DRAFT
ENVIRONMENTAL IMPACT STATEMENT
FOR THE
HUDSON RIVER PCB DEMONSTRATION RECLAMATION PROJECT

May 1981

Prepared by:
U.S. Environmental Protection Agency - Region II

Cooperating Agencies:

U.S. Army Corps of Engineers

New York State Department of Environmental Conservation

Abstract: This environmental impact statement (EIS) has evaluated the proposed Hudson River PCB Reclamation Demonstration Project from the standpoint of public health, environmental impact, cost, and engineering feasibility. As a result of these analyses, U.S. Environmental Protection Agency (USEPA) recommends that the action alternative be implemented. The full scale action alternative estimated at approximately $43 million dollars has been determined to be the most desirable project in terms of potential beneficial impacts. However, since the full scale project may not be realized unless additional funds are obtained by New York State Department of Environmental Conservation (NYSDEC), the reduced scale project is also recommended.

As a part of the action alternative the development of a monitoring program is recommended to demonstrate any improvement in the rate of recovery of the Hudson River and the feasibility of the indefinite storage of PCB contaminated sediments in an upland containment site.

EPA has determined that this action, with the mitigation measures described in the EIS, will not endanger public health, safety, and welfare.

The alternatives discussed in this draft EIS for the proposed Hudson River PCB Reclamation Demonstration project include: the no-action alternative (with and without future maintenance dredging); control of river flow; in-river detoxification; dredging alternatives; remnant deposit alternatives in the area of the former Fort Edward Dam; and full scale or reduced scale dredging program with in-river containment. These alternatives are evaluated to determine both their feasibility and impact on the environment.

This National Environmental Policy Act (NEPA) draft EIS is based largely on the NYSDEC's State Environmental Quality Review Act draft EIS and supporting documents. Significant impacts which were further evaluated in this NEPA draft EIS include primary and secondary impacts on public health, fisheries, maintenance dredging and navigation, and agriculture.

Public Hearings:

June 23, 1981: 7:00PM
Washington County Courthouse
Route 4 and Maple Road
Hudson Falls, New York

June 24, 1981: 7:00PM
Dutchess County Community College
Dutchess Theater
Pendell Road
Poughkeepsie, New York

June 25, 1981: 6:30PM
2 World Trade Center
Main Hearing Room - 44th floor
New York, New York

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Approved by:

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Acting Regional Administrator

5/4/81
Date

EXECUTIVE SUMMARY

DATE:	May 1981
TYPE OF STATEMENT:	Draft
RESPONSIBLE FEDERAL AGENCY:	U.S. Environmental Protection Agency (EPA) Region II
TYPE OF ACTION:	Administrative

RECOMMENDED ACTION

Based on public health, environmental, cost, and engineering evaluations carried out by EPA and its environmental consultants, the EPA recommends that the action alternative be implemented if contingency/mitigation measures ensuring public safety are developed (Table S-1).

Resolution of these issues will ensure that minimal risk to public health, safety, and welfare will result from the implementation of this project. Modifications and contingencies developed will be submitted for public comment before a National Environmental Policy Act (NEPA) decision is reached.

EPA recommends that a project to dredge and/or stabilize all known polychlorinated biphenyl (PCB) hot spots be implemented. After carefully evaluating both the original full-scale proposal and reduced-scale proposal submittted by New York State Department of Environmental Conservation (NYSDEC), EPA recommends funding a modification of the original full-scale project, since greater potential benefits will be realized. However, if additional funding is not available, the reduced-scale project is also recommended, although it offers only a reduced potential benefit, because it will provide for demonstration of river recovery and indefinite storage while not endangering public health, safety, and welfare.

As discussed below, the authorization by Congress under Section 10 of the Clean Water Act (CWA) Amendments is $20,000,000. If the action alternative is

Table S-1

EPA Recommended Program

Full- Scale	Reduced-Scale
Dredging or in-river containment of all 40 hot spot areas in the river bed with containment in a secure upland site.	Reduction of the number of hot spots to be dredged or contained in-river
Design and construction of a secure upland containment site capable of indefinite long-term isolation of contaminated material	Same, except for a reduction in capacity at the containment site
Deletion of remnant deposit removal and upland containment; instead, provision of secure cap and top dressing,and further bank stabilization if necessary	Same
Elimination of provision for the containment of PCB-contaminated material from dumpsites in the Fort Edward area.	Same
Provision for containment of contaminated materials from three New York State Department of Transportation (NYSDOT) dredge spoil sites (212, 13 and 204 Annex)	Same
Provision for dredging and containment operational standards and procedures, mitigation measures, monitoring programs, and contingency plans necessary to safeguard public health and agricultural resources	Same
Provision for research studies/environmental monitoring programs necessary to demonstrate the improvement in the rate of recovery of the river and storage of contaminated material	Same

approved, the recommended action is to undertake the originally proposed $40,000,000 full-scale project with the required modifications. Additional funds from either federal, state, or perhaps outside sources will be required to implement the full-scale project, while affording protection of the public health and the environment. Although not as desirable as the full-scale project, it is recommended that the $26,700,000 reduced-scale project could be undertaken along with the aforementioned project modifications.

HISTORY AND OVERVIEW OF THE EXISTING PROBLEM

Polychlorinated biphenyls are a class of chemical compounds that have been used in agriculture and industry for decades. Since 1930, they have been used principally in electrical transformers and capacitors, but they have also been used in a variety of other products including lubricants, pesticides, cutting oils, plasticizers, and adhesives.

During a thirty-year period ending in 1977, over 227,000 kilograms (kg) (500,000 pounds [lb]) of PCBs were discharged into the Hudson River from two General Electric (GE) capacitor manufacturing plants at Fort Edward and Hudson Falls, New York. Much of the discharged PCBs was adsorbed by the bottom sediments of the river and accumulated behind the Fort Edward Dam. When the dam was removed in 1973 due to its deteriorating condition, a large amount of the PCB-contaminated sediments was released and migrated downstream. The downstream migration was further accelerated during flood situations, causing PCBs to concentrate in river bottom sediments from Fort Edward to New York Harbor.

PROJECT DEVELOPMENT BY NYSDEC

As part of a court settlement between NYSDEC and GE, approximately $3,000,000 was spent by NYSDEC to investigate the extent of PCB contamination in the Hudson River and methods to reduce and remove the threat of continued PCB contamination.

Forty PCB "hot spots" have been identified in the upper Hudson River, based on five years of scientific and engineering studies. Hot spots have been defined as sediments containing 50 micrograms per gram (ug/g) (parts per million [ppm]) or more of PCBs. PCB concentrations along the depositional shore range from 5 to 1,000 ug/g (ppm) in fine grained sediments. In addition, five PCB-contaminated remnant deposits have been identified. Remnant deposits were formed by as a result of the removal of the Fort Edward Dam, which caused water levels of the river behind the dam to drop significantly. This caused once-submerged bottom sediments to be exposed to the atmosphere. At present, PCB concentrations in the remnant deposits range from 50 to 200 ug/g (ppm).

The investigations conducted by NYSDEC resulted in a project which proposed to demonstrate the feasibility of removing PCB-contaminated sediments from the upper Hudson River and deposit those sediments in a secure upland containment site. The environmental analysis, costs, engineering, and feasibility of the project proposed by NYSDEC are presented in a draft environmental impact statement (EIS) prepared in accordance with the State Environmental Quality Review Act (SEQRA). The full-scale project recommended in the draft SEQRA EIS was estimated to cost $40,000,000.

