCB concentration less than 100 mg/kg, the contamination depth is estimated as the length of the core plus 1 ft.

Within an individual target area, the dredging depth was determined by the sample with the greatest depth of contamination. In addition, minimum cut depths were assigned to further ensure that essentially all contamination within that target area would be removed. Based on the average depth of contamination, a minimum dredge cut of 2 ft was assigned to the 3 g/m^2 Tri+ PCB mass per unit area (MPA) and 2.5 ft for the 10 g/m^2 Tri+ PCB MPA target areas.

In addition to using conservative estimates of dredging depths, EPA included overcutting in the calculation of dredging volumes in River Sections 1 and 2. For these river sections, dredging volume was estimated based on removing sediment to a specific elevation or surface and then defining a trapezoidal cross-section of sediment to be removed (Master Comment 313224, Chapter 4 of this RS). Essentially, the area between two contour lines (*e.g.*, 105 and 106 ft above datum) formed a removal trapezoid. For each removal trapezoid, dredging volume was based on the deeper of two adjacent contours. Thus, on the average, in every removal trapezoid, the overcut depth is approximately 0.5 ft.

After dredging, clean backfill will be placed on many targeted areas. To estimate the effective PCB concentration after backfill, EPA assumed that backfill materials would be mixed uniformly with residual sediments. This is a conservative assumption. More likely is that only the bottom layer of backfill will mix with the residual sediment below. Therefore, in areas that are backfilled with clean material, PCB concentrations are expected to approach non-detectable levels. Backfill is not planned for the channel areas (*i.e.*, water depths of 12 feet or greater).

Residual PCB Concentrations at Other Dredging Projects

Results achieved at several environmental dredging projects are presented here. Site-specific circumstances that are not directly applicable to the Upper Hudson appear to be the principal reason for higher residual concentrations for some of these projects.

Grasse River

The Grasse River dredging operation was essentially a hot-spot excavation. The goal of the project was to remove 25 to 30 percent of the total PCB mass from the Grasse River study area; there was no specific goal on the residual PCB level (Alcoa, 1995). The combination of a mechanical excavator and a horizontal auger dredge was selected for use in one area (Area A). In addition, three-inch suction hoses manifolded directly to the horizontal auger pump were used to remove sediment within a second area (Area B). After dredging, an overall arithmetic average of 75 mg/kg was detected within the remaining sediment located in Area A, with concentrations

ranging between 1.1 mg/kg and 260 mg/kg. In addition, up to 130 mg/kg PCBs (average PCB concentration of 108 mg/kg) was detected in Area B. Relative to original conditions, these results represent an overall decrease in average PCB concentration for both areas (*i.e.*, 93 percent reduction in Area A and 64 percent reduction in Area B) (Alcoa, 1995). Post-dredging bathymetric and bed-sampling measurements demonstrated high solids and PCB mass removal, which indicated that the targeted PCB removal was achieved (Thibodeaux, 2000). The presence of boulders significantly interfered with and reduced the efficiency of removal operations. It was concluded that the rocky nature of the river bottom created a less-than-ideal environment for the dredge and, quite frequently, the auger would deflect off obstructions, which limited its ability to remove sediment (Alcoa, 1995).

Project goals and site conditions differed significantly from those of the Hudson River. In the selected remedy, high PCB concentrations in Upper Hudson River sediments are associated with recent deposits of silty materials. Rocky areas were not selected as target areas based on side-scan sonar data and other information. Therefore, problems caused by the presence of boulders and outcrops will be avoided. The post-removal PCB concentrations observed in the Grasse River project include PCB-laden sediments that were targeted for removal but were left because they could not be withdrawn by the dredge's suction. These conditions are not considered directly relevant to the Hudson River, given the manner in which areas are targeted for removal under the selected remedy.

GM Massena Project

The GM Massena project had a cleanup goal of 1 mg/kg total PCBs. Although over 99 percent of the contaminated PCB sediment mass was removed from the St. Lawrence River at the GM site, the 1 mg/kg goal was not met in some areas. In five of six quadrants, the average post-dredging concentration was 3 mg/kg, and in Quadrant 3 the average post-dredging concentration was 27 mg/kg (General Motors Powertrain, 1996). But when considering the relatively high pre-dredging concentrations within these sub-areas (208 mg/kg and 2,170 mg/kg), the reduction can be estimated at 98.6 percent for five quadrants and 98.8 percent 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.

The percent reduction expected for the selected remedy for the Hudson River is very similar to that achieved in the GM Massena project. The ability to overcut soft sediments in the Hudson River, which was not possible at GM Massena, increases the likelihood that a PCB percent removal of 96% to 98% will be achieved. In addition, dredging technology has improved since the GM Massena removal in 1995.

Manistique River

At the Manistique River site, PCB concentration increased with sediment depth, with levels of 16.5 mg/kg in the top 3 inches, 77.5 mg/kg in the 3- to 24-inch range, and almost 200 mg/kg in samples deeper than 24 inches (Thibodeaux, 2000). This differs from the Hudson, where most PCB mass is within the top 9 inches of sediment. The presence of extensive contamination at

depth increased the difficulty of attaining a low residual at Manistique River, and also increased the likelihood of mixing of contaminants with residuals.

The cleanup goals for this project were removal of 95 percent PCB mass and an overall residual layer concentration of less than 10 mg/kg at the conclusion of dredging (Bolen, 2001). Therefore, it should not be expected that residuals approaching 1 mg/kg would be attained here, since the project goal was a substantially higher residual than 1 mg/kg.

Fox River SMU 56/57

Three hydraulic dredges were employed at this site to remove the PCB-contaminated sediments. Target dredge elevations were developed for the sediment bed to correspond to post-dredging PCB concentrations in the surface sediments of less than 1 mg/kg. However, 1 mg/kg was not specified as a hard target (Fort James Corporation, *et al*., 2001). The cleanup objectives were:

- Achieve a surficial sediment concentration of 1 mg/kg PCBs or less, where possible.
- Achieve an average post-dredging surficial sediment concentration of 10 mg/kg or less.
- 90 percent of each subunit should achieve surficial sediment concentrations of 10 mg/kg or less, and the surface sediment concentration should not exceed 25 mg/kg in any subunit.
- Place six inches of clean sand over all subunits that did not attain a surficial sediment concentration of 1 mg/kg or less.

The average post-dredging PCB concentration in the top 4 inches of sediment before backfill with sand was 2.2 mg/kg (the range was from non-detect to 8.5 mg/kg), showing that site-specific goals were achieved. Of 38 post-dredging samples, 11 had concentrations less than 1 mg/kg (Fort James Corporation, *et al*., 2001).

Cumberland Bay

This 75-acre site consisted of underwater areas that contained PCB-contaminated sludge from paper mill operations. The specified target for the project was complete removal of the sludge bed down to the underlying clean sand layer. No specific goal was set for residual concentration. Two-horizontal auger dredges were used and the depth of dredging was based on visual observations: If fine sludge was observed, dredging would continue; if only sand was observed, dredging would stop. The pre-dredging PCB concentrations ranged from 10 mg/kg to 3,000 mg/kg, according to the NYSDEC project manager (Dolata, 2001). Based on further information provided by NYSDEC (Ports, 2001), it was estimated that the average pre-dredging concentration was 135 mg/kg PCBs.

After dredging, 115 confirmation cores were collected. Analysis was not performed for 73 of the 115 cores as a result of either the collection point being located on shore (5 cores) or the core materials being 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 were 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).

New Bedford

A mechanical dredging demonstration project with a cleanup goal of 10 mg/kg residual PCBs was performed at New Bedford during the summer of 2000. Based on information obtained from the US Army Corps of Engineers site representative, pre-dredging depth-averaged sediment PCB concentrations were 857 mg/kg for 0 to 1 ft, 147 mg/kg for 1 to 2 ft, and 26 mg/kg for 2 to 3 ft (Simeone, 2001). 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 percent using the 0 to 1 ft pre-dredging concentration and 91.5 percent using the average concentration of 0 – 3 ft. Similar to Manistique, at New Bedford the project goal for residual contamination was substantially higher than 1 mg/kg. While a direct comparison to the Hudson River is not possible, the percent reductions achieved at New Bedford are similar to those expected for the selected remedy.

Marathon Battery

The Marathon Battery Superfund site is located along the Lower Hudson River near the city of Cold Spring, New York. The site includes a former nickel-cadmium battery plant (operating from 1952 to 1979), the Hudson River in the vicinity of the City of Cold Spring pier, and a series of backwater areas. The site is composed of three study areas. Remediation of Areas I and III included environmental dredging.

The primary cleanup goal for Area I was dredging sediments with greater than 100 mg/kg cadmium (Tames, 2001). In Area I, the average cadmium sediment concentration was 27,799 mg/kg. Post-remediation results for Area I indicated a mean residual sediment concentration of about 12 mg/kg, or a 99.6 percent reduction from average pre-dredge concentrations.

The goal for Area III was a 95 percent removal of cadmium, with a target goal of 10 mg/kg. To achieve this Area III target, the necessary removal depth was determined to be 1 foot. In Area III, the average concentration was 179 mg/kg. The mean post-dredging concentration of cadmium was 10.9 mg/kg, in Area III which represented a 92 percent reduction from pre-dredging levels. The percent reductions achieved at Marathon Battery suggest that EPA's expected PCB reduction for Hudson River (96% to 98%) is reasonable.

Black River

The Black River, Ohio was the site of a remedial dredging project in 1989 that focused on removal of sediments contaminated with polynuclear aromatic hydrocarbons (PAHs). The primary cleanup goal was to remove all PAH-contaminated sediment in the main stem of the Black River to "hard bottom." Overall, this dredging project successfully met the target goals of removing PAH-contaminated sediments to "hard bottom" (Wisconsin Department of Natural Resources, 2001).

Lake Jarnsjon

The primary constituents of concern at this site were PCBs with a maximum detected sediment concentration of 30.7 mg/kg on a dry weight basis (average 5 mg/kg). The cleanup remedy was to dredge from 0.4 to 1.6 meters of sediments from the lake bottom and dispose of the dewatered contaminated materials in a nearby landfill.

The average post-dredging sediment concentration was 0.06 mg/kg. Although not specified as a target goal, this relatively low post-dredging concentration equates to attainment of a 99 percent reduction in sediment PCB levels. Also, PCB concentrations in fish decreased from 34 mg/kg extractable fat before dredging to 16 mg/kg after dredging. Based on data collected for the two-year period following dredging, declines were observed in PCB levels in sediment, lake water, and fish.

The PCB residual concentrations and percentage of PCB reduction in sediments achieved at Lake Jarnsjon are consistent with those expected for the selected remedy for the Hudson River.

CONCLUSIONS

An average residual of 1 mg/kg Tri+ PCBs, within targeted dredged areas, is a reasonable goal for the Hudson River, considering the river's sediment PCB profile and the approach taken by EPA to establish dredging targets under the selected remedy. The percent reduction in PCB concentrations expected to be achieved for the Hudson (approximately 96 to 98 percent) is approximately at the range attained at other sites, some with more difficult environmental conditions. In addition, placement of backfill material will provide a substantial barrier between residual contamination and the water column, thereby providing effective isolation of dredged areas.

REFERENCES

Alcoa, Inc. 1995 Non-Time Critical Removal Action Documentation Report, Volumes I and II, Grasse River Study Area, Massena, NY. Prepared for Alcoa, Inc. by Blasland, Bouck & Lee, Inc. December.

Bolen, W. USEPA Region 5. 2001. Personal communication with John Szeligowski and Hui Pang of TAMS Consultants, Inc. June 22.

Dolata, L. NYSDEC. 2001. Personal communication with John Szeligowski and Hui Pang of TAMS Consultants, Inc. June 26.

Fort James Corporation, Fort & Van Dyke, and Hart Crowser, Inc. 2001. Final Report 2000 Sediment Management Unit 56/57 Project Lower Fox River, Green Bay, Wisconsin. Prepared for USEPA and Wisconsin Department of Natural Resources. January.

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

Kelly, A. USEPA Region 2. 2001. Personal communication with John Szeligowski and Hui Pang of TAMS Consultants, Inc. July 24.

Ports, W. NYSDEC, 2001. Personal communication with John Szeligowski and Hui Pang of TAMS Consultants, Inc. September 12.

Simeone, R. US Army Corps of Engineers, New England District. 2001. Personal communication with John Szeligowski and Hui Pang of TAMS Consultants, Inc. July 23.

Tames, P. 2001. Personal communication from Pam Tames to (USEPA) to Helen Pang (TAMS) on October 11 2001. Cadmium bioaccumulation and tissue data.

Thibodeaux L.J. 2000. The Effectiveness of Environmental Dredging: A Study of Three Sites. Final Report. South and Southwest, Center for Hazardous Waste Research, Louisiana State University at Baton Rouge, LA. Submitted to: Environmental Science and Technology Development Environmental Health Sciences Services, North American, ALCOA.

Wisconsin Department of Natural Resources, 2001. Draft Sediment Technologies Memorandum for the Lower Fox River and Green Bay Feasibility Study. Prepared for the Wisconsin Department of Natural Resources by ThermoRetec Consulting Corporation. July.

Estimate of Dredged Material Exceeding TSCA Criteria
424851

WHITE PAPER – ESTIMATE OF DREDGED MATERIAL EXCEEDING TSCA CRITERIA

(ID 424851)

ABSTRACT

The volume of sediment exceeding the Toxic Substances Control Act (TSCA) criteria for disposal in a non-hazardous-waste landfill was reexamined in response to the revised estimate for the Total PCB inventory of the Thompson Island Pool (TI Pool). This reexamination also took into account the volume of overcut (overcut refers to the volume of uncontaminated sediments that are slated for removal in order to ensure attainment of the target residual PCB concentrations). After accounting for both factors, the anticipated percentage of dredged material from the TI Pool to be treated as TSCA-regulated wastes was reduced from 28 percent (as presented in the FS) to 20 percent. Overall, this reduced the percentage of dredged material for the entire remediation exceeding the TSCA threshold from 42 to 38 percent. Actual classification of material for disposal will occur once sediments have been removed from the river and sampled.

INTRODUCTION

A revised estimate of the volume of dredged materials exceeding TSCA criteria (and thereby precluded from disposal in a non-hazardous-waste landfill) was created in response to the revision of the estimates of the mass of Total PCBs to be removed by dredging from the TI Pool (White Paper – Relationship Between Tri+ and Total PCBs and White Paper – Sediment PCB Inventory Estimates). As discussed in these white papers, estimates of both the Total PCB inventory of the in-place sediments of the TI Pool, as well as the Total PCB inventory in the sediments to be removed, have been revised upward. These changes reflect an improved understanding of the relationship between the original PCB measurements conducted by NYSDEC in 1984 for the TI Pool and the likely Total PCB content of the sediment.

Appendix E-12 ("Distribution of Sediment Volume by PCB Concentration, Range in the Thompson Island Pool and Below Thompson Island Dam") of the FS describes the original approach used to estimate the volume of sediments requiring handling as TSCA-regulated wastes. TSCA-regulated wastes, because of their higher levels of contamination, involve substantially greater costs in handling and landfilling; thus, it was important to determine a reliable estimate of the volume of these materials from the available data. This estimate was calculated individually for each river section. As noted in White Paper – Sediment PCB Inventory Estimates, the estimates for River Sections 2 and 3 for the Total PCB inventories and concentrations have remained largely unchanged between the release of the FS and the release of this RS. As a result, no substantive change in the TSCA estimates for the sediments from these river sections is required. However, as also noted in the White Paper – Sediment PCB Inventory Estimates, this is not the case for the TI Pool.

Based on the improved understanding of the relationship between Total and Tri+ PCBs, the estimates of inventory and concentration of Total PCBs in the TI Pool were increased about

three-fold. Since Total PCB concentration was directly affected by the revised relationship, the TSCA materials analysis presented in the FS, which depends directly on the Total PCB concentration, required some review. The analysis presented in the FS for the TI Pool was based effectively on the Tri+ value; thus, the estimates for the concentrations of Total PCBs did not include the mono- and di-homologue fractions.

Since the preparation of the FS, EPA has conducted additional analyses of the relationship between Tri+ and Total PCBs for the TI Pool. These analyses are presented in White Paper – Relationship Between Tri+ and Total PCBs. The revised relationship between Tri+ and Total PCBs for the TI Pool is not a linear one and has warranted a reanalysis of the Total PCB inventory of the TI Pool sediments (White Paper – Sediment PCB Inventory Estimates), as well as the volume of TSCA material to be processed.

ASSUMPTIONS

For both this analysis and the FS estimate of TSCA material for the TI Pool, the 1984 NYSDEC sediment-sampling data were used to represent conditions at the time of dredging. No corrections for PCB losses from the sediments during the intervening time were made. Since losses have been documented (USEPA, 1998) and continue to occur, this approach is assumed to provide an upper bound on the actual amount of TSCA material to be generated, based on the assumption that the volume of TSCA material has decreased due to PCB release from the sediments since 1984.

In addition to this assumption, the calculation presented in the FS made several other conservative assumptions, some of which are not repeated in the current calculations. These assumptions were useful during the FS since it was known that the estimates of Total PCBs, based on the reported sum of Aroclors for the TI Pool, represented an underestimate of the Total PCB concentrations for the pool. Thus, the use of conservative assumptions helped ensure that a useful estimate of the TSCA volume for the TI Pool was created. These assumptions included the following:

(a) The length-weighted average concentration in the contaminated sediments at each location was assumed to apply over the entire depth to be dredged. This assumption ignored the effect of the planned overcut intended to ensure attainment of the residual target contamination levels. The additional volume should have served to reduce the TSCA volume, since the contaminated sediments and the clean overcut material are largely removed and mixed together during the dredging process. This approach provides an upper-bound estimate of the concentration to be compared with the TSCA criteria.

(b) TSCA material was defined as any sediment having a length-weighted average concentration greater than 32 mg/kg. This value provides a sufficient margin of safety for the landfills accepting non-TSCA-regulated materials; *i.e.*, the chances of a non-hazardous-waste landfill accepting TSCA wastes are substantively reduced, since the criteria is actually 50 mg/kg.

(c) The percentage of material meeting TSCA criteria was then based on the fraction of 1984 sampling locations included in the areas to be dredged that exceeded the TSCA criteria.

This assumption weighted each sampling location based on the volume associated with it (*i.e.*, the product of its area as associated by the Thiessen polygon analysis and the depth of contamination at the sampling location). In this manner, the TSCA percentage was based on the distribution of the volumes of contaminated sediment exceeding the criteria and not simply the number of samples.

In the calculations presented here, assumption (a) is not used, since it has been possible to better estimate the Total PCB concentrations within the sediments. As a result, the estimate of the volume of sediments exceeding TSCA criteria should be more accurate.

Assumption (b) reflects the reality of the classification process, in that non-hazardous-waste landfills typically do not accept materials over this concentration. This threshold criterion has been retained for the current calculation, although the revised calculation includes the material captured by the overcut. Similarly, assumption (c) was also used in this revision.

REVISED ESTIMATE OF THE VOLUME OF SEDIMENTS EXCEEDING TSCA CRITERIA

As stated above, the approach used for the FS provided an upper bound on the actual amount of TSCA-regulated material to be generated and does not account for the overcut volume. To accomplish the current estimate, the revised Total PCB inventory for the TI Pool was used as a basis. The calculations presented in White Paper – Sediment PCB Inventory Estimates provide an estimate of the local PCB mass at each sampling point in the 1984 survey of the TI Pool. These estimates of mass were converted to an estimate of the local concentration in the dredged material as follows:

- An estimate of the concentration of Total PCBs in the contaminated sediments was generated for each sampling location and corresponding polygon using the length-weighted average Tri+ concentration and multiplying by the appropriate conversion factor (White Paper – Relationship Between Tri+ and Total PCBs). As described in the white paper, the factor varied from 2.2 to 3.8.

- The Total PCBs concentration was converted to a mass-per-unit-area (MPA) value in g/m^2 by multiplying the concentration by the depth of contaminated sediment and the mean density of the core.

- The Total PCB mass contained within the polygon was estimated by the product of the polygon area and the MPA.

- Finally, the concentration of Total PCBs in the material to be removed (contaminated sediment plus overcut) was estimated as the quotient of the Total PCBs mass and the mass of sediments to be removed from the polygon. The mass of sediments to be removed was determined from the bathymetric data and the assigned dredging elevation (Chapter 4 of this RS, Master Comment 313219), thus representing the entire mass of sediment to be removed from the location.

The results of this calculation are presented in Figure 424851-1. This figure shows the cumulative fraction of the sediment volume as a function of concentration. The data are represented in log-scale, with a vertical line corresponding to the threshold value of 32 mg/kg. Approximately 80 percent of the sediment to be dredged falls below this value (to the left in the figure), suggesting that, for the TI Pool, only 20 percent of the material to be removed would require handling as TSCA-regulated waste.

This revised estimate is lower than the upper-bound value of 28 percent originally presented in the FS. This is the result of the revised relationship of Total PCB to Tri+ (which serves to increase the volume of TSCA-regulated material) and correcting for the additional overcut material (which serves to reduce the volume exceeding the TSCA criteria). The net result shows that the original, conservative estimate of 28 percent TSCA-regulated material for the TI Pool was a good estimate of the upper bound, as intended in the FS. The revised value of 20 percent represents a best estimate of the volume exceeding the TSCA criteria. The results for this revision, along with the original estimates presented in the FS, are summarized in Table 424851-1.

The table also contains the original estimates of material exceeding the TSCA criteria for Sections 2 and 3. These are included to facilitate the recalculation of the total fraction and volume of materials for the entire remediation exceeding the TSCA criteria. Note that for both Section 2 and Section 3, the calculations were performed on a Total PCB basis directly. However, due to the limited nature of the data in these sections, it was not possible to estimate a distribution of Total PCB concentrations incorporating the volume of overcut. This limitation was derived from the use of dredge-zone-wide mean values, rather the use of polygonal declustering to estimate inventories. As a result, the extent of overcut could not be incorporated in these sediment estimates and the values represent an upper bound on the volume of material exceeding the TSCA criteria. Note that the volumes in Table 424851-1 represent the entire dredge volume, including overcut. The calculation was limited only in that it was not possible to independently assess the impact of the overcut on the distribution of the Total PCB concentrations.

As a point of comparison, if the Total PCB inventory of the TI Pool is integrated without the additional volume from overcut, the TSCA volume rises to 52 percent of the total, or more than twice that of the estimate given above. A similar effect would be expected for River Sections 2 and 3 volumes exceeding the TSCA criteria. This would bring the values presented in Table 424851-1 for these sections more in-line with those of the TI Pool (*i.e.,* it would reduce them by one half or more). The inability to do this directly limits the current estimate of an upper bound on the amount of TSCA material.

Using upper-bound estimates for all three river sections, the original estimate placed the fraction of dredged sediments exceeding the TSCA criteria at 42 percent of the total. The inclusion of the revised TI Pool estimate reduces this fraction to 38 percent. This value is still considered an upper bound for the entire effort, but it is less conservative than the original value.

CONCLUSION

The revised estimates of Total PCB inventory in the TI Pool were incorporated in the estimate of the volume of sediments to be classified as TSCA-regulated wastes. The estimate of TSCA-regulated wastes for the TI Pool incorporated both the new values for Total PCBs as well as the volume of uncontaminated sediments to be removed as overcut. These revisions led to a decrease in the estimate of TSCA-regulated wastes for the TI Pool.

The revised estimate for the TI Pool (20 percent of the dredged material) is considered to be a best estimate, whereas the prior estimate represented an upper bound. Combining the revised percentage for the TI Pool with the previous upper-bound estimates for River Sections 2 and 3 yields a slightly lower estimate (38 percent) of the volume of TSCA-regulated wastes.

In light of the small scale of this revision, the FS cost estimate has not been adjusted. It is expected that the costs of remediation would decrease comparably (less than 10 percent) if this revision were reflected in the cost estimate.

REFERENCES

USEPA. 1998. Further Site Characterization and Analysis. Volume 2C-A Low Resolution Sediment Coring Report (LRC), Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2, New York by TAMS Consultants, Inc., Gradient Corporation, and TetraTech, Inc. July.

Rail Operations
312991

No Figures or Tables

WHITE PAPER – RAIL OPERATIONS

(ID 312991)

ABSTRACT

Commenters questioned whether or not the rail infrastructure of the Upper Hudson River region has adequate capacity to support the proposed remedy. Concerns were raised with regard to rail line capacity, rail yard capacity, rail line safety, rail car availability, and rail operations, among other matters.

The principal rail concerns raised by commenters are addressed below. Input to the responses provided herein was obtained, in part, from representatives of the Canadian Pacific Railroad (CPR), the principal rail system that serves the Upper Hudson River valley. Based on Site inspections conducted by EPA and information provided by CPR and other sources, it has been concluded that the existing rail infrastructure has the capacity to support the selected remedy and that rail operations can be conducted safely and efficiently.

INTRODUCTION

For purposes of the analysis described herein and to allow a detailed evaluation of the current rail line capacities and their ability to support the selected remedy, it was necessary for EPA to assume two example locations for the sediment processing/transfer facilities.[1] These locations were assumed at the northern limit of the project in the vicinity of the Old Moreau Dredge Spoils Area and at the southern limit of the project in the vicinity of the Port of Albany. Please refer to the White Paper – Example Sediment Processing/Transfer Facilities for a discussion of processing/transfer facility site attributes.

RAIL LINE CAPACITY

Commenters suggested that CPR's Fort Edward/Albany rail corridor does not have adequate capacity to handle the traffic that would be generated by the proposed remedy. As presented in the FS, it is anticipated that once remedial operations have reached a steady state (full-production levels), approximately 16 rail car loads of stabilized sediments will be generated per day at the northern sediment processing/transfer facility (NTF) and approximately 29 rail car loads at the

[1] It is important to note that EPA has not yet determined the location(s) of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the Feasibility Study, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the Upper Hudson River valley and farther downstream, are possible.

southern sediment processing/transfer facility (STF), based on a six-day work week. Thus, approximately 90 rail car loads of sediments would need to be hauled to offsite disposal facilities three times each working week.

Conversations with the railroad's representatives indicated that CPR had acquired the Delaware & Hudson (D&H) (the historical rail operator in the Hudson valley) rail assets with the intention of expanding service along the former D&H corridor. One commenter stated that there are five daily passenger trains and two daily freight trains using CPR's Fort Edward/Albany corridor at this time. Furthermore, this commenter indicated that Amtrak passenger service occurs during daylight hours on the Fort Edward/Albany corridor and that freight traffic is relegated to nighttime hours. Finally, this commenter stated that the CPR/Amtrak relationship was one of sharing existing trackage. Based on these statistics, the commenter concluded that the Fort Edward/Albany rail corridor might have inadequate capacity to serve the project.

During a telephone conversation regarding the conclusions drawn by this commenter, CPR indicated that the Ft. Edward/Albany corridor does have adequate rail capacity (CPR, May 17, 2001). The following items summarize CPR's assessment of the current rail situation in the Upper Hudson River valley:

- There are six passenger trains using the Fort Edward/Albany corridor at this time. In addition, up to 14 freight trains (through and local) move along the corridor on a typical day. The freight train movements currently occur during both daytime and nighttime hours. There is no nighttime "window" applicable to this corridor as is the case, for instance, along the Hudson East corridor south of Albany. CPR believes that the commenter may be confusing the Hudson East rail situation (Amtrak and CSX) with the Fort Edward/Albany corridor (Amtrak and CPR). CPR also indicated that it owns the rail line between Fort Edward and Albany (which extends northward to Canada and southwestward to Binghamton) and does not share this line with Amtrak, but leases its use to Amtrak as part of an overall business agreement.

- Depending on details of the project, it is likely that activities at the example NTF will generate one or, at most, two trainloads of sediment each week. Initially, this material would be hauled, on a daily basis, to the Fort Edward Yard. CPR suggested that project rail cars could either be attached to through freight trains or be assembled into complete trainloads at Fort Edward; also, blocks of project rail cars could be assembled and hauled to the Saratoga Springs Yard for assembly into complete trainloads. CPR expressed the view that best shipping economics would be obtained if regular, complete trainloads were assembled at its yards.

- CPR indicated that the commenter's conclusion that there may be inadequate capacity on the Fort Edward/Albany corridor to handle disposal of dredged sediments generated from the project was inaccurate. CPR indicated that its goal is to expand the use of this line, thereby increasing its profitability. It was concluded by the rail company's representative that this is the reason CPR purchased the rail corridor. In addition, CPR has expended considerable resources improving conditions on the line and is now planning additional upgrades (including new sidings) to improve competitiveness.

Safety – Rail Crossings

It was stated by one commenter that there are 26 at-grade rail crossings between Saratoga and Fort Edward. It was indicated that 19 of the 26 crossings do not have electronic controls or signals; as a result, the commenter expressed concern with safety. CPR stated that the 19 uncontrolled crossings are located on private roads (*i.e.*, on farm property with no general public access) (CPR, 2001b). Furthermore, CPR indicated that all public rail crossings between Fort Edward and Saratoga are equipped with automatic highway warning devices consisting of gates, flashers, and bells.

Sediment Processing/Transfer Facility Site Rail Operations

According to the FS, the NTF will load out approximately 16 gondola rail cars each day. Commenters stated that freight trains would not be expected to move any fewer than 32 loaded rail cars and, as a result, the NTF would have to be capable of storing up to 32 gondola rail cars. However, it was indicated by CPR that they would pick up the daily quota of 16 loaded rail cars and subsequently place 16 empty rail cars at the NTF, as stated in the FS. The 16 loaded rail cars would either be stored at the Fort Edward rail yard or hauled to the Saratoga Springs rail yard and assembled into a complete train.

The FS did not identify on-site storage at the NTF for 32 loaded rail cars and 32 empty rail cars as suggested by commenters. Due to the close proximity of the Fort Edward rail yard to the NTF, the FS assumed that a storage track with a capacity for 16 rail cars would be constructed at the NTF, with daily pickup and drop-off by CPR from their Fort Edward facility. This addresses the concerns expressed by commenters with regard to storage space needed at the NTF for 64 gondola rail cars.

Commenters also questioned the availability of room for an additional 90 project-related gondola rail cars at the Albany and Fort Edward rail yards, given the space currently available at these yards. CPR representatives indicated that various reviewers of the FS had asked them "how much storage would be needed to support the remedial operation." The answer provided by CPR was that "storage for about 90 cars at each location would be sufficient to support the proposed plan." Providing storage for 90 rail cars was not intended to be an upper-bound limit of what is available but rather to be a reflection of what would be appropriate for a project of this magnitude.

Safety, Spills, and Contamination

One commenter stated that the railroad requires their customers clean the exteriors of rail cars and wheels to avoid injuries to their employees. CPR representatives stated that there was no specific policy in this regard and they were unaware of where this information was obtained. CPR did state that, in instances where rail cars visibly have stabilized sediment adhering to their exteriors, they would need to be cleaned (pneumatically or hydraulically) before exiting the NTF. The CPR representative stated that the approach to car cleaning would be an individual customer preference and not a railroad requirement.

The railroad currently manages its operations in accordance with a spill control and response plan, since they presently handle hazardous wastes as part of their daily business operations, and have done so historically. The railroad's spill control and response plan will continue to be applicable and will be followed during implementation of the selected remedy.

Gondola rail cars leaving the NTF or STF with stabilized materials will be covered. Spills are not expected to occur from these cars; however, in the event of an accident, it is not anticipated that the stabilized sediment will disperse from the location of the spill since stabilized sediment has qualities similar to those of soil. Therefore, in the remote event of a release or spill, discharged sediment can readily be addressed by following precautions and procedures outlined in the spill control and response plan.

Rail Car Movement/Turnaround Time

One commenter indicated that a four- or six-week turnaround time would be experienced for the movement of TSCA materials to a TSCA landfill located in Andrews, Texas. Note that this rail car turnaround time impacts the number of gondolas that will be needed to run the project. The six-week turnaround was an estimate provided to the commenter by the Andrews, Texas landfill operator. The CPR representatives suggested that a four-week turnaround time was reasonable, and that this time may be decreased if unit trainloads were being handled. In addition, if a non-TSCA facility is selected within New York State or the surrounding area, a two-week turnaround time for gondola rail cars can be expected.

As previously indicated, project-related freight train movements can occur during day or night hours. Rail movements are not currently limited on the Fort Edward/Albany corridor. Project-related rail movements will be dependent upon the schedule agreed upon with the railroad during the project design phase, as well as in accordance with the rate of sediment processing at either the NTF or STF and subsequent loading of processed sediments into rail cars.

Rail Car Availability and Leasing

Commenters suggested that about 1,100 rail cars would be needed for disposal purposes and an additional 200 rail cars needed for hauling backfill. In addition, commenters indicated that 800 gondolas would be needed for mechanical dredging operations and 1,300 for the hydraulic dredging operations. It was also stated by commenters that CPR has 3,000 gondolas on-hand and that dedicating rolling stock to the project could strain the railroad's ability to serve other customers.

During the phone conversation held with CPR regarding these concerns, CPR representatives agreed that the selected remedy demands a large number of gondolas and could burden the railroad's own car resources. However, CPR also stated that the availability of gondolas depends on economic conditions at the time the equipment is needed. Gondolas are not currently in great demand and are instead being scrapped. At this time, it would be possible to lease gondolas for $350 per month. According to CPR, a viable strategy for the project would be to lease gondolas and not rely on CPR-supplied equipment. Therefore, EPA's contracting team would need to obtain rolling stock from various organizations that specialize in rail car leasing.

Assuming a lease arrangement that averages $400 per car per month, the resulting rail car leasing charge to the project would be about five dollars per shipped ton (assuming an average rail car turnaround time of three weeks). However, actual leasing costs to the project may be less, since it should be possible for others to utilize the project's rolling stock of gondola cars during the winter season when dredging operations are in abeyance. Based on the uncertainties inherent in predicting future market conditions, it is EPA's view that the transportation costs presented in the FS are reasonable for the project's feasibility stage.

Shipping Two Commodities

Comments were also received concerning the logistical complexity inherent in managing two different commodities (TSCA and non-TSCA materials). With respect to this issue, CPR representatives stated that the need to manage rail cars loaded with two different commodities would complicate operations at their various yard facilities. In particular, it will result in considerable additional switching activity at the yards, particularly if it were assumed that the two materials were arriving in a random fashion. Active coordination between the in-river work and the railroad would be needed to reduce inefficiencies that could otherwise occur under these circumstances.

A comment was also received to the effect that there would be a need to increase the number of gondolas leased if the output of TSCA and non-TSCA materials is not relatively uniform. This is due to the fact that there is an expected four-week turnaround for cars going to the TSCA landfill in Texas and only a two-week turnaround for cars going to non-TSCA landfills. The commenter may be technically correct in this regard; however, the number of cars necessary will be influenced by many factors (*e.g.*, final disposal destinations, applicability of the unit train concept, the composition of the contractor's team) that are not known at this time.

Rail Car Loading

One commenter stated that EPA has provided no information or engineering analysis for rail car loading at the sediment processing/transfer facility sites. A possible arrangement of transfer site facilities is provided in the White Paper – Example Sediment Processing/Transfer Facilities, which describes concept arrangements for transfer and processing equipment at two of the several possible facility locations. In the case of the example NTF and STF, possible arrangements for rail facilities are also shown on the conceptual drawings. It can be expected that, based on detailed engineering, the actual layouts will differ from those provided conceptually, since detailed engineering analyses and designs are not normally generated, and are not required, at the FS stage of a remedial project.

REFERENCES

Canadian Pacific Railroad (CPR). 2001a. Personal communication via telephone between Ed Fitzgerald of CPR and John Szeligowski of TAMS Consultants, Inc. May 17.

CPR. 2001b. Personal communication via e-mail between Ed Fitzgerald of CPR and John Szeligowski of TAMS Consultants, Inc. May.

Off-Site Disposal of Processed Sediments
253477

No Figures or Tables

WHITE PAPER – OFF-SITE DISPOSAL OF PROCESSED SEDIMENTS

(ID 253477)

ABSTRACT

This white paper addresses the viability of EPA's plans for disposal of sediments removed from the Upper Hudson River, as described in the FS. Commenters raised questions concerning the availability of non-TSCA landfills with adequate capacity, and the effects of non-uniform flows of TSCA and non-TSCA materials.

Based on communications with landfill operators during preparation of the FS (which are documented in the Administrative Record), it is concluded that adequate commercial landfill capacity is available for disposal of Hudson River sediments. Finally, it is expected that, with proper planning, the selected contractor can manage the flow of dredged material so as not to overburden either sediment transfer logistics or transportation systems.

NON-TSCA LANDFILLS – CAPACITY AND RAIL ACCESS

Sediments with PCB levels below 50 ppm do not have to be disposed in landfills permitted pursuant to TSCA, but can be disposed in conventional landfills approved pursuant to RCRA Subtitle D and State regulations. A comprehensive search was conducted to identify landfills that have both the capacity and adequate rail access to manage Hudson River sediments (Table 4-14 of the FS).

Given that overall project costs are particularly sensitive to transportation factors, it appeared reasonable to attempt to identify facilities in New York State that would be suitable for disposal of non-TSCA sediments. However, the search identified only one landfill that would be a plausible candidate in New York: The BFI Waste Systems of North America, Inc., Niagara Falls landfill (formerly the CECOS landfill). Given the limited capacity at this location, the evaluation of non-TSCA landfill alternatives was then expanded beyond New York State to include nearby Canada, Atlantic region states, and states in the Midwest.

From the expanded search it was determined that most landfills capable of handling Hudson River sediments did not have direct rail access. However, in several situations, the landfill operator indicated that rail-delivered sediment could be off-loaded near the landfill and trucked onto the site for final disposal. If such a landfill were proposed, EPA would require the demonstration of the viability of constructing the rail/truck transfer facility in conformance with applicable environmental regulations.

Finally, several full-service waste management companies that operate disposal facilities in various regions of the country were contacted for the purpose of identifying additional suitable disposal options for non-TSCA dredged sediments. A potential advantage of using a full-service waste management organization is that such a company may have access to a number of different facilities authorized to receive processed dredged material. Thus, they may be well positioned to

organize and coordinate a disposal scenario for relatively large projects such as the Hudson River remedy. Additional disposal sites with rail access were, in fact, identified as a result of discussions with national waste management organizations. As a result of these conversations and the numerous other contacts indicated in Table 4-14 of the FS, EPA believes that commercial disposal sites will be found that have both the capacity and transportation infrastructure needed to manage the non-TSCA fraction of Hudson River sediments.

WASTE FLOW

One commenter raised a question concerning characterization of Hudson River sediments for disposal purposes. The question is based on the fact that, in effect, two commodities will be generated during the remedial work: TSCA material (+50 ppm PCB) and non-TSCA material (<50 ppm PCB). It should be noted, however, that since some commercial landfills have selected more conservative TSCA thresholds than those mandated by federal regulation, a concentration of 32 ppm PCB has been used in the FS to discriminate between TSCA and non-TSCA material.

In principle, there are several ways that the issue of waste characterization for disposal can be resolved. One approach is to let the competitive bidding process reach its intended and logical conclusion; *i.e.*, the contractor with the most efficient overall strategy will be selected to perform the work. In order to be successful, contractors will need to weigh the benefits of various sampling and testing strategies against the uncertainty and costs of not knowing where particular carloads of sediment will be transported until those cars are loaded. In selecting their particular strategies, contractors will be able to consider results of EPA's pre-construction sampling program, as well as the entire Hudson River database. Thus, the contractor will be evaluating both an expanding database (as work proceeds) and the risk of some incoming material exhibiting unexpected disposal characteristics.

Alternatively, EPA may categorize some sediments as TSCA materials on the basis of the pre-construction sampling program. This approach will have the benefit of pre-characterizing certain sediments (undoubtedly the most contaminated) as TSCA materials, thereby reducing uncertainties in materials handling and transportation logistics. The contractor will still need to sample each rail car load of non-designated sediment, but the risks of finding TSCA material will be significantly reduced, as will the associated logistical difficulties. Should a limited number of carloads of non-designated material occasionally prove to exceed the TSCA threshold, these loads would need to be segregated and routed for disposition at a TSCA facility.

IMPACT ON RAIL OPERATIONS

One commenter suggested that there will be times when the flow of dredged material will be such that only TSCA-grade sediments will be arriving at the processing/transfer facilities. At these times, there will be a need for additional rail rolling stock because the distance to TSCA landfills is expected to be at least twice that of non-TSCA landfills. There are two matters to consider in this regard:

- As detailed in the previous section, pre-construction sampling data will be used to characterize sediments before removal actually occurs. These data and other information derived from contractor experience will provide a reasonable basis to plan the project's

logistical requirements, including the number of rail cars needed to haul sediments to TSCA and non-TSCA landfills.

- Additional rail stock will be required to transport processed sediment when only TSCA materials are being removed from the river. As long as the contractor has some ability to forecast trends in sediment quality, it will be possible to lease additional gondolas for those periods during which only TSCA sediments are expected to be generated. Thus, the contractor would commit to lease a basic number of cars for the full term of the project and then would locate additional rolling stock for those periods when longer-range movements to the more remote TSCA landfills are necessary.

Additional Technology Evaluation
255314

WHITE PAPER – ADDITIONAL TECHNOLOGY EVALUATION

(ID 255314)

ABSTRACT

A number of vendors have submitted additional information on PCB remediation for evaluation during the public comment period. The vendors claimed that their respective technologies, if applied, will be most effective in remediating the PCBs in the Upper Hudson River. Their main concern was that EPA did not consider their technologies during preparation of the FS. The objective of this white paper is to evaluate the applicability of these specific technologies for remediation of PCBs in the Upper Hudson River.

Based on an evaluation of the technical documents presented by the vendors, there is insufficient information to indicate that these three technologies are feasible for remediation of sediments of the Upper Hudson River and that they will achieve RAOs/PRGs within a reasonable time frame.