Subsequent to the draft SEQRA EIS and in response to Congressional action described below, NYSDEC rescoped the originally proposed project to accommodate the $20,000,000 funding authorized by the amendments to the Clean Water Act (CWA) [Sections 116(a) and (b)] and State matching funds. The reduced-scale project, as developed by NYSDEC, would cost $26,700,000. A comparison of the full- and reduced-scale projects is presented in Table S-2.

CONGRESSIONAL ACTION

In September 1980, Congress passed an amendment to the CWA under Title I, Section 116(a) and (b), entitled the Hudson River PCB Reclamation Demonstration Project. Funds for this project have been authorized under Title II, Section 205(a) of the Act. Under this legislation EPA is authorized to expend up to $20,000,000 towards a proposed demonstration/reclamation project for removing and disposing of PCB-contaminated sediments from the Hudson River.

> Section 116(a). The Administrator is authorized to enter into contracts and other agreements with the State of New York to carry out a project to demonstrate methods for the selective

Table S-2

NYSDEC Recommended Program

Full-Scale	Reduced-Scale
Dredging of all 40 hot spot areas in the river bed with containment in a secure upland site	Reduction of the number of hot spots to be dredged from 40 to approximately 20
Design and construction of a secure upland containment site capable of long-term isolation of contaminated material	Same, except for a reduction in in capacity at the containment site
Excavation of two remnant deposits (areas 3 and 5) located above the former Fort Edward Dam site, and removal to the upland containment site	Deletion of remnant deposit removal and upland containment; instead provision of top dressing and fencing for remnant deposits 3 and 5
Provision for containment of material from three PCB contaminated dump sites (old Fort Edward, Fort Miller and Caputo) should removal be found more suitable than in-place containment	Elimination of provision for the containment of PCB-contaminated material from Old Fort Edward, Fort Miller and Caputo dump sites.
Provision for containment of contaminated materials from three NYSDOT dredge spoil sites (212, 13 and 204 Annex)	Same
Destruction of the recovered PCBs at such time as a technologically and economically feasible procedure becomes available	Same
Provision for funding for research studies related to environmental monitoring	Reduction in the level of funding for research studies

removal of polychlorinated biphenyls contaminating bottom sediments of the Hudson River, treating such sediments as required, burying such sediments in secure landfills and installing monitoring system for such landfills. Such demonstration project shall be for the purpose of determining the feasibility of indefinite storage in secure landfills of toxic substances and of ascertaining the improvement of the rate of recovery of a toxic contaminated national waterway. No pollutants removed pusuant to this paragraph shall be placed in any landfill unless the Administrator first determines that disposal of the pollutants in such landfill would provide a higher standard of protection of the public health, safety, and welfare than disposal of such pollutants by any other method including, but not limited to, incineration or a chemical destruction process.

(b). The Administrator is authorized to make grants to the State of New York to carry out this section from funds allotted to such State under Section 205(a) of this Act, except that the amount of any such grant shall be equal to 75 per centum of the cost of the project and such grant shall be made on condition that non-Federal sources provide the remainder of the cost of such project. The authority of this section shall be available until September 1983. Funds allotted to the State of New York under Section 205(a) shall be available under this subsection only to the extent that funds are not available, as determined by the Administrator, to the State of New York for the work authorized by this section under Section 115 or 311 of this Act or a comprehensive hazardous substance response and cleanup fund. Any funds used under the authority of this subsection shall be deducted from any estimate of the needs of the State of New York prepared under Section 516(b) of this Act. The Administrator may not obligate or expend more than $20,000,000 to carry out this Section.

The overall goal of the Congressional authorization is to allocate funding to assist in the cleanup of the PCBs in the upper Hudson River. The specific purpose of the authorization is to demonstrate the improvement of the rate of recovery of a toxic contaminated national waterway by:

- selective removal of PCB-contaminated sediments from the Hudson River
- treating the contaminated sediments as required and burying those sediments in a secure landfill
- development of monitoring and scientific studies for water quality and fish, and monitoring the landfill site

The legislation also states that prior to placing any contaminated materials in a secure landfill the Administrator of EPA must first determine that the placement of the pollutants in a secure landfill would provide a higher degree of protection of public health, safety, and welfare than either leaving the PCB-contaminated sediments in place or disposition by any other methods. In addition, before funding under Section 116 of the CWA can be provided, the Administrator of EPA must determine that funding is not available under Sections 115 and 311 of the Act, as well as any existing "Superfund" legislation (Comprehensive Hazardous Substance Response and Clean-Up Fund established by the Act).

PURPOSE OF FEDERAL EIS

With the passing of the Section 10 Amendments to the CWA in October of 1980, Congress authorized EPA to make grants to the NYSDEC in order to carry out the intent of the "Hudson River PCB Reclamation Demonstration Project."

On January 12, 1981 EPA-Region II issued a Notice of Intent (NOI) to prepare an EIS. The purpose of NEPA is to identify and analyze any potentially significant impacts on the quality of the human environment resulting from a proposed project.

In addition, the NEPA EIS decision-making process provided the forum for soliciting public comments on the proposed project by conducting a series of public meetings and hearings. A twenty-one member Citizens Advisory Committee (CAC) has been formed to advise EPA on issues of public concern regarding the project.

As stated in the NOI, it was EPA's intent to further evaluate the following in the NEPA EIS:

- no-action alternatives
- control of river flow
- in-river detoxification
- in-river contamination
- remnant deposit alternatives in the area of the former Fort Edward Dam
- complete or partial dredging, combined with upland containment
- dredge spoil disposal and treatment options
- other alternatives concerning PCB removal, including alternative dredging and transport

These alternatives were evaluated for potential beneficial and adverse, short- and long-term impacts under normal river flow, as well as flooding conditions. The major primary and secondary impact assessment objectives are as follows:

A. Public Health

1. Protection of downstream water supply
2. Protection of groundwater in the area of the containment site
3. Reduction of PCB volatilization from river bed/bank, and remnant deposits into the air
4. Reduction of containment site volatilization
5. Reduction of exposure through the ingestion of food

B. Fisheries

1. Permanent reopening of the commercial and recreational fisheries
2. Protection of endangered species (shortnosed sturgeon)
3. Reducing the bioaccumulation of PCBs through the food web.
4. Protection of wetlands

C. Maintenance Dredging and Navigation

1. Mitigation of future maintenance dredging and disposal problems in the upper Hudson River as well as the estuary
2. Maintenance of a navigable waterway serving transportation needs of the upper and lower Hudson communities

D. Agriculture

Protection of livestock and their food sources through:

1. Reduction of river bed/bank, and remmant deposit volatilization
2. Reduction of containment site volatilization
3. Protection of groundwater in the area of the containment site used for dairy industry purposes

E. Other Impacts

1. Evaluation of impacts to future hydroelectric dam construction and usage

FINDINGS OF THE NEPA EIS

1. Disposal of PCB-contaminated dredge spoils in a landfill would provide a higher standard of protection of the public health, safety, and welfare than disposal of such pollutants by other methods including, but not limited to, incineration or a chemical destruction process. The basis of the above conclusion is that alternative disposal methods are either infeasible or highly speculative and would render the entire project economically infeasible within the amounts of money available for the "rescoped" project (i.e., $26.7 million).

2. The proposed containment site, incorporating the modifications and safeguards described below, is environmentally sound for indefinite storage of PCB-contaminated sediments. The storage of contaminated sediments at the proposed containment site will not cause significant long-term adverse environmental impacts to the surrounding communities.