INTRODUCTION

During the public comment period on the FS, a number of vendors submitted treatability study reports or additional technical information on their PCB remediation products for consideration. The objective of this white paper is to evaluate the applicability of these technologies for remediation of PCBs in the Hudson River (either *in situ* or on-site), as well as post-dredging remediation of the residual mass of PCBs in the river.

The processes may be categorized as proprietary *in-situ/ex-situ* bioremediation technologies. Although these types of technologies were evaluated for their applicability in Chapter 4 of the FS, a detailed evaluation of the submitted material is presented in this white paper. The remediation methods and the vendor names are as follows:

Process Name	Vendor Name
Aerobic/Anaerobic Bioremediation/Encapsulation Technology	Huma-Clean, LLC
Cogen V	TAMCO/KATHER
Anaerobic Bioremediation Technology	Geovation

METHOD

The criteria used to evaluate the technologies are described in Chapter 4 of the FS. Personal communication with the vendors or technical experts and the following databases were used to obtain and search for additional information on the processes:

- Superfund Innovative Technology Evaluation (SITE) program (USEPA, 1999).
- USEPA Hazardous Waste Cleanup Information (CLU-IN) Web site (USEPA, 2000a).
- USEPA Remediation and Characterization Innovative Technologies (USEPA REACH IT) database (USEPA, 2000b).

- Remediation Technologies Network (RTN) Remediation Information Management System (RIMS, 2001) database.

The unavailability of additional information in these databases indicates that the processes have never been independently evaluated by EPA. They are considered on the basis of vendor-supplied information in this white paper, and have been incorporated into Table 255314-1 (updated version of FS Table 4.3).

DESCRIPTION OF TECHNOLOGY

Aerobic/Anaerobic Bioremediation/Encapsulation Technology

The process utilizes a proprietary biological culture (H-101) to mineralize the PCBs in soil. The vendor claims that the culture contains a mixture of humic/fulvic acids and other proprietary substances and attacks the PCB molecules by generating aerobic and anaerobic reactions. The vendor also lists a number of projects successfully completed within a very short time (six months) in which site contaminants included pesticides, BTEX compounds, cyanide, phenols, nitrogen compounds, and organics. Although the vendor stated that their technology can treat PCBs in the Hudson River, no technical information is presented involving PCB remediation.

Efforts were made to obtain additional information by contacting the vendor's company consultant. The consultant confirmed that the process has never been applied to PCB-contaminated sediments and the degradation mechanism outlined in the letter is only based on speculation. She also indicated that the application of Huma-Clean might be a problem under riverine conditions.

Cogen V

The Cogen-V treatment consists of injecting bio-treatment fluids containing viable microorganisms and a wide spectrum of multiple hydrocarbon-oxidizing enzymes into the sub-surface sediments, thus allowing direct contact between sediment and the microbial slurry. A network of PVC pipes and a pumping system would be used to deliver the biofluids to the sediments.

Efforts were made to obtain additional information by contacting the vendor's company consultants. The consultants indicated that the company is working on a similar PCB-contaminated river site in Germany and they expect to publish a report on the results.

Anaerobic Bioremediation Technology

The process uses BioGeoCheMix, a pelletized solid-chemical composition, for the anaerobic bioremediation of organic contaminants such as PCBs, organochlorine pesticides (*e.g.*, DDT, toxaphene) and chlorinated solvents (*e.g.*, PCE, TCE), and inorganic contaminants (*e.g.*, arsenic-based pesticides) and oxidized forms of heavy metals (*e.g.*, hexavalent chromium). BioGeoCheMix pellets are designed to sink in water and into aqueous sediments for the remediation of difficult-to-treat contaminated environments such as river sediments, lake bottoms, and lagoons.

The vendor provided a pilot-scale treatability study report entitled "Anaerobic Bioremediation of PCB-contaminated Sludges and Sediments," which addresses the effectiveness of BioGeoCheMix. The study was funded by the New York State Energy Research and Development Authority (NYSERDA). The project consisted of applying Geovation's BioGeoCheMix (solid pellet) and N-Blend (liquid) products to PCB-contaminated sludge in a landfill cell. The cell was divided into three sub-areas (triplicate). A five-gallon plastic bucket buried in one of the sub-areas was used to serve as an untreated control. The experimental plots were covered with geotextile fabric, capillary mattings, and plastic sheets. Initial and subsequent sludge samples (day 34 and day 242) were collected and analyzed using EPA Method 8082 (congeners and Aroclors) and the Green Bay Method.

The data analyzed by Method 8082 showed a small initial decrease, followed by an increase in PCB concentration in the sludge with time. Although the method is widely used for quantitative analysis of PCB, the author attributed the data anomaly to matrix-related inefficiency of Method 8082 PCB-extraction procedures. This statement was not supported by additional laboratory experiments or literature citations; rather, the laboratory confirmed that there is essentially no difference in extraction process between EPA Method 8082 and the Green Bay Method (Kotas, 2001).

The weight percent of individual congeners did not show any decrease/trend with time that indicates that composition of PCBs (*i.e.*, relative proportion of individual congeners) did not change during the experiment. The PCB concentration in the control increased by about 83 percent between day 34 and day 242 – this increase indicates serious reliability concerns associated with the experimental method and subsequent sampling conducted by Geovation staff. The authors did not provide any control PCB concentration data at the start of the test, which is a standard procedure for such treatability studies. Method 8082 PCB Aroclor data from both the test and control samples also showed a similar increasing trend with time. Therefore, based on Method 8082 PCB analysis data, no meaningful performance evaluation of Geovation products could be made.

The PCB concentrations in the sludge were also measured by the Green Bay Method. The high percent-reduction values of the process were calculated using PCB concentrations from the control; however, the control showed a large variation from day 0 to day 34. The homologue distribution as measured by this method did not show any significant changes. The claim that "a slight shift from higher-molecular weight congeners towards lower molecular weight congeners was observed from baseline event to subsequent events" was not evident from the data and may be attributed to an analytical artifact.

The report did not address the effectiveness of BioGeoCheMix to remediate contaminated sediments, as stated in the report title. The product has been applied to "sanitary" sludge that contains far more organic matter and viable anaerobic organisms than would river sediment.

It is also not clear how the vendor envisions the application of a solid pellet and liquid reagent for *in-situ* bioremediation, as would be used in the Hudson River. For *ex-situ* application, assuming a 20-month PCB half-life (per Green Bay Method data), 12-inch thickness of sediment

and a remediation goal of 1 ppm, it would require approximately 1,650 acres of land area for six years in the vicinity of Hudson River Site to treat the sediments.

Given the inconclusive demonstration of the effectiveness of the product to remediate PCB-contaminated river sediment, this technology does not meet the criteria used to evaluate the technologies in Chapter 4 of the FS.

TECHNOLOGY EVALUATION

It is clear from the technology description and the supporting documents presented that the processes mainly rely on indigenous or amended organisms and other nutrients/enzymes/ desorption chemicals. Although all three vendors claim that their particular product will be the most effective to fully remediate the PCBs in the Hudson River sediments, they could not provide any relevant data or results in support of their claim. Some of the technology descriptions and PCB degradation mechanisms as reported in the documents were found to be confusing, and contradict the current peer-reviewed literature.

It should be noted that an *in-situ* PCB bioremediation study was conducted by GE on sediments in the Upper Hudson River (Harkness *et al.*, 1993). Six self-contained steel caisson reactors were driven into the river bottom in the vicinity of Fort Edward. The sediments within the caissons were mixed and subjected to varying additions of oxygen, inorganic nutrients, a co-metabolite, and known PCB-degrading bacteria. Test results showed increases in the numbers of indigenous PCB-metabolizing microorganisms in all experimental caissons. In addition, PCB concentrations, normalized to total organic carbon (TOC) content, decreased by about 50 percent in all caissons. However, biodegradation of the remaining PCBs was not observed, which was attributed to slow desorption kinetics. Garvey and Tomchuk (1997) used the molar dechlorination product ratio (MDPR) to demonstrate the infeasibility of complete PCB biodegradation.

CONCLUSION

Based on the PCB remediation literature reviewed in the FS and an evaluation of the technical documents presented by the vendors, there is insufficient information to indicate that these three technologies are feasible for remediation of sediments of the Upper Hudson River and that they will achieve RAOs/PRGs within a reasonable time frame.

REFERENCES

Garvey, E.A. and D. Tomchuk. 1997. Evidence for Limits on the Extent of Anaerobic Dechlorination of PCBs in the Hudson River Sediments. Presented at the Society of Environmental Toxicology and Chemistry 18th Annual Meeting, Philadelphia, PA. November.

Harkness, M.R., J.B. McDermott, D.A. Abramowicz, and J.J. Salvo. 1993. *In Situ* Stimulation of Aerobic PCB Biodegradation in Hudson River Sediments. General Electric Corporation Report. January.

Kotas, B. 2001. Northeast Analytical, Schenectady, NY. Personal communication with T. Ahmed, TAMS Consultants, Inc. June 15.

US Environmental Protection Agency (USEPA). 1999. The Superfund Innovative Technology Evaluation (SITE) Program: Technology Profiles, Tenth Edition. EPA/540/R-99/500.

USEPA. 2000a. Hazardous Waste Clean-Up Information (CLU-IN) Web site. Provided at http://www.clu-in.org.

USEPA. 2000b. Remediation and Characterization Innovative Technologies (USEPA REACH IT) Database (includes VISITT, Vendor Facts, and ITT). Provided at http://www.epareachit.org.

USEPA. 2001. Innovative Remediation and Site Characterization Technologies Resources, EPA/542-C-01-001.

POTENTIAL IMPACTS OF THE SELECTED REMEDY

Potential Impacts to Water Resources
312851

WHITE PAPER – POTENTIAL IMPACTS TO WATER RESOURCES

(ID 312851)

ABSTRACT

Commenters have expressed concern that implementation of EPA's selected remedy will adversely impact Hudson River water quality due to the release of suspended solids, metals, polycyclic aromatic hydrocarbons (PAHs), nutrients and pathogens. Also, some commenters are concerned that oxygen demand exerted by project discharges may reduce river dissolved oxygen (DO) levels. Finally, it is thought that there may be impacts on nearby groundwater resources from project-related activities. The purpose of this white paper is to evaluate the potential water quality impacts of implementing the selected remedy.

Construction of sediment processing/transfer facilities is not expected to generate water quality impacts since construction activities will be strictly controlled and monitored pursuant to EPA's contract specifications. Operation of sediment stabilization/dewatering processes and water treatment systems at the processing/transfer facilities will conform with substantive federal and State requirements and, therefore, no impacts to water quality are expected. Using conservative calculations it has been determined that water column increases of conventional and trace pollutants will not contravene NY State water quality standards. It is concluded that, overall, work on the selected remedy will not significantly impact either the Hudson River's surface water resources or adjacent groundwater resources.

INTRODUCTION

The selected remedy will involve construction of one or more sediment processing/transfer facilities within the Upper Hudson and removal (dredging) of approximately 2.65 million cubic yards of contaminated sediment by either mechanical or hydraulic dredging methods. Several components of EPA's selected remedy have water quality implications:

- Construction of sediment processing/transfer facilities.
- Operation of sediment processing/transfer facilities.
- Removal of targeted sediments by either mechanical or hydraulic dredging equipment.

Each of these components is evaluated below from the perspective of potential water quality impacts. The water quality parameters that are considered in the following sections are those mentioned by various commenters. It should be noted that PCB water quality impacts are addressed in the Response to Master Comment 365942 in Chapter 9.

SEDIMENT PROCESSING/TRANSFER FACILITIES

Construction

As stated in the FS, one or more facilities will be needed to process sediments that have been dredged from targeted areas of the Upper Hudson. Construction of these sediment

processing/transfer facilities will be accomplished by conventional construction methods using readily available construction machinery. Based on the selected remedy, the following structures/systems may need to be erected at the sediment transfer/processing sites (it should be noted that any particular site may already support one or more of the components listed here):

- Wharf for unloading sediment-laden barges.
- Various sediment dewatering and stabilization systems.
- Water treatment system.
- Rail storage track and loading area.
- Administrative facilities including offices, laboratory, etc.

EPA will require the sediment transfer/processing facility construction specifications to contain a number of conditions focused on controlling construction-related water quality impacts. In fact, such specifications are now routinely incorporated in contract documents for all significant developmental work. Examples of environmental clauses or conditions that may be included in the construction documents are as follows:

- Clauses that require preparation of a construction-period best management practices document.
- Conditions to control soil erosion.
- Conditions for stormwater management.
- Requirements for proper storage of fuels, lubricants, and any other chemicals.

The above list of contract requirements is by no means exhaustive but, rather, is suggestive of the approach EPA will take to avoid mobilization-period water quality impacts. It should be noted that EPA will directly monitor sediment processing/transfer facility construction to confirm that development of the facilities is actually occurring in conformance with project specifications. Given the fact that the contract documents will specifically address the matter of construction-related impacts on water quality, and that EPA will oversee contractor activities, it is not expected that development of the sediment processing/transfer facilities will result in significant water quality impacts.

Operation

Operation of the sediment processing/transfer facilities will entail a number of activities that have the potential to impact water quality without adequate management. As presented in the FS, it is expected that dredged sediments will be removed from barges at these facilities and then processed in one of several ways to improve the handling characteristics of the material. Several activities at these facilities can potentially impact water quality:

- Conveyance of sediments to the sediment processing/transfer facilities.
- Temporary storage of stabilized or dewatered sediments.
- Loading of sediments into rail cars.
- Discharges from water treatment systems.

Basically, from a water quality perspective, sediment processing/transfer activities can be grouped into two categories: Those that involve direct discharges to surface waters and those that

may result in indirect discharges. Point sources such as water treatment system discharges are an example of the first category. It is expected that a water treatment system will be constructed at the processing/transfer sites to manage excess water removed from dredged sediments. In the case of mechanical dredging technology, the water treatment system will be relatively modest, while in the case of hydraulic dredging, the treatment complex may approach 10 mgd throughput.

Direct or point-source discharges are normally regulated via a discharge permit issued pursuant to Section 402 of the Clean Water Act and State law. The discharge permit system has been specifically designed to protect the water resources of locales where discharges are occurring. Discharge permits are not required for facility operations, although point sources at these facilities will comply with substantive requirements of federal and State permits that would otherwise be required. Thus, it is reasonable to conclude that direct or point-source releases from the sediment processing/transfer facilities will not significantly impact water quality in their vicinity. For further information on water treatment systems, refer to White Paper – Example Sediment Processing/Transfer Facilities.

Indirect or non-point source discharges may occur at the sediment processing/transfer facilities in the form of stormwater runoff from processing, storage, and loading areas. If controls are not placed on runoff, it could be possible for sediment-borne contaminants, entrained in stormwater, to enter the river. EPA's approach to controlling non-point sources will be to require the contractor to develop and implement an operating-phase stormwater management plan that will include detailed best management practices that the contractor will follow to control indirect discharges. The stormwater management plan:

- Will require the contractor to direct runoff away from sediment handling and storage areas.
- Will require that contaminated runoff be directed to sediment basins.
- May mandate that certain activities be covered to avoid precipitation and runoff.
- Will require contaminated stormwater to be processed via the same treatment processes that handle excess water removed from incoming dredged material.

Based on EPA's approach to managing indirect discharges, which will also include Agency oversight of the contractor's efforts, it is not expected that indirect discharges from the sediment processing/transfer facilities will significantly impact water quality.

REMOVAL OF TARGETED SEDIMENTS

The process of removing targeted sediments has the potential to introduce sediment-borne contaminants into the Hudson River in the vicinity of work sites. The analysis presented below addresses potential water quality impacts resulting from the introduction of the following conventional and trace constituents into the water column during dredging operations:

- Total suspended solids.
- Nutrients (nitrogen and phosphorous).
- Metals.
- PAHs.

- BOD/COD.
- Pathogens.

Total Suspended Solids

Release of particulate matter to the water column (*i.e.*, total suspended solids, or TSS) during dredging operations has been estimated in White Paper – Resuspension of PCBs during Dredging. A series of mathematical models were presented in the white paper that were used to predict the mass of sediment expected to be resuspended during dredging operations and the extent to which the resuspended material will settle and disperse downstream of the dredge. In addition to TSS load to the water column, the White Paper – Resuspension of PCBs during Dredging also provides an estimate of the PCB mass that would be remobilized during dredging operations.

Water column TSS levels (mg/L) for the hydraulic and mechanical dredging technologies have been estimated in White Paper – Resuspension of PCBs during Dredging and are presented in Table 312581-1. It should be noted that the results presented in Table 312581-1 are in two forms: The "near-field" concentrations are represented as plume TSS concentrations estimated to occur 10 meters downstream of the dredging work. These concentrations do not reflect complete mixing of resuspended sediment into the entire flow of the Upper Hudson. Complete mixing can be expected to occur at some point further downstream of the dredging operations. The fully mixed, "far-field" concentrations are also presented in Table 312581-1. In this instance, the TSS load 10 meters downstream of the dredge head is simply homogenized across the entire river. This calculation represents an upper-bound TSS estimate for the well-mixed flow, since it assumes no subsequent settling occurs beyond 10 meters. TSS levels are calculated for both hydraulic and bucket dredges at similar production rates (*i.e.*, one hydraulic dredge or three bucket dredges in operation). Note that the TSS concentration varies among the river sections due to the variations in sediment type in the section-specific target areas.

In comparison to the levels shown in the table, spring runoff produces increased flows and increased TSS concentrations throughout the entire river. USGS data for Fort Edward show average levels of 13 mg/L in April over the period 1978-1995; Schuylerville averaged 21 mg/L in April from 1977-1989; Stillwater averaged 27 mg/L in April from 1977-1996; and Waterford averaged 40 mg/L in April from 1976-1996 (USGS, 2001). Thus, normal spring runoff produces far greater TSS levels than any increase estimated from dredging operations. Additionally, spring TSS loads encompass the entire river, while dredging operations are projected to increase levels by less than 1.5 mg/L within 10 meters of the dredge. Beyond 10 meters, the incremental TSS levels would be further reduced as water column mixing continues.

Throughout the rest of the year, riverine TSS levels are considerably lower than those observed in springtime, with average concentrations running between 2 mg/L and 3 mg/L. Resuspension from dredging would increase these levels, but only moderately. Given the relatively modest area of influence of the dredging-induced sediment plume, as well as the fact that mixing will further reduce dredging-induced increases, it can be expected that the river will be minimally impacted by sediment resuspension. Note, as well, that subsequent settling of resuspended sediment has not been accounted for here and will also serve to further reduce the impact of dredging. Thus, it is not expected that any downstream users of Hudson River water are likely to be impacted by

dredging-related sediment resuspension, and municipal water treatment facilities designed for year-round operation will readily handle the TSS increases associated with dredging.

Nutrients

Nutrients in Hudson River sediments are the results of historic and current point-source (*e.g.*, wastewater treatment plants) and non-point source (*e.g.*, agricultural runoff) discharges. Potential releases of two nutrients, nitrogen and phosphorous, are evaluated in the following sections.

Nitrogen

High-resolution core samples (USEPA, 1997, 1998) and USGS data (Allen, 2001) were used to investigate the nitrogen profile in Upper Hudson River sediments and the water column, respectively. Figure 312581-1 shows the typical total nitrogen profile in the high-resolution core samples in relation to the total PCB profile as a function of depth. The total nitrogen peak occurs in the same or a more-shallow layer than the total PCB peak. Since the project's dredging plan was developed to remove essentially all PCBs within a target area, most of the nitrogen-bearing compounds in targeted sediments will also be removed.

The average sediment release rate, as predicted in the White Paper – Resuspension of PCBs during Dredging, was used to estimate total nitrogen load to the water column. As detailed in that white paper, the average sediment release rate is estimated at approximately 0.13 percent of the overall mechanical dredging rate and 0.07 percent of the overall hydraulic dredging rate at 10 meters downstream of the dredge head. The maximum, median, and average nitrogen concentration (as N) found in 163 high-resolution core samples was 7,300, 2,800 and 2,600 mg/kg, respectively. Based on this data, the average total nitrogen concentration in targeted sediments may be approximated at 3,000 mg/kg. Table 312581-2 presents the estimated water column nitrogen increase, in comparison to background levels.

Based on these calculations, no water quality impacts are anticipated from the resuspension of nitrogen during dredging, since the estimated increase of this nutrient, above background levels, will be negligible (less than 1 percent).

Phosphorous

Dredging-related water column phosphorous levels were estimated using USGS data (Allen, 2001); from that data, the total phosphorous concentration in sediment is estimated to be 1,500 mg/kg. Table 312581-3 presents an analysis similar to that provided for nitrogen. As shown in Table 312581-3, there is not expected to be a concern over water-column phosphorous during dredging operations. Although the percentage increase is greater than that projected for nitrogen, the net increase of two to three percent is still minor, compared to normal river concentrations.

METALS

As discussed in the White Paper – Metals Contamination, dredging will capture most of the trace metals in targeted sediments along with PCBs. However, metals adsorbed to sediment may enter

the water column as a result of sediment resuspension during dredging. For each metal considered herein, an estimate has been made of the increase in water column concentration during dredging operations, under NYSDEC-specified low-flow conditions. The increase is calculated using the TSS flux 10 meters downstream of dredging operations; similar to the TSS analysis, far-field losses due to settling have not been considered in this analysis.

Metals identified in the White Paper – Metals Contamination as being of concern and having water quality criteria are evaluated here. The analysis presented here compares dredging-induced water column concentration to NYSDEC standards without consideration of ambient levels. Estimated water-column fluxes 10 meters downstream of the dredge head, for each river section and dredge type, are presented in Table 312581-4.

Knowing the metal flux at 10 meters, it is possible to estimate dredging-induced water column concentrations by applying NYSDEC-specified low-flow conditions (seven-day minimum event once in 10 years - 7Q10, and 30 day minimum flow once in 10 years - 30Q10). This analysis has been conducted for the mechanical dredging system, since fluxes are somewhat higher for this system. Resultant water column concentrations have then been compared to the most stringent NYSDEC water quality criteria applicable to the Hudson River (Table 312581-5).

Except for mercury and lead, estimated metal increases are predicted to be less than 1 percent of the NYSDEC water quality standard at the NYSDEC-specified low flow. Lead is predicted to increase under low-flow conditions to about 5.5 percent of the standard. Mercury would approach 87 percent of the NYS WQ standard for fish consumption (although there is currently a fishing advisory for the study area), 0.1 percent of the standard for protection of aquatic life, and 24 percent of the standard for protection of wildlife. However, since dredging-induced increases are transient and the calculations presented here applied a number of conservative assumptions (settling, flow rate, etc), it is not expected that dredging-induced increases in lead or mercury levels will have a impact on fishery resources.

Although elevated levels of titanium have been reported in Hudson River sediments, NYSDEC does not currently maintain a water quality standard for this constituent.

PAHs

Polycyclic aromatic hydrocarbons (PAHs) are formed mainly as byproducts of combustion, such as fossil-fuel power generation, numerous industrial processes, and forest fires. PAH concentration patterns in sediment may be affected by geographic location, proximity to point sources, and/or the character of nearby land uses.

Data detailing the distribution of PAHs in the Upper Hudson River sediment are limited. USGS' National Ambient Water Quality Assessment (NAWQA) Program conducted a study from 1992 to 1995 in the Hudson River Basin and collected sediment samples for PAH analysis near Stillwater and Waterford. Twenty-seven organic compounds identified as PAHs were found in sampled sediments. Concentrations were significantly higher at Waterford than at Stillwater.

Dredging-induced water column levels of these organic compounds may be conservatively estimated using the available data. Again the analysis focuses on increases that may occur

immediately downstream of the dredging activity (10 meters). Tables 312581-6 and 7 provide results for nine trace organics, together with the NYSDEC surface water standards. Although there is no ambient water column data available for PAHs, it is reasonable to conclude that given the predicted low-level increase of these contaminants, there will be no significant impact to water quality during dredging operations.

Dissolved Oxygen

Dissolved oxygen (DO) is a critical water-quality parameter for aquatic organism survival. BOD/COD-bearing constituents such as organic carbon, ferrous iron, and sulfide, found in Hudson River sediments, have the potential to consume water column oxygen.

Both high-resolution core samples (USEPA, 1997) and low-resolution core samples (USEPA, 1998) were evaluated to estimate the total organic carbon (TOC) content in Upper Hudson River sediment. The highest, median, and average TOC concentrations for a total of 188 samples were 11.5 percent, 4.8 percent, and 4.0 percent, respectively. Using these TOC concentrations, and the highest estimated TSS release to the water column during dredging, TOC levels 10 meters downstream of dredging operations have been estimated and presented in Table 312581-8. To estimate the maximum oxygen consumption related to TOC, it was assumed that all the carbon will be instantaneously oxidized stoicheometrically (*i.e.*, 2.67 oxygen to carbon ratio). As shown in Table 312581-8, the oxygen consumption/decrease is predicted to be 0.4 mg/L 10 meters downstream of the working dredge.

No ferrous iron or sulfide data are available for Upper Hudson River sediments. Total iron levels from EPA's ecological sediment samples (USEPA, 1999) and total sulfur in sediment reported by USGS for Upper Hudson River were used to conduct an upper-bound estimate of released ferrous iron and sulfide during dredging. The highest, median, and average iron concentrations for the 31 ecological sediment samples were 2.8 percent, 1.8 percent, and 1.8 percent, respectively. Using the highest concentration, the release of ferrous iron to the water column is estimated to be 0.035 mg/L for mechanical dredging and 0.038 mg/L for hydraulic dredging. Assuming that all ferrous iron is oxidized by the river's dissolved oxygen, the maximum oxygen consumption is calculated to be 0.005 mg/L on the basis of the following reaction:

$$Fe^{2+} + \frac{1}{4}O_2(g) + H^+ \rightarrow Fe^{3+} + \frac{1}{2}H_2o$$

Sediment total sulfur averaged around 0.15 percent in USGS samples. On this basis the maximum possible release of sulfide to the water column is estimated to be 0.002 mg/L (for either the mechanical or hydraulic dredging alternative). Based on the following reaction, the highest oxygen DO reduction is estimated to be 0.004 mg/L.

$$S^{2-} + 2O_2 \rightarrow SO_4^{2-}$$

Surface waters of the Upper Hudson River are designated as Classes A, B, and C by NYSDEC, with an applicable daily average DO standard of 5 mg/L. Additionally, the standard requires that the waters never fall below a value of 4 mg/L. USGS historical data indicate that DO

concentrations in the Upper Hudson River are usually above 7.2 mg/L. Therefore, the conservatively estimated net mean DO reduction of 0.2 mg/L resulting from resuspension-derived TOC, ferrous iron, and sulfide releases will not affect maintenance of acceptable DO levels.

Pathogens

The sources of pathogens in sediments can include animal feed lots, dairy farms, combined sewer overflows (CSOs), wastewater treatment facilities, and stormwater runoff, among others. Figure 312851-2 shows the locations of CSOs and point-source discharges along the Upper Hudson and the sole water supply intake at Waterford.

Once introduced or resuspended into the river, pathogens undergo loss ("die-off") due to various natural processes including settling, thermal stress, solar radiation, and predation by zooplankton. Hence, pathogen levels in the water column decrease with distance downstream from the source.

The only water supply intake in the study area is at Waterford, at approximately RM 157, although a second water intake is currently being planned for Halfmoon, NY, also in the vicinity of RM 157. The intake is more than four miles downstream from the most southerly dredging target area. In fact, most of the dredging will occur between RMs 195 and 183, more than 25 miles upriver from the Waterford intake. Given the distance between Waterford and the dredging operation, and the probability that dredging-induced pathogen increases are not likely to be significant, the Waterford water supply will not experience significant pathogen influx. In addition, the Waterford water treatment facility (which includes operations for coagulation, prechlorination, flocculation, two-stage settling, filtration, and post-chlorination) has been designed to remove such organisms.

GROUNDWATER UNDER THE INFLUENCE OF THE HUDSON RIVER

A concern has been expressed about the possible impact of dredging on groundwater resources under the influence of the Hudson River. Studies have shown that in general the Hudson River is a point of groundwater discharge (i.e., groundwater flows into the river). However, it is possible for flow reversals to occur when seasonal water levels are low or near a dam. It is expected that the process of removing targeted sediments will result in an overall reduction in the potential risk of groundwater contamination, since the primary source of PCB contamination will be removed. Given that the typical flow direction is from groundwater into the river, it is not likely that any short-term increase of contaminants in river water generated by dredging operations will impact groundwater resources.

CONCLUSIONS

In summary, Upper Hudson River water quality is not expected to be significantly impacted by implementation of EPA's selected remedy for the following reasons:

- Construction of sediment processing/transfer facilities will follow best management practices, and will include requirements to control construction-related water quality impacts.

- Operations at the sediment processing/transfer facilities will conform with the substantive requirements of otherwise applicable point-source and stormwater discharge permits.

- Based on an analysis of potential releases of various sediment constituents during dredging operations, it has been determined that either water quality standards will not be contravened or that project releases will represent a minor fraction of applicable NYSDEC regulatory levels. Mercury is the one possible exception, since its release may approach regulatory levels for fish consumption on the basis of the conservative analytical methodologies applied herein.

- Groundwater resources are expected to be unaffected during the implementation of EPA's selected remedy.

- Dredging-induced water quality impact will be insignificant in the Upper Hudson River; therefore, no impact is expected on the water quality of the lower river.

REFERENCES

Allen R.V. 2001. Personal communication by USGS with Hui Pang, TAMS Consultants, Inc., May 30.

Fox River Remediation Advisory Team (FRRAT) and Water Resources Institute (WRI). 2000. Evaluation of the Effectiveness of Remediation Dredging: The Fox River Deposit N Demonstration Project November 1998 – January 1999. June.

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

USEPA. 1998. Further Site Characterization and Analysis. Volume 2C-A Low Resolution Sediment Coring Report (LRC), Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. Prepared for USEPA Region 2, New York by TAMS Consultants, Inc., Gradient Corporation, and TetraTech, Inc. July.

US Geological Survey (USGS). 2000. A Mass-Balance Approach for Assessing PCB Movement During Remediation of a PCB-Contaminated Deposit on the Fox River, Wisconsin. Water-Resources Investigations Report 00-4245. December.

USGS, 2001. Surface water quality data provided by USGS Water Resources at http://water.usgs.gov. Total suspended solids data downloaded on March 21, 2001. Nutrients and other data downloaded on May 23, 2001.

Coastal Zone Management
253238

WHITE PAPER – COASTAL ZONE MANAGEMENT

(ID 253238)

ABSTRACT

Several comments have asked whether or not the selected remedial activities for the Hudson River PCBs Superfund Site will be consistent with New York State's Coastal Zone Management (CZM) policies. One commenter expressed concern that the selected remedy may have adverse effects on the coastal zone as a result of remedial activities that are performed south of the Federal Dam (such as a potential sediment processing/transfer facility[1] near the Port of Albany), or indirect impacts such as resuspension of PCBs during dredging in the Upper Hudson that may enter the Lower Hudson. The coastal zone includes the Hudson River from the Federal Dam in Troy to New York City. The following is a brief summary of the State's CZM Program and the relationship of EPA's selected remedy to the State's CZM policies.

INTRODUCTION

The federal Coastal Zone Management Act (CZMA) requires federal agencies that conduct or support activities that directly affect a coastal use or resource to undertake those activities in a manner that is consistent, to the maximum extent practicable, with State CZM programs that have been approved by the National Oceanographic and Atmospheric Administration (NOAA).

Pursuant to the CZMA, New York State developed and obtained federal approval for its coastal zone program, which is structured in the form of 44 coastal policies. New York State Department of State (NYSDOS) has developed and manages the New York CZM program. In accordance with the CZMA and CERCLA, EPA will ensure that on-site response activities to implement the

[1] It is important to note that EPA has not yet determined the location(s) of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the Feasibility Study, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the Upper Hudson River valley and farther downstream, are possible.

The example facility locations presented in the Feasibility Study have also been used in the Responsiveness Summary in order to clarify material presented in the Feasibility Study and Proposed Plan and in connection with additional noise, odor and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after EPA performs additional analyses and holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, all information provided in this Responsiveness Summary relative to potential impacts of the sediment processing/transfer facilities on communities, residents, agriculture, the environment and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during remedial design.

ROD, including the dredging and the sediment processing/transfer facilities, will comply, to the maximum extent practicable, with substantive requirements of the State's CZM program, including 19 Local Waterfront Revitalization Programs (LWRPs) that are part of the New York State CZM program.

NYSDOS and New York State Department of Environmental Conservation (NYSDEC) believe it would be premature to perform a CZM consistency determination on this project before the ROD is issued. The State believes that such a determination should be performed after the ROD is signed, but before the remedial design is finalized. Nevertheless, EPA has reviewed the selected remedy against applicable State CZM policies, and has determined that the dredging component of the selected remedy will be consistent with New York State coastal management policies. A consistency analysis for the sediment processing/transfer facilities will be done after the locations of those facilities are determined, but before the remedial design is finalized. EPA's CZM review of the dredging is presented below.

Activities in the Coastal Zone

EPA's selected remedy will primarily involve activity north of Federal Dam, beyond the New York State-delineated coastal zone, with the possible exception of a sediment processing/transfer facility that may be located south of the Federal Dam. However, EPA will not select location(s) for sediment processing/transfer facilities until after a public comment period that will be held on the siting issue after the ROD is signed. EPA will further evaluate the consistency of the sediment processing/transfer facilities with the State's coastal management program during the remedial design period. Consequently, the discussion that follows does not address consistency issues related to construction and operation of sediment processing/transfer facilities, but is strictly concerned with effects to the New York State-designated coastal zone associated with the dredging of PCB-contaminated sediments in the Upper Hudson River north of the Federal Dam.

Benefits of the Selected Remedy on the Lower River

EPA’s modeling projects that the coastal Lower Hudson River will experience significant benefits associated with the selected remedy (Chapter 6 of this RS). Human health cancer risks and non-cancer health hazards, as well as risks to ecological receptors, will be reduced as a result of remedial dredging. Implementation of the selected remedy will achieve a 42 to 56 percent reduction in non-cancer health hazards and a 56 to 65 percent reduction in human health cancer risks compared the No Action Alternative. Similarly, reductions in risks to ecological receptors are expected. For example, implementation of the selected remedy will result in a reduction in the toxicity quotients between 43 and 63 percent for mink in the lower river compared to the No Action Alternative.

In addition, the effects of implementation of the selected remedy on Tri+ PCB concentrations in the water column of the Lower Hudson and the subsequent effect of these concentrations on PCB body burdens in fish tissue have been modeled (Response to Master Comment 313787, Section 2.4.3 of the RS). The modeling results show significant reductions in water column Tri+ PCB concentrations and, subsequently, in fish tissue after completion of the selected remedy. Model forecasts show that implementation of the selected remedy will reduce Tri+ PCB concentrations in the water column of the lower river by 70 percent by 2029, compared to the No Action

Alternative. Since there is a strong correlation between PCB levels in the water column and those observed in fish tissue, a significant reduction in PCB body burdens in fish in the lower river is expected to occur in about the same amount of time.

CONCLUSION

The coastal resources of the Hudson River have been exposed to PCB contamination for many years, resulting in fishing advisories and the closure of commercial fisheries once maintained in the Hudson River south of the Federal Dam. In addition, PCB contamination in the Hudson River has been a major factor in the continuing public perception of the Hudson as a "polluted" river. EPA has determined that there will be no significant short-term effects on water quality in the coastal zone as a result of the dredging, and that in the long term the selected remedy will have a beneficial impact on the coastal zone because the remedy will reduce the water-column PCB load to the coastal zone. Further, EPA believes that this remedial action is consistent with the State's efforts to revitalize the environment of the Hudson River, which is expected to not only safeguard State economic, social, and environmental interests, but advance them.

The following evaluation addresses the consistency of the dredging component of the selected remedy with the 44 NYS coastal management policies. In addition, 19 LWRPs have been reviewed as part of this consistency evaluation. Figure 253238-1 depicts the locations of these cities, towns, and villages. Consistency for each LWRP is presented, as appropriate, below.

Policy 1: Restore, revitalize, and redevelop deteriorated and underutilized waterfront areas for commercial, industrial, cultural, recreational, and other compatible uses.

Not Applicable (N/A) for the dredging component of the selected remedy.

Policy 2: Facilitate the siting of water-dependent uses and facilities on or adjacent to coastal water.

N/A for the dredging component of the selected remedy.

Policy 3: Further develop the State’s major ports of Albany, Buffalo, New York, Ogdensburg, and Oswego as centers of commerce and industry and encourage the siting in these port areas, including those under the jurisdiction of State public authorities, of land use and development which is essential to, or in support of, the waterborne transportation of cargo and people.

N/A for the dredging component of the selected remedy.

Policy 4: Strengthen the economic base of smaller harbor areas by encouraging the development and enhancement of those traditional uses and activities which have provided such area with their unique maritime identity.

N/A for the dredging component of the selected remedy.

Policy 5: Encourage the location of development in areas where public services and facilities essential to such development are adequate.

N/A for the dredging component of the selected remedy.

Policy 6: Expedite permit procedures in order to facilitate the siting of development activities at suitable locations.

N/A for the dredging component of the selected remedy.

Policy 7: (Albany LWRP 7, 7a; Beacon LWRP 7, 7a; Croton-on-Hudson LWRP 7, 7a; Esopus LWRP 7, 7a, 7b, 7c, 7d; Kingston LWRP 7, 7a, 7b; Lloyd LWRP 7, 7a, 7b; New York City LWRP 7; Nyack LWRP 7; Ossining LWRP 7, 7a; Piermont LWRP 7, 7a; Poughkeepsie LWRP 7; Red Hook LWRP 7, 7a; Saugerties LWRP 7, 7a; Schodack/Castleton-on-Hudson LWRP 7, 7a, 7b; Sleepy Hollow LWRP 7, 7d; Stony Point LWRP 7, 7a, 7b, 7c, Tivoli LWRP 7, 7a): Significant coastal fish and wildlife habitats will be protected, preserved, and, where practical, restored so as to maintain their viability as habitats.

Current PCB levels measured in the river water and sediment of the Hudson River exceed criteria and guidelines established for the protection of the environment (USEPA, 2000c). Therefore, fish and wildlife in the Upper and Lower Hudson River are currently being exposed to hazardous levels of PCBs being released from contaminated sediments located primarily north of the Federal Dam. The selected remedial action will remove a significant amount of the most highly contaminated sediments from the Upper Hudson River. This will drastically reduce the amount of PCBs flowing into the New York State-designated coastal zone, where they are potentially adversely impacting wildlife.

An analysis of the potential for adverse water-quality impacts as a result of the implementation of the selected remedy has shown that dredging-related concentrations of key water-quality parameters will not contravene water quality standards (White Paper – Potential Impacts to Water Resources, White Paper – Resuspension of PCBs during Dredging). Dredging-related increases in suspended sediments are also not expected to adversely affect coastal fish and wildlife. Currently, concentrations of total suspended solids (TSS) measured in the Hudson River vary significantly throughout the course of a year (Figure 253238-2). TSS varies spatially, as well (*i.e.*, areas near tributaries have greater TSS concentrations). Peak concentrations occur in the spring along with the highest water flows from the spring runoff. Spring is also the spawning season for many fish species and a time during which many aquatic organisms are at sensitive life stages (*e.g.*, larvae, juveniles). Elevated TSS concentrations in the Hudson River resulting from the spring runoff are typically observed throughout March and April.

Any increases in TSS concentrations resulting from the selected remedy are expected to be a small fraction of the Hudson River's natural variation, and as such should not adversely affect fish and wildlife (Figure 253238-2, FS Chapter 9, White Paper – Potential Impacts to Water Resources). In addition, settling and dilution will limit effects experienced in the coastal zone, since dredging work will occur largely in River Sections 1 and 2 (RMs 194.6 – 183.4), located approximately 29 miles north of the Federal Dam at Troy, where the New York State-designated

coastal zone begins. Consequently, EPA believes that implementation of the selected remedy will have a beneficial effect on resources of the coastal zone of New York State. NYSDEC supports active remediation of contaminated sediments in the Upper Hudson River (NYSDEC, 2000). The federal Trustees for Natural Resources also favor an environmental dredging remedy for the Hudson River PCBs Site (USDOI and NOAA, 2001).

There are 34 State-designated Significant Coastal Fish and Wildlife Habitats in the Hudson River south of Federal Dam. In addition, five sites have been identified as containing important animal and plant communities (NYSDOS and The Nature Conservancy, 1990). A discussion of each significant habitat is provided in Table 253238-1. It should be emphasized that all sediment removal associated with this project would occur well north of these habitats. River Section 1, located approximately 34 river miles north of the New York State-designated coastal zone, would account for approximately 60 percent of the total sediment volume to be removed (USEPA, 2000c). In addition, no significant short-term adverse water quality effects or significant increases in resuspended sediment or PCB concentrations are expected in the coastal zone due to environmental dredging. Furthermore, in the long-term, EPA expects that the selected remedy will have a beneficial impact on Significant Coastal Fish and Wildlife Habitats south of Troy, since the selected remedy will reduce the exposure of these habitats to PCBs. Consequently, EPA does not anticipate any adverse impacts to these Significant Coastal Fish and Wildlife Habitats as a result of the implementation of this remedy.

Compliance with this policy also requires that habitats that support rare and endangered species will be protected, preserved, or, where practical, restored to maintain their viability. To determine whether habitat supporting any federally listed or proposed endangered or threatened species exists in the project area, EPA consulted with the US Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS). In an August 17, 2001 letter to EPA, the FWS identified one threatened species (bald eagle) that is known to occur in the project area, as well as two endangered species (Karner blue butterfly and Indiana bat) that may be found in the project area. The FWS recommended that EPA's project documents include an evaluation of potential direct, indirect, and cumulative effects of project-related activities on the bald eagle, Karner blue butterfly, and Indiana bat, and their habitats.