3. The proposed dredging operation, incorporating the modifications and safeguards described below, will not have significant short- or long-term adverse effects on the surrounding community, downstream water supplies or the ecology of the Hudson River.

4. Removal and in-river containment of substantial quantities of PCB-laden sediments should demonstrate an improvement of tha rate of recovery of the Hudson River.

5. Removal and in-river containment of PCBs from the upper Hudson River will also reduce the risk of:

   - contaminating downriver water supplies caused by high flow conditions
   - public health threats due to excessive volatilization from the river bank areas
   - public health threats due to the consumption of contaminated fish
   - the necessity to close the Hudson River fishery due to high flows after projected reopening
   - permanent closure of the striped bass fishery
   - conducting environmentally unsound maintenance dredging and upland disposal of contaminated sediment from the upper Hudson River and estuary
   - closing navigable waterways both in the upper and lower Hudson River due to the inability to provide adequate upland containment of containment dredge spoil
   - endangering aquatic species, in particular the shortnosed sturgeon

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6. Removal and in-river containment of PCBs from the upper Hudson River is not expected to significantly reduce PCB sediment concentrations in the New York Harbor.

7. As presently proposed by NYSDEC, PCB volatilization caused by the discharge of contaminated dredged sediment into the containment site could exceed the New York State Department of Health (NYSDOH) recommended maximum allowable 24-hour average ambient air PCB concentration at nearby residences and at other sensitive receptors under worst case dissolved PCB concentrations and meteorological conditions. However, the analysis conducted by EPA shows that with mitigation measures presented below, the 1 microgram per cubic meter (ug/cu m) ambient air guideline should not be exceeded.

MODIFICATIONS

The modifications to the original project, as well as to the reduced-scale project referenced above, include changes in the design, operational standards, contingencies, and long-term monitoring and maintenance. These recommendations are consistent with the Congressional intent of Section 10 of the CWA Amendments. The purpose of these modifications is to provide a higher standard of protection for public health, safety, and welfare during dredging and disposal operations and throughout the life of the containment site. Prior to the NEPA decision and granting of federal funds to undertake site construction and dredging, the modifications described below must be fully developed, submitted for public comment, and approved by EPA.

Since neither the original or reduced-scale project contains the specific provisions to carry out financial assurances, contingencies, long-term monitoring, operational standards and procedures, operations and maintenance, or land acquisition, the NYSDEC must obtain firm commitments for additional funding for these provisions from either state or other federal sources prior to project approval. Federal or state matching funds currently appropriated for this project are not sufficient to be used for these purposes. These current funds are to be used only for dredging, site construction and closure, and a monitoring program for only the duration of the project operations. Although there are a substantial number of modifications and additions to the original and reduced-scale projects, most are directed toward long-term elements subsequent to containment site closure, the costs of which are to be borne by New York State. Therefore, the modified project should not substantially reduce the material planned to be removed from the river.

The recommended modifications to the project are specified below under the separate categories of "Dredging, In-River Containment, and Stabilization", "Disposal", "Long-Term Storage", and "Water Quality Monitoring".

Dredging, In-River Containment, and Stabilization

1. Study and make recommendations to maximize in-river containment of hot spots where feasible and cost effective. (This will be studied in detail during the 45-day draft NEPA EIS review period).

2. Cap/in-place stabilization and denial of access of remnant deposits 3 and 5 as an immediate measure.

3. Maximize upriver flow regulation at Sagandaga Dam as a flood control measure during the dredging operation.

4. Develop operational standards and procedures, mitigating measures, monitoring programs, and contingency plans to eliminate excessive volatilization and resuspension of PCB-contaminated sediments to protect workers, residents, agricultural resources, and water supplies.

Disposal

1. Modify disposal operations at the containment site, including the provision for smaller containment cells, addition of PCB adsorbents, and possible cell cover during loading operations to minimize volatilization.

2. Develop operational standards and procedures, contingency plans, and monitor program surrounding the proposed containment site for the duration of the disposal operations to assure the NYSDOH 1 ug/cu m ambient air guideline is met, as well as the 0.2 ug/g (ppm) standard for crops set by the U.S. Food and Drug Administration.

3. Develop specific contingency plans for additional treatment of the supernatant from dewatering prior to discharge if permit limits (to be established) are exceeded.

Long-Term Storage

1. Development of long-term maintenance and monitoring programs for a minimum of 30 years with periodic program review by EPA and NYSDOH.

2. Contingency plans for (a) long-term leachate collection and treatment, (b) landfill cap maintenance, (c) excessive PCB volatilization or methane generation, and (d) alternate water supply should monitoring indicate failure of containment site.

3. The development of grievance and arbitration procedures and the investigation of the feasibility of liability insurance for any claims arising in connection with the public health aspects of the project.

4. Provision for specific funding mechanisms by NYSDEC to assure implementation of long-term contingency plans, operation, maintenance, and monitoring.

5. Redesign of the containment site leachate collection and storage system to improve operations and to avoid clogging and buildup of leachate within the site.

6. Provision for storage of NYSDOT maintenance dredging materials from sites 212, 13, 204 Annex from Washington County only (if removal is deemed necessary), under the condition that the state bear the incremental costs associated with disposal and long-term storage.

Water Quality Monitoring

1. Develop a long-term monitoring program to evaluate the improvement of the recovery rate of the river and fisheries.

2. Develop a long-term monitoring and maintenance program if in-river containment is implemented to determine leaching of PCBs back into the river.

3. Develop a downstream public water supply monitoring program for PCBs and heavy metals to be implemented before, during, and after dredging operations, especially during and shortly after high flows. Contingency plans to provide additional water treatment or alternate water supplies also should be developed.

4. Develop a short-term monitoring program for air quality, water quality, and biota during dredging and disposal operations.

CITIZEN INVOLVEMENT

It is also recommended that if either the full-scale or the reduced-scale project is undertaken, the CAC and the Settlement Advisory Committee (SAC) be continued at least through the operational phase of the project, and beyond if so desired by the respective committees. The committees would serve as a community focal point for the distribution of project information and data and, at the same time, provide oversight and local and technical liaison between the affected communities and the operational and regulatory agencies, including EPA.

The CAC has raised two issues of public concern which should be considered by New York State.

1. NYSDOT should develop a comprehensive PCB dredge spoil disposal plan for the upper Hudson River, also within the same time frame as this proposed project.

2. NYSDEC should consider providing assurances that neither the proposed containment site nor the surrounding land acquired by New York State will be used for the future disposal of any hazardous waste generated from either within or outside Washington County.

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SUPPORTING DOCUMENTS (Available for inspection at designated depositories).

Boyce Thompson Institute for Plant Research, Inc. 1977. An atlas of the biologic resources of the Hudson Estuary. Boyce Thompson Institute for Plant Research, Inc. Yonkers, New York.

Malcolm Pirnie, Inc. 1980. PCB hot spot dredging program, upper Hudson River, New York. Draft environmental impact statement. Prepared for New York State Department of Environmental Conservation, Albany, New York.

New York State Department of Environmental Conservation and United States Fish and Wildlife Service. 1978. Hudson River fish and wildlife report. Hudson River level B study. 27 pp. + appendices.

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CHAPTER 1

INTRODUCTION

1. HISTORY OF THE PCB PROBLEM IN THE HUDSON RIVER

The Hudson River is one of the most heavily PCB-contaminated bodies of water in the United States. The greatest mass of contaminated sediments are located in the upper Hudson River above Troy, New York. However, as a result of sediment migration, the effects of PCBs have now been identified farther downstream. As a result, the affected area now encompasses the Hudson River region from Glens Falls to the New York Bight. A map indicating the geographic location of the project study area is presented in Figure 1-1.