In a letter dated May 7, 2001, the NMFS notified the EPA that the federally listed endangered shortnose sturgeon is found in the Hudson River south of the Federal Dam at Troy, and requested that an assessment of the project's impacts to the shortnose sturgeon be prepared.

Consequently, EPA will conduct biological assessments for the bald eagle and shortnose sturgeon, as they have been identified as being in the project area. Moreover, once the locations for the sediment processing/transfer facilities and other necessary land-based infrastructure have been established, EPA will evaluate those locations to determine if they contain habitat suitable to support the Karner blue butterfly or Indiana bat. If suitable habitat is found, additional biological assessment work will be conducted for those species. Any completed biological assessments will be submitted to the FWS or NMFS for review and a final determination of effect. Further, the final remedial design will reflect appropriate measures to protect these species.

Policy 8: (Albany LWRP 8; Beacon LWRP 8; Croton-on-Hudson LWRP 8; Esopus LWRP 8; Kingston LWRP 8; Lloyd LWRP 8; New York City LWRP 8, North Greenbush LWRP 8; Nyack LWRP 8; Ossining LWRP 8; Piermont LWRP 8; Poughkeepsie LWRP 8; Red Hook LWRP 8; Rensselaer LWRP 8; Saugerties LWRP 8; Schodack/Castleton-on-Hudson LWRP 8; Sleepy Hollow LWRP 8; Stony Point LWRP 8; Tivoli LWRP 8): Protect fish and wildlife resources in the coastal area from the introduction of hazardous wastes and other pollutants which bioaccumulate in the food chain or which cause significant sub-lethal or lethal effects on those resources.

Currently, PCB levels measured in the Lower Hudson River exceed standards and guidelines established to be protective of the environment. PCBs are known to bioaccumulate, and their current and future levels are sufficient to pose a risk to piscivorous birds and mammals in the Hudson River (USEPA, 2000a, and USEPA, 2000b). The implementation of the selected remedy will serve to reduce the concentrations of PCBs that fish and wildlife are exposed to in the Hudson River, both within and outside of the coastal zone, and is therefore expected to have a beneficial impact on the entire Hudson River. PCB resuspension associated with the selected remedy is not expected to have long-lasting adverse effects on PCB concentrations in the water column or PCB body burdens in fish in the selected sediment-removal areas, or the portion of the Hudson River south of the Federal Dam.

Policy 9: (Albany LWRP 9; Beacon LWRP 9; Croton-on-Hudson LWRP 9; Esopus LWRP 9; Kingston LWRP 9; Lloyd LWRP 9; New York City LWRP 9; North Greenbush LWRP 9; Nyack LWRP 9; Ossining LWRP 9; Piermont LWRP 9; Poughkeepsie LWRP 9; Red Hook LWRP 9; Rensselaer LWRP 9; Saugerties LWRP 9; Schodack/Castleton-on-Hudson LWRP 9; Sleepy Hollow LWRP 9; Stony Point LWRP 9; Tivoli LWRP 9): Expand recreational use of fish and wildlife resources in coastal areas by increasing access to existing resources, supplementing existing stocks, and developing new resources.

There are no recreational fishing bans for the Hudson River south of Federal Dam. However, the New York State Department of Health (NYSDOH) recommends eating none of the fish in the Upper Hudson River, and that children under the age of 15 and women of childbearing age eat none of the fish in either the Upper or Lower Hudson River, and that the general population eat none of most species of fish caught between the Federal Dam at Troy and Catskill, New York. NYSDOH, 2001. Implementation of the selected remedy will help facilitate the relaxation or termination of these advisories, and as a result could increase recreational utilization of the Hudson River south of Federal Dam. In addition, potential adverse ecological effects to fish and wildlife in the Hudson River due to PCB contamination will be reduced.

Policy 10: (Beacon LWRP 10; Croton-on-Hudson LWRP 10; Esopus LWRP 10; Kingston LWRP 10; Lloyd LWRP 10, 10A; New York City LWRP 10; Nyack LWRP 10; Ossining LWRP 10; Piermont LWRP 10; Red Hook LWRP 10; Sleepy Hollow LWRP 10; Stony Point LWRP 10; Tivoli LWRP 10): Further develop commercial finfish, shellfish, and crustacean resources in the coastal area by encouraging the construction of new or improvement of existing on-shore commercial fishing facilities; increasing marketing of the State's local seafood products; maintaining adequate stocks; and expanding aquaculture facilities.

In 1976, PCB contamination led to the closure of essentially all of the commercial fishery (except for Atlantic sturgeon greater than four feet, American shad, goldfish, and baitfish) once maintained in the coastal Hudson. While the commercial fishery has since been opened for a limited number of species, it remains closed for several species, including striped bass, pumpkinseed, brown bullhead, American eel, white perch, and white catfish (USDOI and NOAA, 2001; NYSDEC, 2000). Implementation of the selected remedy will return the river to a more pristine condition, and may allow the resumption and possible expansion of commercial fishing opportunities in the Hudson River south of the Federal Dam.

Policy 11: Buildings and other structures will be sited in the coastal area so as to minimize damage to property and the endangering of human lives caused by flooding and erosion.

N/A for the dredging component of the selected remedy.

Policy 12: Activities or development in the coastal area will be undertaken so as to minimize damage to natural resources and property from flooding and erosion by protecting natural protective features including beaches, dunes, barrier islands, and bluffs.

N/A for the dredging component of the selected remedy.

Policy 13: The construction or reconstruction of erosion protection structures shall be undertaken only if they have a reasonable probability of controlling erosion for at least 30 years as demonstrated in design and construction standards and/or assured maintenance or replacement programs.

N/A for the dredging component of the selected remedy.

Policy 14: Activities and development, including the construction or reconstruction of erosion protection structures, shall be undertaken so that there will be no measurable increase in erosion or flooding at the site of such activities or development, or at other locations.

N/A for the dredging component of the selected remedy.

Policy 15: (Albany LWRP 15; Beacon LWRP 15; Croton-on-Hudson LWRP 15; Esopus LWRP 15; Kingston LWRP 15; Lloyd LWRP 15; New York City LWRP 15; North Greenbush LWRP 15; Nyack LWRP 15; Ossining LWRP 15; Piermont LWRP 15; Poughkeepsie LWRP 15; Red Hook LWRP 15; Rensselaer LWRP 15; Saugerties LWRP 15; Schodack/Castleton-on-Hudson LWRP 15; Sleepy Hollow LWRP 15; Stony Point LWRP 15; Tivoli LWRP 15): Mining, excavation, or dredging in coastal waters shall not significantly interfere with the natural coastal processes which supply beach materials to land adjacent to such waters and shall be undertaken in a manner which will not cause an increase in erosion of such land.

N/A for the dredging component of the selected remedy.

Policy 16: Public funds shall only be used for erosion-protective structures where necessary to protect human life and new development which requires a location within or adjacent to an erosion hazard area to be able to function or existing development; and only where the public benefits outweigh the long term monetary and other costs including the potential for increasing erosion and adverse effects on natural protective features.

N/A for the dredging component of the selected remedy.

Policy 17: Non-structural measures to minimize damage to natural resources and property from flooding and erosion shall be used whenever possible.

N/A for the dredging component of the selected remedy.

Policy 18: (Albany LWRP 18; Beacon LWRP 18; Croton-on-Hudson LWRP 18; Esopus LWRP 18; Kingston LWRP 18; Lloyd LWRP 18; New York City LWRP 18; North Greenbush LWRP 18; Nyack LWRP 18; Ossining LWRP 18; Piermont LWRP 18; Poughkeepsie LWRP 18; Red Hook LWRP 18; Rensselaer LWRP 18; Saugerties LWRP 18; Schodack/Castleton-on-Hudson LWRP 18; Sleepy Hollow LWRP 18; Stony Point LWRP 18; Tivoli LWRP 18): To safeguard the vital economic, social, and environmental interests of the State and of its citizens, proposed major actions in the coastal area must give full consideration to those interests and to the safeguards which the State has established to protect valuable coastal resource areas.

Since EPA's 1984 interim No Action decision for PCB-contaminated sediments in the Upper Hudson River, PCB concentrations have remained elevated in Hudson River sediments, water, and fish. Some changes have occurred during this period, but in general conditions have not improved substantially for the last five years (USEPA, 2000c). The coastal resources of the Hudson River have been exposed to PCB contamination for many years, resulting in fishing advisories and the closure of the commercial striped bass fishery, among others, in the Lower Hudson River. In addition, PCB contamination has been a major factor in the continuing public perception of the Hudson as a "polluted" river. Implementation of the selected remedy will help to remediate PCB-contaminated sediments, which will ultimately help to reduce exposure of the Hudson's coastal resources to PCB contamination. Further, this remedial action will continue New York State's efforts to revitalize the environment of the Hudson River, which EPA believes will not only safeguard State economic, social, and environmental interests, but advance them.

Policy 19: Protect, maintain, and increase the level and types of access to public water-related recreation resources and facilities.

N/A for the dredging component of the selected remedy.

Policy 20: Access to the publicly owned foreshore and to lands immediately adjacent to the foreshore or the water edge that are publicly owned shall be provided and it shall be provided in a manner compatible with adjoining uses.

N/A for the dredging component of the selected remedy.

Policy 21: (Albany LWRP 21; Beacon LWRP 21; Croton-on-Hudson LWRP 21; Esopus LWRP 21; Kingston LWRP 21; Lloyd LWRP 21; New York City LWRP 21; North Greenbush LWRP 21; Nyack LWRP 21; Ossining LWRP 21; Piermont LWRP 2; Poughkeepsie LWRP 21; Red Hook LWRP 21; Rensselaer LWRP 21; Saugerties LWRP 21; Schodack/Castleton-on-Hudson LWRP 21; Sleepy Hollow LWRP 21; Stony Point LWRP 21; Tivoli LWRP 21): Water-dependent and water-enhanced recreation will be encouraged and facilitated and will be given priority over non-water-related uses along the coast.

Remediation of PCB-contaminated sediments in the Hudson River north of the Federal Dam will do much to foster a public perception that the river is now "safe." In addition, a reduction in PCBs entering the coastal zone may facilitate the relaxation or lifting of current health advisories recommending against eating fish in the Hudson River south of the Federal Dam at Troy. An increase in water-dependent and water-enhanced recreation (*e.g.*, recreational boating and fishing) in the portion of the Hudson River located in the New York State-designated coastal zone may result from the remedial action.

Policy 22: Development, when located adjacent to the shore, will provide for water-related recreation, whenever such use is compatible with reasonable anticipated demand for such activities and is compatible with the primary purpose of the development.

N/A for the dredging component of the selected remedy.

Policy 23: Protect, enhance, and restore structures, districts, areas, or sites that are of significance in the history, architecture, archaeology, or culture of the State, its communities, or the nation.

N/A for the dredging component of the selected remedy.

Policy 24: Prevent impairment of scenic resources of Statewide significance.

N/A for the dredging component of the selected remedy.

Policy 25: Protect, restore or enhance a natural and man-made resources which are not identified as being of Statewide significance but which contribute to the overall scenic quality of the coastal area.

N/A for the dredging component of the selected remedy.

Policy 26: (Esopus LWRP 26; Lloyd LWRP 26; Red Hook LWRP 26; Schodack/Castleton-on-Hudson LWRP 26; Tivoli LWRP 26): Conserve and protect agricultural lands in the State's coastal area.

EPA has determined that dredging-related concentrations of key water-quality parameters such as TSS, nutrients (phosphorus, nitrogen), polycyclic aromatic hydrocarbons (PAHs), dissolved oxygen (DO), metals, and pathogens will represent only a fraction of their ambient levels. Additionally, resuspended sediment concentrations resulting from dredging operations and

subsequent PCB water-column concentrations are within the Hudson River's natural range of variation. As a result, farmers who use Hudson River water for irrigation purposes will not be adversely affected by implementation of the selected remedy.
See the discussion under Policy 30 for further information.

Policy 27: Decisions on the siting and construction of major energy facilities in the coastal area will be based on public energy needs, compatibility of such facilities with the environment, and the facility's need for a shorefront location.

N/A for the dredging component of the selected remedy.

Policy 28: Ice management practices shall not interfere with the production of hydroelectric power, damage significant fish and wildlife and their habitats, or increase shoreline erosion or flooding.

N/A for the dredging component of the selected remedy.

Policy 29: Encourage the development of energy resources on the outer continental shelf, in Lake Erie, and in other water bodies and ensure the environmental safety of such activities.

N/A for the dredging component of the selected remedy.

Policy 30: (Albany LWRP 30; Beacon LWRP 30; Croton-on-Hudson LWRP 30; Esopus LWRP 30; Kingston LWRP 30; Lloyd LWRP 30; New York City LWRP 30; North Greenbush LWRP 30; Nyack LWRP 30; Ossining LWRP 30; Piermont LWRP 30; Poughkeepsie LWRP 30; Red Hook LWRP 30; Rensselaer LWRP 30; Saugerties LWRP 30; Schodack/Castleton-on-Hudson LWRP 30; Sleepy Hollow LWRP 30; Stony Point LWRP 30; Tivoli LWRP 30): Municipal, industrial, and commercial discharges of pollutants including, but not limited to, toxic and hazardous substances into coastal waters, will conform to State and national water quality standards.

EPA has performed detailed analyses on the potential for adverse water quality impacts resulting from sediment removal operations in the Upper Hudson River, including the potential for PCB resuspension and the discharge of other sediment-borne contaminants.

PCB concentrations entering the Hudson River from above Rogers Island currently exceed federal and State criteria. Consequently, the federal Ambient Water Quality Criterion, the New York State standard for protection of wildlife, and the New York State standard for protection of human consumers of fish will continue to be exceeded during implementation of this remedy.

In order to reduce the potential for resuspension of PCBs during the sediment removal process, EPA will utilize environmental dredges and engineering controls. However, it is possible that there will be a temporary increase in PCB concentrations caused by sediment resuspension during dredging. EPA estimates that a maximum 61 kgs per operating season of total PCBs will be released in one operating season as a result of implementation of the selected remedy, which is only a small fraction of the average annual release (calculated for the last 10 years) of 272 kgs that would persist under the No Action Alternative. Further, the coastal zone is located 10 river

miles downstream from the southernmost remedial dredge site, well beyond the area predicted to experience impacts from resuspended sediment (Figure 253238-1).

In addition, EPA has evaluated the effect of implementation of the sediment removal on other water quality parameters to determine if the process of removing sediments has the potential to introduce other sediment-borne contaminants into the Hudson River in the vicinity of the work sites. EPA has performed analyses on conventional and trace water quality parameters including suspended solids (TSS/Turbidity), nutrients (*i.e.*, nitrogen and phosphorus), PAHs, DO, selected metals, and pathogens to address potential adverse water-quality impacts that could result from implementation of the selected remedy. Each contaminant listed was evaluated with respect to existing river background levels and published State and federal standards.

Water column TSS levels (mg/L) have been estimated for both the mechanical and hydraulic dredging alternatives. The results indicate that, upon mixing, water column TSS levels are expected to be only a fraction of that experienced during normal spring runoff. In addition, the plumes of TSS that will result from dredging would only extend a short distance from the dredge, and not river-wide. Even for times of the year when river TSS levels are relatively low, overall TSS concentrations resulting from implementation of the selected remedy are expected to be elevated only marginally in comparison to the spring conditions. This, coupled with the small area affected, leads to the conclusion that the river will be minimally impacted by resuspension from dredging.

Project-related concentrations for the remaining conventional and trace parameters were evaluated using the modeled TSS release rate. This analysis determined that:

- Increased nutrient concentrations in water will be negligible compared to the normal concentrations carried by the river. It has been estimated that the increase in nitrogen will be less than 1 percent and phosphorus will see a net increase between 2 and 3 percent above background levels.

- Metal-related water quality impacts of dredging operations will not be significant. The estimated water column increases of cadmium, chromium, copper, manganese, and nickel in the 'near-field' (*i.e.*, within 10 meters of a dredge site) due to dredging are relatively minor and do not represent a significant concern relative to regulatory levels. Lead is conservatively estimated to increase about 5.5 percent of the regulatory value, which should not be a concern. Mercury is estimated to be close to the regulatory criterion (87 percent) for consumption of fish, but since a fishing ban is in place for PCBs and will remain so during the dredging operations, this does not represent a new regulatory issue. Mercury is not expected to exceed the regulatory values for the protection of wildlife and aquatic organisms; thus, no ecological risks are anticipated.

- Estimates of increases in PAH concentrations resulting from dredging are minor. Therefore, it has been concluded that there will be no significant adverse water quality effects during dredging resulting from the introduction of trace organics to the water column.

- DO concentrations will continue to comply with water quality standards.

Accordingly, dredging-related concentrations of various water quality parameters will not contravene NYSDEC standards and applicable or relevant and appropriate State and federal water quality standards. Moreover, there are no known pollutant discharges expected as part of this project that would impact the New York State-designated coastal zone, and there will be no significant short-term impacts on water quality in the coastal zone as a result of the dredging. Further, in the long-term, the selected remedy will have a beneficial impact on the coastal zone, since the water column PCB load to the coastal zone will be reduced, resulting in improved overall water quality in the Hudson River. In the event that project-related discharges become necessary, all of these discharges would be in compliance with all applicable or relevant and appropriate State and federal water quality standards.

Policy 31: State coastal area policies and management objectives of approved local waterfront revitalization programs will be considered when reviewing coastal water classifications and while modifying water quality standards. However, those waters already overburdened with contaminants will be recognized as being a development constraint.

N/A for the dredging component of the selected remedy.

Policy 32: Encourage the use of alternative or innovative sanitary waste systems in small communities where the costs of conventional facilities are unreasonably high, given the size of the existing tax base of these communities.

N/A for the dredging component of the selected remedy.

Policy 33: Best management practices will be used to ensure the control of stormwater runoff and combined sewer overflows draining into coastal waters.

N/A for the dredging component of the selected remedy.

Policy 34: (Albany LWRP 34; Beacon LWRP 34; Croton-on-Hudson LWRP 34; Esopus LWRP 34; Kingston LWRP 34; Lloyd LWRP 34; New York City LWRP 34; North Greenbush LWRP 34; Nyack LWRP 34; Ossining LWRP 34; Piermont LWRP 34; Poughkeepsie LWRP 34; Red Hook LWRP 34; Rensselaer LWRP 34; Schodack/Castleton-on-Hudson LWRP 34; Sleepy Hollow LWRP 34; Stony Point LWRP 34; Tivoli LWRP 34): Discharge of waste materials into coastal waters from vessels subject to State jurisdiction will be limited so as to protect significant fish and wildlife habitats, recreational areas, and water supply areas.

Discharge of waste materials into coastal waters from project-related vessels could be in the form of sanitary and/or thermal wastes. These discharges will be in compliance with applicable or relevant and appropriate State and federal standards, including those of the Coast Guard and the NYSDEC.

Policy 35: Dredging and dredge spoil disposal in coastal waters will be undertaken in a manner that meets existing State dredging permit requirements and protects significant

fish and wildlife habitats, scenic resources, natural protective features, important agricultural lands, and wetlands.

N/A for the dredging component of the selected remedy.

Policy 36: (Albany LWRP 36; Beacon LWRP 36; Croton-on-Hudson LWRP 36; Esopus LWRP 36; Kingston LWRP 36; Lloyd LWRP 36; New York City LWRP 36; North Greenbush LWRP 36; Nyack LWRP 36; Ossining LWRP 36; Piermont LWRP 36; Poughkeepsie LWRP 36; Red Hook LWRP 36; Rensselaer LWRP 36; Schodack/Castleton-on-Hudson LWRP 36; Sleepy Hollow LWRP 36; Stony Point LWRP 36; Tivoli LWRP 36): Activities related to the shipment and storage of petroleum and other hazardous materials will be conducted in a manner that will prevent or at least minimize spills into coastal waters; all practicable efforts will be undertaken to expedite the cleanup of such discharges; and restitution for damages will be required when these spills occur.

It is possible that barge transport of petroleum, specifically diesel fuel, will be necessary to support project operations occurring north of the Federal Dam at Troy. Petroleum products have been transported and stored in the coastal zone as a commodity moving through the Port of Albany (POA, 2001). Best management practices will be established for the safe transport of petroleum products. In order to address the unlikely event of a spill, remediation contractors will be required to have a spill response plan in place. Consequently, EPA activities related to the shipment and storage of petroleum and other hazardous materials associated with this remedial project will be conducted in a manner that will prevent or at least minimize spills into coastal waters

Policy 37: (Albany LWRP 37; Beacon LWRP 37; Croton-on-Hudson LWRP 37; Esopus LWRP 37; Kingston LWRP 37; Lloyd LWRP 37; New York City LWRP 37; North Greenbush LWRP 37; Nyack LWRP 37; Ossining LWRP 37; Piermont LWRP 37; Poughkeepsie LWRP 37; Red Hook LWRP 37; Rensselaer LWRP 37; Saugerties LWRP 37; Schodack/Castleton-on-Hudson LWRP 37; Sleepy Hollow LWRP 37; Stony Point LWRP 37; Tivoli LWRP 37): Best management practices will be utilized to minimize the non-point discharge of excess nutrients, organics, and eroded soils into coastal waters.

The potential for increased nutrient levels to occur in the Upper Hudson as a result of the selected remedy has been analyzed. EPA has determined that elevated nutrient levels are unlikely to result from implementation of the selected remedy. Sediments with high nutrient concentrations generally occur concurrently with the PCB-contaminated sediments targeted for removal. Therefore, sediments with higher nutrient concentrations will be removed and not left exposed to the water column. Increases in nutrient concentrations resulting from resuspension caused by sediment-removal activities are expected to be within State and federal standards. Since adverse effects associated with elevated nutrient concentrations are not anticipated in the Hudson River north of the Federal Dam, EPA does not believe that there will be adverse effects in the coastal section of the river south of the Federal Dam.

Policy 38: (Albany LWRP 38; Beacon LWRP 38; Croton-on-Hudson LWRP 38; Esopus LWRP 38; Kingston LWRP 38; Lloyd LWRP 38; New York City LWRP 38; North Greenbush LWRP 38; Nyack LWRP 38; Ossining LWRP 38; Piermont LWRP 38; Poughkeepsie LWRP 38; Red Hook LWRP 38; Rensselaer LWRP 38; Saugerties LWRP

38; Schodack/Castleton-on-Hudson LWRP 38; Sleepy Hollow LWRP 38; Stony Point LWRP 38; Tivoli LWRP 38): The quality and quantity of surface water and ground water supplies will be conserved and protected, particularly where such waters constitute the primary or sole source of water supply.

Dredging-related concentrations of key water-quality parameters, such as TSS/Turbidity, nutrients (nitrogen and phosphorous), PAH, DO, metals, and pathogens will not contravene water quality standards in the Upper Hudson River. Therefore, it is not expected that contaminant resuspension associated with sediment removal activities will adversely impact water quality in the New York State-designated coastal section of the Hudson River. See the discussion under Policy 30 for further information on the effect of the selected remedy on surface water quality.

In order to protect primary water supplies in the Lower Hudson River, EPA intends to establish a notification system for municipal water suppliers located downstream of the active remedial areas. In the highly unlikely event of an observed release of sediments, municipal water suppliers will be alerted, so they can take action with regard to their river intakes. In addition, when appropriate, ongoing sampling results will be made available to municipalities so that they can assess the need for any actions necessary to protect their water supplies.

Dredging-related increases in water column TSS levels will be marginal, when compared to existing springtime conditions. Thus, water treatment facilities designated for water use during the spring would easily be able to handle the minor TSS increases associated with dredging. It should be noted that in the last 10 years, even during release events that have resulted in PCB concentrations in the water column that are much higher than those expected from dredging, there were no reported exceedances of PCB standards in water supplied by municipalities to residential and commercial users in any of the water supply districts currently obtaining their water from the Hudson River. EPA does not expect there to be any adverse effects on groundwater supplies as a result of the dredging (Chapter 9 of this RS).

Policy 39: The transport, storage, treatment, and disposal of solid wastes, particularly hazardous wastes, within coastal areas will be conducted in such a manner so as to protect groundwater and surface water supplies, significant fish and wildlife habitats, recreation areas, important agricultural land, and scenic resources.

N/A for the dredging component of the selected remedy.

Policy 40: Effluent discharged from major steam electric generating and industrial facilities into coastal waters will not be unduly injurious to fish and wildlife and shall conform to State water quality standards.

N/A for the dredging component of the selected remedy.

Policy 41: Land use or development in the coastal area will not cause national or State air quality standards to be violated.

N/A for the dredging component of the selected remedy.

Policy 42: Coastal management policies will be considered if the State reclassifies land areas pursuant to the prevention of significant deterioration regulations of the federal Clean Air Act.

N/A for the dredging component of the selected remedy.

Policy 43: Land use or development in the coastal area must not cause the generation of significant amounts of acid rain precursors: nitrates and sulfates.

N/A for the dredging component of the selected remedy.

Policy 44: (Beacon LWRP 44, 44a; Croton-on-Hudson LWRP 44, 44a; Esopus LWRP 44; Kingston LWRP 44; Lloyd LWRP 44; New York City LWRP 44; North Greenbush LWRP 44; Nyack LWRP 44; Ossining LWRP 44; Piermont LWRP 44, 44a; Poughkeepsie LWRP 44; Red Hook LWRP 44; Rensselaer LWRP 44; Saugerties LWRP 44, 44a; Schodack/Castleton-on-Hudson LWRP 44; Sleepy Hollow LWRP 44; Stony Point LWRP 44; Tivoli LWRP 44): Preserve and protect tidal and freshwater wetlands and preserve the benefits derived from these areas.

Wetlands found in the New York State-designated coastal zone will not be directly affected by dredging. The majority of the dredging will occur in River Sections 1 and 2, located approximately 29 miles north of the coastal zone (Figure 253238-1). In the event that a sediment processing/transfer facility is located in the coastal zone, potential impacts to wetlands will be evaluated during remedial design.

With respect to water quality-related indirect impacts to coastal wetlands, significant adverse water quality effects in the coastal zone are not expected to result from the selected remedy, as has been stated throughout this document. Analyses of key water quality parameters such as nutrients (nitrogen and phosphorus), PAH, DO, metals, and pathogens indicate that dredging-related concentrations will likely represent only a fraction of their ambient levels. Implementation of the selected remedy is expected to be beneficial to coastal wetlands as it will reduce the current PCB loads being introduced to the coastal section of the Hudson River.

REFERENCES

Biology, Management and Protection of Sturgeon. 2000 Annual Meeting of the American Fisheries Society, St. Louis, MO. August 23-24.

New York State Department of Environmental Conservation (NYSDEC). 2000. Comments to EPA National Remedy Review Board on EPA's preferred remedial alternative for the Hudson River PCBs Superfund Site. November 14.

New York State Department of Health (NYSDOH). 2001. Web site: www.health.state.ny.us/nysdoh. Accessed October 23.

NYSDOS and The Nature Conservancy. 1990. Division of Coastal Resources and Waterfront Revitalization. Hudson River Significant Tidal Habitats: A guide to the functions, values, and protection of the river's natural resources. 184 pp.

Port of Albany (POA). 2001. Website accessed at www.portofalbany.com. July 26.

US Department of the Interior Fish and Wildlife Service (USDOI) and US National Oceanic and Atmospheric Administration (NOAA). 2001. Comments on the Proposed Plan for the Hudson River PCBs Superfund Site submitted to EPA. April 16.

US Environmental Protection Agency (USEPA). 2000a. Further Site Characterization and Analysis, Revised Baseline Modeling Report Hudson River PCBs Reassessment RI/FS. Prepared for EPA Region 2 and US Army Corps of Engineers, Kansas City District. Prepared by Limno-Tech, Inc. (LTI), Menzie-Cura & Associates, Inc. (MCA), and Tetra-Tech, Inc. January.

USEPA. 2000b. Further Site Characterization and Analysis, Revised Baseline Ecological Risk Assessment (ERA), Volume 2E, Hudson River PCBs Reassessment RI/FS. Prepared for EPA Region 2 by TAMS Consultants, Inc., and Menzie-Cura & Associates, November.

USEPA. 2000c. Hudson River PCBs Reassessment RI/FS, Phase 3 Report: Feasibility Study. Prepared for EPA Region 2 by TAMS Consultants, Inc. December.

PCB Releases to Air
253202

WHITE PAPER – PCB RELEASES TO AIR

(ID 253202)

ABSTRACT

Emission of PCBs from dredging and operation of sediment processing/transfer facilities[1] and potential impact on ambient air quality was one of the concerns expressed by the public and various organizations during the public comment period. This white paper briefly describes the methods used for estimating the PCB flux, and provides comparison to relevant air quality standards. In addition, the white paper evaluates potential risks to residents in the vicinity of environmental dredging operations, to residents outside the processing facility boundary, and to processing facility workers.

The modeled PCB concentrations in air within the facility are compared to existing occupational standards developed by the Occupational Safety and Health Administration (OSHA). All predicted PCB concentrations in air within the facility boundary, ranging from 1-hour to annual average periods, are well below these standards. As noted in the FS, off-site modeled concentrations (*i.e.*, exposures to children, adolescents, and adults) are compared to the New York State Annual Guideline Concentrations (AGC). The modeled annual concentrations outside the facility boundary are 10 or more times lower than the AGC value. In addition to these comparisons, a risk analysis was performed to evaluate the human health cancer risks and non-cancer human health hazards to the sediment processing/transfer facility workers and those living outside the facility (*i.e.*, child, adolescent, and adult residents) using reasonable maximum exposure (RME) assumptions. The risk analysis shows that modeled PCB concentrations do not pose an unacceptable risk to human health.

[1] It is important to note that EPA has not yet determined the location(s) of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the Feasibility Study, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the Upper Hudson River valley and farther downstream, are possible.

The example facility locations presented in the Feasibility Study have also been used in the Responsiveness Summary in order to clarify material presented in the Feasibility Study and Proposed Plan and in connection with additional noise, odor and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after EPA performs additional analyses and holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, all information provided in this Responsiveness Summary relative to potential impacts of the sediment processing/transfer facilities on communities, residents, agriculture, the environment and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during remedial design.

Air monitoring, engineering controls, appropriate worker personal protection equipment, and standard safety procedures will be used as appropriate to protect the sediment processing/transfer facility workers. EPA will implement an air monitoring program to prevent unacceptable exposures to the community associated with dredging and processing of the PCB contaminated sediment. Air sampling results will also be used to confirm the modeled predictions.

INTRODUCTION

Numerous studies have documented the volatilization of PCBs from contaminated water, sediment, and soil, both in the laboratory (Larsson, 1985; Okla and Larsson, 1987; Chiarenzelli *et al.*, 1996; Chiarenzelli *et al.*, 1997; Bushart *et al.*, 1998) and in the environment (Cirpka *et al.*, 1993; Achman *et al.*, 1993; Commoner *et al.*, 1999; Harza, 1990, 1992a, 1992b; WDNR, 2001). Volatilization is an important phenomenon controlling the fate and transport of PCBs in the environment (Andren, 1983).

Review of PCB Concentrations Near Hudson River and Other Dredging Projects

The 1984 Hudson River Feasibility Study (NUS, 1984) reported air sampling in farm fields near the river in 1981. The results showed an average total PCB concentration of about 0.005 $\mu g/m^3$. General Electric sampled air-phase PCBs in the Upper Hudson River during construction of the caps for the remnant deposits between Hudson Falls and Fort Edward (Harza, 1990, 1992a, 1992b). The pre-construction samples contained no detectable levels of PCBs at a detection limit of 0.02 – 0.04 $\mu g/m^3$. During construction, samples were collected within several feet of the heavy machinery moving contaminated dredged sediments; PCB levels as high as 2.77 $\mu g/m^3$ were detected. The post-construction positive results ranged from 0.02 to 0.13 $\mu g/m^3$.

As part of the *hot spot* remedial action at New Bedford Harbor Superfund site (1997), an air monitoring program was implemented. Six monitoring stations were in the dredging area, six in the confined disposal facility (CDF) area, and four at off-site locations around the CDF. Of the 4,041 total samples, 1,063 (26 percent) exceeded the 50 ng/m^3 level, 49 exceeded the 500 ng/m^3 level and 10 exceeded the 1,000 ng/m^3 level. All but one of the 10 exceedances of the 1,000 ng/m^3 occurred at CDF monitoring stations. The one dredge area exceedance of the 1,000 occurred at the closest dredge area station, approximately 30 ft away from the most-contaminated *hot spot* area during initial deployment of various dredging related equipment. As discussed above, the calculated PCB concentrations in Tables 253202-5 and 6 compares well with those measured in the field.

The mechanism of PCB volatilization from environmental dredging and subsequent sediment associated with the selected remedy processing may be described as a two-step process. It involves desorption of PCBs from the solid into the liquid phase, followed by volatilization of the solubilized PCBs from the liquid to the air phase. Desorption of PCBs from the sediment is linear and is related to organic carbon content of the dredged sediment, particle size, and octanol/water partition coefficient. Subsequent PCB volatilization flux from liquid to air may be estimated using mass transfer correlations from the scientific literature and the concentration gradient between the liquid and the air phase.

The dredging and the sediment processing/transfer facilities are identified as the potential PCB release areas for the selected remedy. The quantity of PCBs released to the air is a function of the total surface area available for PCB release and flux of PCBs from the surface. The total PCBs released from the dredging or the sediment processing/transfer facilities may be used as input to air dispersion models for estimating the air-phase PCB concentrations at specific receptor locations. The PCB concentration values may be used to quantify the risk associated with inhaling PCBs released to air from the dredging and the sediment processing/transfer facilities. Therefore, the objective of this white paper is to present the details of a conservative estimate of:

- PCB mass transfer coefficient.
- PCB concentration estimates at nearby receptor location with highest possible impact.
- Risks associated with the sediment processing/transfer facility and the dredging site.

THEORETICAL CONSIDERATIONS

The mass transfer of a constituent across the surface microlayer can be described by the two-phase resistance model (Liss and Slater, 1974; Burkhard, 1995). The equation is given as:

$$F = K_{OL} (C - C_A) \qquad (1)$$

where:

F	=	constituent flux,
K_{OL}	=	gas transfer coefficient,
C	=	concentration of the dissolved constituent in the bulk water phase, and
C_A	=	concentration of the constituent in air expressed as the water concentration in equilibrium with the air.

The mass transfer coefficient is affected by, among other factors, the thickness of the microlayer, which is in turn affected by the turbulence in the medium. For the purposes of this analysis, the PCB concentration in Hudson River water is assumed to be much larger (orders of magnitude) than the surrounding air-phase concentration and so the flux equation can be written as:

$$F = K_{OL} * C \qquad (2)$$

Equation 2 can be applied to estimate the PCB flux across the air-water interface.

Liquid-Air Interface Mass-Transfer Coefficient, K_{OL}

The magnitude of K_{OL} is dependent on the physical and chemical properties of the compound as well as environmental conditions. The reciprocal of K_{OL} is the total resistance to transfer expressed on a gas RT/Hk_a and liquid $1/k_w$ phase basis as (Achman, 1993):

$$1/K_{OL} = 1/k_w + RT/Hk_a \quad (3)$$

where:

k_W	=	the water side gas transfer velocity in m/day,
k_a	=	the air side gas transfer velocity in m/day,
R	=	the universal gas constant (8.2057×10^{-5} atm-m^3/mol K),
H	=	the Henry's Law constant in atm-m^3/mol, and
T	=	the absolute temperature in ^{o}K.

In the above equations, k_W and k_a are estimated from published data for PCBs as discussed below.

Gas Film Coefficient

Schwarzenbach *et al.* (1992) proposed the following equation to estimate the k_a value for an organic chemical:

$$k_{a,\ organic} = k_{a,\ H2O} * [D_{organic}/D_{H2O}]^{0.61} \quad (4)$$

where:

$k_{a,\ organic}$	=	the gas film transfer coefficient for the constituent in cm/sec.
$k_{a,\ H2O}$	=	the gas film transfer coefficient for water vapor in cm/sec.
$D_{organic}$	=	the molecular diffusivity of the constituent in air in cm^2/s.
D_{H2O}	=	the molecular diffusivity of water in air in cm^2/s.

The mass transfer coefficient for water can be estimated by the following equation (Schwarzenbach *et al.*, 1992):

$$k_{a,\ H2O} = 0.2 * u_{10} + 0.3 \quad (5)$$

where:

u_{10}	=	the wind speed at a reference height of 10 m in m/s.

Using the average wind speed of 3.52 m/sec obtained from the National Climatic Data Center (NCDC, 1996) for the month of July (approximately the middle of dredging period) for the Albany Airport, eq (5) can be used to calculate the k_a for water vapor as:

$$k_{a,\ H2O} = 0.2 * u_{10} + 0.3$$

$$= 0.2 * 3.52 + 0.3$$

$$= 1.0 \text{ cm/sec}$$

Molecular diffusivities for various congeners of PCB in air were calculated by Achman *et al.* (1993); an average molecular diffusivity of PCB of 0.0527 cm^2/sec was used here. Using air-water diffusivity of 0.26 cm^2/sec (Cussler, 1984), k_a for PCBs transfer can be calculated as:

$$k_{a,\ organic} = k_{a,\ H2O} * [D_{organic}/D_{H2O}]^{0.61}$$

$$= 1.0 * [0.057/0.26]^{0.61}$$

$$= 0.396 \text{ cm/sec}$$

Liquid Film Coefficient

Liss and Marlivat (1986) proposed the following relationship based on laboratory and field data to estimate the liquid film mass transfer coefficients:

$k_w = 0.17 * u_{10}$	for $u_{10} < 3.6$ m/sec
$k_w = 2.85 * u_{10} – 9.65$	for $3.6 < u_{10} < 13$ m/sec
$k_w = 5.9 * u_{10} – 49.3$	for $u_{10} > 13$ m/sec

In the above equations, the k_w has the units of cm/hr and the relationships have been normalized to CO_2 at 20^oC. Assuming 13 m/sec wind speed to represent the mixing conditions during dredging and handling, the k_w can be calculated as:

$$k_w = 5.9 * u_{10} – 49.3$$
$$= 5.9 * 13 – 49.3$$
$$= 27.4 \text{ cm/hr}$$
$$= 0.0076 \text{ cm/sec}$$

Liss and Marlivat (1986) also suggested the following Schmidt number (Sc) relationship for estimating the k_w for other compounds:

$$k_{w,CO2} / k_{w,organic} = [Sc_{CO2} / Sc_{organic}]^n \qquad (6)$$

where:

n = -2/3 for $u_{10} < 3.6$ m/sec, and
n = -1/2 for $u_{10} > 3.6$ m/sec.

Using Schmidt numbers for CO_2 and PCBs as 600 and 2,400 (Achman *et al.*, 1993), respectively, in eq. (6), the k_w for PCBs can be calculated as:

$$k_{w,CO2} / k_{w,organic} = [Sc_{CO2} / Sc_{organic}]^n$$

or,

$$k_{w,\ organic} = k_{w,\ CO2} * [Sc_{CO2} / Sc_{organic}]^{-0.5}$$
$$= 0.0076 * [2400/600]^{-0.5}$$
$$= 0.0038 \text{ cm/sec}$$

Mass Transfer Coefficient

As stated earlier in eq. (3), the mass transfer coefficient is given by:

$$1/K_{OL} = 1/k_w + RT/Hk_a$$

where

k_w = 0.0038 cm/sec = 3.28 m/day and

k_a = 0.396 cm/sec = 342.14 m/day

Using an average Henry's Law constant of 0.00025 atm-m^3/mol for PCBs at 25°C (Brunner *et al.*, 1990) and substituting, the mass transfer coefficient can be estimated as:

$$1/K_{OL} = 1/k_w + RT/Hk_a$$
$$= 1/3.28 + 8.2057 \text{ X } 10^{-5} * 298 / (0.00025 * 342.14)$$
$$= 0.59$$

or,

$$K_{OL} = (1/0.59) \text{ m/day}$$
$$= 1.695 \text{ m/day}$$
$$= 0.0019 \text{ cm/sec}$$

The estimated value of the PCB volatilization mass transfer coefficient is consistent with the values reported in the scientific literature and EPA reports (Stumm and Morgan, 1981; EPA, 2000b).

Aqueous-Phase PCB Concentration in the Dredging and Sediment Processing/Transfer Facilities

The following two assumptions were made for calculating the PCB flux from the liquid to the atmosphere (USEPA, 2000a):

- Average sediment PCB concentration is about 31.2 mg/kg (31.2 ppm).
- Organic fraction (f_{oc}) of sediment is approximately 4 percent.

Using the organic carbon partition coefficient of PCBs (K_{oc}) as 5.3 X 10^5 mL/g, K_d, the distribution coefficient for PCBs can be calculated as:

$$K_d = K_{oc} * f_{oc} \quad (7)$$

$$= 5.3 \text{ X } 10^5 * 0.04$$

$$= 21{,}200 \text{ mL/g}$$

Assuming a linear isotherm that relates the concentration of PCBs in the aqueous phase (C) and the solid phase (S), the aqueous phase concentration can calculated as (LaGrega, 2001):

$$S = K_d * C \quad (8)$$

or:

$$31.2 = 21200 * C$$

or:

$$C = 1.47 \text{ X } 10^{-3} \text{ mg/L} = 1.47 \ \mu\text{g/L}$$

Equilibrium Air-Phase PCB Concentration

$$\text{Henry's Constant,} \quad 0.00025 = P \text{ (atm)} / C(\text{mol/m}^3) \quad (9)$$

or:

$$P = 0.00025 * [(1.47 \text{ X } 10^{-6}) \text{ g/L}] * [1/(240 \text{ g/mole})] * [1000 \text{ L/m}^3]$$

$$= 1.53 \text{ X } 10^{-9} \text{ atm}$$

Using the Ideal Gas Law:

$$PV = nRT \quad (10)$$

or:

$$6.26 \text{ X } 10^{-8} * 1 = n * 8.2057 \text{ X } 10^{-5} * 298$$

or:

$$n = 1.00 \text{ X } 10^{-7} \text{ mole/m}^3$$

Therefore,

$$C_{air} = (6.26 \text{ X } 10^{-8} \text{ mole/m}^3) * (240 \text{ X } 10^{-6} \ \mu\text{g/mole})$$

$$= 15.02 \ \mu\text{g/ m}^3$$

PCB Flux from the Air-Water Interface

Substituting K_{OL} and C in eq. (2), the PCB flux from water at 25°C can be estimated as:

$$F = K_{OL} * C$$

$$= (1.695 \text{ m/day})*(1.47 \ \mu\text{g/L})*(1000 \text{ L/m}^3)$$

$$= 2491.65 \ \mu\text{g/m}^2\text{-day}$$

$$= 2.49 \text{ mg/m}^2\text{-day}$$

ESTIMATION OF POTENTIAL PCB EXPOSURE LEVELS

The dredging sites and the sediment processing/transfer facilities for both the mechanical and hydraulic dredging operations are areas that may release PCBs into the atmosphere.

Mechanical Dredging

As stated in the FS, sediment removed by the mechanical environmental dredges would be placed into barges and towed to the processing/transfer facility. For the purpose of this analysis, it was assumed that the example northern processing/transfer facility (NTF) would be utilized to its maximum processing and transfer capacity of 1,460 tons/day (one-half of the daily amount, which equals 3,000 cy/day); the remaining dredged sediment would be processed at the southern processing/transfer facility (STF).

The preliminary design of the processing/transfer facility is presented in White Paper – Example Sediment Processing/Transfer Facilities. The system consists of a pug mill for stabilizer addition, temporary staging area, railcar loading area and a water treatment plant. The estimated surface area of each component at the processing facility for mechanical dredging is given in Table 253202-1.

It should be noted that due to the heat generated during the cement hydration reaction, the processed sediment from the pugmill would be at a higher temperature. An estimate (Kosmatka and Panarese, 1988) of the adiabatic temperature rise can be made using the following equation:

$$T = CH/S \qquad (11)$$

where:

T = temperature rise in °F of the concrete due to heat generation of cement under adiabatic conditions

C = proportion of cement in the concrete, by weight

H = heat generation due to hydration of cement, Btu/lb/°F

S = specific heat of concrete, Btu/lb/°F

Assuming the specific heat of sediment and the heat of hydration of cement are 0.2 Btu/lb/^{o}F and 100, respectively in eq (11), the change in temperature can be calculated as:

$$T = (0.08*100)/0.25$$

$$= 32^{o}F$$

$$= 17.8\ ^{o}C$$

Considering the heat dissipation associated with pugmill operation and subsequent handling of the sediment, the final processed sediment temperature may be estimated to be 30°C (assuming average sediment temperature = 18°C).

Hydraulic Dredging

The hydraulic dredging alternative proposes the use of a 12-inch hydraulic cutterhead dredge for remediation of all targeted areas in River Sections 1 and 2 and environmental mechanical dredging equipment in River Section 3. The mechanically dredged sediments will be barged to the STF and all hydraulically dredged contaminated sediments will be pumped to the NTF for processing (approximately two-thirds of the volume). Due to the estimated 1,600 ton per day shipping limit at the NTF, half of the processed river sediments will be transported to the STF for rail car loading and final disposal. Therefore, the PCB volatilization potential from STF, under the hydraulic dredging option, will essentially be the same as the mechanical dredging option.

The preliminary conceptual design of the processing/transfer facility is presented in White Paper – Example Sediment Processing/Transfer Facilities. The main components of the system include coagulation/flocculation and belt filter press for solids processing and filtration and granular activated carbon columns for water treatment. The estimated surface area of each component at the processing/transfer facility for hydraulic dredging is given in Table 253202-2.

Dispersion Model and Meteorological Data Used

Dispersion Model Used

The Industrial Source Complex Short Term (ISCST3) model, the USEPA-approved refined air quality dispersion model for simple terrain, was used in PCB concentration modeling analysis. ISCST3 is a steady-state Gaussian plume dispersion model and is used to assess pollutant concentrations for industrial facilities and to calculate concentrations for several different averaging periods such as 1-hour, 8-hour, and annual. The main Gaussian dispersion equation for calculating pollutant concentration at a given distance and height is expressed as:

$$\chi = QKVD * \exp\left[0.5\,(y/\sigma_y)^2\right] / (2\pi\, u_s\, \sigma_y\, \sigma_z) \qquad (12)$$

Where:

χ = pollutant concentration,

Q = pollutant emission rate,

K	=	a scaling coefficient to convert calculated concentrations to desired units,
V	=	vertical dispersion term,
D	=	decay term,
y	=	distance between the source and the receptor,
σ_y, σ_z	=	standard deviation of lateral and vertical concentration distribution, and,
u_s	=	mean wind speed at release height.

The parameters in the above equation are estimated using site specific conditions and guidelines provided in the *User's Guide for the Industrial Source Complex (ISC3) Dispersion Model - Volume II* (USEPA, 1995). A summary of the ISCST3 modeling inputs used in the PCB concentration calculations is presented in Table 253202-3.

Dredging Period

The dredging period is assumed to be from May to November each year for six years.

PCB Emission Rate

Liquid-Air Interface PCB Flux

The scientific literature indicates that the rate of PCB volatilization is highly dependent on temperature (Okla and Larson, 1987; Chiarenzelli *et al.*, 1996, 1997; Bushart, 1998), however, the availability of data required to quantify the effect of temperature on the rate of volatilization is limited. The results reported by Okla and Larson (1987) and others may be used to predict the effect of temperature on the rate of PCB volatilization; a 26.6 percent increase in volatilization flux may be assumed for each 10°C rise in temperature. Therefore, the following PCB emission rates were used for model input based on the expected pre- and post-cement addition temperature of the dredged sediment.

Temperature (^{o}C)	PCB Flux (mg/m^2-day)
18	2.02
30	2.82

An unit area emission rate of 2.02 mg/m^2-day was applied to PCB transfer areas under the normal temperature condition including:

- Two barge areas along each side of the river under mechanical dredging conditions.

- Areas in each sediment processing/transfer facility under the hydraulic dredging scenario. These areas were grouped into three areas as unloading, processing, and loading areas in the model.

- Unloading barges and water treatment areas in each sediment processing/transfer facility under the mechanical dredging scenario.

An unit area emission rate of 2.82 mg/m^2-day was applied to post cement mixing areas in each sediment processing/transfer facility under a mechanical dredging scenario.

PCBs Associated with Suspended Particles

As indicated in White Paper – Air Quality Evaluation, the total suspended particles (TSP) emission rate from the NTF during sediment handling process was estimated to be 8 g/hour. Using an average overall sediment PCB concentration of 31.2 mg/kg, the PCB flux associated with TSP in sediment handling would be about 0.0016 mg/m^2-day. This value is about three orders of magnitude lower than the volatilization flux, and therefore, was not considered in the PCB dispersion modeling or risk calculation since these risks are below levels of concern.

LOSS OF PCBS BY VOLATILIZATION FROM SEDIMENT PROCESSING/ TRANSFER FACILITY

The loss of PCBs by volatilization from the barge (during loading/unloading) and various treatment processes can be estimated using PCB flux and the total transfer area. The PCB loss from the northern and the southern transfer facility for both mechanical and hydraulic dredging options are presented in Table 253202-4. The volatilization loss represented as a fraction of total PCB removed by the selected remedy is also presented.

Sources Modeled

Processing/Transfer Facility

The sources at each facility were conservatively modeled as ground level-release area sources with zero exit velocity. Given the limited design specifics, the modeled area sources are assumed to be located at three areas (unloading, processing and loading areas) with each area covering the whole potential exposure area. For example, at the unloading area, the size of source is equal to the entire barge area assuming each unit area on the barge would emit the same amount of PCB. This approach would result in conservative estimates of PCB levels.

Dredging Process

The same area source modeling approach described above was employed to two dredging barges (one along the river west bank and one along the river east bank) simulated under the worst-case condition in a mechanical dredging scenario. Each barge has approximately 6,000-ft^2 of exposure area and was placed 100 ft from each side of the shoreline.

Receptors

Processing/Transfer Facility

- Discrete receptors were assumed at typical residential locations adjacent to each facility. The distance between the center of facility to the typical receptor location was assumed to be approximately 300 meters.

- Discrete receptors were assumed within the processing facility that were 1 and 10 meters from each side of each modeled area source.

Dredging Process

A series of hypothetical residences along both sides of the river were modeled. Two Cartesian receptor grid systems were placed along the river. Each grid system started 50 ft from each shoreline and covers an area 150 ft wide and 6,000 ft long that is close to a typical dredging site. This 6,000-ft distance is equivalent to the length of river that would be dredged by a single dredge within a year, under a mechanical dredging scenario.

Meteorology

The most recent and complete five consecutive years of meteorological air data were used in the ISCST3 model. The data included:

- 1993-1997: Five consecutive years of Glens Falls surface air data were used for NTF and in-river dredging.
- 1995-1999: Five consecutive years of Albany surface data were used for STF and in-river dredging.

Averaging Period Modeled

For the evaluation of human health cancer risk and non-cancer health hazards, the appropriate time-frame for averaging chronic impacts during the remediation is an annual period. In order to examine possible short-term PCB concentration in air, shorter averaging periods (*e.g.*, 1-, 8-, 24-hour and monthly) were considered in the PCB modeling. Within each modeled period, both PCB sources and receptor locations were assumed to be stationary. For example, in in-river dredging impact modeling, the predicted 8-hour level was calculated assuming the dredging equipment would be operated at the same spot for 8 hours. In the same way, it was assumed that processing facility workers would not move during the 8-hour modeled period.

Methodology for Predicting Annual Average Level from Dredging Activities

Modeling potential annual average impact from moving dredging activities along the river is extremely difficult, especially using actual meteorological data. Therefore, an equivalent stationary source approach was developed and a moving source PCB release impact at a given receptor location on an annual basis was simulated as an average of a stationary source release

impacts on a series of receptors along the river. These receptors cover a distance that takes a moving barge one year to cross.

Since dredging activities would move down the river from time to time over the entire six-year dredging period, the potential PCB emission impact on a given receptor location from dredging barges due to volatilization along the river would vary from time to time, unlike a stationary source. At a given receptor location along the river, PCB concentration levels would be expected to be higher when a barge is close and lower when it moves away. Therefore, even though the actual PCB release from a barge is constant, PCB concentration levels would vary with time at a given receptor. This moving effect can be approximated as the effect on a moving receptor from a stationary barge. Based on this analogy, the dispersion model was used to predict concentrations from two stationary barge area sources (each along one side of the river) at a receptor grid that consists of 61 receptor locations placed between 3,000 ft downstream and 3,000 ft upstream with 100-ft spacing. These receptors cover a distance (6,000 ft range along the river) that is equal to the distance that a dredge would progress in a year.

An annual average PCB level from two stationary barges was predicted at each of 61 stationary grid receptors. The average of the annual levels at these 61 receptor locations was then calculated and this level is considered equivalent to the annual concentration at a given receptor location from moving barge operations. Moreover, since the number of mechanical dredging hours on an annual basis would be approximately 47 percent of the total hours within a 30-week working period, a factor of 0.47 was used to calculate the annual average level near a typical dredging site in either the Albany or the Glens Falls area.

Modeled PCB Concentration Levels

The modeled PCB concentrations are summarized in Tables 253202-5 and 6 for processing/transfer facility operations and dredging activities in the river, respectively. Based on the assumptions described above, the predicted PCB levels may be considered to be conservative.

RISK ANALYSIS

Cancer risks and non-cancer health hazards due to possible inhalation of PCBs in air as a result of the selected remedy were evaluated for adult workers and residents (adult, adolescent, and child). Note that because a non-cancer inhalation toxicity factor does not exist for PCBs, the oral RfD was applied to the inhaled dose of PCBs. While there is uncertainty with this approach, it is recognized in EPA guidance (USEPA, 1993), and it was done here in order to avoid neglecting the consideration of potential adverse non-cancer health effects. In general, EPA's position is that, "the potential for toxicity manifested via one route of exposure is relevant to considerations of any other route of exposure, unless convincing evidence exists to the contrary." (USEPA, 1993). PCBs are absorbed through ingestion, inhalation, and dermal exposure, after which they are transported similarly through the circulation. This provides a reasonable basis for expecting similar internal effects from different routes of environmental exposure. Information on relative absorption rates suggests that differences in toxicity across exposure routes may be small (USEPA, 2000a).

With this one additional consideration of applying the oral RfD to inhaled doses of PCBs, this risk analysis is consistent with the revised baseline Human Health Risk Assessment (HHRA) using the same toxicity factors, as well as reasonable maximum exposure (RME) assumptions.

For the inhalation pathway, intake is calculated as:

$$\text{Intake}_{\text{inhalation}}\ (\text{mg/kg} - \text{d}) = C_{air} * IR * EF * ED / (BW * AT) \qquad (13)$$

where:

C_{air}	=	Concentration of the chemical in air (mg/m^3),
IR	=	Inhalation rate (m^3/day)
EF	=	Exposure frequency (days/yr)
ED	=	Exposure duration (yrs)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

- *PCB Concentration in Air (C_{air}).* Predicted PCB concentrations are summarized in Tables 5 and 6. The annual predicted PCB concentrations were used for the adult worker and the adult, adolescent, and child residents. As stated earlier, for the evaluation of possible human health cancer risks and non-cancer health hazards, the appropriate time-frame for averaging chronic impacts during the remediation is an annual period.

- *Inhalation Rate (IR).* For adult workers and residents, an inhalation rate of 20 m^3/day was used, which is the recommended value for long term exposure assessments for Superfund risk assessments (USEPA, 1991). The inhalation rate for young children (8.3 m^3/day) and adolescents (13.5 m^3/day) are current recommendations in the 1997 Exposure Factors Handbook for long term exposures (USEPA, 1997). These values are consistent with those used in the revised baseline HHRA.

- *Exposure Frequency (EF).* A full work year (250 days/year) was assumed for the adult worker. Residents may be exposed to PCBs in air when performing activities outside their homes as well as when they are inside (through outside air exchange); therefore, a RME scenario assuming exposure for 350 days a year was used (which assumes two weeks away from the residence).

- *Exposure Duration (ED).* The entire duration of the selected remedy (six years) was evaluated in this analysis.

- *Body Weight (BW).* Age-specific body weights were used. The mean BW for children aged 1 to 6 is 15 kg, for adolescents aged 7 to 18 is 43 kg, and for adults (over 18 years old) is 70 kg (USEPA, 1991).

- *Averaging Time (AT).* A 70-year averaging time of 25,550 days is used for cancer evaluations (365 days/year × 70 years), while a six-year averaging time (*i.e.*, the entire duration of the selected remedy) of 2,190 days is used for non-cancer evaluations (365 days/year × 6 years).

The evaluation of non-cancer health effects involves a comparison of average daily intake levels with RfDs. The hazard quotient is calculated by dividing the estimated average daily intake estimate by the RfD as follows (USEPA, 1989):

$$\textit{Hazard Quotient (HQ)} = \textit{Intake(mg/kg-day)/RfD(mg/kg-day)} \qquad (14)$$

The evaluation of carcinogenic risks involves the evaluation of lifetime average daily intake levels with cancer slope factors (CSFs) as follows (USEPA, 1989):

$$\textit{Cancer Risk} = \textit{Intake (mg/kg-day)} * \textit{CSF (mg/kg-day)} \qquad (15)$$

The annual predicted PCB concentrations in air were used and RME exposures were assumed for screening purposes. The calculated outside facility boundary cancer risk and non-cancer health hazard for both mechanical and hydraulic dredging options are presented in Tables 253202-7 and 8, respectively. The calculated cancer risk and non-cancer health hazard for inside facility boundary workers are presented in Tables 253202-9 and 10, respectively. Using assumptions for an RME, the cancer risks and non-cancer health hazards to processing/transfer facility workers and outside boundary adult, adolescent, and child residents are *de minimis* (*i.e.*, several orders of magnitude below a cancer risk of 1 in 1,000,000 and a hazard index of 1.0).

Comparison of Modeled PCB Concentrations with Other Guidelines

The modeled PCB concentrations in air within the facility are compared to existing occupational standards developed by the Occupational Safety and Health Administration (OSHA). For PCB workplace exposures, based on an eight-hour time-weighted average (TWA), the standards are 1,000 $\mu g/m^3$ for Aroclor 1242 and 500 $\mu g/m^3$ for Aroclor 1254 (29 CFR 1910.1000). The National Institute for Occupational Safety and Health (NIOSH) guideline concentration, based on a 10-hour work shift, is also presented in Table 253202-5. All predicted PCB concentrations in air within the facility boundary, ranging from 1-hour to annual average periods, are well below these standards (Table 253202-5).

The PCB concentrations outside the facility boundary (*i.e.*, exposures to children, adolescents, and adults) near the processing/transfer facility and the dredging site were also calculated and presented in Table 253202-5 and Table 253202-6, respectively. The concentration values are compared to the New York State Annual Guideline concentrations (AGCs) in NYSDEC's Air Guide 1 – Guidelines for the Control of Toxic Ambient Air Contaminants. The AGC value for PCBs (Aroclors 1248 and above) is 0.002 $\mu g/m^3$. The modeled annual concentrations outside the facility boundary were found to be a factor of two to several orders of magnitude lower than the AGC values. It should be noted that the AGC values are derived by New York State on the basis

of continuous (daily) inhalation of PCBs over a lifetime (70 years), while remediation is expected to take six years.

In addition to the comparisons described above, a risk analysis was performed to evaluate the human health cancer risks and non-cancer human health hazards to the sediment processing/transfer facility workers and those living outside the facility (*i.e.*, child, adolescent, and adult residents) using reasonable maximum exposure (RME) assumptions. The risk analysis shows that modeled PCB concentrations do not pose an unacceptable risk to human health (*i.e.*, human health cancer risks are below 1 in 1,000,000 and the non-cancer human health hazards are significantly less than 1). It should be noted that the calculated PCB flux associated with the total suspended particles (TSPs) is about three orders of magnitude lower than those due to volatilization. Therefore, the PCB exposures due to TSP are below a cancer risk of 1 in 1,000,000 and the non-cancer health hazards are significantly less than 1 and are, therefore, not quantitatively evaluated in the risk assessment.

CONCLUSIONS

This white paper describes the methods used for estimating the PCB flux from the dredging and the sediment processing/transfer sites, and the potential risks to processing/transfer facility workers and nearby residents. The cancer risks and non-cancer health hazards due to inhalation of volatilized PCBs in air by processing/transfer facility workers and residents living near the river or the sediment processing/transfer facility were found to be below *de minimis* levels of regulatory concern (*e.g.* below a cancer risk of 1 in a million, and below a non-cancer hazard index of 1.0). PCB exposure associated with the suspended particles were found to be about three orders of magnitude lower than the volatilized PCB and, therefore, do not pose an unacceptable cancer risk or non-cancer health hazard.

Air monitoring, engineering controls, appropriate worker personal protection equipment, and standard safety procedures will be implemented to protect the processing/transfer facility workers. EPA will conduct air monitoring and establish engineering controls to prevent unacceptable exposures to nearby residents associated with implementation of the remediation. EPA will also conduct a detailed analysis to quantify the exposure potential of PCBs from the dredging and the sediment processing/transfer facilities and implement a comprehensive air monitoring and health and safety program to address community concerns as appropriate. Air monitoring will be used to confirm the model predictions.

REFERENCES

Achman, D.R., Hornbuckle, K.C. and Eisenreich, S.J. 1993. Volatilization of Polychlorinated Biphenyls from Green Bay, Lake Michigan. *Environmental Science and Technology*, 27:1:75-87.

Andren, A.W. 1983. Processes determining the flux of PCBs across air/water interface. In: Physical Behavior of PCBs in the Great Lakes, D. Mackay, S. Paterson, S.J. Eisenreich and M.S. Simmons, eds. *Ann Arbor Science*, Ann Arbor, MI, pp. 127-140.

Brunner, S., Hornung, E., Santl, H., Wolff, E and Piringer, O. 1990. *Environmental Science and Technology*, 24:1751-1754.

Burkhard, L.P., Armstrong and Andren, A.W. 1985. Henry's Law constant for the polychlorinated biphenyls. *Environmental Science and Technology*, 19:590-596.

Bushart, S.P., Bush, B., Barnard, E.L. and Bott, A. 1998. Volatilization of Extensively Dechlorinated Polychlorinated Biphenyls from Historically Contaminated Sediments. *Environmental Toxicology and Chemistry*, 17:10:1927-1933.

Chiarenzelli, J. R., Scrudato, R.J. and Wunderlich, M.L. 1997. Volatile Loss of Aroclors from Subaqueous Sand. *Environmental Science and Technology*, 31:2:597-602.

Chiarenzelli, R., Scrudato, G., Arnold, G., Wunderlich, M. and Rafferty, D. 1996. Volatilization of Polychlorinated Biphenyls from Sediment during Drying at ambient Condition. *Chemosphere*, 33:5:899-911.

Cirpka, O., Relchert, P., Wanner, O., Muller, S.R. and Schwarzenbach, P. 1993. Gas Exchange at River Cascades: Field Experiments and Model Calculations. *Environmental Science and Technology*, 27:10:2086-2097.

Commoner, B., Bush, B., Bartlett, P.W., Couchot, K. and Eisl, H. 1999. The Exposure of the New York City Watershed to PCBs Emitted from the Hudson River. Final Report to the New York Community Trust. October.

Cussler, E.L. 1984. Diffusion, Mass Transfer in Fluid Systems. Cambridge University Press.

Harza Engineering. 1990 Fort Edward Dam PCB Remnant Deposit Containment Environmental Monitoring Program Baseline Studies, Report of 1989 Results. August-December 1989 Report to General Electric Company, Fairfield Conn. February.

Harza Engineering. 1992a. Fort Edward Dam PCB Remnant Deposit Containment Environmental Monitoring Program Baseline Studies, Report of 1990 Results. March – December 1990 Report to General Electric Company, Fairfield, Conn. January.

Harza Engineering. 1992b. Fort Edward Dam PCB Remnant Deposit Containment Environmental Monitoring Program Baseline Studies, Report of 1991 Results. January – November 1991 Report to General Electric Company. Fairfield, Conn. March.

LaGrega, M.D., Buckingham, P.L., Evans, J.C. and Environmental Resources Management. 2001. Hazardous Waste Management (2nd ed.), McGraw-Hill, New York.

Larsson, P. 1985. Change in PCB (Clophen A 50) composition when transported from sediment to air in aquatic model system. *Environmental Pollution*, 9:81-84.

Liss, P.S. and Merlivat, L. 1986. In The Role of Air-Sea Exchange in Geochemical Cycling; Buat-Menard, P. Ed.; NATO ASI Series C; D. Reidel Publishing Co.: Dordrecht, Holland, 185:113-127.

Kosmatka, S. H. Panarese, W.C. 1988. Design and Control of Concrete Mixtures, 13th Ed., Portland Cement Association, Skokie, IL.

Liss, P.S. and Slater, P.G. 1974. Flux of Gases across air-sea interface. *Nature*, 247:181-184.

National Climatic Data Center (NCDC). 1996. Data downloaded from NCDC website (http://www.ncdc.gov) on May 17, 2001.

New York State Department of Environmental Conservation (NYSDEC), 2000. Air Guide 1 – Guidelines for the Control of Toxic Ambient Air Contaminants.

NUS Corporation. 1984. Feasibility Study: Hudson River Site, New York. Vol. 1, Pittsburgh.

Okla, L. and Larsson, P. 1987. Day-Night Differences in Volatilization Rates of Polychlorinated Biphenyls from Water to Air. *Environmental Toxicology and Chemistry*, 6:659-662.

Schwarzenbach, R.P., Gschwend, P.M. and Imboden, D.M. 1992. Environmental Organic Chemistry, *Wiley Interscience*, New York, NY.

Stumm, W. and Morgan, J. 1981. Aquatic Chemistry, 2nd Ed., *Wiley Interscience*, New York, NY.

U.S. Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund (RAGS), Volume I. Human Health Evaluation Manual (Part A). USEPA, Office of Emergency and Remedial Response, Washington, D.C. USEPA/540/I-89/002, December.

USEPA. 1991. "Risk assessment guidance for Superfund. Volume I: Human health evaluation manual – Supplemental Guidance: Standard default exposure factors." Office of Emergency and Remedial Response (Washington, DC). OSWER Directive 9285.6-03; NTIS PB91-921314. 20p. March 25.

USEPA. 1993. "Integrated Risk Information System, Reference Dose (RfD): Description and Use in Health Risk Assessments, Background Document 1A." March 15.

USEPA. 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Model – Volume I & II. September.

USEPA. 1997. "Integrated Risk Information System Chemical File for Polychlorinated Biphenyls." National Center for Environmental Assessment, Cincinnati, Ohio. June 1. (IRIS file accessed in 2001.)

USEPA. 1997. Exposure Factors Handbook, Volume I-III. Office of Research and Development, USEPA/600/P-95/002Fa. August.

USEPA. 2000a. Hudson River PCBs Reassessment RI/FS Phase III Report: Feasibility Study. Prepared for the USEPA Region 2 and USACE by TAMS Consultants, Inc. December.

USEPA. 2000b. Further Site Characterization and Analysis, Revised Human Health Risk Assessment (HHRA) Volume 2F, Hudson River PCBs Reassessment RI/FS. Prepared for the USEPA Region 2 and USACE by TAMS Consultants, Inc. and Gradient Corporation. November 2000.

Wisconsin Department of Natural Resources (WDNR). 1999. Fox River Remediation Air Monitoring Report: Ambient PCBs during SMU 56/57, Demonstration Project, www.dnr.state.wi.us/org/water/wm/lowerfox/sediment/56_57airmgmt.html.

Air Quality Evaluation
313846

WHITE PAPER – AIR QUALITY EVALUATION

(313846)

ABSTRACT

Commenters raised concerns regarding potential air quality impacts from the proposed dredging and/or operation of the sediment processing/transfer facilities.[1] This white paper discusses the potential pollutant-emission sources associated with various activities, provides an impact analysis methodology, estimates emission rates for each National Ambient Air Quality Standards (NAAQS) criteria pollutant, and predicts concentration levels at the potential worst-case residential locations. The results of these analyses show that predicted criteria pollutant concentration levels, including background levels, do not exceed the NAAQS. Therefore, the project would not significantly impact air quality and appropriate monitoring will be implemented to confirm these results.

INTRODUCTION

The potential air quality impacts from the selected remedy may be divided into two categories:

- Long-term impacts, such as:
  - In the neighborhood of the sediment processing/transfer facilities, due to operation of those facilities.
  - Along transfer routes, due to the transfer and disposal of processed sediment via barge or railroads.
  - Along the river, due to booster-pump operation during hydraulic dredging.

[1] It is important to note that EPA has not yet determined the location(s) of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the Feasibility Study, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the upper Hudson River valley and farther downstream, are possible.

The example facility locations presented in the Feasibility Study have also been used in the Responsiveness Summary in order to clarify material presented in the Feasibility Study and Proposed Plan and in connection with additional noise, odor and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after EPA performs additional analyses and holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, all information provided in this Responsiveness Summary relative to potential impacts of the sediment processing/transfer facilities on communities, residents, agriculture, the environment and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during remedial design.

- Short-term impacts, such as:

  - Construction of the sediment processing/transfer facility and associated buildings, roads, parking lots, etc.
  - Dredging and backfilling activities, which would be moving downstream along the river.

Potential air pollutant emissions will result from:

- Fuel-burning diesel engines, such as used by non-road equipment, trucks, locomotives, tug boats, etc.

- The sediment-handling process.

Detailed design plans and locations for the sediment processing/transfer facilities and disposal/transfer routes have not been finalized. Therefore, the assessment of air quality effects from on-road/in-river mobile-source operations cannot be quantitatively evaluated for truck, boat, and train operations at this time. However, these mobile-source operational impacts will not be significant, given the small number of daily trips (13 truck trips when applicable, two train trips, and a few tug boat trips) generated from operations.

Based on the conceptual design plan at each potential processing facility site, a quantitative air quality impact analysis was performed at the likely "worst-case" site, the Northern Sediment Processing/Transfer Facility (NTF) (White Paper – Example Sediment Processing/Transfer Facilities), for the following reasons:

- The facility would use the greatest amount of equipment.

- An on-site unpaved roadway associated with truck transfer operations would contribute dust emissions under the mechanical dredging scenario.

- Sensitive receptors are adjacent to the facility.

The long-term impact analysis was also performed for a stationary booster-pump operation near the river.

Given the differences in impact duration between long- and short-term activities, the short-term impacts from the selected remedy would be similar to impacts from a typical construction project; *i.e.*, impacts would occur only for a short period of time at any given receptor location. The air quality effects of short-term activities are generally of less concern than those from continuing operations (long-term effects) and are generally evaluated qualitatively in most environmental analyses (*e.g.*, environmental assessments and environmental impact statements). However, for this analysis, potential impacts on any given receptor location near the river from short-term dredging activities, is compared with concentration levels predicted from long-term stationary booster-pump operation. In general, the following sections mainly discuss long-term air quality effects due to the selected remedy.

NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)

Under the requirements of the 1970 Clean Air Act (CAA) as amended in 1977 and 1990, EPA establishes NAAQS for six contaminants, referred to as criteria pollutants (40 CFR 50). The criteria pollutants are:

- Ozone (O_3).
- Carbon monoxide (CO).
- Sulfur dioxide (SO_2).
- Nitrogen dioxide (NO_2).
- Particulate matter (PM10).
- Lead (Pb).

The NAAQS include primary and secondary standards. The primary standards (Table 313846-1) were established at levels sufficient to protect public health with an adequate margin of safety. The secondary standards were established to protect public welfare from the adverse effects associated with pollutants in the ambient air. The NYS Department of Environmental Conservation (NYSDEC) adopts the EPA's NAAQS as the statewide ambient air quality standards.

O_3 is a regional concern and is usually not addressed on a project-by-project basis. Lead emissions from mobile sources are not significant and have declined in recent years through the phased out use of lead in gasoline. Therefore, the localized air-quality concentrations from the sediment processing/transfer facilities, and stationary booster-pump operations would result from emissions from CO, SO_2, PM10, and NO_2.

The analysis presented below compares the modeled concentrations for each of the relevant pollutants with the corresponding NAAQS averaging periods to evaluate the potential air quality impacts.

It should be noted that for potential non-criteria pollutants, such as metals, a limited discussion is included in this paper based on the lack of detailed emission factors, or emission rates for each potential source at this time. Emissions estimates will be conducted during the design phase. In addition, when the project is implemented, EPA will conduct ambient air monitoring for a series of sediment-related air pollutants, as necessary, to address community concerns and confirm modeled results.

ANALYSIS SCENARIOS AND SOURCES ANALYZED

The project would involve: 1) continuous sediment processing operations at fixed locations and stationary booster operations under a hydraulic dredging process at a given location; and 2) dredging activities that would move along the Hudson River over a six-year period (It is important to note that EPA has not yet determined the locations of sediment processing/transfer facilities).

Unlike the continuous stationary operations that will occur at the sediment processing/transfer facilities, dredging activities will result in only temporary air quality effects at any given receptor location, as the dredging will occur in individual areas for brief amounts of time. Dredging activities are similar to construction activities, and were not considered quantitatively in this evaluation.

Over a six-year period, operations at the sediment processing/transfer facilities will consist of continuous loading, processing, and unloading for 20 hours per day, six days per week, from May 1 to November 30 of each year. Each facility would process 80 tons per hour of sediment, plus eight tons per hour of cement materials to be mixed with the dredged materials. The sediment moisture content is expected to be about 96 percent (assuming 20 percent excess water) in the barge before cement addition, and about 72 percent after decanting excess water. All emission sources can be mainly characterized into two types: Equipment engine exhausts and dust emissions from the sediment handling process.

Each sediment processing/transfer facility can be constructed for either mechanical or hydraulic dredging processes. For purposes of this RS, the two example facilities are being used: the Northern Sediment Processing/transfer Facility (NTF) and the Southern Sediment Processing/transfer Facility (STF)

Long-Term Operational Activity at the Sediment Processing/transfer Facilities

NTF

A mechanical dredging facility will have the following potential emission sources:

- Two front-end loaders in the enclosed, temporary staging building to load sediment onto dump trucks.
- Three dump trucks near the unloading dock.
- Two front-end loaders in the semi-open loading area, loading sediment onto rail cars.
- Two dump trucks near the loading area.
- One locomotive running for 30 minutes during the daytime period (between 7 am and 10 pm), twice a day.
- A 350-hp tug boat running continuously for 30 minutes each trip. For each 24-hour period, a total of six trips will occur during the daytime hours (between 7 am and 10 pm).
- A 350-hp tug boat running continuously for 30 minutes each trip. For each 24-hour period, a total of three trips will occur during the nighttime hours (between 10 pm and 7 am).
- Five round trips each hour along the on-site roadways.
- One electrical-powered materials handler (CAT 375 MH). Note: The emissions from such a machine are minimal compared to a diesel excavator of the same capacity (Stonehocker, June 15, 2001); the materials handler is, therefore, omitted from the air quality analysis.
- Pug mill, conveyor, and other necessary small generators and compressors will be electrical-powered to the extent possible, resulting in negligible emissions. Therefore, they are not considered in this analysis.

A hydraulic dredging facility will have the following potential emission sources:

- One locomotive running continuously for 30 minutes, twice a day, during the daytime periods (between 7 am and 10 pm).
- One 1,000-hp tug boat running for 60 minutes, three times a day, during daytime periods (between 7 am and 10 pm)
- Other necessary small horsepower generators, auxiliaries, and boosters potentially used are minor sources with negligible emissions; therefore, they are not considered in this analysis.

STF

The STF would include one more excavator than the NTF and use a 1,000-hp tug boat for two trips per day, compared to 350-hp tug boat for nine trips per day for the NTF. However, the STF would eliminate loader operations at the loading area and all truck operations. Overall, this facility is expected to emit fewer pollutants than the NTF. Unlike the NTF, no sensitive receptor locations are adjacent to the facility site. Therefore, the STF is not considered the worst-case scenario and an air quality impact analysis was not conducted, since the ambient air concentrations are less than those found at the NTF, which meets all standards.

Long-Term Stationary Booster Pump Operations along the River

Under a hydraulic dredging scenario, one 1,000-hp booster pump would be installed and operated 17 hours per day per each 10,000-ft dredging-distance increment.

Emission Rate Estimates

Emission Factor References

The following EPA-published emission factor references and models were used in determining emission rates at the NTF for both mechanical and hydraulic dredging scenarios and for a stationary booster near the Hudson River:

- AP-42 (January 1995).
- Non-road Engine and Vehicle Emission Study Report (November 1991).
- Exhaust Emission Factors for Non-road Engine Modeling – Compression-Ignition (April 2000).
- Median Life, Annual Activity, and Load Factor Values for Non-road Engine Emissions Modeling (June 15, 1998).
- Procedures for Emission Inventory Preparation – Volume IV – Mobile Sources (July 1992).
- Commercial Marine Emissions Inventory for EPA Category 2 and 3 Compression Ignition Marine Engines (August 1998).
- Final Emissions Standards for Locomotives (December 1997).
- Guideline on Air Quality Models (July 1, 1999).
- Mobile 5b Model (September 1996).

- Part5 Model (February 1995).

The peak hourly and daily average hourly emission rates were estimated based on the operational conditions for each identified emission source and the emission factors (provided in the above references) for the criteria pollutants for the two main source categories – equipment engine exhaust and the sediment handling process.

Engine Exhaust Emission Rates

Non-Road Diesel Equipment

The selected remedy will use a series of non-road diesel equipment and trucks to process and transfer dredged sediment. The EPA has developed a database for non-road engine and vehicles emission factors as a function of the type and size of the equipment, and has provided guidance for developing emission inventories for these engines. Since the selected remedy is not expected to occur before year 2005, emission factors for the Tier 1 type of diesel engines were used in the estimates. It should be noted that emission factors for particulate matter (PM) are developed for total particulates (*i.e.*, all particle sizes); therefore, using PM emission factors for the PM10 evaluation is a highly conservative approach.

The EPA recommends the following formula to calculate hourly emissions from non-road engine sources:

$$M_i = N \times HP \times LF \times EF_i$$

where:

M_i = mass of emissions of ith pollutants during inventory period
N = source population (units)
HP = average rated horsepower
LF = typical load factor
EF_i = average emissions of ith pollutant per unit of use (*e.g.*, grams per horsepower-hour)

Based on the equipment operation schedule, emission rates were calculated as: 1) peak hourly rates used for a short-term averaging period (a less-than-24-hour average period) concentration prediction, and 2) daily average hourly rates for the long-term (24-hour and annual average periods) concentration calculation.

The estimates of peak and daily average hourly non-road diesel engine emission rates are presented in Table 313846-2. It should be noted that in predicting the annual average NO_x concentration level from an in-river stationary booster pump operation, an annual average hourly emission rate was used. This emission rate (2,618 grams/hour as compared to the peak hourly rate of 4,292 grams/hour in Table 313846-2) was calculated based on the projected percentage of booster usage hours over the total annual working hours, which is 61 percent.

On-Site Truck

Under the mechanical dredging scenario, on-site truck operations will be part of the sediment transportation plan. Criteria pollutants will be emitted from the truck engines at the site, as well as from the on-site roadway.

Based on the processing capacity of the facility, a total of 10 one-way truck trips (five two-way trips) per hour, from a total of five trucks, would occur between the unloading and loading areas. The five truck operations were modeled as continuously running vehicles, as follows:

- Two hours of idling at the unloading area.
- Two hours of idling at the loading area.
- One hour of running at a speed of five miles per hour along the on-site unpaved road.

Therefore, all five trucks are conservatively assumed to be running without a break during each operating hour. Truck-engine exhaust emission rates were calculated using EPA's Mobile5b emission factor model, and the dust emissions from the on-site roadway were estimated using EPA's Part5 model. Based on EPA's emission-factor document for various industrial operations (September 1988 and AP-42, January 1995), a water-suppression method can be expected to result in dust-control efficiency of more than 50 percent. Therefore, given: 1) the high water content (more than 50 percent) in the sediment to be transferred by trucks, and 2) periodically spraying the on-site unpaved roadway surface, which will be performed using water hoses or water trucks, a 50-percent dust-control efficiency was used in unpaved roadway PM emission estimates. Truck operation-related emission rates are presented in Table 313846-3.

Locomotive

The locomotive engine emission rates (Table 313846-2) were conservatively estimated based on the emission standards established by the EPA (December 1997) for the switch duty-cycle type of Tier 1 engine. The average power of each locomotive was assumed to be 3,000 hp. It should be noted that emission factors for PM are developed for total particulates (*i.e.*, all particle sizes); therefore, using PM emission factors for the PM10 evaluation is a highly conservative approach.

Tug Boat

The emission rates (Table 313846-2) for tug boats were estimated based on a unit fuel consumption rate of 0.06 gal/hp-hr provided by Gahagen and Bryant Associates, Inc. (GBA) (Thomas, June 1, 2001) and the emission factor for an uncontrolled diesel industrial engine in EPA's AP-42. It should be noted that emission factors for PM are developed for total particulates (*i.e.*, all particle sizes); therefore, using PM emission factors for the PM10 evaluation is a highly conservative approach.

Sediment Handling and Storage Pile Dust Emissions

Dust emissions (Table 313846-4) due to a drop-type operation will occur at several stages in the storage and transport cycle, with the most emissions occurring under a mechanical dredging scenario. Stages at which such emissions could occur are when:

- An excavator unloads sediment from a barge and onto a conveyer.
- The conveyer transfers the dredged sediment onto a pug mill to be mixed with cement materials.
- The materials are transferred to a staging area.

- A loader places processed sediment onto a truck.
- A truck is moving sediment along the on-site unpaved roadway to the loading area.
- A loader places sediment onto a rail car.

Three sediment-dropping operations will occur before dewatering (loading from barge by an excavator, unloading to a conveyer, and then dropping to a pug mill). Three sediment-dropping operations will occur after dewatering but before transporting to the loading area (dropping onto a conveyer from a pug mill, dropping to a staging area from a conveyer, and loading onto a truck). Two sediment-dropping operations would occur in the loading area (unloading from a truck and loading onto a rail car). The quantity of unit-dust emissions generated by each of the above dropping operations was estimated based on the weight of sediment and the water content of sediment transferred and the following EPA AP-42 empirical equation:

$$EF \text{ (lb/ton)} = k * (0.0032) * (u/5)^{1.3} / (M/2)^{1.4}$$

where:

EF = emission factor
k = particle size multiplier (0.35 for PM10 and 0.74 for total suspended particles [TSP]);
U = mean wind speed (mile/hour), in this case, an average mean wind speed of 5 miles per hour was used
M = material moisture content (defined as the ratio of weight of water to weight of solids)

The weights of sediment materials transferred would be 80 tons per hour before dewatering and 88 tons per hour after dewatering and cement mixing. The moisture (water) content in sediment was conservatively assumed to be 50 percent in emission estimates. The estimated uncontrolled sediment handling emission rates are summarized in Table 313846-4. The total suspended particle (TSP) emission rate estimates were further used in determining the potential impacts from dust-adhered PCBs (White Paper – PCB Releases to Air).

Sediment Stabilization and Solicitation Dust Emissions

Fugitive dust emissions may potentially be released during the sediment mixing and processing period. However, stabilization and solidification of sediment will be designed to occur within enclosed areas in each sediment processing/transfer facility. These enclosures will include areas for the cement mixing operations, the sediment staging locations, etc. Therefore, sediment stabilization and solicitation PM emissions would likely be negligible and are not addressed further in this paper.