Polychlorinated biphenyls (PCBs) are a class of chemical compounds that have been used in agriculture and industry for decades. Since 1930, PCBs have been principally used in electrical transformers and capacitors but they also have been used in a variety of other products, including lubricants, pesticides, cutting oils, plasticizers, and adhesives.

Malcolm Pirnie, Inc. (MPI, 1980d), reports that during a 30-year period ending in 1977, over 22,700 kilograms (kg) (500,000 pounds [lb]) of PCBs were discharged to the upper Hudson River in the waste stream of two General Electric (GE) capacitor manufacturing plants at Fort Edward and Hudson Falls and from other relatively minor sources. Much of the contaminated material that had accumulated behind the former Fort Edward Dam was released downstream when the dam was removed in 1973 and during subsequent floods. Belatedly, PCBs were recognized as toxic, persistent pollutants. Though ubiquitous in their distribution, they were found in higher concentrations and mass in the Hudson River than were previously known to exist in any other North American body of water (MPI, 1980d).

Theoretically, there are 210 types (homologs) of PCBs. PCBs were available commercially as mixtures (aroclors) of 20 to 75 homolgs and marketed by the weight of chlorine contained in the mixtures. (MPI, 1980d). The composition of the PCBs discharged into the upper Hudson River by GE is reflected by purchase records of the two GE plants (Bopp and others, 1981). Between 1966 and 1970 more than 98 percent of their PCB purchases consisted of Aroclor 1242. In 1971, Aroclor 1242 was replaced with Aroclor 1016, a very similar aroclor. Between 1972 and 1976 more than 99 percent of the purchases were Aroclor 1016. Cumulative purchases between 1966 and 1975 were 68 percent Aroclor 1242 and 31 percent Aroclor 1016 small quantities of Aroclor 1254 were used in the GE plants prior to 1966. A reasonable estimate for the entire period of plant operations is that 1242 comprised 80 percent of total purchases with the remainder principally 1016 and 1254 (Bopp and others, 1981). All three aroclors are now found in the sediments, water column, and biota of the Hudson River (MPI, 1980d).

In a suit brought by New York State Department of Environmental Conservation (NYSDEC) in 1976, GE was found to be largely responsible for the high concentrations of PCBs found in the Hudson River water, sediments, and organisms. As a result, GE was required to reduce its daily discharges of PCBs to 454 grams (g) (1 lb) and to build wastewater treatment facilities at their Hudson Falls and Fort Edward plants. By 1977, daily PCB discharges from the GE plants had been reduced to less than 1 g (0.022 lb) (NYSDEC, 1977a). A brief outline of the history of the PCB problem is listed in Table 1-1.

Much of the PCB-contaminated material that washed downstream after the removal of the Fort Edward Dam concentrated in riverbed sediments from Fort Edward to the Federal Dam at Troy. In some cases, the concentration of PCBs in these sediments exceeds 50 micrograms per gram (ug/g) (50 parts per million [ppm]). These highly contaminated sites have been labeled hot spots. As a result of a survey completed during the summer of 1976, 40 hot spots have been identified in the upper Hudson River. An additional five areas of PCB deposition were exposed to the air when water levels dropped after the Fort Edward dam

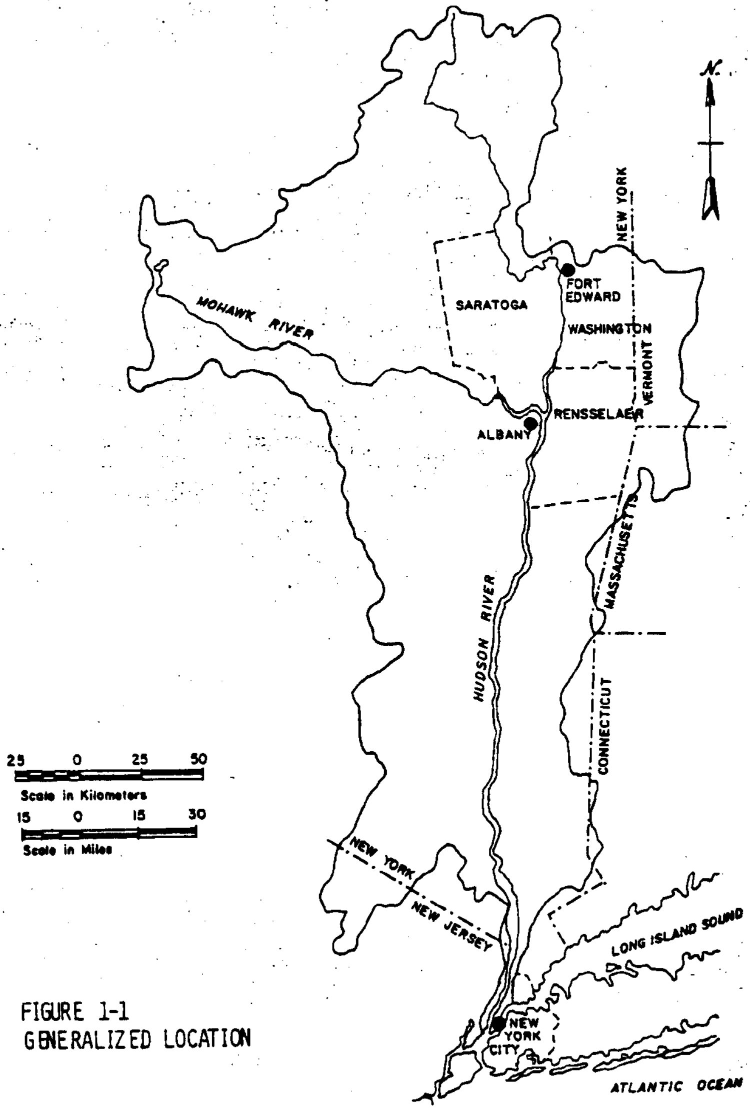

FIGURE 1-1
GENERALIZED LOCATION

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Table 1-1
Major Events in the Hudson River that Pertain to the PCB Problem

Date	Event
1822	Fort Edward Dam completed
1898	Fort Edward Dam reconstructed
1950-1970	Navigational dredging removes an average 17,600 cu m (23,000 cu yd) per year in Fort Edward area
1950-1976	General Electric discharges some 22,700 kg (500,000 lb) PCBs to Hudson River from two capacitor plants in Hudson Falls and Fort Edward
1973 (July-October)	Fort Edward Dam removed because its condition is deteriorating
1973-1974 (July-July)	650,000 cum (850,000 cu yd) are scoured from former dam pool and 604,000 cu m (790,000 cu yd) deposited in east and west channels near Rogers Island
1973 (Spring)	22,900 cu m (30,000 cu yd) dredged by contractor to Scott Paper Company
1974-1975	470,200 cu m (615,000 cu yd) dredged by NYSDOT from east and west channels near Rogers Island
1974-1975 (October-July)	Timber rock cribs removed; rock placed to stabalize remnant deposits 3 and 4; banks shaped; dumped rock stabilizes remnant deposit 5
1976 (April 2)	100-year flood occurs; additional 198,800 cu m (26,800 cu yd) scoured from unstabilized areas in former dam pool
1976 (September)	General Electric reduces daily PCB discharges to 454 g (1lb) PCBs into Hudson River from the capacitor plants in Hudson Falls and Fort Edward
1976	26,800 cu m (35,000 cu yd) dredged in the vicinity of of buoy 212 by NYSDOT; fishery closed
1977 (July)	General Electric reduces daily PCB discharges to less than 1 g (0.022 lb) PCBs into Hudson River from two capacitor plants in Hudson Falls and Fort Edward
1977 (September-December) 1978 (April-June)	37,600 cu m (180,000 cu yd) dredged from east channel and placed in new Moreau site

Table 1-1 (continued)

Date	Event
1978 (June-August)	Banks of remnant deposits 3 and 5 restabilized
1978 (October)	10,750 cu m (14,000 cu yd) excavated from remnant deposit 3a and moved to Moreau site

Note: Place names referred to in this table may be located on Plates 1 and 2 of this report.