Other Pollutant Emissions

In addition to the criteria pollutants discussed above, certain non-criteria pollutants with the potential to be emitted from a stationary source are also regulated under the Title V of the Clean Air Act and the NYSDEC Part 201 regulation. Non-criteria pollutants, such as volatile organic compounds (VOCs), certain metals, hydrogen sulfide (H_2S), etc. have the potential to be emitted from stationary sources in the sediment processing/transfer facility. Typical stationary sources may include aboveground storage tanks (ASTs), pug mills, fugitive dust sources, etc.

Based on the forecasted fuel-consumption data for the selected remedy (Chapter 8 of this RS), the EPA TANKS model (Version 4.09) was used to estimate VOC emissions associated with the diesel fuel requirements for operations at both the NTF and STF. It was assumed that the AST needed would have an external floating roof with a 20-ft diameter and would be refilled once a week, for a total of 30 times, between May and November of each year. The fuel consumption data and estimated annual VOC emissions are presented in the following table:

Aboveground Storage Tank Annual VOC Emission Rate

Facility	Dredging Condition	Fuel Consumption (gallons/yr)	Annual Emission Rate (lbs/yr)
NTF	Hydraulic	104,950	14.5
	Mechanical	91,670	14.4
STF	Hydraulic	160,150	15.2
	Mechanical	145,850	15.0

Additionally, certain metals may adhere to fugitive dust emissions. Due to the lack of detailed emission factors or emission rate data for each potential source, the metals emissions cannot be quantified at the present time but will be addressed during the design phase.

IMPACT DISPERSION MODELING

The dispersion modeling techniques used in this paper are consistent with the *Guideline on Air Quality Models* (EPA, 1999). The most recent version of the EPA-approved numerical air dispersion model was used. Air quality impacts for the modeled criteria pollutants were determined at receptor locations adjacent to the NTF and a potential booster pump near the river's shoreline for the applicable averaging periods. Results were then compared to the ambient air quality standards established by the EPA and NYSDEC in order to determine the compliance of the proposed operations with these regulations .

ISCST3 Dispersion Model

For this analysis, ISCST3, an EPA-approved refined air quality dispersion model, was used. ISCST3 is a steady-state Gaussian plume dispersion model designed for a simple terrain analysis (*i.e.*, terrain elevation below the stack height). This model is used to assess pollutant concentrations for industrial facilities and to calculate impacts for several different averaging periods, ranging from one-hour and annual concentrations. A summary of the ISCST3 modeling inputs for this study is provided in Table 313846-5.

Modeled Sources

The sources at the NTF were conservatively modeled as ground level-release area sources with zero exit velocity. The area sources are located at unloading, processing, and loading areas, as appropriate. It is noted that this source modeling approach is very conservative, given the limited design information available at this phase of the project.

A point source with an exit velocity of 1 m/sec was conservatively modeled at a hypothetical location along the river, such as where a stationary booster barge will be installed every 10,000 ft to support a hydraulic dredging activity. The point source was assumed to be 12-ft high with a 6-inch diameter, which is similar to a typical diesel-engine truck exhaust stack, and was placed 150 ft from either shoreline of the Hudson River. Potential impacts from stationary booster operations were modeled within two areas, Glens Falls and Albany.

Meteorology

In predicting potential impacts from the NTF operations using the ISCST3 model, the most recent and complete five consecutive years of meteorological data (1993-1997) were used. The data included hourly surface observations from the Glens Falls weather service station and coincidental daily mixing heights from the Albany, New York National Weather Station (NWS). The Glens Falls station is the closest weather station to the NTF and the data collected at this station are considered representative of the facility site.

Potential booster pump operational impacts were modeled for: 1) the Albany area, using five consecutive years of both surface and upper air data (1995-1999) collected in Albany; and 2) the Glens Falls area, based on the same data used for the NTF impact modeling.

Receptors

A total of five sensitive receptors were modeled near the NTF including four residential houses and one club that are close to the facility. Since emission sources were modeled as ground-level area sources with no plume rise at the NTF, the greatest potential pollutant impact from continuous operations would occur at those sensitive receptors that are adjacent to the facility site. This would also be true for those receptors near both shorelines when a stationary booster is nearby, given that the source is only 12 ft high with an exit velocity of only 1 m/s.

A series of hypothetical residential houses along both sides of the river were modeled for a nearby stationary booster operated 150-ft from either shoreline. Two Cartesian receptor grid systems were placed along the river. Each grid system started 50 ft from each shoreline and extended to cover an area 150 ft wide and 2,000 ft long that is close to a potential stationary booster pump when hydraulic dredging is occurring.

Impact Results

As indicated above, many conservative assumptions were used in estimating emission rates, which consequently resulted in higher concentration forecasts. Use of the ISCST3 modeling approach to simulate all emission releases as either ground-level area sources or near-ground-

level point sources with minimal exhaust velocity also resulted in conservative concentration calculations.

For the applicable averaging time periods, the worst-case concentrations at modeled sensitive receptor locations were identified for each pollutant for each dredging scenario at the NTF (Tables 313846-6 and 7). The model also simulated the potential impact along the river near a stationary booster pump in both the Glens Falls and Albany areas (Tables 313846-8 and 9). A 75-percent conversion factor recommended by the EPA (1999) was applied in converting NO_X levels (for which the emission estimates were conducted) to NO_2 levels in the concentration calculations.

In order to estimate the maximum expected total impact at a given receptor location, the facility impact was added to a representative background level that accounts for existing pollutant concentrations contributed from other sources in the region. The background levels in the project area can be characterized based on air quality data collected at State air-monitoring stations and published by NYSDEC (June 2000). Data collected at the closest monitoring location to each project site are considered representative of the background levels for the northern and southern project areas.

Total "worst-case" concentrations at the NTF are presented in Tables 313846-6 and 7. No exceedances of the NAAQS are predicted. Therefore, even using conservative assumptions and modeling approaches, the air quality impacts from continuous operations at the NTF would not be significant, and the facility operations would be in compliance with the applicable ambient air quality standards. The same conclusion is expected to be applicable for the STF, as the NTF is the worst-case site.

Total worst-case concentrations at theoretical residential houses along both sides of the Hudson River near the stationary booster pump under the hydraulic dredging scenario are presented in Table 313846-8 for the Glens Falls area and Table 313846-9 for the Albany area. No exceedances of the NAAQS were predicted; therefore, the operation of stationary booster pumps would not be expected to have a significant air quality impact.

Unlike the stationary booster pump operation, mobile dredging activities would have short-term effects on any given residential house along the river, which are of less concern. Furthermore, the combined engine horsepower from two dredge machines (one along each side of the river) is less than the engine size from one booster pump. Based on the concentration levels predicted from a stationary booster pump operation, it can be concluded that short-term dredging activities would not have significant air quality impact near the river.

Metals Associated with Airborne Suspended Particles

The sediment metal-concentration data reported by various parties have been discussed and summarized in the White Paper – Metals Contamination. A review of the risk factors (*i.e.*, sediment concentration and toxicity values [either the cancer slope factor or 1/RfD value for those metals for which they exist]) revealed the following four metals to have the highest risk associated with them:

- Lead.
- Chromium.
- Cadmium.
- Titanium.

The emission rate of total suspended particles (TSPs) from the processing/transfer facilities was estimated to be 8 g/hour during the sediment handling process (Table 313846-4). Using the average sediment metal concentrations (White Paper – Metals Contamination) and the suspended particle emission rate, the metal flux associated with TSPs from sediment-handling facilities were calculated (Table 313846-10). The annual and 8-hr maximum metal concentrations at the receptors were calculated using the ISCST3 results, and also are presented in Table 313846-10. The airborne metal concentration values were predicted to be several orders of magnitude lower than the corresponding applicable standards (these ambient and OSHA standards are also presented in Table 313846-10 for comparison). Therefore, the release of metals associated with the suspended particles is not expected to cause any adverse health effects.

REFERENCES

Auer, A.H. 1978. Correlation of Land Use and Cover with Meteorological Anomalies. *Journal of Applied Meteorology*. 17:636-643.

New York State Department of Environmental Conservation (NYSDEC). June 2000. New York State Air Quality Report Ambient Air Monitoring System.

NYSDEC. July 12, 2000. DAR-1 (Air Guide-1) AGC/SGC Tables.

NYSDEC. February 21, 2001. Part5 and Mobile 5b Sample Input Files.

Stonehocker, Stephen. Caterpillar Inc. June 15, 2001. Personal communication.

Thomas. Gahagen and Bryant Associates, Inc. (GBA). 2001. Personal communication via e-mail with T. Ahmed, TAMS Consultants, Inc. June 1.

US Environmental Protection Agency (USEPA). 1985 (revised January 1995). Compilation of Air Pollutant Emission Factors, Fifth Edition, AP-42. September.

USEPA. 1988. Control of Open Fugitive Dust Sources. September.

USEPA. 1991. Non-road Engine and Vehicle Emission Study-Report. November.

USEPA. 1992. Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources.

USEPA. 1995. PART5 User’s Guide. February.

USEPA. 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Model - Volume I & II. September.

USEPA. 1996. Mobile 5b User's Guide. September.

USEPA. 1997. Final Emission Standards for Locomotives. December.

USEPA. 1998. Median Life, Annual Activity, and Load Factors Values for Non-road Engine Emissions Modeling. June 15

USEPA. 1998. Commercial Marine Emissions Inventory for EPA Category 2 and 3 Compression Ignition Marine Engines. August.

USEPA. 1999. Guideline on Air Quality Models. July 1.

USEPA. 2000. Exhaust Emission Factors for Non-road Engine Modeling - Compression-Ignition. April.

Odor Evaluation
255361

WHITE PAPER – ODOR EVALUATION

(ID 255361)

ABSTRACT

This white paper evaluates the potential to generate nuisance odors during implementation of the selected remedy. Based on the analysis of diesel air emissions from construction equipment that is presented in White Paper – Air Quality Evaluation and experience at numerous construction sites and the fact that new equipment must comply with rigorous air emission standards, no nuisance odor at nearby residences is expected due to the use of diesel-engine equipment. The potential for nuisance odor due to release of hydrogen sulfide (H_2S) or ammonia was also evaluated. The available data for the relevant parameters (sediment sulfate, nitrogen, organic carbon, pH, dissolved oxygen, oxidation-reduction potential, etc.) were reviewed; however, most of the required information is unavailable for the Hudson River. Therefore, porewater data from Mississippi River sediments were used to estimate the potential for odor associated with dredging in the Upper Hudson River.

Based on this analysis, there is a hypothetical potential for short-term episodes of occasional H_2S odor outside sediment processing/transfer facility boundary and near dredging locations if no mitigation measures are employed. However, the likelihood of odor problems is believed to be small based on experience at other sediment sites. During remedial design, Site-specific porewater H_2S concentration data will be collected and the odor generation potential of the sediment will be evaluated in greater detail. A number of mitigation measures may be employed to address potential H_2S odor generation, if necessary. The predicted H_2S concentrations inside and outside the facility boundaries as well as at dredging locations, were projected to comply with applicable ambient and workplace standards. Based on un-ionized ammonia levels, concentrations of ammonia in the air at receptor locations were found to be several orders of magnitude lower than applicable ambient and workplace standards. In addition, the occurrences of odor problems associated with a number of river-dredging projects were investigated. Project personnel indicated no significant odor problems from dredging or sediment processing facilities.

INTRODUCTION

Several commenters were concerned that implementation of the selected remedy will generate nuisance odors at the dredging locations and the sediment processing/transfer facilities.[1] The

[1] It is important to note that EPA has not yet determined the location(s) of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the Feasibility Study, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is

possible sources of odors are operation of construction equipment, the dredged material itself, and processing operations. This white paper evaluates the potential that nuisance odors may be generated during the construction and operational phases of the selected remedy.

CONSTRUCTION EQUIPMENT

Implementation of EPA's selected remedy will entail the use of diesel-driven construction equipment both during project mobilization and actual in-river dredging operations. The equipment that will be used on the Upper Hudson River is typical of conventional construction machinery that is seen operating on most land-based and marine work sites. Examples of diesel equipment that may be employed on the Upper Hudson River are as follows:

- Backhoes, graders, and front-end loaders during construction of the sediment processing/transfer facilities.
- Mechanical and hydraulic dredges.
- Towboats and survey vessels.
- Sediment processing/transfer facility vehicles and machinery.

Equipment such as that identified above typically does not generate nuisance odor complaints. Diesel-engine emissions are regulated by both federal and State agencies, and manufacturers of new construction equipment are required to comply with increasingly stringent emission standards. Thus, based on experience at numerous construction sites and the fact that new equipment must comply with rigorous air emission standards, there will be little likelihood that diesel-driven systems will generate nuisance odors at nearby residences.

An air quality analysis has been conducted for EPA's selected remedy (White Paper – Air Quality Evaluation). Among other matters addressed in that analysis are the impacts of project-related diesel emissions on ambient conditions. On the basis of the analysis, EPA has concluded that diesel emissions from project construction equipment will not generate a significant ambient impact.

SEDIMENT PROCESSING/TRANSFER FACILITY CONSTRUCTION

One commenter raised the possibility of odors that may be generated if an existing landfill, such as Moreau, is selected as the location of a sediment processing/transfer facility. As has been

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representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the Upper Hudson River valley and farther downstream, are possible.

The example facility locations presented in the Feasibility Study have also been used in the Responsiveness Summary in order to clarify material presented in the Feasibility Study and Proposed Plan and in connection with additional noise, odor and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after EPA performs additional analyses and holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, all information provided in this Responsiveness Summary relative to potential impacts of the sediment processing/transfer facilities on communities, residents, agriculture, the environment and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during remedial design.

stated elsewhere in this Responsiveness Summary, processing/transfer facility sites will be determined during remedial design; thus, the site identified by the commenter may not be selected.

However, in the event that the Old Moreau Dredge Spoils Area is considered and subsequently selected, it should be noted that dredged sediments from the Hudson River were deposited at this location more than 30 years ago. These sediments had migrated from above the Fort Edward Dam to the channel near Rogers Island, from which they were mechanically dredged and hauled by truck to the Moreau location. It is expected that, given the limited excavation that would be likely to occur in this area in order to construct a sediment processing/transfer facility, the age of the materials in the Old Moreau Dredge Spoils Area, and EPA's experiences at the Remnant Deposits, it is not expected that odors would be generated by construction work at this location.

DREDGED MATERIAL

Hydrogen Sulfide

Hydrogen sulfide (H_2S) gas is produced from the microbial decomposition of sulfur-containing organic matter and sulfate (SO_4^{-2}) under anaerobic conditions (Water Environment Federation [WEF], American Society of Civil Engineers [ASCE], 1995). An analysis of the equilibrium speciation of sulfur is presented by Stumm and Morgan (1981). Any significant reduction of SO_4^{-2} to H_2S requires a strong reducing environment; therefore, the availability of H_2S in the porewater of dredged sediment will depend on the sediment characteristics and the *in-situ* redox condition.

Mass Transfer Coefficient

The mechanism of H_2S transfer from the dredged sediment/water mixture to air is the same as aqueous-phase PCB transfer to air. The water-to-air PCB transfer has been analyzed in detail in White Paper – PCB Releases to Air. The H_2S transfer flux from the sediment/water mixture may be estimated by multiplying the mass transfer coefficient and the concentration gradient between the liquid and the air phase. The same mass transfer correlations may be used as those presented in White Paper – PCB Releases to Air; the equation numbers in the following paragraphs refer to the equation numbers in that white paper.

The diffusion coefficient of H_2S in air is estimated using the empirical equation of Fuller, Schettler, and Giddings (Geankoplis, 1982) to be 0.175 cm^2/sec. The diffusion coefficient may be substituted in the equation below to calculate the $k_{a,H2S}$ as:

$$\begin{aligned} k_{a,H2S} &= k_{a,\,H2O} * [D_{H2S} / D_{H2O}]^{0.61} \\ &= 1.0 * [0.175/0.26]^{0.61} \\ &= 0.767 \text{ cm/sec} \\ &= 662.68 \text{ m/day} \end{aligned}$$

The liquid diffusivity of H_2S is reported to be 0.000141 cm^2/sec (Cussler, 1984); therefore, the Schmidt number (Sc) for H_2S is estimated to be 709. The Sc may be substituted in the equation below to calculate the $k_{w,H2S}$ as:

$k_{w,H2S}$ $= k_{w,\,CO2} * [Sc_{CO2} / Sc_{H2S}]^{-0.5}$
$= 0.0076 * [709/600]^{-0.5}$
$= 0.007$ cm/sec
$= 6.048$ m/day

Using an average Henry's Law constant of 0.01086 atm-m^3/mol for H_2S (Metcalf and Eddy, 1991) and substituting the mass transfer coefficient can be estimated as:

$1/K_{OL}$ $= 1/k_w + RT/Hk_a$
$= 1/6.048 + 8.2057 \text{ X } 10^{-5} * 298 / (0.01086 * 662.68)$
$= 0.1689$
or: K_{OL} $= (1/0.1689)$ m/day
$= 5.92$ m/day
$= 0.0068$ cm/sec

Air and Aqueous-Phase H_2S Concentration

In the Upper Hudson River sediments, the organic carbon content is between 0.13 and 0.15 percent and the sulfur content is between 1 and 4 percent (USGS, 2001). These organic carbon and sulfur contents in the river sediments indicate that there is potential for microbial production of H_2S in the anaerobic sediment. However, no data for H_2S concentrations in porewater of the Upper Hudson River sediments was found in the published scientific literature. A review of related literature found that only one recent study has been conducted to evaluate porewater characteristics (*i.e.*, for Mississippi River sediment [Dwyer *et al.*, 1997]).

It is possible that the results from the Mississippi River may be comparable to porewater characteristics of the Upper Hudson River. The organic carbon content of Mississippi River sediment ranged from 0.2 to 5.2 percent and the sulfide levels ranged from 0.005 µmoles/g (0.000016 percent) to 63.0 µmoles/g (0.216 percent). These values are comparable to those reported by USGS (2001) for the Upper Hudson. Assuming that the sediment porewater characteristics, (including pH, dissolved oxygen, and oxidation-reduction potential) of the Mississippi River are similar to those in the Upper Hudson River, the H_2S concentration in the porewater may be assumed to be the same in the Upper Hudson, as a preliminary estimate. The reported mean ammonia and H_2S content of Mississippi River sediment porewater (ranges in parentheses) are as follows: un-ionized ammonia 0.007 (0.000 to 0.025) mg/L and hydrogen sulfide 0.023 (0.000 to 0.569) mg/L.

Assuming 20 percent excess water by volume and 40 percent porosity of the mechanically dredged material, the resulting liquid-phase H_2S concentration is:

$(0.023 * 0.32)/(0.32 + 0.2)$
$= 0.014$ mg/L

Substituting K_{OL} and C in eq. (2), the H_2S flux from water can be estimated as:

$F = K_{OL} * C$

$= (5.92\ m/day)*(0.014\ mg/L)*(1000\ L/m^3)$
$= 82.88\ mg/m^2\text{-day}$

One-hour and annual maximum H_2S concentrations at the receptor locations outside the facility boundary and at the dredging location were calculated using the ISCST3 model and are presented in Table 255361-1. The H_2S concentrations (8-hour) inside the facility boundary were also calculated and are presented in Table 255361-1. The relevant New York State and OSHA standards are also presented in Table 255361-1 for comparison. The predicted airborne H_2S concentration values were found to be lower than the corresponding applicable State or OSHA standards; therefore, the release of H_2S is not expected to cause regulatory exceedances or adverse health effects.

The H_2S recognition threshold level (WEF and ASCE, 1995) relates to the minimum H_2S concentration required for a typical person to perceive and recognize its odor and is also presented in Table 255361-1. Based on porewater H_2S data from other riverine sites (*i.e.*, Mississippi), the predicted short-term airborne H_2S concentrations outside the facility boundary and near dredging locations indicate the hypothetical possibility of brief episodes of occasional H_2S odor if no mitigation measures are taken. Site-specific porewater H_2S concentration data will be collected during remedial design and the odor generation potential of the sediment will be evaluated in greater detail. A number of mitigation measures, including oxidation of H_2S (using chlorine or hydrogen peroxide) or use of covered tanks followed by air treatment, for example, may be employed to address potential H_2S odor generation, if necessary. However, it must be emphasized that the evaluation described above is hypothetical as no Site-specific data are currently available. The likelihood of odor problems is believed to be small based on experience at other sites.

Air and Aqueous-Phase Ammonia Concentration

Ammonia may be released during dredging if the porewater pH is high (above 8) and there is sufficient ammonia present in the porewater. The nitrogen data for Hudson River sediments indicate that average total nitrogen concentrations are typically 0.3 percent (White Paper – Potential Impacts to Water Resources). Conditions in the water column of the Hudson River are not favorable for ammonia formation, which typically forms at or above pH 8. The Hudson River has a pH range of 6 to 8.

Using the same mass transfer correlations from the White Paper – PCB Releases to Air and the aqueous-phase NH_3 concentration from the Mississippi River sediment (Dwyer *et al.*, 1997), the un-ionized ammonia flux from the sediment/water mixture may be estimated to be 45.36 mg/m^2-day. One-hour, 8-hour and annual maximum NH_3 concentrations were calculated using the ISCST3 results and are presented in Table 255361-2. The New York State, OSHA standards and recognition threshold value are also presented in Table 255361-2 for comparison. The predicted airborne NH_3 concentration values were found to be several orders of magnitude lower than the corresponding applicable standards or threshold value; therefore, the air phase NH_3 release is not expected to cause any odor problems or adverse health effects.

ANECDOTAL EVIDENCE

Several commenters provided information on other contaminated sediments projects gathered from agencies and Potential Responsible Parties (PRPs). It is noteworthy that the information submitted provides little mention of negative odors at other locations.

For this RS, EPA has queried participants in several dredging projects that involved the removal of contaminated sediments. A brief synopsis of odor-related comments from these discussions follows:

- Dredging of sediments near Rogers Island in the mid-1970s apparently generated no significant issues with regard to odor, based on the recollection of one participant (Thomas, 2001). It was also noted that Hudson River sediment-sampling work completed during the early and mid-1990s did not generate a noticeable odor.

- Work at Fox River's Sediment Management Unit (SMU) 56/57 in Wisconsin raised no odor issues and there was virtually no odor noted (Bories, 2001). It is important to note that this dredge site was located three miles downstream of two wastewater treatment plant outfalls; thus, the sediments removed at SMU 56/57 could be considered representative of sediments in the Upper Hudson with respect to sulfur compounds since there are also wastewater treatment outfalls in the Upper Hudson. Since no odor problems were noted at SMU 56/57, no odor problems are anticipated for sediment removal in the Upper Hudson.

- Recent demonstration dredging (mechanical) at New Bedford Harbor in Massachusetts generated only minor, musty, marine-type odors from sediments.

- Dr. G-Yull Rhee of the New York State Department of Health is conducting a study of odors in water supplies. Dr Rhee stated that, other than some low-level musty odors, the Hudson River sediments will not cause an odor nuisance (Rhee, 2001, pers. comm.) Dr. Rhee also stated that where higher levels of organic compounds (including PCBs) are encountered, odor-generating potential does exist. However, targeted Hudson River sediments contain about 31.2 ppm PCBs on average and do not meet the criteria for higher levels of organics suggested by Dr. Rhee.

- At the Pine River site in Michigan, noticeable odor levels were when dredging occurred in areas heavily contaminated with DDT. In addition, targeted areas located in vegetation produced a strong vegetative decomposition odor; however, this odor was described as a musty odor, not a hydrogen sulfide odor, according to the US Army Corps of Engineers staff person (Bories, 2001). This experience is not considered relevant to the Upper Hudson River due to substantially different site-specific conditions. For instance, the main contaminants at Pine River were pesticides (specifically, DDE and DDT); the sediments also contained various solvents and total petroleum hydrocarbons at 1 percent levels, which emit odors. In contrast, the main contaminants at the Hudson River PCBs Site are PCBs, which are considered odorless.

SUMMARY

Nuisance odor associated with operating diesel-engine construction equipment and dredging, barging, and processing PCB-contaminated sediment in the Upper Hudson River is expected to be of little or no impact to the surrounding community. Due to the low organic matter content, as well as the low nitrogen and sulfur concentrations in the Hudson River sediments, nuisance odor associated with H_2S gas and ammonia is not expected. Experiences at other contaminated sediment dredging sites support this conclusion. Based on data obtained from the Mississippi River, there is a hypothetical potential for short-term episodes of occasional H_2S odor outside the sediment processing/transfer facility boundary and near dredging locations if no mitigation measures are employed. During remedial design, Site-specific data of H_2S concentrations in sediment porewater will be collected and the odor generation potential of the sediment will be evaluated in greater detail. A number of mitigation measures may be employed to address potential H_2S odor generation, if necessary.

REFERENCES

Bories, S. 2001. Personal communication with J. Szeligowski of TAMS Consultants, Inc.

Cussler, E.L. 1984. Diffusion, Mass Transfer in Fluid Systems. Cambridge University Press.

Dwyer, F.J., E.L. Brunson, T.J. Canfield, C.G. Ingersol, and N.E. Kemble. 1997. An Assessment of Sediments from the Upper Mississippi River – Final Report, USEPA Project #DW14935486-01-0.

Geankoplis, C.J. 1982. Mass Transport Phenomena, Ohio State University Bookstore, Columbus, OH.

Rhee, G., NYSDOH. 2001. Personal communication with J. Szeligowski of TAMS Consultants, Inc.

Stumm, W. and J. Morgan. 1981. Aquatic Chemistry, 2nd Ed., Wiley Interscience, New York, NY.

Tchobanoglous, G. and F. Burton. 1991. Wastewater Engineering Treatment Disposal Reuse. Third Edition.

US Geological Survey (USGS). 2001. Data downloaded from USGS website (http://www.usgs.gov) on May 23, 2001.

Water Environment Federation (WEF) and American Society of Civil Engineers (ASCE). 1995. Odor Control in Wastewater Treatment Plants, WEF Manual of Practice No. 22 and ASCE Manuals and Reports on Engineering Practice No. 82.

Noise Evaluation
312685

WHITE PAPER – NOISE EVALUATION

(ID 312685)

ABSTRACT

Concerns were raised regarding the potential for nuisance noise from the dredging and operation of the sediment processing/transfer facilities.[1] This white paper provides discussions of potential noise sources associated with various activities, discussions of analysis methodology, and prediction of noise levels at the worst-case receptor location. Noise effects were evaluated through comparisons with appropriate guidelines, with the finding that predicted noise levels would not exceed guidelines for most activities. One exception would be noise levels from stationary booster pump operations at potential receptor locations under the hydraulic dredging scenario. However, if such a situation arose, a series of noise mitigation measures can be applied to reduce stationary booster pump noise to acceptable levels.

During the remedial design phase of the project, EPA will monitor existing noise conditions to better assess the impact of potential noise increases resulting from the selected remedy. EPA will also consider noise-mitigation measures to minimize potential noise impact to communities.

INTRODUCTION

Potential noise impacts from the selected remedy can be divided into two categories:

- Long-term impacts, such as would result from:

[1] It is important to note that EPA has not yet determined the location(s) of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the Feasibility Study, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the Upper Hudson River valley and farther downstream, are possible.

The example facility locations presented in the Feasibility Study have also been used in the Responsiveness Summary in order to clarify material presented in the Feasibility Study and Proposed Plan and in connection with additional noise, odor and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after EPA performs additional analyses and holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, all information provided in this Responsiveness Summary relative to potential impacts of the sediment processing/transfer facilities on communities, residents, agriculture, the environment and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during remedial design.

- Equipment operation at sediment processing/transfer facilities.
- The transfer of processed, dredged materials via barge or railroad.
- Booster pump operation along the river (under the hydraulic dredging scenario).

- Short-term impacts, such as would result from:

  - Construction of the sediment processing/transfer facility and associated buildings, roads, parking lots, etc.
  - Dredging and backfilling activities, which would be constantly moving along the river.

As the location and detailed design of the sediment processing/transfer facility sites have not been finalized, the assessment of noise effects from long-term, on-road, mobile-source operations cannot be accurately and quantitatively performed for either truck or train operations at this time. However, these mobile-source operational impacts will not be significant, given the projected number of trips (13 daily truck trips and two daily train trips, when applicable) that would occur even with seasonally continuous operations. The analysis presented in this white paper includes a quantitative evaluation of long-term noise from the sediment processing/transfer facility operations and booster-pump operations.

Given the difference in duration between long- and short-term activities, the short-term impacts from the selected remedy would be similar to impacts from a typical construction project; *i.e.*, they would only occur for a short period of time at any given receptor location. The noise effects of short-term activity are generally of less concern than those from long-term seasonally continuous operations and are generally handled qualitatively in most environmental documentation (*e.g.*, Environmental Assessments [EAs], Environmental Impact Statements [EISs], and Records of Decision [RODs]). However, a quantitative noise evaluation for dredging activities was performed for the selected remedy and is discussed herein.

Noise impact is typically assessed in two ways: the absolute noise level compared to the applicable noise criteria, and the net change in noise levels compared to existing conditions.

Because the locations of the sediment processing/transfer facilities have not yet been determined, noise surveys to establish existing ambient noise conditions at potentially impacted areas cannot be conducted at this time. Potential noise impacts based on the net change in noise levels resulting from the selected remedy will be assessed after an on-site noise monitoring study is performed. In this future noise increment analysis, the New York State Department of Transportation- (NYSDOT) recommended increment impact criterion would be used as the impact assessment guideline for long-term continuing operations.

This white paper deals only with potential noise effects related to absolute noise levels from seasonally continuous sediment processing/transfer facility operations and stationary booster-pump and dredging operations moving along the Hudson River.

NOISE FUNDAMENTALS

One way of describing fluctuating sound is to describe the fluctuating noise, heard over a specific time period, as if it had been a steady, unchanging sound. For this condition, a descriptor called the equivalent sound level, or L_{eq}, can be computed. The L_{eq} descriptor is the constant sound level that, in a given situation and time period (*e.g.*, one-hour L_{eq} [$L_{eq}(1)$], or 24-hour L_{eq} [$L_{eq}(24)$]), conveys the same sound energy as the actual time-varying sound. Statistical sound-level descriptors such as L_1, L_{10}, L_{50}, L_{90}, and L_x are also sometimes used to indicate noise levels which are exceeded 1, 10, 50, 90, and x percent of the time, respectively. These terminologies can be found from many noise reference books or noise analysis guidance, such as the New York City Environmental Quality Review Technical Manual (1993).

The $L_{eq}(1)$ descriptor is in standard use by various agencies as the most appropriate metric for estimating the degree of nuisance or annoyance that would occur from increased noise levels occurring during a typical peak hour.

It is often useful to account for the difference in response of people in residential areas to noises that occur during sleeping hours as compared to waking hours. A descriptor, the day-night noise level (L_{dn}), is defined as the A-weighted average sound level in decibels during a 24-hour period, with a 10-decibel (dBA) weighting applied to nighttime sound levels. The 10-dBA weighting accounts for the fact that noises at night are more perceptible to humans because there are fewer background sounds to obscure the noise. The L_{dn} descriptor has been proposed by the US Department of Housing and Urban Development (USHUD), the EPA, and other organizations as one of the appropriate criteria for estimating the degree of nuisance or annoyance that increased noise levels would cause in residential neighborhoods.

Given the characteristics of the selected remedy, $L_{eq}(1)$ and L_{dn} have been selected as the noise descriptors to be used in the noise impact analysis. $L_{eq}(1)$ is used to evaluate peak-hour noise conditions and L_{dn} is used to evaluate the nighttime noise component.

Human response to changes in noise levels depends on many factors, including the quality of the sound, the magnitude of the change, the time of day at which the changes take place, whether the noise is continuous or intermittent, and the individual's own ability to perceive the changes. The average ability of an individual to perceive changes in noise levels is presented in the table below.

Average Ability to Perceive Changes in Noise Levels

Change in Decibels (dBA)	Human Perception of Sound
2-3	Barely perceptible
5	Readily noticeable
10	A doubling or halving of the loudness of sound
20	A "dramatic change"
40	Difference between a faintly audible sound and a very loud sound
Source: FHWA, June 1995.	

Generally, a 3-dBA or smaller change in noise level would be barely perceptible to most listeners but a 5-dBA level would be readily noticeable. A 10-dBA change is normally perceived as a

doubling (or halving) of noise levels. These thresholds permit estimation of an individual's probable perception of changes in noise levels.

Noise Standards and Criteria

There are a number of standards and guidelines adopted by federal and State agencies for assessing noise impacts. These regulations and standards are useful to review in that they provide both a characterization of the quality of the existing noise environment as well as a measure of project-induced impacts.

Federal Highway Administration (FHWA) (23 CFR 772)

The FHWA noise regulations contain noise abatement criteria (NAC) that the FHWA considers to be the acceptable limits for noise levels for exterior land uses and outdoor activities and for certain interior uses (Table 312685-1). While the selected remedy is not a highway project, the FHWA noise regulations offer measures that can be evaluated in the context of the selected remedy. According to the FHWA NAC, if noise levels from highway traffic at an impacted receptor location exceed the corresponding L_{eq} or L_{10} criteria listed in Table 312685-1, abatement measures, such as the installation of noise barriers, if feasible or reasonable, need to be considered. Although it is EPA's expectation that the facilities well be located in an industrial or commercial area, the determination of which NAC will apply will depend on where the sediment processing/transfer facilities are sited.

US Department of Housing and Urban Development (USHUD) Environmental Criteria and Standards

As shown in the table below, USHUD Site Acceptability Standards, USHUD has adopted environmental standards, criteria, and guidelines for determining acceptability of federally assisted projects and has proposed mitigation measures to ensure that activities assisted by USHUD will achieve the goal of a suitable living environment. These guideline values are strictly advisory.

USHUD Site Acceptability Standards

Noise Zone	Day/Night Sound Level (L_{dn})
Acceptable	Not exceeding 65 dB
Normally Unacceptable	Above 65 dB but not exceeding 75 dB
Unacceptable	Above 75 dB
Source: 24 CFR Part 51	

USHUD funding assistance for the construction of new noise-sensitive land uses is generally prohibited for projects with "unacceptable" noise exposure (as defined in the table above) and is discouraged for projects with "normally unacceptable" noise exposure, without suitable mitigating measures.

This policy applies to all USHUD programs for residential housing, college housing, mobile home parks, nursing homes, and hospitals. It also applies to USHUD projects for land

development, new communities, redevelopment, or any other provision of facilities and services that is directed toward making land available for housing or noise-sensitive development.

Sites falling within the "normally unacceptable" zone require implementation of sound mitigation measures: 5 dB if the L_{dn} is greater than 65 dB but does not exceed 70 dB, and 10 dB if the L_{dn} is greater than 70 dB but does not exceed 75 dB. If the L_{dn} exceeds 75 dB, the site is considered "unacceptable" for residential use.

USHUD encourages noise attenuation features in new construction or in alterations of existing structures. The USHUD-mandated or recommended design mitigation measures to eliminate or minimize "unacceptable" or "normally unacceptable" levels, respectively, include well-sealed double-glazed windows, forced-air ventilation systems (which permit windows to remain closed in summer), acoustic shielding, and insulation.

New York State Department of Transportation (NYSDOT) Construction Guidelines

Given its temporary effects on any given receptor location, construction activity (similar to dredging or backfill operation for the selected remedy) noise is normally considered less critical than noise from a continuing operation (most noise criteria were established for continuing operations). Construction noise impact guidelines have been developed by NYSDOT for transportation projects. Relevant to the selected remedy is the guideline for temporary construction noise, which defines "impact" as occurring at levels exceeding $L_{eq}(1)$ = 80 dBA (NYSDOT, 1998).

ANALYSIS SCENARIOS AND SOURCES ANALYZED

Again, it is important to note that EPA has not yet determined the locations of the sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the FS, example locations were assumed to include a northern transfer facility (NTF) and a southern transfer facility (STF).

The project would involve 1) seasonal sediment processing/transfer operations at fixed locations and 2) a dredging process that would move along the Hudson River over a six-year period. Unlike the operations at a sediment processing/transfer facility, the dredging process, much like construction activity, would result in only temporary noise effects at any given receptor location.

For purposes of the noise analyses, the sediment processing/transfer facility operations would include seasonal operations at loading, processing, and unloading areas for approximately 20 hours per day, including a total of five nighttime hours. Each sediment processing/transfer facility could be constructed for either mechanical or hydraulic dredging processes.

In identifying the type of noise source that would likely contribute the most to noise levels, the basic noise fundamental concept considered in this analysis is that a small noise source contributes negligible noise emissions if a large noise source exists. For example, if a 100-hp generator has a noise reference level of 65 dBA and a 1,000-hp generator has a noise reference level of 90 dBA, the total combined noise level of these two generators would be 90.01 dBA (*i.e.*, the small source only contributes 0.01 dBA increase of the total noise level compared to the

large source alone). Since a 3-dBA difference is a barely perceptible noise change, small noise source contributions were omitted in this analysis in order to simplify the study. The sample calculation is shown below by using an equation for calculating the combined L_{eq} as $L_{eq} = 10 \log \Sigma 10^{Leq(i)/10}$:

$$10 \log \Sigma 10^{Leq(i)/10} = 10 \log (10^{90/10} + 10^{65/10}) = 90.01 \text{ (dBA)}$$

A complete project equipment list can be found in White Paper – River Traffic. However, it should be noted that, for noise analysis purposes, the following noise sources and associated operational conditions are not necessarily described in the same way as in other white papers. For example, three tug boats to be operated 30 minutes each in a non-overlapped way in one day are considered, in the noise analysis, as one tug boat to be operated 30 minutes for three times in a day.

Long-Term Operational Activity at Sediment Processing/Transfer Facilities

Northern Transfer Facility

Mechanical Dredging Scenario

With respect to operation under the mechanical dredging scenario, the NTF would include the following potential noise sources:

- Two front-end loaders in the enclosed, temporary staging building loading sediment onto dump trucks.
- Three dump trucks near the unloading dock.
- Two front-end loaders in the semi-open loading area loading sediment onto rail cars.
- Two dump trucks near the loading area.
- One locomotive running for 30 minutes during the daytime period (7 am – 10 pm) twice a day.
- A 350-hp tugboat running continuously for 30 minutes each trip, with a total of six daytime (7 am – 10 pm) trips needed per day.
- A 350-hp tugboat running continuously for 30 minutes each trip, with a total of three nighttime (10 pm – 7 am) trips needed per day.
- Five round trips each hour along on-site roadways.
- One electric-powered material handler (CAT 375 MH). However, the noise from such a machine is substantially lower than a diesel-powered excavator of the same capacity

because of the lack of diesel engine noise (Stonehocker, June 15, 2001); this machine is, therefore, omitted from the noise analysis.

- Pug mill, conveyor belts, and other necessary small generators would not likely generate a noticeable difference in noise levels from the large noise sources listed above. Furthermore, most of these small sources would be electric-powered or installed in an enclosed room or building, as they would be in a typical water-treatment plant, so the exterior noise from these small sources would not be significant. Therefore, they are not considered in the evaluation.

Hydraulic Dredging Scenario

With respect to operation under the hydraulic dredging scenario, the NTF would include the following potential noise sources:

- One locomotive running continuously for 30 minutes, twice a day, during daytime periods (7 am – 10 pm).

- One 1,000-hp tugboat running for 60 minutes, three times a day, during daytime periods (7 am – 10 pm).

- Other necessary small-horsepower generators, auxiliaries, and boosters would not be likely to generate a noticeable difference in noise levels from the large noise sources listed above. Furthermore, most of these small sources would be electric-powered or installed in an enclosed room or building, as they would be in a typical water-treatment plant, so the exterior noise from these small sources would not be significant. Therefore, they are not considered in the evaluation.

Southern Transfer Facility

Mechanical Dredging Scenario

With respect to operation under the mechanical dredging scenario, the STF would include the following potential noise sources:

- Three front-end loaders within an enclosed and temporary staging building.

- Two diesel-powered excavators (CAT345).

- One locomotive running continuously for 30 minutes twice a day during daytime periods (7am-10pm).

- One 1,000-hp tugboat running continuously for 60 minutes three times a day during daytime periods (7am-10pm) and once a day during nighttime periods (10pm-7am).

- Pug mill, conveyor belts and other necessary small generators would unlikely generate a noticeable difference in noise levels from the above large noise sources. Furthermore,

most of these small sources would be electrical-powered or installed in an enclosed room or building, as they normally would be in a typical water treatment plant, so that the exterior noise from these small sources would not be significant. Therefore, they are not considered in the evaluation.

Hydraulic Dredging Scenario

An STF configured for hydraulic dredging would involve operation of fewer noise sources than a mechanical-dredging facility. Therefore, the potential noise effects would be less than from a mechanical dredging facility, and were not analyzed in this white paper.

Long-Term Booster Pump Operations

Under the hydraulic dredging scenario, one stationary 1,000-hp booster pump would be installed along the river at each 10,000-foot increment of dredging distance. For purposes of this noise analysis, it is assumed that each booster pump would be operated 17 hours per day, including two nighttime hours.

Short-Term Dredging Activity

Mechanical Dredging

Short-term mechanical-dredging activities would include the following potential noise sources:

- One large excavator (CAT 375) for deep dredging 100 ft from the west bank shoreline.
- One small excavator (CAT 345) for shallow dredging approximately 400 ft from the west bank shoreline.

Hydraulic Dredging

Short-term hydraulic-dredging activities would include the following potential noise sources:

- One 600-hp dredge machine operating approximately 150 ft from the west bank shoreline.
- One 1,000-hp booster operating approximately 150 ft from the west bank shoreline and trailing 2,000 ft behind the dredge machine.

Equipment Noise Reference Levels

Reference noise levels (measured at 50 ft) for each major noise source to be used for the project are identified below.

Excavators

The noise emission reference levels for the specific excavator models proposed for the mechanical dredging activities (*e.g.*, CAT 345 and CAT 375) were obtained from the manufacturer (Foley Inc., 2001). Based on the levels for various operational movements for each excavator, the highest tested level was conservatively used for the $L_{eq}(1)$ in the analysis (79 dBA for the CAT 375 model and 74 dBA for the CAT 345 model).

Hydraulic Dredge Machine

In a hydraulic dredging scenario, the $L_{eq}(1)$ reference level of 77 dBA at 50 ft is assumed in this analysis for the proposed 600-hp dredge machine. This level was the highest level measured on June 11, 2001, based on a series of on-site measurements approximately 50 ft away from an active dredging spot near Cape Cod. The dredge machine on the site was an Ellicott Wheel Dragon B890 model with a 624-hp pump plus a 210-hp auxiliary pump. The dredging process and capacity monitored are similar to that proposed for the selected remedy.

Booster

In a hydraulic dredging scenario, a 91 dBA $L_{eq}(1)$ reference level was used for the 1,000-hp booster, based on the manufacturer-provided noise reference level for a 1,020-hp diesel engine (Thomas, February 2, 2001).

Front-End Loader

A typical front-end loader can result in a peak noise level of 84 dBA at 50 ft (Table 312685-2). It should be noted that the noise levels summarized in Table 312685-2 are the peak levels for each piece of equipment. The average noise levels would likely be 2 dBA lower than the peak levels, as suggested by FHWA (FHWA, 1976).

Locomotive

An 80.4 dBA $L_{eq}(1)$ noise reference level was provided in the US Federal Transit Administration (FTA) guidance (April 1995).

Tugboat

Tugboat noise levels were considered to be comparable to a diesel engine with a similar operational capacity. However, since a tugboat is normally operated at less than 60 percent of its rated power (Thomas, June 1, 2001), especially during low-speed barge loading and unloading processes, and furthermore, the boat's engine noise is shielded to a certain degree by either the tugboat deck or an engine room, the average noise from a tugboat with a rated horsepower of

1,000 hp is expected to be less than that from a 600-hp diesel engine. Therefore, a reference level of 77 dBA $L_{eq}(1)$ was assumed for the 1,000-hp tugboat, based on the 600-hp hydraulic dredge machine reference level measured at Cape Cod and discussed above. Subsequently, a 74 dBA $L_{eq}(1)$ reference level was used for the 350-hp tugboat, due to the same load factor considerations discussed above. The level is based upon a full-powered 286-hp excavator (CAT 345).

Truck

Noise reference levels for an idling truck engine during loading and unloading process are conservatively assumed to be 80 dBA under the worst-case (full throttle) condition (FHWA, 1998).

ANALYSIS METHODOLOGY

Equipment Noise

Estimated equipment noise levels were derived from recommendations provided in *Highway Construction Noise: Measurement, Prediction and Mitigation* (FHWA, 1976) as per the following:

$$EL(i) = L(i) + EF$$

$$L_{eq}(i) = EL(i) - 20 \log D(i)/D_0$$

$$L_{eq} = 10 \log \Sigma\, 10^{Leq(i)/10}$$

where:

EL(i) is the average cycle noise emission level for equipment i;

L(i) is the peak noise emission level of i equipment obtained in Table 312685-2 or from manufacturer;

EF is the equivalency factor to adjust peak noise level to average equipment cycle noise level. Here an average EF is about -2 dBA for equipment at material processing facilities and 0 for dredging excavators;

D(i) is the distance from receptor to construction equipment i;

D_0 is the reference distance at which L(i) is measured (*e.g.*, D_0 = 50 ft for the level identified in Table 312685-2 for a front end loader);

$L_{eq}(i)$ is the sound level resulting from operation of equipment i; and

L_{eq} is the cumulative sound level from all equipment.

Truck Running Noise

Heavy truck-running noise along the truck route between loading and unloading areas within the NTF was modeled using the FHWA's Traffic Noise Model (TNM), assuming an average travel speed of 25 miles per hour.

Nighttime Background Noise

In order to determine L_{dn}, a 40-dBA background-noise level was assumed for those nighttime hours in which no operations would occur. This level is typical for a quiet suburban nighttime background condition (NYCDEP, 1993) and would result in a conservative L_{dn} level in the calculation if the area were rural. Noise levels for the remaining nighttime hours were the same as the daytime levels as a result of the project's long-term operations, plus a 10 dBA nighttime noise penalty.

RECEPTORS

The sensitive noise receptor locations analyzed include:

- In the long-term sediment processing/transfer facility impact evaluation – The residences that are closest to each facility site (a camp location near the NTF was also considered).

- In the short-term dredging impact evaluation – Typical residences approximately 50, 100, and 200 ft from the west bank shoreline along the river near any dredging site. This includes a total of 49 homes located within 200 ft or less of the river's shoreline. Of these 49 homes, 8 are located within 50 ft, 12 are located within 50 to 100 ft, and 29 are located within 100 to 200 ft.

ANALYSIS ASSUMPTIONS

Sediment Processing/Transfer Facility

A conservative building noise attenuation of only 10 dBA was applied to noise that would be generated from operation of equipment inside the enclosed staging area at both the NTF and STF. This attenuation level is equivalent to the typical noise reduction from a normal residence with open windows (FHWA, June 1995).

A 3-dBA noise shielding is applied to the noise levels to be generated from equipment operation at the semi-enclosed structure at the loading area at both the NTF and STF. This level is considered achievable, even with a long-but-discontinuous wall that blocks 40-65 percent of the area between a source and a receptor (FHWA, 1978). Since the structure at the loading area would be constructed as an enclosed building (except that it will have the built-in flexibility of either end being capable of opening for entering and exiting rail cars), a more-than 3-dBA reduction is expected from this building.

Stationary Booster Operation

For purposes of this analysis, it was assumed that, under the hydraulic dredging scenario, each needed stationary booster would be installed at a distance greater than 400 ft from the closest receptor location near the river.

Short-Term Dredging Activity along Hudson River

Mechanical Dredging

Deep dredging activities would move along a river path approximately 100 ft from the shoreline and shallow dredging activities would be stationed approximately 100 ft from the opposite shoreline.

Based on an estimated rate of movement of 2.5 ft per hr, the mechanical dredge would take 407 hours, or approximately five weeks, to move a distance of 1,000 ft. Thus, the mechanical dredge would be in a zone of 1,000 ft that is close to any given receptor along the river for a 10-week period.

Hydraulic Dredging

The hydraulic dredge machine, trailed by a booster pump 2,000 ft behind it, would move along a river path approximately 150 ft from the shoreline. Each additional 10,000 feet of moving distance would require the addition of a booster pump. Therefore, any affected residents would first hear the noise from the hydraulic dredge working and, once work is accomplished and the dredge moves farther downstream, they would then hear the noise produced from the trailing booster pump.

The hydraulic dredge and the booster pump would move down the river at an estimated rate of 6.5 ft per hr and would operate seasonally for 17 hrs per day, six days per week. Based on these parameters, the hydraulic dredge would be in a zone of 1,000 ft that is close to any given receptor along the river for a three-week period.

When the dredge machine moves away and the trailing booster pump moves closer to any given receptor, the booster pump would then dominate temporary noise effects. In order to evaluate the worst-case noise impact range from a moving booster-pump operation, a 3,000 ft worst-case zone, in which the trailing booster would stay for a total of nine weeks, was used for noise evaluation.

ANALYSIS RESULTS

Based on the methodology and the assumptions described above, the potential noise effects from both sediment processing/transfer facility and dredging activities were estimated at the worst-case receptor locations.

Long-Term Operational Noise Levels

The long-term predicted noise levels from the sediment processing/transfer facilities and a stationary booster are summarized and compared to the appropriate noise guidelines in Tables 312685-3 and 4, respectively. Overall, the sediment processing/transfer facility operational noise levels would be below the applicable guidelines at any existing receptor locations. However, noise effects from a stationary booster pump would be significant for receptors along the Hudson River within approximately 1,000 ft of the booster.

Short-Term Dredging Noise Levels

Mechanical Dredging

At the worst-case receptor (50 ft off the shoreline) within the worst-case 10-week period (1,000-ft dredging zone), the $L_{eq}(1)$ would begin at 57 dBA level, then reach a peak level of 70 dBA at the end of the fifth week, and return to 57 dBA after a 10-week period as the dredging operations move down the river. These worst-case dredging noise levels (Table 312685-5) would not exceed the NYSDOT construction-noise impact guideline of 80 dBA.

Hydraulic Dredging

During the worst-case nine weeks (in which the trailing booster would move in a zone from 3,000 ft upstream to 3,000 ft downstream) when a dredge machine and a trailing booster pump are close to any given receptor location along the river, the noise levels (Table 312685-6) at the closest receptor location (50 ft off the shoreline) would vary as follows:

- $L_{eq}(1)$ would start from 57-dBA level and approach mid-peak of 66 dBA within two weeks, when the dredge machine is at the nearest point.

- $L_{eq}(1)$ would remain at mid-60s levels during the following four weeks, before the trailing booster becomes a dominant noise source.

- $L_{eq}(1)$ would reach a peak level of 79 dBA in the middle of the fifth week, when the trailing booster is at the nearest point to the receptor.

- $L_{eq}(1)$ would drop to the level of 56 dBA from the peak of 79 dBA within the next four weeks after the booster reaches the downstream worst-case zone boundary (3,000 ft downstream), at the end of nine-week period.

Overall short-term noise levels during the worst-case nine-week dredging period would not exceed the available NYSDOT construction-noise impact guideline of 80 dBA at any existing receptor locations.

DISCUSSION AND MITIGATION CONSIDERATIONS

The above noise levels were predicted using various conservative assumptions such as:

- Each piece of equipment, truck, booster, etc., was assumed to run continuously during the identified operational time period. For example, a truck within the NTF loading area was

assumed to run continuously for 60 minutes per hour and 20 hours per day without a break. In fact, all equipment operations would need maintenance work periodically and thus lower noise levels would occur compared to predicted levels.

- Each piece of equipment, truck, booster, etc., except for tugboats, is assumed to run continuously under the full capacity during all phases of operations. For example, a 1,000-hp booster pump to be stationed in the river under the hydraulic dredging scenario is assumed to run continuously for 60 minutes per hour and 17 hours per day at the maximum load condition. In fact, all equipment would be operated at full capacity only occasionally, rather than continuously as assumed in the analysis. Thus, in reality, lower noise levels would occur compared to predicted levels.

- For equipment operations that have an operational cycle with different movements or functions under various power-settings (such as digging, moving, and dumping movements during an excavator cycle), the maximum reported L_{eq} level was conservatively assumed as an average level for the equipment.

The results of the noise analyses using the conservative assumptions discussed above are summarized in the following sections.

Long-Term Operational Effects from Sediment Processing/Transfer Facilities

- Noise levels generated from the sediment processing/transfer facilities at receptor locations near each facility would not exceed the FHWA NACs for Category B and C. As indicated above, it is EPA's expectation that the facilities well be located in an industrial or commercial area. The determination of which NAC will apply will depend on where the sediment processing/transfer facilities are sited.

- Day-and-night noise levels generated from the sediment processing/transfer facilities at receptor locations near each facility would not exceed the USHUD acceptability guidelines for housing.

- Sediment processing/transfer facility noise effects from hydraulic dredging would be generally less than for mechanical dredging.

- The greatest noise effects would occur at the NTF under the mechanical dredging scenario but would be still below applicable guidelines.

Long-Term Operational Effects from Stationary Boosters

- Noise levels generated by a 1,000-hp stationary booster at residences within a 1,000-ft radius of the booster would be significant.

- Mitigation measures can include:

  – Enclosure of the booster operation.
  – Using an electric-powered booster.

- Carefully selecting booster location as far away as possible from the nearest receptor.
- Reducing nighttime booster operational hours to the extent possible.

Short-Term Effects of Dredging Noise

- Noise levels under both mechanical and hydraulic dredging scenarios would not exceed the NYSDOT short-term construction impact guideline.

- Noise effects from mechanical dredging would be less than those from hydraulic dredging.

General Noise Mitigation Consideration

Even though most of the absolute noise levels summarized for various activities would not exceed the applicable guidelines, a perceptible noise increase may occur, especially during nighttime operations. As indicated in the beginning of this paper, the potential noise increase will be assessed after an extensive on-site noise monitoring study is performed during remedial design.

However, as per a series of conversations with the company providing noise-control measures for typical diesel equipment (MacDonald, August 2, 2001), a 10-dBA reduction of equipment noise can be readily achieved through special design considerations. These noise-reduction measures include utilizing insulation, silencers, etc. Therefore, the noise levels summarized in this white paper can be reduced, when specific equipment is considered during the project's design phase.

REFERENCES

Foley, Inc. 2001. Noise emission data run for CAD 375 and CAD 345 models. January 16.

MacDonald, Rod. Noise Solutions, Inc. 2001. Personal communication with TAMS Consultants, Inc. via e-mails. August 2.

New York City Department of Environmental Protection (NYSDEP). 1993. Environmental Quality Review Technical Manual. December.

New York State Department of Transportation (NYSDOT). 1998. Environmental Procedures Manual – Noise Analysis Policy. August.

Stonehocker, Stephen. Caterpillar, Inc. 2001. Personal communication with TAMS Consultants, Inc. via telephone. June 15.

Thomas, Richard. GBA, Inc. 2001. Personal communication with TAMS Consultants, Inc. via e-mails. February 2, June 1.

US Federal Highway Administration (FHWA). 1998. FHWA Traffic Noise Model User's Guide. January.

US FHWA. 1998. FHWA Traffic Noise Model Technical Manual. February.

US FHWA. 1995. Highway Traffic Noise Analysis and Abatement Policy and Guidance. June.

US FHWA. 1976. Highway Construction Noise: Measurement, Prediction and Mitigation.

US FHWA. 1978. Highway Traffic Noise Prediction Model. December.

US Federal Transit Administration. 1995. Transit Noise and Vibration Impact Assessment. April.

Project-Related Traffic
253245

WHITE PAPER – PROJECT-RELATED TRAFFIC

(ID 253245)

ABSTRACT

Commenters raised concerns with regard to the potential for impacts to local communities from project-related traffic. While implementation of the selected remedy would generate additional truck and auto trips mainly in the vicinity of the sediment processing/transfer facilities,[1] it has been suggested that the project will also create congestion on adjoining roadways at these locations, thus increasing the need for road maintenance and resulting in a higher occurrence of accidents. EPA has estimated the traffic that will be generated by the proposed activities and evaluated it in the context of current area road capacities and volumes.

Using available traffic data, an analysis has been conducted for select roadways in the vicinity of the Thompson Island Pool (TI Pool) (assumed for the purpose of this study to be the location of a northern transfer facility [NTF]). It is concluded from the analysis that traffic generated by the project will not be disruptive to local communities in the TI Pool vicinity, as the volume increase on nearby roadways will be minor. Also, since the increase in road usage is relatively small, it is not likely that there will be a need for significant road maintenance as a result of the selected remedy. Impacts for a southern transfer facility (STF) site were not evaluated, as that area, assumed to be near the Port of Albany, is highly industrialized and experiences much greater vehicular activity than would be generated by project operations.

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[1] It is important to note that EPA has not yet determined the location(s) of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the Feasibility Study, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the Upper Hudson River valley and farther downstream, are possible.

The example facility locations presented in the Feasibility Study have also been used in the Responsiveness Summary in order to clarify material presented in the Feasibility Study and Proposed Plan and in connection with additional noise, odor and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after EPA performs additional analyses and holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, all information provided in this Responsiveness Summary relative to potential impacts of the sediment processing/transfer facilities on communities, residents, agriculture, the environment and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during design.

TRUCK AND AUTO GENERATION

Mobilization Phase

The construction and mobilization phase of the project will involve developing the sediment processing/transfer facilities. Facility expansion will require movement of employees and materials to and from the project sites. It should be noted that the areas discussed herein are only for analytical purposes.

Northern Transfer Facility

As indicated in the FS, construction costs to develop the NTF have been estimated at approximately $15.1 million for construction-related labor, materials, and equipment. For purposes of this discussion it is assumed that construction of the NTF will take nine months and that traffic will be generated as a result of the need to bring labor and material onto the site on a regular basis. It is further assumed that 40 percent of the construction cost is for labor (about $6 million), 40 percent is for materials, and about 20 percent is for equipment costs.

With respect to generation of traffic, it can be expected that the busiest phase of construction will be the site preparation phase, when grading materials are being brought in and concrete is being placed for foundations and structures. It is assumed that this phase of the construction work will take about three months and that construction of the remainder of the facility (*i.e.*, dewatering facilities, water treatment systems, etc.) will require about six months. Since the first phase of construction involves importing relatively low-priced commodities (concrete, grading materials, etc.), it is estimated that about 25 percent ($1.5 million) of the materials cost will be for these commodities (with about $755,000, or 50 percent, for grading materials and $755,000 for concrete).

Traffic associated with bringing in the grading materials and concrete may then be estimated on the basis of the cost of these commodities ($20 per ton for grading materials and $95 per yard for concrete) and the quantity that can be hauled in each truckload (20 tons per load for grading materials and 15 tons per load for concrete). Using these parameters, it is estimated that about 34 truckloads per day of low-cost commodities will arrive at the NTF site during the first three months of construction. The material that arrives over the remaining six months will consist of relatively costly commodities (on a per-unit weight basis) such as pumps, conveyors, valves, pipes, electrical gear, etc. It is estimated that up to five truckloads of these materials will arrive at the NTF site each day over the remaining six months of construction.

Neither the 34 truckloads per day of low-value materials nor the five truckloads per day of higher-valued commodities will create congestion on local roadways. As discussed in the next section of this white paper, there is substantial existing capacity on the roadways that are assumed to be used for project deliveries. In addition, material deliveries are expected to occur throughout the workday and not during peak commuting hours when roads are most congested. Please note that the volume of trucks addressed here is for the mobilization phase, and is not representative of the truck deliveries estimated for the operational phase.

Construction employment is expected to average 50 workers over the nine-month construction period for the NTF. This number was estimated on the assumption that average labor costs (including benefits, other overheads, and contractor profit) will be $80 per hour and that work occurs five days per week for nine months. Since construction phase employment at the processing/transfer sites is less than that expected during the project's operational phase, the estimate of operational phase traffic impacts that follows is applicable to the construction phase as well. As will be noted from the information provided below, vehicular movements associated with commuting employees will only have a minor impact on nearby roadways.

Southern Transfer Facility

The assumed siting of the STF in an industrial zone in the Port of Albany area will limit the impacts of traffic associated with the construction of this sediment processing/transfer facility. The Port of Albany is a very active industrial waterfront area that is served by excellent road and highway connections, including a component of the interstate system. In addition, materials deliveries can be readily accomplished by either rail or barge, thereby avoiding the roadway system entirely. Thus, a specific analysis of traffic impacts at this location is not presented herein since no significant impacts are expected.

Operational Phase

Northern Transfer Facility

During routine operations, trucks will deliver supplies to the NTF site, including fuel, stabilization agents, water treatment supplies, equipment/lubricants, and office/cafeteria supplies, and remove trash. It should be noted that EPA does not intend to haul dredged material by truck but rather to move this commodity by rail to suitably permitted landfills, thus avoiding local roadways. In addition, EPA has committed to moving backfill materials within the Upper Hudson River area either by rail or in river barges. Thus, movements of neither dredged material nor backfill will contribute to traffic near the NTF.

In addition to the routine delivery of supplies, additional vehicular movements will occur during the project's operational phase as a result of employees commuting to work each day. Employees will arrive at the NTF site to operate the sediment processing/transfer facilities, as well as to support in-river operations such as dredging. An evaluation of the potential for project operations to cause roadway congestion follows.

- **Stabilization Agent:** A stabilization agent is required to improve the handling properties of mechanically dredged sediments. It has been estimated that 112 tons per day of agent will be required for sediment processing. Assuming the use of 20-ton delivery trucks, six trucks per day will required at the NTF. In the case of hydraulic dredging, there is no need for stabilization agent, but additional materials are required to support the large slurry processing and water treatment plant. The number of trucks needed to deliver processing materials is also estimated to be six per day.

- **Fuel:** The total diesel fuel requirements for each dredging scenario are addressed in Chapter 8 of the RS. Assuming the use of 5,000-gallon delivery trucks, the fuel deliveries required per week for each dredging scenario are outlined in Table 253245-1.

- **Other:** Trucks will also be needed to deliver general supplies, chemicals, equipment/lubricants, and office/cafeteria supplies and for trash removal. The frequency of the delivery will depend on the type of material. A summary of the truck delivery schedule for the NTF is contained in Table 253245-2.

  The number of deliveries required at the NTF, assuming a six-day workweek, will be approximately 13 trucks per day: seven large (*i.e.*, 20-ton trucks for stabilization agent and 5,000-gallon diesel tanker trucks) and six small/medium (*i.e.*, standard parcel-delivery trucks) vehicles. It is not expected that trucks will make their deliveries at peak commuter hours. As a result, they are not expected to contribute to roadway congestion, which, as explained below, is most likely to occur at peak commuting hours.

- **Employees:** The number of operational-phase employees was evaluated based on the nature of activities occurring at the sediment processing/transfer facility. It is estimated that there will be 34 employees per day shift, 32 employees per night shift, and 10 visitors per day at the sediment processing/transfer facility. In addition, there will be 12 employees per day per shift to support the dredging equipment, 6 employees per day per shift for the towboats, and 14 employees per day per shift to support workboat operations. It is assumed that visitors will not arrive during peak-hour times, and so they are not included the congestion analysis. Therefore, it is expected that 130 employee auto movements could occur during peak traffic conditions when sediment processing/transfer facility work shifts change (for example, between 5:00 pm and 6:00 pm).

- **Estimating Traffic Impacts:** Annual average daily traffic (AADT) volumes were obtained from the NYS Department of Transportation (DOT) Web site (NYSDOT, 2001) for several roads in the Upper Hudson River valley. The AADT represents the number of vehicles traveling in both directions over a designated section of highway in a 24-hour period. Each roadway section represents an area where volumes are approximately equal. The AADT values were used to determine the impacts, generally, of traffic generated by project activities. An industry standard assumption is that nine percent of the AADT occurs during the peak hours.

  As stated in the previous section, the potential exists for 130 employee trips to occur during a shift change at the NTF. If it is assumed that these additional vehicular movements were to occur at the time local roadways experienced peak traffic flows, it is be possible to estimate project impacts under these relatively conservative conditions.

  In order to complete the calculation it is also necessary to assume a directional flow of traffic leaving and arriving at the NTF. For this purpose it is assumed that no employee vehicles move south along West River Road, that 50 percent of the movements are along Route 197 to the west, and the remainder are along Route 197 to the east. On this basis, the percentage increase in vehicular movements under peak-hour conditions has been estimated for several local roadway segments, as shown in Table 253245-3.

As an example, Route 197 between Route 32 and the Washington County line has 713 vehicles traveling along this road at the peak hour (in both directions). It is estimated that the project could add 65 cars to this section of highway, with a resulting 9 percent increase in traffic under peak-hour conditions. It also should be noted that County Road 197/Reynolds Road and Route 9 are two-lane roadways that typically have a maximum capacity of approximately 1,800 cars under peak-hour conditions. Thus, these roadways are currently operating at well below capacity, and the additional project-related traffic will not substantially change the performance of the roads.

In addition to the AADT, the design-hour volume to the rated capacity (*i.e.*, volume-to-capacity ratio) was reviewed. Project-related traffic will not adversely affect the volume-to-capacity ratio of roads near the NTF, further indicating that there is sufficient capacity in the vicinity of the NTF to accommodate project-related traffic. However, it should be noted that a level of service (LOS) analysis is required in order to fully understand traffic impacts. A LOS analysis, which measures the operating conditions within a traffic system and how those conditions are perceived by drivers, will be performed during the project's design phase.

Southern Transfer Facility

There will be an increase in employee vehicular activity and truck deliveries when transfer/processing operations are initiated at the STF. Approximately six trucks per day will be required to support project operations. Employee commutation-related traffic is estimated at 102 auto trips per day. The impacts of project-related traffic are expected to be negligible due to the industrial character of the Albany area, where the sediment processing/transfer facility is assumed to be for the purpose of this study. Thus, a general roadway congestion analysis has not been conducted for this location.

CONCLUSIONS

Project-related traffic in the vicinity of the NTF is not anticipated to be disruptive to local communities. The principal roadways expected to be used by project employees and for deliveries are not currently operating at capacity, and the additional project traffic will increase vehicular flows by four to nine percent under peak-hour conditions. This additional traffic load is ascribed to employees traveling to and from the NTF under typical commuting conditions. The STF is not expected to impact traffic congestion because of the existing industrial nature of the area and the presence of both interstate highways and alternative modes for materials delivery, such as rail and barge.

REFERENCE

New York State Department of Transportation (NYSDOT). 2001. Web site: www.dot.state.ny.us. Accessed June 7.

River Traffic
337804

WHITE PAPER – RIVER TRAFFIC

(ID 337804)

ABSTRACT

Several commenters suggested that implementation of the selected remedy will create untenable vessel traffic congestion on the Upper Hudson River. Commenters particularly assert that the congestion would take the form of bottlenecks at various locks along the Champlain Canal and interference with the routine passage of vessels along the canal's navigational channel. Based on the analyses presented in this white paper, it is concluded that there may be some interference with other vessels passing through the canal; however, it is expected that any such impacts can be controlled with proper management of remedial work and that, overall, project-related interferences will not be significant.

INTRODUCTION

The navigable waterway within the Upper Hudson River valley, the Champlain Canal, is managed by the New York State Canal Corporation, a subsidiary of the New York State Thruway Authority. The canal typically operates from early May to late November, depending on weather conditions. The canal's navigable channel is authorized for a depth of 12 feet, and its width varies from 75 feet (land cuts) to somewhat over 200 feet (in-river reaches) (J. Dergosits, pers. comm., February 9, 2000). Hudson River water levels and navigational access are managed through a series of locks and dams located throughout the system. The river pools upstream of each lock and dam, thereby allowing a more or less constant water depth to be maintained. In relation to normal pool elevations, the canal provides a 15.5-foot headroom clearance, with the current exception of the railroad bridge located north of Lock 3. To obtain full clearance at this bridge, the pool level must be lowered by lowering flashboards at the Lock 3 Dam.

Lock dimensions are the principal limitations on the size of vessels able to use the canal. Typical lock dimensions are 328 feet by 45 feet, and the actual available horizontal clearance for vessels passing through the locks is 300 feet by 43.5 feet (J. Dergosits, pers. comm., February 9, 2000). The locks are operated on an as-needed basis during regular hours of operation, which are from 7 am until 10:30 pm. However, with advance notice, commercial users may pass through the locks 24 hours per day (J. Dergosits, pers. comm., February 9, 2000).

Passage time through a lock (called a "lockage") is approximately 30 minutes (J. Dergosits, pers. comm., February 9, 2000). For commercial traffic, one barge can lock-through at one time. Under normal situations, a barge is moved into the lock by its attendant towboat. In the case of specialty barges of approximately 300 feet in length, the barge is pulled through the lock with a winch and the attendant tug passes through in a separate lockage. The situation with smaller pleasure craft differs, however. According to Canal Corporation staff, there have been instances wherein as many as 20 pleasure craft have moved through a lock at one time (J. Dergosits, pers. comm., May 25, 2001).

Presently, there is essentially no commercial traffic that involves shipment of industrial commodities on the Champlain Canal. Commercial traffic currently consists of cruise ships and tour boats. In the recent past, the Champlain Canal was used to transport petroleum products and jet fuel to Plattsburgh Air Force Base (AFB). After closure of the base in 1994, bulk commodity traffic dwindled to zero (J. Dergosits, May 25, 2001). Table 337804-1 lists commercial traffic moving along the Hudson River prior to the Plattsburgh AFB closure in 1994. It should be noted that the number of barge loads shown on the table was computed assuming approximately 1,500 tons of commodity per barge.

As shown in Table 337804-1, there were approximately 150 commercial barge loads moving along the Hudson in 1989. Since it is likely that most of these barges moved through all locks on the canal, each of those locks would have experienced 150 lockages as loaded barges passed through and 150 lockages as empty barges returned, for a total of 300 lockages due to movements of industrial commodities in 1989.

CURRENT CONDITION OF THE CHAMPLAIN CANAL

Historically, the Canal Corporation routinely dredged the canal to maintain the 12-foot water depth. However, no dredging has occurred along the canal between Locks 1 and 7, the area designated as River Sections 1, 2, and 3 in the FS, since 1979, with an exception in the area where the Hoosic River discharges coarse-grained materials between Locks 3 and 4 (J. Dergosits, February 9, 2000). Annual sweeps, or depth measurements, are conducted by the Canal Corporation to determine where the river has shoaled, creating potential vessel-clearance limitations. The sweeps, conducted largely by manual methods, are recorded as feet of sediment accumulated above nominal bottom elevation. After completing the canal sweeps, the Canal Corporation publishes a Notice to Mariners identifying current water depths and areas considered to be navigational hazards due to sediment accumulation. The notice indicates numbered buoys where the shoal condition occurs and the depth of water across the channel at that location.

A recent Notice to Mariners, published in April 2001 and based on the year 2000 canal sweeps, identified maximum sedimentation at buoy number R160, north of Lock 5 and south of the Route 4 Bridge. This location is within the proposed work zones. Here, the sweeps identified only 4 feet of water on the west side of the channel, 7 feet in the center, and 12 feet on the east side of the channel. Shoaling also occurs within many other sections of the river, but is not as severe as at buoy R160.

IN-RIVER CONGESTION DUE TO EQUIPMENT REQUIREMENTS

Mechanical Dredging

As stated in the FS, excavators fitted with two-cubic-yard and four-cubic-yard buckets would conduct the bulk of removal operations, should mechanical dredging be selected as the preferred dredging technology. Sediment removed by the larger excavators would generally be placed into hopper barges that would be loaded with about 1,000 tons of material, and the hopper barges then towed to the southern transfer facility (STF). Material removed by the smaller dredge would be placed into deck barges loaded to about 200 tons, which would then be towed to the northern transfer facility (NTF).

In order to meet the removal target volume of 2.6 million cubic yards in six construction seasons, approximately 3,000 cubic yards of sediment must be removed each working day. To accomplish this it is assumed, for purposes of this analysis, that four mechanical dredges, six hopper barges, and six deck barges will be needed. If backfill material were transported to the remediation area in hopper barges, either one or two barge loads per day will be needed. Two hopper barges and two tow boats will be needed to support backfill operations, assuming that backfill is obtained from sources beyond River Sections 1 and 2. Table 337804-2 identifies the vessels and other in-river equipment that may be required to support mechanical dredging operations under the selected remedy.

As shown in the table, an estimated total of 39 vessels will be required to support the project. It is important to note that the equipment will be dispersed over 40 miles of river. There will be barges located at the dredge site, barges and towboats in transit, barges secured at sediment processing/transfer facilities, and other supporting equipment in various river sections conducting surveys and performing other work. It is expected that the worst-case situation for in-river congestion would occur when four dredges and associated supporting equipment are located in the Thompson Island Pool (TI Pool) (River Section 1).

Of the 39 project vessels shown in Table 337804-2, 24 are likely to be actively involved at TI Pool work sites (dredging, restoring shorelines, backfilling, planting) at any one time under this scenario. The other 15 pieces of equipment, not actively engaged in River Section 1, would be located throughout the 40-mile length of river. For instance, three hopper barges could be in transit with three large towboats moving toward or away from the STF. Two deck barges could be moored at the NTF for unloading and the associated towboats could be in transit**.** The second backfill barge and towboat could be situated at a bulk-materials transfer facility beyond River Section 1, outside the project area. The second fuel barge could also be at either the NTF or STF for loading purposes. Lastly, two shoreline restoration and habitat replacement vessels could be either in transit or moored for restocking with supplies.

Given that the length of the TI Pool (River Section 1) is approximately 6.3 miles, it is not expected that 24 vessels actively involved in remedial work will generate either an actual or perceived congestion problem. Several factors support this conclusion:

- Much of the work will occur off-channel in shallower sections of the river. Thus, movements of pleasure craft and tour boats in the channel will not be impacted by much of the working equipment.

- Some of the working vessels are similar in scale to tour boats and pleasure craft already using the river. This is particularly the case for various survey vessels and possibly for vessels engaged in restoration activities.

- Major pieces of equipment will tend to work in clusters and, therefore, the number of possible interactions between working vessels and other river traffic will be less than otherwise expected. The equipment clusters will include dredges and associated barges, debris collectors and associated barges, and backfill equipment and associated barges.

Most importantly, the work will be conducted in a way that limits the potential for interference with other river traffic. The contractor will be required to maintain sufficient clearance in the navigation channel for other river users to move through areas where work is in progress. In addition, movements of dredges, barges, and other vessels associated with the remediation will be directed to favor off-peak hours to avoid inconveniencing other canal users.

Hydraulic Dredging

The hydraulic dredging scenario proposes the use of a 12-inch hydraulic cutter head dredge for remediation of all targeted areas in River Sections 1 and 2, and mechanical dredging equipment in River Section 3 to perform both remediation and navigational dredging in this section. All hydraulically dredged contaminated sediments will be pumped to the NTF for processing. Due to the estimated 1,600-ton-per-day (TPD) shipping limit at the NTF, three barge loads per day, on average, of processed river sediments will be transported to the STF for rail car loading and final disposal. In addition, if backfill material were transported to the remediation area in hopper barges, either one or two barge loads per day would be needed. Two hopper barges and two tow boats would be needed to support backfill operations.

Table 337804-3 identifies the vessels and other in-river equipment required to support hydraulic dredging operations under the selected remedy.

As shown in the table, an estimated total of 39 vessels and other in-river equipment will be required to support the project. As noted with the mechanical dredging scenario, it is important to note that these vessels will be dispersed over 40 miles of river. It is expected that the worst-case situation for in-river congestion would occur when the hydraulic dredge and all supporting equipment are located in the TI Pool (River Section 1). As indicated in Table 337804-3, of the estimated 39 project vessels, 18 are likely to be actively involved at TI Pool work sites (dredging, restoring shorelines, backfilling, planting) at any one time under this scenario.

The other 21 pieces of equipment would be either located in River Section 3 (spread out over 30 miles) or situated outside the remediation area. For instance, three hopper barges could be in transit, with three large towboats moving toward or away from the STF. The second backfill barge and towboat could be situated at a bulk-materials transfer facility beyond River Section 1, outside the remediation area. The second fuel barge could also be at either the NTF or STF for loading purposes. Lastly, one shoreline-restoration vessel and one habitat-replacement vessel could be expected to be either in transit or stationary somewhere, being restocked with supplies.

Given the 6.3-mile length of the TI Pool (River Section 1), it is not expected that 18 vessels actively involved in remedial work will generate either an actual or perceived congestion problem. Factors supporting this conclusion are the same as those previously presented under the mechanical dredging scenario.

In addition, in the case of hydraulic dredging, EPA will require the remedial contractor to develop a work plan that limits the potential for interference with other river traffic. As with the mechanical dredging scenario, the contractor will be required to maintain sufficient clearance in the navigation channel for other river users to move through areas where work is in progress. Movements associated with the remedial work will be directed to favor off-peak hours to avoid

inconveniencing other canal users. Finally, the contractor will be required to distribute both the equipment and its movements so as to minimize the potential for project-related congestion

LOCK CONGESTION

Current Traffic on the Champlain Canal

Data is available from the Canal Corporation (J. Dergosits, pers. comm., May 25, 2001). on the number of commercial (mostly tour boats) and pleasure vessels that utilize the locks each season on a monthly basis. For the 1999 canal season, 1,361 commercial vessels and 14,298 pleasure craft traveled through Locks 1 through 6, for a total of 15,569 vessels during the period from May through November 1999. Commercial and pleasure traffic was most active at Lock 5 (Schuylerville) during the month of July 1999. Lock 1 (Waterford) had the second-highest usage in July 1999, with Lock 6 (Fort Miller) being heavily used by pleasure vessels at this time as well. The second-busiest month in relation to lock usage was August 1999 at Lock 4 (Stillwater) and Lock 1 (Waterford).

The greatest potential project-related congestion may occur from Locks 1 (Waterford) through 6 (Fort Miller). Although Lock 7 is located in the vicinity of the remedial work, it is not expected that significant project-related traffic will move through that lock. It is possible that some backfill material may come by barge from the lower Lake Champlain region, but this would involve only one, or at most two, daily movements. Since, as discussed below, arrival of backfill is not a time-critical activity, it is not expected that these one or two movements will have a significant congestion impact on Lock 7.

Table 337804-4 presents vessel traffic at Locks 1 through 6 during the July and August 1999 canal season.

Impacts Associated with Lock Passage and Lock Capacity

For purposes of this analysis it was assumed that only one commercial vessel (cruise or tour boat) could be locked through at any one time. Note that a lockage represents vessel movement through a lock in one direction. Recreational traffic consists of personal boats used for cruising, water skiing, and fishing. As discussed, Canal Corporation staff stated that up to 20 pleasure vessels have been observed being locked through at one time. Therefore, lockages associated with pleasure craft traffic were analyzed for three situations: (1) each pleasure craft is locked through individually; (2) two pleasure craft are, on average, locked through simultaneously; and (3) three pleasure craft are, on average, locked through simultaneously. These assumptions represent a range from worst-case to more probable situations likely to be encountered at the locks.

Table 337804-5 presents the canal operating schedule for the 2001 season and an estimate of the number of total lockages (both upstream and downstream) that will be available in 2001. It is assumed that each movement through the locks requires an average of 30 minutes.

The remedial project may require use of the lock system on a 24-hour-a-day basis. Table 337804-6 identifies the available lockages for the canal operating season.

Current Daily Lockages at Lock 5

As mentioned previously, Lock 5 was the busiest lock in the month of July during the 1999 canal season. This suggests that project movements through this lock may potentially cause a congestion-related impact. Table 337804-7 compares the available lockages at Lock 5 (for calendar year 2001 operating hours) to those that were actually utilized during the 1999 canal season. Usage during 1999 was derived from the three scenarios previously described, since neither specific data indicating actual vessel lockages nor data on actual lock-operating cycles were available at this time.

The table indicates that presently, assuming the worst-case scenario (Case 1), Lock 5 capacity is fully utilized during normal operating hours. This implies that any additional traffic generated by remedial work will have to move off-hours. Assuming that Case 2 more accurately portrays current Lock 5 usage, there are 10 available lockages not used during normal operating hours, implying that there would be capacity to support project-related movements during the daytime. Lastly, if Case 3 accurately portrays lock operations, there would be considerable capacity for project-related movements during the normal canal-operating day.

A similar analysis was conducted for Lock 6 (Table 337804-8), where Case 1 would suggest that Lock 6 is almost fully utilized during normal canal operating hours and, therefore, project traffic would be relegated to off-hours. Cases 2 and 3 have results similar to those for Lock 5, suggesting that project traffic could pass through Lock 6 during normal canal operating hours.

DAILY LOCKAGES ASSOCIATED WITH THE SELECTED REMEDY

Mechanical Dredging

The potential for the project to generate congestion at various locks will vary, depending on the location of the dredging operations. It is expected that sediment removed from River Section 3 will be barged southward to the STF, resulting in impacts to Locks 4 through 1. The equipment estimated to be traveling through these locks would be three hopper barges and supporting towboats (barge and towboat pass through lock simultaneously) generating requirements for six lockages at each lock in a 24-hour period. The addition of six lockages is not expected to cause congestion, since these locks are not utilized at full capacity (based on 1999 data) during the normal canal operating hours.

Removal operations in the TI Pool (River Section 1) will impact Locks 1 through 6. However, additional lockages required will be minimal, since the vessels traveling south would be three hopper barges and supporting tow boats, requiring six lockages in a 24-hour period. Additionally, one backfill barge and tow boat would move through either Locks 1 through 6 per 24-hour period or through Lock 7 depending on the source of backfill. Remaining support equipment would be traveling to and from the NTF, with no lock passage.

The worst-case congestion scenario appears to occur when two dredges operate in River Section 1 and two dredges operate in River Section 2. With this setup, project equipment (barge and tow

boat combinations) is required to move both north and south through Locks 5 and 6, resulting in the greatest impact to these locks, which are the Canal's busiest.

To evaluate this particular situation, several assumptions have been made concerning the working strategy that may be adopted by the contractor. It is assumed that smaller craft (survey vessels and small work boats) will either move through the locks together with pleasure craft or will find windows of opportunity when the locks are not otherwise being used. Also, it is assumed that barges hauling backfill materials need not utilize the locks during normal operating hours, since their arrival at the work site is not likely to be time-critical. Thus, the principal project-related movements that are likely to occur during normal operating hours are those associated with moving loaded barges to the transfer facilities and those associated with returning empty barges to the work area. Table 337804-9 portrays project barge and towboat movements that have the potential to generate lock congestion.

As shown in Table 337804-10, when dredging is occurring in both River Sections 1 and 2, a total of 18 daily lockages are assumed at Lock 6 and a total of 6 daily lockages are assumed at Lock 5. It should be noted that these are lockages associated with time-critical movements; *i.e.*, movements that cannot readily be delayed to an off-hour. The table also suggests that Lock 6 will incur the most project-related traffic. The table compares current and project-related activity at Lock 6 to the available capacity at that location.

Results shown in Table 337804-10 suggest that when the worst-case scenario is assumed (one pleasure craft per lockage), there would be a potential for lock congestion at this location even assuming 24-hour operation. However, under Case 2 and 3 assumptions, considerable lock capacity would exist and there would be sufficient flexibility to allow efficient management of project traffic.