Source: MPI, 1980d

was removed. A portion of one of these five remnant areas was removed by NYSDEC in October 1978, and deposited in the new Moreau landfill. At present five remnant areas remain in the Fort Edward area and may be contributing to PCB contamination of the Hudson River and the ambient air. The locations of the identified hot spots and remnant areas are shown on Plates 1 and 2.

In addition to the hot spots and remnant areas, several landfills and New York State Department of Transportation (NYSDOT) dredge disposal sites in the area are known to contain PCBs and may contribute to PCB levels in the Hudson River and the air. Other as yet unidentified sources of PCB contamination may also exist.

2. PURPOSE OF AND NEED FOR THE PROJECT

PCBs have several characteristics that make them toxic to animals, including human beings. They collect (bioaccumulate) and concentrate (biomagnify) in the fatty tissue of all organisms (e.g., the amount of PCBs in a fish can be many times greater then the amount in the surrounding water). Because they are chemically stable compounds, they persist in the environment for many years. They have been shown experimentally to have a wide range of toxic effects. In addition to the health effects associated with PCBs, toxic impurities such as polychlorinated dibenzofurans (PCDFs) and chlorinated napthalenes are often closely associated with PCBs (MPI, 1980d). The presence of these impurities amplifies the PCB problem (Appendix A).

The presence of PCBs, as well as heavy metals in the sediments of the upper Hudson River, poses a potential health risk to humans and other organisms from three principal sources:

- drinking contaminated water
- eating contaminated food
- breathing contaminated air

2a. Drinking Water

Several communities obtain their drinking water from the Hudson River. These communities include the Village of Waterford, Port Ewen Water District, the Village of Rhinebeck, the City of Poughkeepsie, and the Highland Water District. In addition, several municipalities, such as Stillwater and Green Island, draw water from infiltration galleries located along the upper Hudson River. Many households draw water from wells located close to the Hudson River.

The U.S. Geological Survey (USGS) maintains five gaging stations in the upper Hudson River at Glens Falls, Rogers Island, Schuylerville, Stillwater, and Waterford (MPI, 1980d). At the Glens Falls gaging station, located above the GE plants, concentrations of PCBs are usually below the detectable level of 0.1 micrograms per liter (ug/l) (0.1 parts per billion [ppb]) (Tofflemire, NYSDEC, 1980). From 1976 to 1979 the average concentrations at Schuylerville and Stillwater ranged from 0.568 ug/l (ppb) to 0.687 ug/l (ppb) (Tofflemire, 1980). However, where suitable treatment facilities are available, PCBs can be removed from river water, leaving it suitable for drinking. As shown by tests conducted in 1972 by the City of Poughkeepsie, PCB levels in Hudson River water can be reduced by 40 to 80 percent through activated carbon filtration (Cranston, 1977). This removal rate resulted in PCB concentrations in the treated water below the maximum level of 1.0 ug/l (ppb) presently recommended by the New York State Department of Health (NYSDOH). At present there are no PCB standards in either the federal or state drinking water regulations.

2b. Food

As mentioned previously, a characteristic of PCBs that makes them dangerous to humans and other animals is that they collect and concentrate in the fatty tissues and the fatty portions of blood and milk. This characteristic causes PCBs to appear in relatively high concentrations in meat, fish, and poultry products.

Comprehensive human food monitoring data on PCB levels are not available for the Hudson River area. However, the U.S. Food and Drug Administration (FDA) conducts an annual comprehensive food surveillance program to determine the concentrations of pesticide residues, PCBs, heavy metals, and other contaminants in the diets of U.S. consumers. Data for the period from 1969 to 1977 indicate that during this period the total daily intake of PCBs per person dropped from 15.0 to 8.7 micrograms per day (ug/d). However, intake of PCBs from the meat-fish-poultry categorize changed little (9.5 to 8.1 ug/d). The decrease of PCBs in total diet is attributable to decreasing levels of PCBs in food packaging material after 1974 (USEPA, 1976b).

The present FDA standards for PCB in food are:

Milk fat and dairy products	1.5 ug/g (ppm)
Poultry	3.0 ug/g (ppm)
Eggs	0.3 ug/g (ppm)
Fish and shellfish	5.0 ug/g (ppm)
Finished animal feed (including hay)	0.2 ug/g (ppm)

Since the FDA data indicate that the meat-fish-poultry category is primarily responsible for dietary intake of PCBs, the possible local exposure to PCBs resulting from the opening of the fishery in the upper Hudson River must be considered. The FDA data on PCB concentrations in fish ranged from trace levels to 0.05 ug/l (ppm); the data on PCB levels in fish from the the upper Hudson River indicate levels ranging up to 500 ug/l (ppm) (Thomann and St. John, 1979). Some illegal commercial fishing and some subsistence fishing are believed to take place in the upper Hudson River despite the NYSDEC ban. Populations along the Hudson River that do not consume fish taken directly from the river are expected to be exposed to at least 9 ug/d of PCBs through injestion of food. This figure represents the national background level estimated by EPA. Consumption of Hudson River fish with PCB levels at the 5 ug/g (ppm) FDA standard could increase this amount by 100 times to approximately 900 ug/d (Appendix A).

2c. Air

PCBs volatilize, or escape into the air, from a variety of sources including plastics, gas lines, and oils. For example, the average PCB concentration in a kitchen has been reported at 0.32 micrograms per cubic meter (ug/cu m) (USEPA, 1976b). The populace in Fort Edward and Hudson Falls is exposed to a general background concentration of 0.05 to 0.10 ug/cu m (Kerr, NYSDEC, May 8, 1980), and the rural populace is exposed to concentrations of less than 0.01 ug/cu m (Buckley, Boyce Thompson Institute for Plant Research, Inc. [BTI], April 9, 1981). These exposure levels are due to PCB volatilization from the river, remnant deposits and disposal sites. Residents of the upper Hudson River are therefore exposed to between 0.7 to 4.6 ug/d of PCBs, depending on the amount of time an individual spends indoors (Appendix A). Residents adjacent to existing dumpsites containing PCBs could be exposed to greater levels.

In 1977, the National Institute of Occupational Safety and Health (NIOSH) proposed an 8-hour (hr) maximum allowable PCB exposure in air of 1 ug/cu m. The existing Occupational Safety and Health Administration (OSHA) standard for 8-hour maximum allowable PCB exposure in air is 500 ug/cu m. However, these standards refer to industrial situations and are therefore not directly applicable to outdoor ambient air conditions. In a letter dated March 25, 1981, NYSDOH recommended that "...the 24 hour average PCB concentrations in the ambient air at occupied residences and other sensitive receptors...do not exceed 1 ug/cu m" (Appendix I).

2d. Health Effects

PCBs have been associated with a variety of adverse health effects (World Health Organization [WHO], 1976). Studies performed with rats, mice, and monkeys revealed that various types of toxicity are associated with PCBs, including liver damage, reproduction effects, skin disturbances, and cancer. Although most of these data are available for species other than humans, humans appear to be the species most sensitive to PCBs (WHO, 1976).