Table 337804-11 compares current and project-related activity at Lock 5 to the available capacity at that location. The analysis shown in the table indicates that the situation at Lock 5 is similar to that at Lock 6, particularly with regard to lock usage during normal canal operating hours under Case 1 conditions. However, when consideration is given to off-hour use of the lock, Lock 5 shows somewhat better performance under Case 1 conditions than Lock 6. For Case 2 and 3 assumptions, there appears to be adequate lock capacity to manage project-generated traffic efficiently.

Hydraulic Dredging

Assuming hydraulic dredging is conducted within River Sections 1 and 2, the greatest impact to locks would result at Lock 6, from small craft such as vessels associated with survey, sampling, habitat restoration, and backfill operations. It is expected that sediment dredged from River Section 3 will be removed with mechanical dredging equipment. Once removed, the dredged sediments will be placed onto hopper barges and sent to the STF, resulting in impacts to Locks 4 through 1. The equipment transiting through Locks 4 through 1 would be six hopper barges and supporting towboats, resulting in a total of 12 lockages at each lock in a 24-hour period. The addition of 12 lockages is not expected to cause congestion, since these locks are not utilized at full capacity (based on 1999 data) during the normal canal operating hours.

Removal operations in the TI Pool (River Section 1) will impact Locks 6 through 1. However, additional lockages will be minimal since the only vessels traveling south would be three hopper barges and supporting tow boats, requiring six lockages in a 24-hour period, and one backfill barge and tow boat per 24-hour period coming from either the north (Lake Champlain) or south (downstream of Lock 1). Remaining supporting equipment would be traveling to and from the NTF with no lock passage.

The worst-case lock congestion scenario would be created when the hydraulic dredge is operating in River Section 2. With this setup, project equipment (barge and tow boat combinations) is required to move both north and south through Lock 6. This setup will result in the largest impact to the busiest lock (Lock 6). Smaller craft (survey vessels and small work boats) will either move through the locks together with other vessels using the canal, or these craft will find windows of opportunity when the locks are not otherwise being used. Also, it is assumed that barges hauling backfill materials need not utilize the locks during normal operating hours, since their arrival at the work site is not likely to be time-critical.

Thus, the principal project-related movements that are likely to occur during normal operating hours are those associated with moving loaded barges to the sediment processing/transfer facilities and those associated with returning empty barges to the work area. Table 337804-12 portrays barge and towboat movements that have the potential to generate lock congestion at Lock 6 under the hydraulic dredging scenario.

Results shown in the table suggest that when the worst-case scenario is assumed (one pleasure craft per lockage), there would be a potential for lock congestion at this location under normal operating hours. However, assuming the project utilizes the locks 24 hours per day, it is anticipated that congestion at Lock 6 would not occur. In addition, under Case 2 and 3 assumptions, considerable lock capacity would exist and there would be sufficient flexibility to allow efficient management of project traffic both during normal canal operating hours and over a 24-hour-per-day operating period.

SUMMARY

Results of the analysis presented lead to the conclusion that, if appropriately managed, the proposed mechanical and hydraulic dredging alternatives will not result in navigational or lock congestion. Project vessels will be located largely shoreward of the channel during dredging operations. When work is occurring in the channel, the contractor will be required to provide adequate clearance to allow non-project traffic to move through the work area. In addition, many of the craft associated with the remedial work will be survey vessels similar in scale to other vessels that routinely navigate the Hudson.

The proposed dredging alternatives potentially cause the largest impact for Lock 6, where mechanical dredging would result in 18 additional vessel movements over a 24-hour period and hydraulic dredging would result in six additional vessel movements over a 24-hour period. These movements are not anticipated to impact current vessel traffic at this lock, and the analysis presented above indicates that the addition of project-related vessel movements to current canal traffic at locks will not exceed the capacity of the locks.

REFERENCES

Dergosits, John. New York Canal Corporation. 2000. Personal communication with John Szeligowski, TAMS Consultants, Inc. February 9.

Dergosits, John. New York Canal Corporation. 2001. Personal communication with John Szeligowski, TAMS Consultants, Inc. May 25.

Socioeconomics
313617

WHITE PAPER – SOCIOECONOMICS

(ID 313617)

ABSTRACT

This white paper addresses the major potential socioeconomic impacts of implementing the selected remedy, as identified by business organizations and other members of the public in the upper Hudson region. It first reviews the scale of the dredging of PCB contaminants along limited sections of the 40-mile reach of the Hudson River between the Federal Dam at Troy and Fort Edward, concluding that there is little credibility to charges that the dredging will create a regional economic disruption and stigma. It is additionally concluded that the region's economy can easily absorb the anticipated stimulus. This economic impact is estimated using the US Bureau of Economic Analysis RIMS-II economic model for the five-county upper Hudson region. Conservatively applying only 38 percent of total expenditures as expended in the region, the model forecasts $576 million in additional output for the region, $126 million in additional earnings, and more than 500 jobs per year over the six-year dredging operation.

This socioeconomic study continues with a review of some key sectors of the river-oriented economy – in particular, navigation (this section of the river is part of the New York Canal System), commercial and recreational fishing, and tourism. It is noted that this region of the Upper Hudson River valley appears not to have shared in the growth typically identified with such tourist activities elsewhere in upstate New York. Navigation will be much improved by the dredging, and short-term impacts will be minimal on existing canal traffic. Recreational fishing and wildlife observation are identified as highly valued recreational activities whose economic benefits to the region will be enhanced by the PCB cleanup. The cleanup will also substantially improve the long-term potential for commercial fishing on the Hudson River.

The white paper concludes with an examination of the potential for impacts on property values. The short-term impacts of a temporary dredging operation are not considered sufficient to generate discernable property-value losses. In fact, evidence indicates that river-property values in the Upper Hudson River valley have been depressed, compared to the value of property elsewhere in the region. The cleanup of PCBs offers the prospect of increasing property values both in the Upper Hudson River valley and along the entire river.

Property in close proximity to the sediment processing/transfer facilities[1] may be subject to some depreciation in value. The professional literature on property values and proximity to hazardous

[1] It is important to note that EPA has not yet determined the location(s) of sediment processing/transfer facilities necessary to implement the selected remedy. For purposes of the Feasibility Study, example locations were identified from an initial list of candidate sites based on screening-level field observations which considered potential facility locations from an engineering perspective. In the Feasibility Study, it was necessary to assume the locations of sediment processing/transfer facilities in order to develop conceptual engineering plans, analyze equipment requirements, and develop cost estimates for the remedial alternatives. For this purpose, two example locations were identified: one at the northern end of the project area in the vicinity of the Old Moreau Dredge Spoils Area, and one at the southern end of the project area near the Port of Albany. Each of these example locations fulfills many of the desired engineering characteristics for such a facility to support the remedial work, and is representative of reasonable assumptions with regard to distance from the dredging work and cost. Other locations, both within the Upper Hudson River valley and farther downstream, are possible.

materials, landfills, and other heavy industrial uses has been studied, but the literature is often inconsistent and indicates that impacts are affected by a variety of factors. However, the literature does appear to confirm that losses are typically recouped following the remediation. The sediment processing/transfer facilities will be carefully sited and operated to minimize potential off-site impacts so that their usage will have few negative impacts on property values. It is anticipated that the long-term benefits of the selected remedy will represent the means to significantly improve property values throughout the region.

INTRODUCTION

Several of the "umbrella" groups for the region (*i.e.*, the Adirondack Regional Chambers of Commerce [ARCC], the New York Farm Bureau, Inc., Farmers against Irresponsible Remediation [FAIR], and Scenic Hudson [along with their consultant KLIOS, Inc.]), have made substantive comments on the potential social and economic impacts of the selected remedy. These comments range widely, are sometimes highly specific, but are often of a generic nature. This white paper attempts to capture the essence of many of these comments under broad categories of concern, including impacts on tourism, fishing, navigation, and property values, and respond to these concerns. It begins with an overall review of comments and potential impacts on the regional economy and then provides reviews of the specific socioeconomic sectors.

OVERALL IMPACTS ON REGIONAL ECONOMY

Comments from ARCC assert the dredging would result in uncertainty for business, a stigma to the region, and difficulty attracting labor or new businesses. Examples of these comments are:

> "*…the uncertainty from the proposed dredging project has had, and will continue to have, a significant chilling effect on local business activity*." (ARCC, p 22.)

> "*Business may find it difficult to attract new employees…A limited labor pool could cause the overall wages to increase and local businesses would suffer. A massive dredging project could also consume most of the*

The example facility locations presented in the Feasibility Study have also been used in the Responsiveness Summary in order to clarify material presented in the Feasibility Study and Proposed Plan and in connection with additional noise, odor and other analyses that were performed in order to respond to public comments. EPA will not determine the actual facility location(s) until after EPA performs additional analyses and holds a public comment period on proposed locations and considers public input in the final siting decision. Thus, all information provided in this Responsiveness Summary relative to potential impacts of the sediment processing/transfer facilities on communities, residents, agriculture, the environment and businesses should likewise be considered representative and illustrative. Further specific assessment of and, as necessary, mitigation of, potential impacts will be addressed during design.

available rail transportation in the region. Some businesses may be forced to incur higher operating costs as they switch to truck transportation." (ARCC, p 22.)

Stigma

Impacts of the remediation program will be related to dredging operations on sections of the 40.9 miles of the Hudson River/Champlain Canal between the former dam at Fort Edward and the Federal Dam at Troy, and to proximity to the sediment processing/transfer facilities (which will export the stabilized dredged material by rail). Historically, navigational dredging was a familiar feature in this section of the river/canal, and continues to be along other sections of the Hudson River and the Erie Canal, until it was constrained by the presence of concentrated PCBs in the late 1970s.

The dredging operations, in brief, involve a cluster of barges working over a period of six years, six days per week, up to 14 hours per day, 30 weeks per year. (For more-detailed information on the dredging operations, see White Paper – Dredging Productivity and Schedule.) The dredging will be targeted to three particular sections of the river:

- River Section 1 is the northernmost, between Fort Edward and the Thompson Island Dam (6.3 miles).
- River Section 2 is between Thompson Island Dam and the Northumberland Dam (5.1 miles).
- River Section 3 is between the Northumberland Dam and the Federal Dam at Troy (29.5 miles).

River Section 1 will undergo the most-concentrated dredging activity, with most of its six-mile length subject to dredging. Of River Section 2's five miles, about two miles will be subject to dredging, typically near only one bank. Of River Section 3's 29.5-mile length, a total of only 1.75 miles, comprising three locations on one bank of the river, will be dredged, although additional isolated areas (total of about one mile) will be dredged for navigational purposes. Thus, in linear terms, only 11 of the 40.9 miles of the upper river will experience dredging activity. The remaining 73 percent of the upper river will not be subject to dredging; in terms of surface area, only 493 (or 13 percent) of the 3,900 acres of the Upper Hudson River will be remediated.

In terms of the major urban centers along the river (Fort Edward, Stillwater, Mechanicville, Pleasantdale, Waterford, Lansingburgh, and Troy), dredging will only be adjacent to Fort Edward and Stillwater (at Mechanicville, there will be some navigational dredging on the other side of the island separating the navigational channel from this town). Although low-density residential areas are scattered all along the riverbanks, the dredging will not occur adjacent to the majority of residences comprising the study area. Proximity effects of dredging, therefore, will be substantially limited by the geography of the targeted dredging, as well as by the relatively brief duration when dredging activity will be proximate. The dredging will only be directly in front of a particular residence in a targeted area for about one week, with proximity effects, such as noise, perceptible for only about one or two weeks longer where hydraulic dredges are used, or up to six weeks longer when the mechanical dredges are used.

Once the dredging and backfill operations have passed by, the only remediation-associated activity will be ongoing monitoring activities in the river. At the sediment processing/transfer facilities, work will continue over the planned six-year period. These facilities are assumed to operate 24-hour days during the 30-week annual operating season.

For those properties along the river, the proximity impacts will be very temporary and far less than if, for example, a new building were to be built nearby. For those properties in proximity to the sediment processing/transfer facilities, there will be impacts that last for the six-year period of active operation. The sediment processing/transfer facility locations will be carefully selected to minimize potential impacts, with access to rail and water transportation for the movement of materials; they are likely to be areas with an industrial land-use history and are likely to be substantially screened and buffered from residential and other sensitive land uses (White Paper – Example Sediment Processing/Transfer Facilities). Potential impacts from the facilities will thus be relatively limited and apply only to areas of close proximity.

It is difficult, however, to predict the degree of impact that the sediment processing/transfer facilities will have on nearby property values, because such effects are dependent on many factors, ranging from the degree of odor, noise, traffic, etc.; negative media publicity; and the relative value of homes to the presence of off-setting amenities (employment centers, parks, etc.). The kind of facilities proposed here have not been studied in the scientific literature on property-value impacts, which typically deals with land uses such as landfills, incinerators, or contaminated sites. In reality, the proposed sediment processing/transfer facilities will have operational characteristics more akin to a quarry or small concrete-manufacturing plant, rather than a landfill or incinerator. Later sections of this white paper address impacts on property values and provide a review of the literature on these effects.

As indicted in the White Paper – Project-Related Traffic and White Paper – Rail Operations, the region's rail system (largely operated by the Canadian Pacific Railroad) will be able to handle the additional rail traffic without displacing existing users or creating congestion delays that will adversely affect business in the region.

The potential for the selected remedy to create a regional and long-lasting stigma is quite remote, given the temporary and limited impacts on particular locations along the 40 miles of river, and the finite operations (six years) of the sediment processing/transfer facilities that will rely on water and rail transportation. In fact, it is the selected remedy that offers the potential for removing a long-lasting stigma to the region associated with the existence of PCBs in the river.

Regional Economy

The ARCC comments present an overview of the local economy, noting that the region is finally recovering after decades of economic stagnation, with a growth in population, decline in unemployment, and increases in personal income. ARCC is correct in noting the economic gains following the recession of 1990-92 (Figure 313617-1). However, it should also be recognized that the region (whether the focus is on the four counties along the affected area – Albany, Rensselaer, Saratoga, and Washington – or if adjacent Warren County is included) experienced lower economic impacts, in terms of unemployment, than the State as a whole. For example, in

1992, the unemployment rate for New York State was 8.6 percent, whereas in the four counties it was 33 percent less, at 5.8 percent. While this favorable regional position has continued, the region's advantage has narrowed, so that in April of 2001, the State unemployment rate was 4.1 percent and the four-county region was 30 percent less, at 2.9 percent (NYS Department of Labor, 2001). Contrary to ARCC's assertion, the unemployment data indicate that the region has in fact enjoyed an advantaged position in recent economic terms.

Over the period from 1989-2001 (April), the four-county region experienced a 9 percent increase in the number of employed and an 8.4 percent increase in the labor force (NYS Department of Labor, 2001). However, the patterns of employment have significantly shifted among industries. More-detailed industry-level data, available through 1998, indicate declines in farm employment (-41 percent), manufacturing (-24 percent), construction (-17 percent), and State and local government (-7 percent) (US Bureau of Economic Analysis, 2001a). These losses were offset by gains in services (21 percent), finance, insurance, and real estate (FIRE) (14 percent), and transportation and utilities (8 percent).

ARCC acknowledges the significance of service industries in the new regional economy, especially of tourism, and goes on to claim that the dredging will adversely impact these activities (tourism is addressed later in this white paper). One of the dredging impacts ARCC claims would be the difficulty of employers to find new employees and, with a limited labor pool, dredging would cause labor costs to rise and local businesses to suffer.

It is true that the resurgent regional economy has seen a decline in the number of unemployed (Figure 313617-2). Nonetheless, in April 2001, the numbers of unemployed in the region remain substantial, with 10,500 unemployed in the four-county region and 11,700 when Warren County is added. This is a substantial pool of labor actively seeking work. The direct and indirect employment estimated to be generated by the dredging is 533 for each of the six years of the project's duration (employment impacts are discussed in greater detail elsewhere in this white paper). Moreover, to assume that the alleged stigma of dredging would inhibit recruiting new employees to the region is hardly credible, given the limits of the affected area (a narrow swath along 11 miles of river in a five-county region of almost 3,700 square miles) and the duration of impacts (which, except for the sediment processing/transfer facility sites, will pass by any particular location on the river in a matter of weeks).

The pattern of earnings and employment generated directly and indirectly by the selected remedy is discussed in greater depth elsewhere in this white paper, where an input-output (I/O) model for the region is developed. The key findings from this I/O model indicate that, of the total 3,200 jobs that will be generated in the five-county region over the six years, the construction sector will account for 25 percent (almost 800 jobs) of the employment created by the expenditures on dredging. Construction employment is followed by various business services, with about 670 jobs (21 percent), and transportation, with about 560 jobs (17 percent). A variety of other services account for the bulk of the remaining projected employment, notably in retail, health services, and eating and drinking places.

Employment in construction in the region has experienced a slower rebound than in other economic sectors, with 11.8 percent (or 2,898) fewer employed in 1998 than in 1989 (US Bureau of Economic Analysis, 2001a). It is likely, therefore, that the selected remedy, with its demand

upon the labor pool, will, in fact, be a welcome addition to this economic sector of the region. Figure 313617-3 shows the recent historical trends in construction employment in the region.

The combined direct and indirect increase in employment in the region that will be generated from the dredging operation is estimated at 3,200 jobs over the six years or, if the expenditures were evenly distributed over the period, an average of 533 jobs per year. As a percent of current employment, this represents an increment of 0.14 percent to the April 2001 employed population of 386,000 in the five-county region (NYS Department of Labor, June 2001). Of the presently unemployed population of 11,700, the 533 jobs will represent 4.5 percent, or, if all the employees are drawn from this unemployed pool, the unemployment rate will be reduced from 3 percent to 2.8 percent. Therefore, the expected scale of the dredging employment is not sufficient to create discernable labor shortages or wage pressures that will adversely impact business.

REGIONAL ECONOMIC MODEL

The comments from ARCC on the regional economic impacts of the proposed PCB dredging that were noted and discussed earlier in this white paper are also relevant to this section, which continues the broad regional economic focus and also responds to comments from Scenic Hudson and Sloop Clearwater's consultant, KLIOS Inc., which estimates the positive economic impacts associated with the dredging.

KLIOS applies an I/O econometric model developed for the region by Regional Economic Models, Inc. (REMI). This model makes several input and output assumptions that are different from the US BEA RIMS II model adopted here (US BEA, 2001b). These differences include KLIOS' consideration of only a two-county region (Saratoga and Washington), the assignment of $225 million in dredging expenditures to the region (compared to $262 million in a five-county region adopted here), and their model purports to identify not only direct and indirect earnings and employment (considered in the RIMS II model), but also induced, dynamic, and structural changes in the local economy. As a result, KLIOS comments that:

> *"The overall impact of the proposed cleanup project on the regional economy between 2003 and 2008 is as follows:*
>
> - *3,543 new direct jobs.*
> - *1,028 new indirect and induced jobs.*
> - *4,571 total new jobs.*
> - *$88.5 million new direct wages.*
> - *$141 million new indirect and induced wages.*
> - *$229.5 million total new wages.*
> - *$800 million Gross Regional Product."* (KLIOS, p.19).

These estimates are greater than those generated by the RIMS II model adopted here, even though KLIOS was considering only a two-county region. The remainder of this section discusses the findings of the RIMS II model, comparing them as appropriate with the KLIOS findings.

Direct and Indirect Economic Impacts of Dredging Expenditures

The estimated total expenditure for dredging and related disposal and monitoring activities (in year 2000 dollars) is $461.9 million (FS, Table 8-11b). Of these dollars, $262.2 million, or 38 percent, are conservatively assigned as expenditures within the five-county region (Albany, Rensselaer, Saratoga, Warren, and Washington Counties). This is accomplished by a line-by-line consideration of the type and location of expenditures. For example, 10 percent of the costs associated with the transportation of sediments to Texas (if this is the ultimate disposal location) are allocated to the region, or 50 percent of the costs of barging are assigned to the region because a substantial amount of this equipment will be imported to the region. The US BEA RIMS II I/O model is used to predict the direct and indirect economic impacts of these expenditures in the region. Projections of output, earnings, and employment are possible from this model, which US BEA customized for the analysis of this specific five-county region.

The allocations of dredging and disposal expenditures were compiled into the appropriate US BEA industrial codes, of which five were used as the industries receiving direct changes in final demand (*i.e.*, an increase in these industries' total expenditures for goods/services from all other industries and households). These projected increments represent the "inputs" to the model. The five industries assigned these expenditures are: industrial-buildings construction; other new construction; rail transportation; water transportation; and engineering, architectural, and surveying services (Table 313617-1). The US BEA model creates "final demand multipliers," which are used from the 38-by-490 industry matrices to compute the total dollar output, earnings, and employment generated by the dredging activities in the five-county region.

The expenditures for dredging, disposal, and monitoring were assigned to each of the input industries, as shown in Table 313617-1. These data represent the changes to final demand in each of the industries in time-adjusted dollars (year 2000 dollars). The $262.2 million represent *direct* changes in output in the identified industries; the model also permits identification of the *indirect* economic effects generated by these inputs.

Outputs

The RIMS II I/O model identifies total changes in output in the five-county region, projected as $576.2 million, which is $314 million (or 120 percent) more than the $262.2 million in direct expenditures associated with dredging in the region. The $314 million represent additional indirect or secondary effects, as the original dollars expended on labor and materials circulate in the local economy, in turn creating increased demand in a host of other industries, as well as in the original input industries. Of the 38 industries for which the model computes outputs, those representing one percent or more of the total increase in output are identified in Table 313617-2.

Table 313617-2 indicates that the greatest share of output is allocated to households (as wages), at $126.8 million, or 22 percent of the total. The increases in construction, transportation, and business services represent a total of $309.3 million, $47 million more than the $262.3 million in direct changes in these industries, thus representing additional indirect or secondary increases in demand for these industries. Other indirect beneficiaries range from real estate ($22.4 million, or 3.9 percent) to printing and publishing, at $6 million (1 percent). KLIOS estimates an increase of

$800 million in regional product, about 39 percent more than the $576 million in output projected by the RIMS II model.

Earnings

The same approach described for projecting increases in total output is used for projecting total earnings generated by the dredging activity. The RIMS II model projects that the $262.2 million in direct expenditures will generate total earnings (wages) of $126.8 million in the five-county region. The distribution of these earnings among the different industries is shown in Table 313617-3. As would be expected, the industries representing the inputs (business services, construction, and transportation) account for the major portion of total earnings at $91.9 million, or 72.5 percent. Other industries sharing in the secondary economic impacts range from health services at $6.5 million (5.1 percent), to lodging/recreation at $1.2 million (1 percent). KLIOS estimates $229.5 million in total new wages, or 80 percent more than the RIMS II model.

Employment

The RIMS II model also projected the total (direct and indirect) employment from the dredging and disposal activities. A similar approach to that described for output and earnings is applied, except that the dollars expended in the region must be further adjusted to the 1997 benchmark data upon which labor inputs to the model are based. The discounting adjustment reduces the $262.2 million to $248.2 million, in 1997 dollars.

Table 313617-4 shows that a total increase of 3,214 jobs is predicted over the period of the dredging and subsequent monitoring operations in the five-county region. Some of these jobs will be created for the whole period, others only for a particular phase. If the new employment were evenly spread over six years, it would imply the creation of 533 jobs for each of the six years. The great majority of these jobs (63 percent) will be in those industries where the direct expenditures occur: construction (24.7 percent), business services (20.9 percent), and rail and marine transportation (17.3 percent). As deduced from Table 313617-2, about 20 percent of the jobs in these direct-input industries will be generated from the secondary, or indirect, effects and 80 percent will be created directly. Additional indirect employment will occur in a wide variety of service industries, ranging from 277 jobs in retail (8.6 percent) to 40 jobs in banking (1.2 percent).

KLIOS does not attempt to break out the industry sectors in which the new employment will occur, but estimates a total of 4,571 new jobs, which is 42 percent more than the RIMS II model predicts. The REMI model used by KLIOS is a proprietary model whose internal assumptions remain private. Perhaps a reasonable approach is to recognize that the RIMS II model presents a baseline estimate of potential impacts and that the REMI model represents an upper boundary of the positive economic impacts that the direct expenditures on dredging will generate in the immediate region. Still greater, albeit often more intangible, economic benefits will accrue to the much larger region of the entire Hudson Valley south of Fort Edward. As KLIOS suggests, these will relate to waterside economic development, commercial and recreational fishing, tourism, navigation, and property values. These subject areas are addressed as separate sections of this white paper.

IMPACTS ON TOURISM

Comments from ARCC assert the dredging will have a deterrent effect on tourism in the region. In contrast, comments from Scenic Hudson and their consultant KLIOS (Appendix A) claim that the dredging will improve the long-term potential for tourists in the region.

Short-Term Impacts

ARCC comments that the dredging operations would "*choke the canals with dredging equipment and barge traffic. The roadways will be heavily congested from increased truck and rail transportation. Tourists would avoid the area because of the noise, odors, light pollution, visual nuisances, and the threat of PCB resuspension from the project"* (ARCC, p. 19-20).

Remedial dredging operations are estimated to take six years to complete along the targeted sections of the Hudson River. Under one scenario, the plan calls for the simultaneous use of four dredges and associated barges. PCB dredging in or near the navigation channel is very limited and will be organized so that river navigation will continue to function during the day, with the possible exception of short-term restrictions when maneuvering in limited areas is required. The dredging operation's impacts on tourism, each of which will be addressed in turn, will be primarily limited to:

- Traversing the section of the river where dredging will be in operation.
- Tourists staying at a fixed location along the river (*e.g.*, an inn).
- Limited delays at locks when loaded barges transit during daylight hours.

It is clear that, at any one time, the dredging operation will cover much less than one percent of the affected length of the Upper Hudson River, and in total, over the six years, will affect only 27 percent of the upper river's length. The tourist experience on the river will remain substantially unaffected in those areas away from the dredging operation.

Travelers on the river or moving along adjacent roadways will pass through areas where dredging is in progress in a matter of minutes. For these individuals, project-generated noise, odor, and visual intrusion will be of little consequence once they are beyond the immediate work area. In these situations the impacts will be quite minimal and travelers on the Upper Hudson River, in particular, will find 99 percent of the river unaffected by the physical presence of the dredging barges. Noise impacts and the potential for odor generation are detailed in White Paper – Noise Evaluation and White Paper – Odor Evaluation; noise levels are projected to be below NYSDOT construction-impact guidelines at a relatively short distance from the dredging equipment, and odor is not anticipated to be an issue.

For those tourists that will be non-mobile (*e.g.*, staying at an inn on the river), the dredging operations will be slowly moving into proximity and then receding. The rate of movement will depend on the amount of dredging targeted at that location; however, on average, the dredging operation will be adjacent to a given location for about one week. Assuming the river has no bends, islands, or other obstructions close to the hypothetical inn, the operation will be audible for about two to six weeks. It is true that during this relatively brief period, the river will lose some of its aesthetic attraction for tourists staying at the inn; however, there is also the

possibility that the dredging work will engender some interest for tourists, as it is a high-profile, if temporary, activity with a unique and historical environmental objective.

Sixteen hotels, motels, and bed-and-breakfast inns have been identified in the communities along the 40-mile section of the Upper Hudson River from Fort Edward to the Troy Dam; these are addressed in more detail elsewhere in this white paper.

Canal Navigation Congestion

With respect to the potential congestion of the river and canal locks, the operational demands and lock capacities are discussed in White Paper – River Traffic. The conclusions of the analysis are that, based on 1999 use patterns by pleasure vessels and projections of dredging operations, under all reasonable scenarios there will continue to be excess lock capacity with no congestion for pleasure vessels at locks. Consequently, few adverse impacts are anticipated for recreational boaters during the proposed remediation. Moreover, a significant portion of the dredging is oriented to navigational dredging that, when completed, will provide an expanded and safer capacity for recreational and commercial use of the river.

The following is a list of identified marinas located between Fort Edward and the Troy Dam with a brief assessment of their potential for any direct impacts from the proposed dredging, where possible. In general, potential impacts have to do with proximity to the proposed dredging site and its associated activities.

- West River Road Marina in Fort Edward is situated in the immediate proximity of a prospective dredging site. This marina could also be in the area of the proposed northern processing/transfer facility (NTF), depending upon where it is ultimately sited. For these reasons, this marina and its activities could at least temporarily be adversely affected by the remediation. Although dredging operations are likely to occur for only a few weeks near this location, its proximity to a potential sediment processing/transfer facility may generate additional longer-term impacts during the facility's anticipated six-year life, depending on the facility's actual location and design. However, it now appears that this marina may no longer be in operation, so potential adverse impacts may not be an issue.

- Coveville Marina in the vicinity of Schuylerville is more than 3,000 feet north of a small section of the river targeted for navigational dredging. Thus, the activities of this marina are unlikely to be adversely affected by the remediation operations.

- Schuyler Yacht Basin is a marina in Schuylerville. The closest dredging site is about a mile upstream, above the Northumberland Dam. Thus, the activities of this marina are unlikely to be adversely affected by the remediation operations.

- Admiral's Marina is located in Stillwater. Proposed dredging sites are almost a mile from this facility. There is a proposed dredging site situated slightly less than a mile upstream from this marina, and a navigational dredging site about a mile downstream from it. Thus, no adverse effects on the marina are likely to ensue as a result of the proposed dredging.

- Mechanicville Terminal is a public marina in Mechanicville. There is a PCB dredging site located about 4,000 feet upstream, adjacent to Riverside. There is also a navigational dredging site located about 2,500 feet downstream. Thus, no direct adverse impacts on the marina are anticipated.

- Lock 1 Marina is situated by Lock 1 in Waterford. This marina and its activities are unlikely to be affected by the proposed PCB remediation because of its distance (over five miles) from any prospective dredging sites.

- Van Schaick Island Marina in Cohoes is, similar to Lock 1 Marina, unlikely to be affected because all prospective dredging is more than five miles away upstream.

- Troy Town Dock and Marina, again, is unlikely to be influenced by the dredging activities because it is located significantly far downstream of any prospective dredging.

- Troy Motor Boat and Canoe Club is a marina in Lansingburgh. Again, this is unlikely to be affected by dredging activities because all prospective dredging is more than five miles away upstream.

- Albany Yacht Club in Rensselaer is also unlikely to be affected by the PCB cleanup operations, because it is far downstream from any proposed dredging sites.

- Waterford Harbor Visitors Center is a free-access marina in Battery Park in Waterford. This marina is unlikely to be affected by the dredging operations, because it is located more than five miles downstream of the nearest proposed dredging sites.

This review of the identified marinas and their proximity to the proposed dredging sites indicates that only one marina, the West River Road Marina near Fort Edward, which may no longer be in operation, will be proximate to any proposed dredging. The proximity of dredging here, were the marina to remain open, may require the temporary closure of this marina when dredging is undertaken at its entrance. However, the duration of the dredging activities will be relatively brief (one or two weeks) and may be timed to interfere minimally with the peak boating season. As stated, proximity to the proposed NTF operations, including barge unloading, may result in adverse impacts to the marina.

Existing Tourism

ARCC, in its comments, presents an overview of tourism-related activity in the economy of the upper Hudson region, citing Warren, Washington, and Saratoga Counties. The four counties that are actually proximate to the dredging are Albany, Rensselaer, Washington, and Saratoga. It appears rather arbitrary, therefore, to omit two counties and include Warren, which is not directly affected by the selected remedy and whose tourism is more oriented to the Adirondacks and Lake George than it is to the Hudson River. Also important to note is that Saratoga's tourist attractions are much more oriented to I-87 and Saratoga Springs than they are to the Hudson River. Washington County is much more representative, as a whole, of the stretch of river that will be affected (*i.e.*, more rural and with relatively few built tourist amenities).

ARCC cites a US Census Bureau (County Business Patterns) study on the number of hotels in Warren and Saratoga Counties, citing 556 hotels and lodging places in Saratoga County and 755 amusement and recreation establishments (US Census Bureau, 1999). However, in fact, 1999 data from this source cites 52 accommodation establishments in Saratoga County and 62 amusement and recreation establishments. ARCC states equivalent data are not available for Washington County; in fact, equivalent data are available for Washington County and there are no accommodation establishments and 15 amusement and recreation establishments reported (however, the discussion on river-oriented accommodations below identifies one motel in Fort Edward, Washington County, that was open in 1999, implying that the data source may not be completely inclusive).

Analysis of US BLS ES-202 data over 1988-99 using a detailed list of tourism and recreation-oriented activities[2] reveals a more complete perspective on trends in tourism in the region (US BLS, 2001). Comparison of the counties in the Upper Hudson region with others outside the region in upstate New York that have freshwater recreation resources (*i.e.*, Herkimer, Cayuga, and Seneca Counties) provides a reasonable control sample for the counties in the upper Hudson. The data reveal that Washington County's small tourist-oriented employment has declined since 1988, whereas Cayuga County's has grown 63 percent over the period 1988-99. Table 313617-5 shows the changes for each of eight counties. If, for example, this sector had grown in Washington County at the same rate as in Herkimer County (23 percent), it would have added 500 tourism-oriented jobs or, similarly, Albany County would have added 3,266 such jobs.

The census bureau's county business patterns report records employment in the tourist-relevant categories of arts, entertainment, and recreation (North American Industrial Coding System [NAICS] 71) and accommodations and food service (NAICS 72). In 1999, these categories accounted for 7.3 percent of all employment in Washington County; this compares to 11.3 percent in Saratoga, 10.6 in Cayuga, 9.5 percent in Herkimer, and 8.9 percent in Seneca Counties.

With Washington County so far behind the tourism growth of other counties, both in the upper Hudson region and elsewhere in the State, it is quite apparent that the county that typifies the target area for dredging has not shared in this important growth industry. The image of one of its key tourist amenities, the Hudson River, as contaminated with PCBs may well have contributed to this poor performance.

Potential Impacts on Existing Parks, Festivals, and Tourist Accommodations

Parks and Festivals

A number of parks (federal, State, and local) and other recreational attractions are located on or near the waterfront in the area between Fort Edward and the Federal Dam at Troy. This

[2] The list of SIC code industries was: Fish hatcheries and preserves; hunting & trapping; water transportation of passengers; marinas; other water services; arrangement of passenger transportation; eating and drinking places; real estate operators; real estate managers; real estate developers; hotels/motels; rooming and boarding houses; camps; organized hotels/lodging; auto rental; auto repair; auto services; motion picture theaters/distribution; amusement & recreation; museums & art galleries.

subsection contains a list of these parks, identifying their location and proximity to dredging. Depending upon the distance of each facility from proposed dredging sites, the type of dredging (hydraulic or mechanical), and whether or not the facility is available for use at night, there could be short-term impacts at some locations that EPA will seek to mitigate, if possible. EPA has examined the potential for impacts to the community in various white papers and in responses to master comments throughout this document. These sources should be consulted for further discussion on the likelihood and magnitude of potential impacts.

- *Champlain Canal Scenic Byway*, stretching for 64 miles from Waterford to Whitehall, is a part of the National Scenic Byways program initiated by the US Department of Transportation and Federal Highway Administration. The canal's virtue as a scenic byway is that it provides attractive views to the motorists driving alongside it (for example, on Route 4). Whether or not the passing motorists will continue to be able to enjoy the canal's scenery during dredging depends on a number of factors, including season, location of the dredging equipment, and characteristics of the surrounding landscape that may, for example, partially conceal dredging equipment and facilities. The tract of the canal designated as a scenic byway also features picnic parks and trails at the 11 locks located between Waterford and Whitehall. (Two of the parks by the canal locks, as well as some other parks adjoining the Champlain Canal Byway, are discussed in greater detail below.) Parks, boating facilities, and other amenities of the canal are open May through November; the parks operate from dawn until dusk. The section of the Champlain Canal Byway between Waterford and Fort Edward includes a number of the proposed PCB dredging sites. Dredging will occur at the time of year and during the hours when parks and boating facilities along the Champlain Canal Byway are open. In all, about 11 miles of the 40.9 river miles between Fort Edward and the Federal Dam are targeted for some amount of dredging activity over six years. The first six miles south of Fort Edward is almost entirely targeted. Thereafter, targeting is sporadic, with long reaches of the river unaffected and with many of the areas being targeted only for navigational dredging. Of the seven locks, three (Locks 2, 3, and 5) will require dredging immediately to their north, and Lock 7 in Fort Edward will see dredging 300 feet to its north and south. Locks 1 and 3 (Stillwater) will experience no proximate dredging.

- *Rogers Island Visitors Center* is a historical attraction on Rogers Island in Fort Edward. The center has recently undergone large-scale renovations, including installation of a professionally designed exhibit covering 5,000 years of history of Rogers Island and the surrounding area, from prehistoric time to the Civil War. Archeological artifacts from the region are incorporated into the exhibit. The visitor's center also features a gift shop and is open all week in the summer season. Dredging operations are proposed in the eastern channel for about 2,000 feet alongside the southern section of the island, and in the midsection of its western channel for about 1,000 feet. During the several weeks dredging will be in operation here, enjoyment of this historical site might be at least somewhat impacted. EPA will work with the community to mitigate these potential impacts. The center could also be relatively close to a potential site for the NTF, but because the actual facility has not yet been sited, it is premature to attempt an assessment of potential impacts on the center from processing/transfer operations. Further, if a nearby site were to be selected, design factors may be able to substantially buffer the facility and minimize discernable impacts on the visitors' center.

- *Bradley Beach* is a recreational area along the Hudson River in Fort Edward that offers facilities for picnicking. Bradley Beach is obscured from the river by Rogers Island and is upstream from the nearest proposed dredging sites, which are over 2,000 feet to the south.

- *Fort Edward Yacht Basin* is a public park and dock located in downtown Fort Edward, over 1,000 ft north of proposed dredging. The facility has recently benefited from a $2 million renovation and it now hosts a variety of community events, such as summer concerts and Fort Edward Heritage Days. Shallow depths (three to five feet in the summer) presently inhibit the full potential of this facility. Dredging this channel to the east of Rogers Island will enhance the site's attraction to recreational boating.

- The *French and Indian War historic site* in the vicinity of Fort Edward is a historical attraction that has yet to be constructed along the river. The proposed facility's exact location is still unclear.

- *McIntyre Park, Feeder Canal, and the adjacent bike trail* in Fort Edward are all located near the Champlain Canal, away from the Hudson River.

- *Fort Miller Recreation Area* is situated alongside the Hudson River in the historic village of Fort Miller. The recreation area is still under construction; a ball field, playground equipment, and a picnic area are to be installed there, in addition to already-existing facilities for sports fishing. Dredging is proposed about 1,000 feet south of Lock 6 and about 2,000 feet to the north around a bend in the river.

- *Starks Knob Scientific Reservation* can be defined as an educational resource, an "open-air museum" of natural and historical significance. At this point, Starks Knob Scientific Reservation, located near Northumberland, is undergoing transformations to improve and facilitate public access to the site. Since the site overlooks the Hudson River, certain visual impacts of the dredging activities north of the Northumberland Dam are possible.

- *Fort Hardy Park* in Schuylerville is almost a mile downstream of the nearest proposed dredging site, and adjoins historic Fort Hardy. The park features a beach and a recreation center. The park also hosts some activities of the Schuylerville community, most notably Family Day in January and Scared in Schuylerville (a variety of Halloween festivities) in October.

- Another *waterfront park near Schuylerville* is located at Lock 5. This park features picnicking equipment. The nearest dredging site is north of the Northumberland Dam, almost a mile further upstream.

- *Lock 4 parks* are located in Stillwater. These parks are a mile south of, and around a bend of the river from, the nearest PCB dredging site. A site designated for navigational dredging is located approximately 4,000 feet south of the parks.

- *Saratoga National Historical Park* is the site of the Saratoga Battle of 1777; thus, most of the activities that take place in this four-square-mile park are linked to this event. The majority of the organized events in the park occur by the park's interpretive center, which is about three miles away from the river. A small section of the river in proximity to the park is targeted for navigational dredging, likely to have a duration of about a week or two; no PCB dredging is proposed near the park.

- *Blockhouse Park and Museum* in Stillwater are represented by a Revolutionary War-era timber structure surrounded by the riverfront park, which offers some picnicking facilities. The proposed dredging sites are over a mile from this park.

- There are *two golf courses* across the Hudson River from Mechanicville in Hemstreet Park, one of which borders the river. Sections designated for PCB and navigational dredging are north of Lock 3, about 2,000 feet from the golf courses. The temporary effect of dredging on these golf courses will depend on the visibility of the dredging equipment, the extent of noise and odor, and duration of the operations.

- *Peebles Island State Park* is at the confluence of the Hudson and Mohawk Rivers in the vicinity of Waterford. The visitors to the park can enjoy a variety of activities, such as hiking, jogging, picnicking and fishing in summer, and cross-country skiing in winter. The nearest dredging sites are about five miles upstream from the park.

- *Soldiers and Sailors Park* in Waterford overlooks the Hudson and features the Soldiers and Sailors Monument. Waterford is about five miles downstream of the nearest proposed dredging.

- *Battery Park* in Waterford is also about five miles downstream of the nearest proposed dredging.

- *Button Park, Old Champlain Canal Park and bike trail, Waterford Flight of Locks, RiverSpark Lock 2 Park,* and *Waterford Village Canal Promenade and Docks* in Waterford are also well downstream of the dredging operations.

- *Riverfront Park* in downtown Troy occupies 4.10 acres of land substantially south of any proposed dredging, and is the newest public park in the city. The park was dedicated in 1982, and since then, it has hosted a variety of the community activities and gatherings.

- *Burden Park* along the bank of the Hudson in South Troy opened in 1919. This park occupies the grounds of the old steel works, again substantially downstream of any proposed dredging.