Considerable study has been given to an incident that occurred in 1968 in Japan. Rice oil contaminated with PCBs was consumed by the general populace (WHO, 1976). Health effects included chloracne, increased pigmentation of the skin, increased eye discharge, visual disturbances, weakness, numbness, headachas, and liver dysfunction. Babies born to exposed mothers during this time were smaller than average and had skin discoloration. By May of 1975 a total of

1,291 related disease cases were reported. However, it was discovered than an extremely toxic impurity, PCDF, was present in the contaminated oil and that this may have been responsible for some or all of the toxic effects. Rhesus monkeys exposed to pure PCBs at levels similar to those in the rice oil, however, developed similar symptoms (Allen and others, 1974).

Health effects specific to PCB exposure have been documented for industrial workers involved in the direct manufacture or use of PCBs. These effects include chloracne, fatigue, headaches, numbness of limbs, and swelling of joints (Matthews and others, 1979). However, PCB effects on the general population from environmental exposure have not been well documented (MPI, 1980d). Health effects of exposure to PCBs are discussed in more detail in Appendix A.

2e. Routine Maintenance Dredging

The regulations pursuant to the Toxic Substances Control Act (TSCA) of 1976 require that special precautions for upland disposal be provided for those substances, such as sediments and liquids, contaminated by greater than 50 ug/g (ppm) of PCBs. Based on required procedures for determining the disposal options for the dredge spoils obtained through normal channel maintenance operations in the lower Hudson River, the presence of concentrations of PCBs greater than 4 ug/g (ppm) could make ocean disposal infeasible in the future (Curll, Save Our Ports, March 24, 1981). Therefore, the PCB-contaminated sediments in the Hudson River, as discussed above, have the potential for imposing severe economic hardships on upper and lower Hudson River communities that depend on dredging to keep ports operating and channels navigable.

2f. Hudson River Fishery

The Hudson River fishery resource is of considerable local and regional importance. It serves as a commercial and recreational fishery as well as a major spawning area for fishes of the eastern Atlantic. Sheppard (1976) estimated that the Hudson River could potentially produce an annual commercial finfish catch of 600,000 to 900,000 kg (1,240,000 to 1,960,000 lb), worth $261,000 to $426,500 (in 1976 dollars).

The recreational fishery in the upper Hudson River is presently closed because of PCB contamination. In 1976, Sheppard estimated that the upper Hudson River could potentially support 100,000 man-days of fishing (angler days), which, at an average angler expenditure of $12.50 per day, would be worth $1,250,000 annually (in 1976 dollars). The recreational value of the lower Hudson River fishery is currently on the order of $1,350,000 annually. Sheppard (1976) estimates that the lower Hudson River may potentially provide over of a million angler days of recreational fishing annually, worth over $12,500,000 (in 1976 dollars).

3. CONGRESSIONAL ACTION

In September 1980, Congress recognized the existing PCB problem in the Hudson River by passing an amendment to the Clean Water Act (CWA) under Title I, Section 116(a) and (b), entitled the "Hudson River PCB Reclamation Demonstration Project". Funds for this project have been appropriated under Title II, Section 205(a) of the CWA. Under this legislation, the United States Environmental Protection Agency (EPA) is authorized to expend up to $20,000,000 toward a proposed demonstration reclamation project to remove and dispose of PCB-contaminated sediments from the Hudson River. The amendment reads as follows:

> Sec. 116. (a) The Administrator is authorized to enter into contracts and other agreements with the State of New York to carry out a project to demonstrate methods for the selective removal of polychlorinated biphenyls contaminating bottom sediments of the Hudson River, treating such sediments as required, burying such sediments in secure landfills and installing monitoring systems for such landfills. Such demonstration project shall be for the purpose of determining the feasibility of indefinite storage in secure landfills of toxic substances and of ascertaining the improvement of the rate of recovery of a toxic contaminated national waterway. No pollutants removed pursuant to this paragraph shall be placed in any landfill unless the Administrator first determines that disposal of the pollutants in such landfill would provide a higher standard of protection of the public health, safety, and welfare than disposal of such pollutants by any other method including, but not limited to, incineration or a chemical destruction process.
>
> (b) The Administrator is authorized to make grants to the State of New York to carry out this section from funds allotted to such State under Section 205(a) of this Act, except that the amount of any such grant shall be made on condition that non-Federal sources provide the remainder of the cost of such project. The authority of this

section shall be available until September 30, 1983. Funds allotted to the State of New York under Section 205(a) shall be available under this subsection only to the extent that funds are not available, as determined by the Administrator, to the State of New York for the work authorized by this section under Section 115 or 311 of this Act or a comprehensive hazardous substance response and clean up fund. Any funds used under the authority of this subsection shall be deducted from any estimate of the needs of the State of New York prepared under Section 516(b) of this Act. The Administrator may not obligate or expend more than $20,000,000 to carry out this Section.

4. ACTIONS PROPOSED BY THE NYSDEC

As a result of enforcement action taken by the NYSDEC against GE and a subsequent settlement, NYSDEC spent approximately $3,000,000 to investigate the PCB contamination problem in the Hudson River. These studies described the extent of PCB contamination and proposed methods to reduce and remove the threat of continued PCB contamination of the Hudson River. The culmination of this effort was the issuance of a draft State Environmental Quality Review Act (SEQRA) Environmental Impact Statement (EIS) prepared by MPI (1980d).

The alternative originally recommended by NYSDEC in the draft SEQRA EIS (MPI, 1980d) included the following components:

- dredging of 40 hot spot areas in the river bed with containment in a secure upland site
- design and construction of a secure upland containment site capable of long-term isolation of contaminated material
- excavation of remnant deposits 3 and 5, located above the former Fort Edward Dam site, and removal to the upland containment site
- provision for containment of material from three PCB-contaminated dumpsites in the Fort Edward area should removal be found more suitable than in-place containment
- provision for containment of contaminated material from three NYSDOT dredge spoil sites
- destruction of the recovered PCBs at such time as a technically and economically feasible procedure becomes available

In arriving at their recommended alternative, NYSDEC and its consultant, MPI, first examined the feasibility of several alternative methods of managing

Table 1-2

Methods of Managing PCB-Contaminated Sediments in the Hudson River

Alternatives	Status of Technologic Development	Potential Constraints or Environmental Problems
In-Situ Control		
Degradation by ultraviolet ozonation	Developed for closed system applications	Treatment requires closed reaction vessel
Chemical treatment	Conceptual	Possible ecological side effects
Erosion control of river bottom	Conceptual	Interference with navigation
Covering PCB-contaminated sediments	Conceptual	Massive disturbance of ecosystem. Rupture of seal or ballooning of plastic due to gas formation. Placement and stabilization of cover difficult
Removal		
Bioharvesting	Conceptual	The time and costs involved with harvesting enough fish are prohibitive. Tremendous ecological side effects
Activated carbon adsorption	Laboratory	Technology for application and retrieval has not been proposed
Dredging	Demonstrated on small scale, Fort Edward Channel	Untested on a large scale

Table 1-2
(Continued)

Methods of Managing PCB-Contaminated Sediments
in the Hudson River

Alternatives	Status of Technologic Development	Potential Constraints or Environmental Problems
On Land Control		
Containment in disposal site	Demonstrated at new Moreau site	Lont-term monitoring and maintenance
Incineration	Demonstrated on small scale	Large scale incinerator, extensive use of fuel, wet sediments
Chemical detoxification	Laboratory	Best results with high PCB concentrations
Biodegradation	Laboratory	Aerobic reaction only, with potential undesirable byproducts

Source: MPI, 1980d

PCB-contaminated sediments in the Hudson River, including the ultimately recommended dredge and encapsulation alternative. These alternatives are summarized in Table 1-2. Most of them, however, are somewhat conceptual in nature and therefore would require several years of research and field demonstration before they could be implemented. Hence, they failed to satisfy the dominant criterion that led to the selection of the more feasible solution of hot spot dredging, transport, and encapsulation: the need to remove PCBs as quickly as possible from the river bottom in order to avoid downstream dispersal during flood flows.

Once NYSDEC concluded that dredging presented the most feasible means of hot spot management, alternative dredging programs, various types of dredge equipment, alternative remnant deposit excavation programs, candidate containment sites, and various mitigation measures for maximizing long-term isolation of PCB-contaminated material at the containment site were evaluated. The draft SEQRA EIS and its supporting documents indicate that these components of the recommended alternative would result in the containment of 40 to 50 percent of the PCB estimated to be in the upper Hudson River. The following sections briefly describe each of the components of the alternative recommended by the NYSDEC.

4a. Dredging

The dredging operation would be preceded by an extensive sampling program to specify further the exact locations and concentrations of PCB hot spots. A combination of clamshell and hydraulic dredging, depending on distance from the containment site, would then be used to remove the 40 hot spots from the river bottom (Plates 1 and 2). Modifications to the equipment would be made to limit the escape of contaminated dredge spoils back into the river. Again, depending on the distance, the dredge spoil would either be pumped out hydraulically or be transported by barge to the containment site.

4b. Remnant Excavation

Two of the remnant deposits that have accumulated behind the former Fort Edward Dam would be excavated and their material transported to the containment site. It was decided to excavate portions of remnant areas 3 and 5, which contain the highest PCB levels, after evaluating various partial removal, in-place encapsulation, and no-action alternatives for the remnant sites.

4c. Containment Site

A 100-hectare (ha) (250-acre [a]) containment site (Site 10), located 4 kilometers (km) (2.5 miles [mi]) south of the Village of Fort Edward, was selected on the basis of size, clayey subsoil, accessibility, and environmental and socioeconomic factors (Plate 3). A single site, rather than multiple sites, was identified in order to realize economies of scale, to limit contaminated material to a single location, and to reduce the amount of land needed for buffer areas. The proposed site, which in addition to the containment area includes a roughing and storage pond, surge pond, pump station, treatment plant, and leachate collection and stormwater drainage systems, would be fenced to restrict public access, and a clay cover would be installed over the containment area to reduce infiltration, erosion, and volatilization. The proposed cover consists of a 46-centimeter (cm) (18-inch [in]) thick layer of clay overlain by gravel, topsoil, and a shallow-rooted vegetative groundcover.

4d. Mitigating Measures

Various measures aimed at mitigating adverse environmental impacts at each step of NYSDEC's recommended alternative are described in Chapter 9 of the draft SEQRA EIS (MPI, 1980d). Of particular interest are the long-term maintenance and moitoring activities proposed for the containment site and its environs. Maintenance would include leachate collection, cap repairs, reseeding, mowing, application of lime, and repair of drainage ditches. Monitoring includes groundwater sampling, inspection of cap and cover crop, and sampling of cover crop and adjacent vegetation for PCB contamination.

5. RESCOPING OF THE RECOMMENDED ALTERNATIVE

Cost estimates for the alternative originally recommended by NYSDEC calculated for base year 1979 and escalated for inflation over a 3-year implementation period, are shown in Table 1-3. The estimated total cost of the

Table 1-3

Estimated Program Costs

(Thousand Dollars)

Phase	Base Year 1979	1980	1981[4]	1982[4]	1983[4]
Site Construction	$2259[1]	$2711[2]	$2982		
Thompson Island Pool Dredging	4847	6011[3]		$7272	
Remnant Pool Deposits Removal	1698	2106[3]		2548	
Lock 5 - Lock 6 Hot Spots Dredging	2982	3698[3]			$4922
Locks 2, 3 & 4 Hot Spots Dredging	3359	4165[3]			5040
Sub-Total			$2982	$9820	$9962
Contingencies			796	2664	2712
Engineering Design			278	930	1018
Field Engineering & Construction Administration			384	1062	1493
Legal & Administrative			69	257	293
Totals By Year			$4509	$14733	$15478
Total For Project				$34,720	
Scientific, Engineering, Monitoring & Administrative Costs 9/76-3/80				3,480	
Scientific, Monitoring & Administrative Estimated 4/80-3/83				1,800	
				$40,000	

Notes:

1. Includes site work costs for all phases
2. Escalated 20 percent
3. Escalated 24 percent
4. Escalated 10 percent/year

Source: MPI, 1980d

project is $40,000,000. This amount is twice the level of federal funding authorized by Congress in October 1980, under amendments to the CWA for the Hudson River Reclamation Demonstration Project. As a result, the recommended project was rescoped (scaled down) by NYSDEC to bring it within the total funding available at the present time -- $20,000,000 of federal monies and $6,700,000 of New York State monies.

The following criteria were used for the rescoping:

- maximization of PCB removal from the Hudson River
- program performance
- cost-effectiveness
- avoidance of wetlands
- flexibility

Using these criteria, the NYSDEC proposed the following modifications to the original project:

- deletion of remnant deposit relocation and containment
- provision of top dressing and fencing for remnant areas 3 and 5.
- deletion of provision for NYSDOT spoil areas containment
- elimination of provision for the containment of PCB-contaminated dumps
- reduction of the number of hot spots to be dredged
- reduction of capacity at the containment site
- reduction in the scope of research studies

Reduction in the capacity of the containment site would result from reductions in the volume of material to be encapsulated, as well as a refined definition of materials handling requirements at the site. The reduced dredging program is justified by NYSDEC on the basis that lower pool hot spots are more expensive to recover, while containing less than one quarter of the PCBs (and at a generally lower concentration) than PCBs found in the Thompson Island Pool. Furthermore, lower pool hot spots, some of which are associated with wetlands, are further from the proposed containment site and therefore more costly to transport and encapsulate upland.

6. ACTION BY EPA

With the passage of the Section 10 amendments to the CWA in October 1980, Congress authorized EPA to make grants to the NYSDEC to carry out the intent of the Hudson River PCB Reclamation Demonstration Project. The intent of the legislation is discussed above (Section 3).

On January 12, 1981, EPA Region II issued a Notice of Intent (NOI) to prepare an EIS in accordance with the National Environmental Policy Act (NEPA). The purpose of NEPA is to identify and analyze significant impacts on the quality of the human environment that may result from the federal funding of a proposed action; in this case, the proposed dredging, disposal, and storage activities associated with the Hudson River PCB problem.

In addition, the NEPA EIS decision-making process provided the forum for soliciting public comment on the proposed project by conducting a series of public meetings and hearings and by the formation of a Citizens Advisory Committee (CAC).

7. PERMITS

State and Federal permits which would be required for the dredge, fill, and discharge operations are enumerated below. Additional information regarding State and Federal permits is presented in Appendix B of the SEQRA EIS (MPI, 1980d).

7a. State

360 Permit

A complete application for a construction permit pursuant to the New York State Solid Waste Management Facilities Rules must be submitted to NYSDEC for the purpose of constructing a solid waste management facility.