- *Herman Melville Memorial Park* in Lansingburgh is located in the riverfront section of land that was sold by the Troy City Council to the Lansingburgh Historical Society in 1972. Like other parks in Troy and its vicinity, this park is substantially downstream of any proposed dredging.

- *Bikeway 9* is a proposed bike trail to be introduced along the Champlain Canal. No definite information is available at this time as to the trail's length, its exact location, or the date when it will be opened.

A series of events and festivals is associated with the parks and/or the waterway. A number of annual events were identified based on the 2001 calendar. Depending on the location of a particular event in relation to the proposed dredging sites, the type of dredging (mechanical or hydraulic) that occurs at a specific site, and whether the event occurs in the daytime or nighttime, there may be some potential short-term noise, odor and aesthetic impacts. EPA will work with the communities involved to mitigate impacts to the maximum extent practicable. EPA has examined the potential for impacts to the community in various white papers and in responses to master comments throughout this document. These sources should be consulted for further discussion on the likelihood and magnitude of potential impacts.

- *Third Annual Tugboat Roundup* – A tugboat parade from Albany to Waterford, more than five miles south of any area to be dredged (September 7 – 9, 2001).

- *Fourth Annual Canal Cruise and Trek* – Boating and cycling along the canal system (Fort Edward – Waterford, July 11, 2001). This event, sponsored by the Canal Corporation, traverses the study area during one day of the trip from Whitehall to Buffalo. If deemed appropriate, arrangements could be made in advance to avoid any potential conflict with dredging operations.

- *CanalFest* – A festival in Waterford, more than five miles from any proposed dredging site, that includes fireworks display, vendors, and live entertainment (May 12, 2001).

- *Memorial Day Parade in Waterford*, five miles downstream of any proposed dredging site.

- *Christmas Parade in Waterford* – This event is outside the dredging season and substantially downstream of any proposed dredging (December 2, 2001).

- *Family Day* – Skating and games on the canal in Fort Hardy Park in Schuylerville (January 21, 2001). The activities associated with Family Day take place immediately on the canal; however, dredging operations are not scheduled during winter, and thus, the event will not be affected.

- *Victorian Stroll* – A history-themed festival taking place in Troy in December. This event is outside the dredging season and substantially downstream of any proposed dredging.

- *Riverfront Arts Fest, Troy* – Art exhibits and entertainment (Father's Day weekend in June). This riverfront park is located substantially south of where any dredging will occur and will not, therefore, be affected.

- *Carama 2001, Waterfront Park, Troy* – Caribbean carnival (July 11, 2001). As noted above, this park is located south of where any dredging will occur and will not be affected.

- *Waterfront Farmers Market, Hedly Park Place, Troy* – As noted above, this park is located south of where any dredging will occur and will not be affected (every Sunday from June 23 to October 27).

- *Scared in Schuylerville* – Halloween festivities and costume judging in Fort Hardy Park in Schuylerville. This event is almost a mile away from the proposed dredging site in the vicinity of the Northumberland Dam, and thus is unlikely to be affected by the dredging activities (October 28, 2001).

- *Summer Concerts in the Park, Hudson Falls-Kingsbury* – One night per week during July and August. These events are held upstream from where the dredging will occur.

- *Antique Auction and Country Fair, Fort Edward* – Arts and crafts vendors. This event is held alongside the Champlain Canal. It is premature to know whether the timing of this one-day event may coincide with the period when dredging may occur nearby, along the east bank of Rogers Island (July 29, 2001)

- *Summer Concerts in the Yacht Basin, Fort Edward* – Concerts one night per week in August. As with the previous event, it is premature to know whether the timing of this series may coincide with the period when dredging may occur nearby.

- *Fort Edward Heritage Days* – If this is an annual event, as with the previous events noted in Fort Edward, it is premature to know whether the timing may coincide with the period when dredging may occur nearby (July 7 – 8, 2001).

- Saratoga National Historic Park hosts a series of events each year, including:

  Stillwater Heritage Day (October 7, 2001)
  History Hikes (every Sunday in July and August)
  24th Regiment Encampment (August 4 – 5, 2001)
  August Lunch Series (every Tuesday in August)
  18th Century Weekend (August 4 – 5, 2001)
  Colonial Concert (July 29, 2001)
  Happy Birthday NPS! (August 25, 2001)

  Most of these events occur at or near the park's interpretative center some three miles from the river, rather than anywhere close to the river. Moreover, no PCB dredging is proposed in proximity to the park and its waterfront sections, although a small section (less than 2,000 feet) is proposed for navigational dredging in this general area of the river.

Thus, of these identified events and festivals, only the Canal Cruise and events at Fort Edward could potentially be affected by the dredging. Although the brief duration of the dredging at any particular location minimizes potential conflict with any of these annual events, EPA plans to work with the community if conflicts arise to mitigate impacts to the extent practicable.

Lodgings and Accommodations

Following is a list of the hotels, motels, and bed and breakfast inns that have been identified in the communities along the 40-mile section of the Hudson River from Fort Edward to the Federal Dam at Troy and which are located close to where dredging will occur. Included is a brief description of each of these accommodations and their distances from proposed remedial dredging sites. Depending upon the distance from the dredging sites and the type of dredging that occurs there (mechanical or hydraulic), there could be some short-term nighttime noise impacts at some of these locations that will be mitigated as much as practicable. EPA has examined the potential for impacts to the community in various white papers and in responses to master comments throughout this document. These sources should be consulted for further discussion on the likelihood and magnitude of potential impacts.

- Victorian Motel, at 215 Broadway in Fort Edward, is located within 500 feet of the Hudson River at a location where PCB dredging is proposed. It is likely, therefore, that during the one or two weeks when dredging operations will be underway here that business at the motel might be adversely impacted. Possible mitigation of these impacts will be to attempt to schedule dredging to avoid the peak season.

- Inn on Bacon Hill, at 200 Wall Street in Schuylerville, is a bed-and-breakfast inn. This inn is relatively distant from the river (about 4,000 feet away). Additionally, the closest proposed dredging site, which is in the vicinity of the Northumberland Dam, is about a mile away from the Inn on Bacon Hill.

- Marshall House, at 136 Route 4 North in Schuylerville, is a bed-and-breakfast inn located within 200 feet of the Hudson/Champlain Canal at Lock 5. The inn, also about one mile downstream of the proposed dredging site near Northumberland Dam, is situated near a long downstream reach of the river (over five miles) without proposed dredging sites.

- Burgoyne Motor Inn, at 220 Broad Street in Schuylerville, is an 11-room motel. This motel is located within 500 feet of the river. The nearest dredging site is over a mile upstream, in the vicinity of Northumberland Dam.

- Dovegate Inn, at 184 Broad Street in Schuylerville, is a three-room bed-and-breakfast. Dovegate Inn is located within 1,000 feet of the river; the nearest prospective dredging site is over a mile away upstream, in the vicinity of Northumberland Dam.

- Empress Motel, at 177 Broad Street in Schuylerville, features 12 rooms and is located within about 1,000 feet of the river. The nearest prospective dredging site is over a mile away upstream, in the vicinity of Northumberland Dam.

- Lee's Deer Run, at 411 County Road 71 in the Stillwater area, is a bed-and-breakfast inn. This inn is located over a mile away from the river and there are no proposed PCB dredging sites near this section of the river.

- River's Edge B & B, at 90 Wrights Loop near Saratoga National Historical Park in Stillwater, is a bed-and-breakfast inn consisting of two rooms and a guesthouse. As the

name implies, the inn is situated at the riverfront; however, there are no PCB dredging sites within several miles of the accommodation. There is a navigational dredging site about a mile downstream, around a bend in the river.

- Wolff's Diner and Motel, on Route 4 near Saratoga National Historical Park in the Stillwater area, is situated within about 1,000 feet of the river. There is a navigational dredging site about 3,000 feet upstream of the motel. Additionally, there is a PCB dredging site about a mile downstream.

- Grace Guest Home, at 122 North Main Street in Mechanicville, is a bed-and-breakfast inn of five rooms. It is located within 200 feet of the river and there is a proposed PCB dredging site about 2,500 feet upstream at Lock 3. There is also a navigational dredging site about 3,500 feet downstream.

- Waterford Inn, the Olde Judge Mansion in Troy, Park Hotel in Green Island, the Schuyler Inn in Menands, and the Super 8 Motel and the Best Western Rensselaer Inn in Troy are situated more than five miles downstream of any proposed dredging sites.

Thus, of the parks, festivals, and accommodations at or near the river, very few are in close proximity to any proposed dredging; most of the potentially affected facilities are located near Fort Edward. Proposed dredging activities are substantial in this area; however, their duration and impacts will be relatively brief, and EPA will work closely with the community specifically to mitigate impacts during that period.

Long-Term Prospects for Tourism in the Hudson Valley

Scenic Hudson comments:

> *"Tourism is a major industry, today. Many sources regard it as the fastest growing industry in the world. The economic potential for tourism stems from amenities and services in combination with image and marketing. Tourism has always been important along the Hudson River Valley… At present, the stigma of Superfund site designation clouds the Hudson River Valley…. Without dredging, the full economic benefits to be reasonably expected from such a world class resource as the Hudson River will never come close to being realized."* Scenic Hudson Comments, April 17, 2001, p. 39-40.

Scenic Hudson's consultant, KLIOS, Inc., in Appendix A of its comments, addresses the economic potential of tourism in the Hudson Valley, noting a variety of literature sources on the value of recreational tourism. Among these:

- Recreational boating on the Ottawa River (Hushak, 2000).

- Recreational boating in Maryland (Lipton, 1995).

- Scenic corridor tourism on the coast of New Hampshire (Robertson, 1997).

- Value of coastal theme festivals on southern Lake Michigan (Wicks, 1992).

- A profile of Columbia River Gorge tourism (Anderson, 1988).

The authors noted, for example, that the value of recreational boating in Maryland exceeded $1 billion in 1993, that Lake Michigan festivals in 1992 grossed revenues of $51 million, and that recreational boating on the Ottawa River added $14 million in sales to the local economy. The authors note that specific studies on the value of tourism in the Hudson Valley are not available.

Tourism involves a wide variety of recreational activities. Among those most relevant for the upper Hudson valley will be outdoor recreation, as compared to visiting museums or movie theaters. A common way of differentiating among outdoor recreation activities is to classify them as "user-oriented" or "resource-based" activities. User-oriented activities, such as team sports, are not usually dependent on any natural resources other than space, whereas resource-based activities, such as bird watching and fishing, depend on the existence and quality of supporting natural resources (fishing is examined as a separate section of this white paper).

A national survey of recreation and the environment conducted in 1994 and 1995 (Outdoor Coalition of America, 1997), a follow-up to a similarly extensive survey conducted 10 years earlier, reports high participation rates for activities relevant to the upper Hudson valley. For the U.S., these include the following annual data:

- Viewing/studying (76.2 percent, or 152.6 million persons).
- Visiting beach/waterside (62.1 percent, or 124.4 million persons)
- Sightseeing (56.6 percent, or 113.4 million persons).
- Freshwater fishing (24.4 percent, or 48.8 million persons).
- Boating (29 percent, or 58.1 million persons).

Those activities that saw major increases in participation over the decade were bird watching (an increase from 21.2 million to 54.1 million persons) and hiking and backpacking (an increase from 33.5 million to 63 million persons).

Another key database on this type of tourist activity is the National Survey of Fishing, Hunting. and Wildlife-Associated Recreation (US Fish and Wildlife Service [FWS], 1998). This source reported 62.9 million people participated in watching wildlife, generating associated expenditures of $29 billion for the US. Of these participants, 23.7 million took trips away from home to participate in this recreation. This same source cites 3.3 million wildlife-watching participants in New York State, of whom 1.173 million were nonresidential. Total expenditures for wildlife watching in New York were almost $1.3 billion, of which trip-related expenditures were $139.7 million, with $1.1 billion for equipment and other expenditures.

It is clear that the upper Hudson River valley ought to be a major participant in these outdoor, nature-oriented modes of recreation (the economic potential of recreational boating and fishing are discussed as separate sections of this white paper). The available data on the economic

significance of these activities points to their substantial scale; however, the riverside communities of the four counties near the targeted PCB dredging appear to share much less than would be expected, especially given the world-class resource that the river provides in its own right along this reach of the river, and as a connector to other magnificent resources such as Lake Champlain and the St. Lawrence River, and the Mohawk River/Erie Canal to the Great Lakes. With the remediation of the PCBs, the river will have a much greater likelihood of securing these tourism and recreational benefits.

IMPACTS ON FISHING

Comments from Scenic Hudson and their consultant KLIOS (Appendix A) claim that the dredging would substantially improve the long-term potential for recreational and commercial fishing in the region. Comments from the ARCC assert that resuspension of PCBs from dredging would keep anglers from the region.

Short-Term Impacts

ARCC comments that the National Survey of Fishing, Hunting and Wildlife-Associated Recreation (US FWS, 1996) reported that $3.9 billion was spent in New York State in 1995 and, although the study does not break out expenditures by region, ARCC states: *"Nonetheless, given the interest in hunting, fishing and wildlife watching in the upper Hudson River, the expenditures in this region are no doubt substantial"* (ARCC, p 10). ARCC's position is that dredging would adversely impact this activity (ARCC, p 21).

Commercial Fishing

Commercial fishing was banned in the Hudson River in February 1976; this ban remains in effect with the exception of baitfish, American shad, and Atlantic sturgeon over four feet. Thus, there will be few or no short-term impacts on commercial fishing as a result of the proposed remedial dredging.

Recreational Fishing

After the 1976 ban, catch-and-release sport fishing in the upper Hudson was not reinstated until 1995; advisories against eating Hudson River fish remain in effect. It is, however, the presence of PCBs that has caused the bans/advisories and only remediation of the pollution will return commercial and much of the potential recreational fishing to the river south of Fort Edward.

It is interesting to note that the New York Canal Corporation, which is responsible for the entire New York canal system, including the Erie Canal and the Champlain Canal (of which the upper Hudson is part), markets the waterways as a major tourist/recreational resource, with fishing as one of the key activities (New York Canal Corporation, Recreationway Plan, 1995). Its 2001 season Web page, *Get Hooked on Fishing,* notes:

> *"The most common species caught along the Canal System include small and large mouth bass, walleye, panfish, northern pike, blueback herring and Coho Salmon. One can also find yellow and white perch,*

pumpkinseed, channel catfish and crappie at various locations along the system.

"Fishing is available almost entirely throughout the 524 miles of water, except on the Champlain Canal south of Fort Edward. Fisherman say that areas outside of locks provide one of the best areas to make a prize catch. In addition, as the gateway to the Great Lakes and rivers of western and upstate New York, the Canal System will lead you to some of the country's best trout and salmon fishing."

It is the PCB contamination that prevents the Champlain Canal south of Fort Edward from joining this world-class recreation resource. While no reliable data are maintained on existing fishing in this section of the waterways, it is safe to say that recreational fishing is only a faint shadow of what its full potential might be.

If the proposed remediation operations were to inhibit the present limited fishing, as ARCC claims, it will be from one or more of the following:

- The proximity of the dredging barges.
- The resuspension of PCBs.
- The destruction of fish habitat.

In the case of proximity to the dredging, such operations will occupy less than one percent of the 40-mile reach of the river such that, at any particular time, anglers will be able to find alternate sites to fish where the dredging and backfill operations are not proximate.

In the case of the resuspension of PCBs, the threat of contamination will be only marginally greater than at present and will be closely monitored to assure that this remains so; it should not affect catch-and-release fishing.

The destruction of habitat will be temporary and will affect only certain species over the short term. Some species of fish are likely to return sooner than others but ultimately, the dredged waterway is predicted to return to conditions that will support a major recreational fishery.

Further downstream, the effective removal of PCBs will enable the removal or relaxation of bans and advisories on fishing and fish consumption and so restore the Hudson River to its full potential for both recreational and commercial fishing.

Long-Term Impacts

As noted in the introduction to this section on fishing, comments from Scenic Hudson claim that the PCB dredging would substantially improve the long-term potential for recreational and commercial fishing in the region.

Commercial Fishing

Before 1976, commercial fishing was allowed on the Hudson River south of the Federal Dam at Troy. In February 1976, all commercial fishing was banned; this ban remains in effect for several species, including striped bass and American eel. The result of this ban is a diminished commercial fishing industry employing a small fraction of Hudson River commercial fishermen compared to the period before the 1976 ban. Also, the number of commercial fishermen currently employed in other states with important freshwater, estuarine, and marine fisheries is far greater than the number employed in the remaining Hudson River commercial fisheries. KLIOS, Inc. states that commercial and recreational fishing, including striped bass, American eel, and shad, were valued at $40 million annually before they were closed down in 1976 (KLIOS, p 21-22).

Commercial fishing, both estuarine and marine, at other East Coast locations has experienced varying trends over the period since 1988. Massachusetts' fisheries, for example, experienced a decline of over 50 percent in their employment over the period 1988-99, whereas Cape May County, New Jersey, has been more or less stable over the same period and Washington County, Rhode Island, experienced modest growth over the 1990s. In 1999, commercial fishing based in Cape May County supported 204 jobs with wages of $6.2 million, and Washington County supported 65 jobs with annual wages of $2.9 million. These activity levels are small compared to, for example, Bristol County, Massachusetts, which in 1999 supported 857 jobs with wages of $50.7 million (US BLS, 2001). It should also be recognized that many fishing enterprises are sole proprietorships operating on a cash basis and are thus not included in State labor department ES-202 data.

In addition to the direct wages associated with commercial fishing, the activity generates a variety of support, trade, and indirect economic activity that add a substantial multiplier to these direct earnings. US BEA I/O models typically produce employment multipliers in the 2.6 to 2.8 range for commercial fishing. Consequently, in Cape May County, for example, we might expect total direct and indirect employment on the order of 550 jobs. KLIOS estimates that a fully functioning Hudson River fishery would support 450 direct and indirect jobs with annual earnings of $18 million. This is not an unreasonable estimate.

Recreational Fishing

As KLIOS and Scenic Hudson comment: "*The region surrounding the Hudson River does not obtain the full economic benefit that would accrue if restrictions on commercial and recreational fishing were eased or removed*" (Scenic Hudson, p 39).

Recreational fishing along the river is likely to be a more significant economic activity than its commercial counterpart. The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation indicates that there is a population of recreational anglers in the US of 35.2 million, who spend $38 billion per year (US FWS, 1998). Of this population of anglers, 84 percent are freshwater fishermen.

In New York State, the survey reports 1,493,000 anglers who are New York residents (over age 16) and spend an average of 18 days at this activity with average annual expenditures of $942

each. Non-New York residents add to the fishing days in New York by 11 percent, with a total spent in the State (after excluding expenditures by New York residents out of State) of $1.3 billion. Of New York's resident anglers, 996,000 (or 67 percent) fished in freshwater (excluding the Great Lakes), making 13.5 million trips covering 16.2 million days. In 1996, of the $1.3 billion fishing expenditures in New York, trip-related expenditures, including food, lodging, transportation, and boat rentals, came to $601 million; each angler spent an average of $353 on trip-related costs.

In addition to these direct expenditures by anglers, there are secondary economic benefits as these dollars circulate in the local economy, generating additional indirect jobs and earnings. Employment multipliers from service activities in the upper Hudson region, such as hotels and eating/drinking establishments, are on the order of 18-28 jobs per million dollars expended (US BEA, 2001b). Thus, if, for example, the Upper Hudson were to generate a direct increment of $100 million of expenditures in these service industries important to anglers, another 1,800 to 2,800 new jobs will be created.

It is important to recognize that with the bans and advisories in effect, the communities along the Hudson River south of Fort Edward have a limited participation in these huge recreational expenditures, despite some of the most magnificent scenery and fishing opportunities in the State. It is also appropriate to note that the benefits of recreational fishing are hardly limited to economics. The social, physical, psychological, and educational benefits of intimate contact with nature, while intangible, provide significant opportunities for personal renewal and reflection, accounting for much of fishing's broad popularity.

EPA's remedy offers the long-term prospects of a renewed and enhanced recreational fishing industry. This will generate a range of positive benefits that include a substantial boost to local economies and, indirectly, a greater sensitivity to preservation of the natural environment, an intrinsic quality of recreational fishing.

IMPACTS ON PROPERTY VALUES

Comments from ARCC assert the dredging would result in declining property values on both sides of the river and near the sediment processing/transfer facilities. Comments from Scenic Hudson and their consultant KLIOS (Appendix A), citing EPA and other studies, claim that the proximity to Superfund sites generates a negative impact on property values of two to eight percent and declines with distance from the site. However, successful remediation is seen to restore or increase property values, on a situation-dependent basis (*e.g.*, values may exceed pre-contamination levels when use of the site provides for neighborhood enhancements such as parks).

Existing Values

Data on property values along the Hudson River and Champlain Canal were studied in detail in the New York Canal Corporation's study of economic benefits of operation on flood damages (New York Canal Corporation 1990). The corporation collected and refined data on property values for 1,592 residential properties along the river's floodplain in the following municipalities: Village of Waterford, Town of Waterford, Mechanicville, Schaghticoke, Village

of Stillwater, Town of Stillwater, Schuylerville, Fort Miller, and Fort Edward. While the purpose of the study was to assess potential flood damages on different types of residences (*e.g.*, with and without basements, second floors, trailers, etc.), it also allows an identification of the average values of the residences near the water. For those in Saratoga County, the average value in 1990 was $61,218; for those in Rensselaer it was $68,331; and for those in Washington County it was $50,406.

The 1990 census records median owner-occupied values for these counties of $107,600, $92,500, and $69,900, respectively for Saratoga, Rensselaer, and Washington Counties. While *average* and *median* values as indicators of centrality may not be identical, the differences between values along the river's floodplain and the rest of the county are very substantial. In Saratoga County those in the floodplain were 43 percent less than the county as a whole; in Rensselaer County 26 percent less; and in Washington County, 28 percent less. Exactly what specific factors account for this variation in values are uncertain, but the potential that the PCB issue was a contributing factor in lowering these values must be considered. Only if these data were reversed, and property along the river was valued more highly, could proximity to the PCB contamination be discounted.

One former property broker in Saratoga County, Michael Burns, who provided testimony at the EPA public hearing in Queensbury in February 2001, stated: "I got used to out-of-towners saying, please don't show us anything near the Hudson River, we don't want to live there." Another broker in Saratoga County noted that despite a very active practice with property elsewhere in the county, she had experienced no demand for buying riverfront property (Merling, 2001). While such views remain anecdotal, they indicate the exact opposite of what would ordinarily be a major property amenity and attraction, capable of commanding a substantial price premium.

Proximity Effects on Property Values

Riverfront Property

As noted in previously, existing property values along the river may have already suffered because of their proximity to PCB contamination. ARCC, however, comments that it is the proposed remedial dredging that would depress property values. The discussions presented earlier in this white paper on the likely scale and operational patterns of the dredging are relevant to this section also.

The dredging scenario presents a remediation effort that will involve a cluster of working barges and their support vessels steadily moving along the river for six years. The pace of the barges will be such that its adjacency to most locations will be limited to only a few weeks. At other times, loaded and empty barges and supply vessels are likely to pass by a few times a day. These are patterns of operation that are reminiscent of the 1970s and earlier, when numerous commercial barges were using the canal and navigational dredging was a regular requirement.

The operational characteristics of the proposed PCB dredging, the brief duration of the dredging at any particular location, and the targeted dredging of only 13 percent of the river bottom on sections that extend for only 27 percent of the river length between Fort Edward and the Federal

Dam at Troy, are highly unlikely to generate any significant or permanent adverse impacts on the adjacent waterfront properties. Over the longer term, after the PCB remediation, owners will enjoy the prospect of substantially enhanced property values. Similarly, owners along the entire Hudson River south of Troy will obtain an increased amenity from the cleanup of the river that could translate into substantial gains in aggregate property value.

Property Proximate to Sediment Processing/Transfer Sites

Description of the Sediment Processing/Transfer Facilities

The remediation program requires a sediment processing/transfer facility site or sites where the dredged material is dewatered and stabilized and from which the stabilized material will be transported by rail to sites situated well beyond the Hudson Valley. These facilities will operate for approximately six years and operations will occur around the clock when dredging is in progress so that a relatively smooth flow of processed sediments will be generated for loading onto rail cars.

Should mechanical dredging be selected as the preferred removal technology, stabilization of sediments will occur in a facility that looks somewhat similar to a concrete batch plant. Incoming sediments will be reclaimed from barges at the site wharf, placed into a receiving hopper, and then conveyed to a pug mill that blends cement (or some other stabilizing agent) into the dredged material stream. Stabilized sediments will then be placed into a small surge or storage area or, alternatively, directly into rail cars. The processing section of the site will encompass two to five acres and the rail yard may require another 10 acres of property.

Should hydraulic dredging be selected as the preferred technology, incoming sediment slurry will be processed through a series of hydrocyclones, where coarse and fine fractions will be separated. The finer-grained material will then be pumped to a processing facility that incorporates several stages of treatment including coagulation, sedimentation, and mechanical dewatering. Overall, the processing site, under the hydraulic dredging scenario, will appear as a medium-sized processing complex supporting a number of tanks, pumps, considerable piping, and a mechanical dewatering plant covering, in total, approximately 10 acres. The additional significant feature on the site will be the rail car loading area.

As discussed in the white papers that address matters such as PCB volatilization and general air quality, no significant hazards are likely to be associated with operations of the sediment processing/transfer facility sites (*e.g.*, White Paper – PCB Releases to Air). The principal contaminant of concern for the Hudson River is PCBs, which bioaccumulate in aquatic ecosystems and then pose a risk to humans as fish consumers. The handling of PCBs at the sediment processing/transfer facility sites will not pose an undue risk to nearby communities since EPA will impose strict operating controls on the contractor and will then monitor site operations to confirm adherence to the project's technical specifications. It is expected that the overall perception of the sediment processing/transfer facility sites will be similar to that of modest industrial complexes that operate for several years and are then recycled for other uses or dismantled.

Other factors such as noise, lights, odor, and traffic will also have a bearing on the manner in which the sediment processing/transfer facilities are perceived and received. These issues are discussed in several white papers and chapters of the Responsiveness Summary. The general conclusions of those documents are as follows:

- *Traffic* – The sediment processing/transfer facilities will generate traffic both during the project's mobilization phase and during the six-year period of dredging operations. However, the expected level of vehicular activity is not expected to generate a significant impact on roadways near the sediment processing/transfer facilities.

- *Odor* – Activities at the sediment processing/transfer facility sites will not be a source of odor to nearby communities.

- *Noise* – Operations at the sediment processing/transfer facilities will generate low, though perceptible, levels of noise in their immediate vicinity.

- *Lighting* – Nighttime operations at the sediment processing/transfer facilities will require lighting for worker safety reasons. It is expected that site lighting can be designed so as to avoid nuisance impacts to nearby residential land uses.

Despite the careful design and selection of sites for these facilities to minimize their potential for adverse impacts, there remains the potential for temporary adverse impacts to property values in close proximity.

The literature of empirical studies on the negative effects of Superfund sites on property values does not examine any facility such as that proposed. Rather, the professional literature typically deals with unremediated sites, where hazardous materials have penetrated aquifers or generate hazardous air emissions. Property value impacts from such sites examined in the literature generally ranges from 2 to 8 percent, with such negative effects declining with distance from the site. A variety of factors appear to influence the level of effect, amongst which a very powerful influence can be negative publicity by the media, in the mode of a "self-fulfilling prophecy." A review of the literature follows.

Literature Review

As noted, the literature does not address a project of the kind proposed here; however, a review of the professional literature on the proximity effects of undesirable land uses such as hazardous sites, landfills, and incinerators illustrates a range of discernable impacts, often with little consistency. However, some basic patterns tend to be that negative impacts decline with distance from the site, values are likely to rebound after remediation or cessation, adverse media publicity can play a marked role in depreciating prices, and other amenities or facilities may play a positive role. A synopsis of the literature follows, first on hazardous materials sites and then on non-hazardous landfills, incinerators, and other industrial facilities. Table 313617-6 presents a matrix indicating the general conclusions of these studies.

Hazardous Waste Sites

The presence of a hazardous waste site may exert a significant negative impact on surrounding property values, as documented by the body of research on the subject (Thayer, Albers, & Rahmatian 1992; Ketkar 1992; Reichert 1997; McClelland, Schulze, & Hurd 1990; Kohlhase 1991; Smolen, Moore, & Conway 1992; Kiel 1995; Greenberg & Hughes 1992; Greenberg & Hughes 1993; McCluskey & Rausser 1999a; McCluskey & Rausser 1999b; Dale, Murdoch, & Waddell 1997).

As a rule, values of the properties in the immediate proximity of a hazardous waste site suffer the most, while the depreciating effect of a site diminishes as distance from the site increases (Smolen, Moore, and Conway, 1992; Reichert, 1997; Kohlhase, 1991). Greenberg and Hughes (1993) note that in the judgment of 28 percent of tax assessors (out of 150 comprising their sample) property values within 0.25 miles of a hazardous waste site suffer as a result of such proximity. However, it must also be noted that 26.7 percent of the participants of the same sample opine that hazardous waste sites in their communities do not damage or otherwise affect property values.

A number of factors associated with the hazardous waste facilities have been noted to influence property depreciation. Clearly, among the most notorious ones are perceptual cues, such as noxious odor emanated by the sites (Kiel 1995). On the other hand, McClelland, Schulze, and Hurd (1990) found no relationship between the odor emitted by a hazardous waste site and property values in the surrounding community. Their findings link property depreciation to *ungrounded* beliefs shared by the community residents concerning health risks posed by the facility in question.

Attempts to gauge a relationship between actual risks posed by a site and the surrounding property values also show inconclusive results. Thayer, Albers, & Rahmatian (1992) indicate a clear correlation between the level of potential danger posed by the site and property depreciation rates. According to this study, property value depreciation near a hazardous waste site constitutes 2.7 percent, as compared to 0.7 percent depreciation for properties near a non-hazardous landfill. However, other studies (Greenberg & Hughes 1992; Kohlhase 1991) suggest that property values do not depend on a site's toxicity level.

Media coverage of a hazardous waste site may be an important factor in determining property value trends (Reichert, 1997; McCluskey and Rausser, 1999a). However, Dale, Murdoch, Thayer, and Waddell (1997) failed to confirm their findings regarding media coverage.

The impact of the hazardous waste sites on property values tends to fluctuate over time (Kiel 1995; Kohlhase 1991; McCluskey & Rausser 1999b; Dale, Murdoch, Thayer, & Waddell 1997). Kiel, and McCluskey and Rausser documented property value depreciation becoming harsher with the passage of time, pointing to the existence of stigma. On the other hand, Dale, Murdoch, Thayer, and Waddell observed a property value rebound coinciding with the remediation of the site. The results of research by Ketkar (1992) support this conclusion. Namely, her findings suggest that if the number of hazardous waste sites in any given municipality included in her sample (consisting of 64 New Jersey municipalities) was reduced by one, an increase of property values by two percent will be likely to ensue. One study of several Superfund sites in Houston,

Texas (Kohlhase, 1991), found that property values rebounded fairly quickly following completion of cleanup activities.

Real estate appraisal theory and practice supports the premise that if the displeasing aspects of a site are corrected, property values are likely to recover. However, a perceived stigma may attach to an area and reduce post-clean-up recovery of property values. Little empirical evidence is available on this issue. Markets generally take time to adjust to new information and time patterns vary from site to site. McCluskey (1999b) hypothesizes that permanent stigma effects are usually related to a change in the demographic composition of neighborhood during the site's discovery, investigation, and remediation, when high-income households move out and are replaced by low-income households.

It is, however, rare that Superfund sites are found in high-income communities; moreover, the price effect (2 to 8 percent) is usually not enough to motivate such demographic recomposition of neighborhoods. Another factor is that some sites are rezoned, permitting less valuable uses to occupy the land and thereby permanently depreciating values. The case of Love Canal in Niagara, New York, is cited where, despite the enormous negative publicity, homes in the remediated neighborhood went from zero value to within 10 to 15 percent of comparable values in the area.

Non-Hazardous Landfills, Incinerators, and Other Industrial Facilities

Non-hazardous landfills may negatively affect surrounding property values, as well. In this case, the magnitude of the impact appears to depend on the amount of activity occurring at the site (Nelson, Genereux, and Genereux, 1992; Cartee, 1989). Reichert, Small, and Mohanty (1992) reported a 5.5 percent negative effect on the real estate values in the surrounding affluent community, attributed to the nearby landfill, which increased to 7.3 percent for the properties within sight of the facility; however, surprisingly, the landfill in their study also appeared to exert a positive impact on properties in other, less affluent communities they investigated. The findings of Nelson, Genereux, and Genereux (1997) indirectly support those of Reichert, Small, and Mohanty. Nelson, Genereux, and Genereux (1997) found that values of more expensive homes suffer more as a result of the proximity to a landfill. A number of other investigators found no statistically significant impact of sanitary landfills on surrounding property values (Zeiss & Atwater 1989; Bleich & Findlay 1991; Cartee 1989). Moreover, Cartee points out that in one case discussed in his literature review, property values appeared to increase due to the presence of a landfill, and in two other cases, since the construction of a landfill, host neighborhoods became more residential.

As another type of a waste treatment facility, incinerators may also influence property values in host communities, as exemplified by Kiel and McClain (1995 and 1996). For instance, according to Kiel and McClain (1995), an operating incinerator reduced property values by 5.13 percent; however, as residents adjusted to the presence of the facility, the negative impact of incinerator on real estate values diminished to 4.19 percent. Zeiss (1990) found a weak negative impact of an incinerator in Oregon on marketability of the surrounding properties; namely, for every kilometer (.625 miles) of distance closer to the facility, a property's time on the market increased by two days. However, as reported by Zeiss and Atwater (1989), the incinerator studied by Zeiss (1990) did not have any apparent effects on property values per se.

Even though industrial facilities such as plants and factories may be hypothesized to exert an impact on surrounding property values, the findings in this area are also mixed. Kiel and McClain (1996), for example, found an 8 percent negative impact on property values attributed to a brick plant, and 4.9 percent effect ascribed to a recycling plant. On the other hand, Bui and Mayer (1999) found no discernible effect of the toxic emissions reported by manufacturers on housing prices in Massachusetts.

Conclusion

By and large, hazardous waste sites do appear to depress surrounding real estate values, albeit to varying degrees that typically range from 2 to 8 percent; such effects may be aggravated if a great deal of media attention is paid to the facility and its potential problems. On the other hand, remediation of hazardous waste sites does appear to moderate stigma and its effect on prices. In general, the influence of non-hazardous landfills and incinerators on property values is more limited in scope. The research regarding the correlation between industrial facilities and property values yields rather inconclusive results.

In light of the operational characteristics of the proposed PCB remediation, with active dredging proximate to any particular location for only a matter of weeks, it is not likely that properties along the river will suffer any significant or permanent loss of value. Rather, the remediation of the PCB problem is much more likely to see a rebound in these properties' value, to levels that are more appropriate for waterfront property in the region. Moreover, property values along the entire Hudson River south of Fort Edward are similarly likely to see some enhancement of value once the remediation has been completed. No attempt is made here to value the enhancement that a river clean of PCBs will generate for property owners along its banks.

For those properties more proximate to the sediment processing/transfer facilities, impacts on their value will be likely to depend on several key factors. Among these will be the proximity of any sensitive receptors (residences, schools, churches, etc.), the degree of any substantive adverse emissions, such as noise, odor, light, dust, or health risks (all of which can be effectively controlled by design and operational programs), or the less tangible effects of negative media publicity and the creation of self-fulfilling prophecies of property value losses.

While the potential for property value losses exists, the extent of these will certainly be ameliorated by careful siting decisions, effective buffering, the location of processing activities within structures, the use of rail and barge for transportation of materials, and other design elements that will be applied. Moreover, the six-year design life of these sediment processing/transfer facilities places their effects within a relatively short-term horizon that will generate less significant impacts on property values and is more likely to see a quick rebound from any potential for adverse impacts.

REFERENCES

Adirondack Regional Chambers of Commerce. 2001. Resolution on Proposed Plan of Dredging and Hudson River PCBs Superfund Site Comments on EPA's Proposed Dredging Plan, April.

Bleich, D. H., and Findlay, C. 1991. “An evaluation of the impact of a well-designed landfill on surrounding property values.” *Appraisal Journal* 59:2, 247-253.

Bui, L.T.M. and Mayer, C.J. 1999. “Regulation and capitalization of environmental amenities: Evidence from the Toxic Release Inventory in Massachusetts.” Online. 34 pages.
Cartee, C. 1989. “A review of sanitary landfill impacts on property values.” *Real Estate Appraiser and Analyst.* Spring, p 43-46.

Dale, L., Murdoch, J.C., Thayer, M.A., and Waddell, P.A. 1997. “Do property values rebound from environmental stigmas? Evidence from Dallas.” Online.

Farmers Against Irresponsible Remediation (FAIR). 2001. Public Comments Submission Hudson River Reassessment. April 13.

Greenberg, M., and Hughes, J. 1992. “The impact of hazardous waste Superfund sites on the value of houses sold in New Jersey.” *Annals of Regional Science* 26, 147-153.

Greenberg, M., and Hughes, J. 1993. “Impact of hazardous waste sites on property value and land use: Tax assessors’ appraisal.” *Appraisal Journal* 61:1, 42-52.

Hudson River Sloop Clearwater. 2001. Public Comment on EPA’s Hudson River PCBs Superfund Reassessment and Proposed Remediation Plan. April 17.

Ketkar, K. 1992. “Hazardous waste sites and property values in the state of New Jersey.” *Applied Economics* 24, 647-659.

Kiel, K.A. 1995. “Measuring the impact of the discovery and cleaning of identified hazardous waste sites on house values.” *Land Economics* 71:4, 428-435.

Kiel, K.A., and McClain, K.T. 1995. “House prices during siting decision stages: The case of an incinerator from rumor through operation.” *Journal of Environmental Economics and Management* 28, 241-255.

Kiel, K.A., and McClain, K.T. 1996. “House price recovery and stigma after a failed siting.” *Applied Economics* 28, 1351-1358.

KLIOS, Inc. 2001. Hudson River Regional Economic Impact Analysis: Impact of Environmental Remediation. (Appendix A of Scenic Hudson’s and Sloop Clearwater Comments). April 12.

Kohlhase, J.E. 1991. “The impact of toxic waste sites on housing values.” *Journal of Urban Economics* 30, 1-26.

McClelland, G.H., Schulze, W.D., and Hurd, B. 1990. “The effect of risk beliefs on property values: A case study of a hazardous waste site.” *Risk Analysis* 10:4, 485-497.

McCluskey, J.J. and Rausser, G.C. 1999a. “Estimation of perceived risk and its effect on property values.” Online. 30 pages.

McCluskey, J.J. and Rausser, G.C. 1999b. "Stigmatized asset value: Is it temporary or permanent?" Department of Agriculture and Resource Economics, University of California, Berkeley, CA, July 2, 1998. Revised 1999 online.

Merling, Jennifer, 2001. Personal telecommunication with TAMS Consultants, Inc. June 21.

Nelson, A.C., Genereux, J.H., and Genereux, M. 1992. "Price effects of landfills on residential land values." *Journal of Urban Planning and Development* 118:4, 128-137.

Nelson, A. C., Genereux, J., and Genereux, M.M. 1997. "Price effects of landfills on different house value strata." *Journal of Urban Planning and Development* 123:3, 59-67.

New York Canal Corporation. 1990. Champlain Canal of the New York State Barge Canal: Economic Benefits of Operation, Appendix A13, Flood Damages. September.

New York Canal Corporation. 1995. Recreationway Plan. August.

New York Canal Corporation. 2001. "Get Hooked on Fishing." Accessed online at: www. nycanal.com/recreation/canalfishing.html.

New York Farm Bureau. 2001. Comments on the Proposed Plan to Clean Up Hudson River PCBs. April 16.

New York State Department of Labor. 2001. Local Area Unemployment Statistics, June.

Outdoor Coalition of America. 1997. Emerging Markets for Outdoor Recreation in the United States: Results of the National Survey of Recreation and the Environment.

Reichert, A.K. 1997. "Impact of a toxic waste Superfund site on property values." *Appraisal Journal* 65:4, 381-393.

Reichert, A.K., Small, M., and Mohanty, S. 1992. "The impact of landfills on residential property values." *The Journal of Real Estate Research* 7:3, 297-314.

Scenic Hudson. 2001. Scenic Hudson's Proposed Remedy for the Hudson River PCBs Superfund Site, April 17.

Scenic Hudson News. 2001. Online newsletter: www.scenichudson.org/news/news16.htm.

Smolen, G.E., Moore, G., and Conway, L.V. 1992. "Economic effects of hazardous chemical and proposed radioactive waste landfills on surrounding real estate values." *The Journal of Real Estate Research* 7:3, 283-295.

Thayer, M., Albers, H., and Rahmatian, M. 1992. "The benefits of reducing exposure to waste disposal sites: A hedonic housing value approach." *The Journal of Real Estate Research* 7:3, 265-282.

US Bureau of Economic Analysis, Department of Commerce (US BEA). 2001a. Regional Economic Information System.

US BEA. 2001b. Regional Input-Ouput Modeling System II (RIMS II), customized computer model for the five-county upper Hudson region, March.

US Census Bureau, Department of Commerce. 1999. *County Business Patterns* (Washington County).

US Environmental Protection Agency. 2001. Property Values, Stigma, and Superfund. Working paper online at http://www.epa.gov/oerrpage/superfund/programs/recycle/stigma.htm.

US Fish and Wildlife Service, Department of the Interior. 1998. National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

Zeiss, C. 1990. "Incinerator impacts on residential property sales: Beyond price effects." *Journal of Urban Planning and Development* 116:2, 80-97.

Zeiss, C., and Atwater, J. 1989. "Waste facility impacts on residential property values." *Journal of Urban Planning and Development* 115:2, 64-80.

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