Article 24

In accordance with recommendations of W.A. Huermann, Region 5W, Bureau of Regulatory Affairs, a Freshwater Wetlands Permit will be required to construct Site 10 and to dredge the river near hotspot No. 18 and hot spot No. 39.

364 Permit

If trucking is required for the removal and transport of contaminated material from the remmnant deposits, the contractor must secure a permit pursuant to the rules governing Collection and Transport of Industrial - Commercial and Certain Other Wastes.

State Pollution Discharge Elimination System

A SPDES permit will be required for the discharge from the containment site.

Streambed Disturbance Permit

This permit will not be required since the state is the applicant for this project.

New York State Siting Board

A certificate of Environmental Safety and Public Necessity must be issued by the Hazardous Waste Facilities Siting Board.

7b. Federal

Toxic Substance Control Act

A PCB disposal approval must be issued for this project by the EPA Regional Adminstrator.

The Clean Water Act: Section 404

This permit will be required by the U.S. Army Corps of Engineers (USACOE) if the discharge from the containment area is into navigable waters or adjacent wetlands of the United States.

River and Harbor Act: Section 10

This permit will be required by the USACOE for dredging in navigable waters.

8. PCB STANDARDS AND RECOMMENDATIONS

The PCB standards and recommendations promulgated by state and federal agencies are summarized in Table 1-4.

Table 1-4

PCB STANDARDS AND RECOMMENDATIONS

Source of Intake	Maximum Allowable PCBs
Food (FDA standards)	
Milk fat and dairy products	1.5 ug/g (ppm)
Poultry	3.0 ug/g (ppm)
Eggs	0.3 ug/g (ppm)
Fish and shellfish	5.0 ug/g (ppm)[1]
Finished animal feed (including hay)	0.2 ug/g (ppm)
Drinking Water (NYSDOH recommendation)	1.0 ug/l (ppb)
Ambient Air	
Occupied residences and other sensitive receptors (NYSDOH recommendation)	1.0 ug/cu m [2]
Worksite (OSHA standard)	500 ug/cu m [3]
Workside (NIOSH recommendation)	1.0 ug/cu m [3]

Note: 1. Proposed FDA revision to 2.0 ug/g (ppm)

2. 24-hour average; applicable to Hudson River reclamation project only (Appendix I)

3. 24-hour average; if exceeded, respirators are required

CHAPTER 2

ALTERNATIVES CONSIDERED

This chapter presents a further evaluation and discussion of the alternatives that NYSDEC offered in its draft SEQRA EIS, as well as additional alternatives investigated by EPA in addressing the PCB problem in the Hudson River. In some cases, a major alternative is comprised of a number of components. Table 2-1 lists the major alternatives and components being examined. Each major alternative and its respective components are discussed in the following sections.

I. MAJOR ALTERNATIVES

1. THE NO-ACTION ALTERNATIVE

This EIS is being prepared in accordance with NEPA. Of great importance in the NEPA EIS process is the evaluation of the no-action alternative. The no-action alternative is typically an alternative not to fund any proposal (as for example, the PCB dredging project proposed by NYSDEC) and includes a consideration of what may happen in the project area if no action is taken. The impacts of the no-action alternative in this case depend on two options: the continuation of routine channel maintenance dredging or the cessation of it. The effects of these options on the no-action alternative are discussed below.

1A. No-Action Alternative (Assuming That Routine Channel Maintenance Dredging will Continue)

The no-action alternative includes no work beyond routine channel maintenance dredging. If routine channel maintenance dredging continued over the next 10 years, it would remove an estimated 2,300 kg per year (5,000 lb/yr) of PCBs, or an estimated 15 percent of the PCBs present in the upper Hudson River bed (Hetling and others, 1978).

Based on WAPORA's evaluation of the upper Hudson River PCB No-Action Alternative Study (Lawler, Matuskey, and Skelly [LMS], 1978) presented in Appendix C, the results of the LMS model can be considered as the best available estimates of average annual PCB loadings from the upper Hudson River to the

Table 2-1

Major Alternatives and Alternative Components

I. MAJOR ALTERNATIVES

1. THE NO-ACTION ALTERNATIVE
   - 1A. Assuming that routine channel maintenance dredging will continue
   - 1B. Assuming that routine channel maintenance dredging will be halted

2. CONTROL OF RIVER FLOWS

3. IN-RIVER DETOXIFICATION
   - 3A. Degradation by ultraviolet ozonation
   - 3B. Chemical treatment
   - 3C. Bioharvesting
   - 3D. Activated carbon adsorption

4. DREDGING ALTERNATIVES--THE FULL-SCALE PROJECT

5. DREDGING ALTERNATIVES--THE REDUCED-SCALE PROJECT

6. BANK-TO-BANK DREDGING PROJECT

II. ALTERNATIVE COMPONENTS

1. IN-RIVER CONTAINMENT (as an alternative to dredging))

2. REMNANT DEPOSIT ALTERNATIVES
   - 2A. No-action
   - 2B. Denial of access
   - 2C. In-place containment
   - 2D. Complete or partial removal
   - 2E. Transportation alternatives

3. IN-RIVER DREDGING MECHANISMS
   - 3A. Clamshell dredging/mechanical unloading
   - 3B. Clamshell dredging/hydraulic pumpout unloading
   - 3C. Hydraulic dredging and transport
   - 3D. Other dredging systems

4. DREDGE SPOIL DISPOSAL
   - 4A. Detoxification
     - physical destruction through incineration
     - chemical treatment
     - biodegradation
   - 4B. Containment in upland disposal sites
     - dewatering by gravity
     - dewatering by mechanical methods

III. SELECTION OF THE RECOMMENDED ACTION

1. RECOMMENDED ACTION

2. FINDINGS

3. MODIFICATIONS

4. CITIZEN INVOLVEMENT

MONS 009799

estuary at Troy. It is important to note that, while the LMS model adequately reflects the effects of short duration high flows on increasing PCB transport, it does not take into account volatilization of PCBs nor routine maintenance dredging. PCBs are currently volatilizing from the upper Hudson River water at an estimated rate of 1,350 kg/yr (3,000 lb/yr) (Shen and Tofflemire, 1979). Adjusting the LMS model for a 35-yr average annual volatilization rate of 680 kg/yr (1,500 lb/yr) of PCBs from the upper Hudson River and assuming a 35-yr average routine dredging removal rate of 1,100 kg/yr (2,500 lb/yr) of PCBs from the upper Hudson River, the no-action alternative would result in the transport of 82,800 kg (182,000 lb) of PCBs into the estuary over the next 33 years, where they would be essentially unrecoverable (Table 2-2). During this period, 37,500 kg (82,500 lb) of PCBs would have been removed from the upper Hudson River by routine channel maintenance dredging, and 22,500 kg (49,500 lb) of PCBs would have been volatilized.

The estuarine portion of the river below the Federal Dam is estimated to contain 75,700 kg (167,000 lb) of PCBs (Bopp, 1979; Bopp and others, 1981). New York Harbor is considered to have the greatest mass of PCBs below the dam, totaling 23,100 kg (51,000 lb) at an average concentration of 3 ug/g (ppm) (MPI, 1980d). This mass of PCBs in New York Harbor is 31 percent of the PCB load below the Federal Dam. Bopp (1979) estimates that over the past 20 years, 1,800 kg/yr (4,000 lb/yr) of PCBs have been dredged from the harbor and that 70 to 75 percent of the harbor's PCBs originated from discharges to the upper Hudson River. Applying the results indicated in Table 2-2 and assuming that 1,800 kg/yr (4,000 lb/yr) of PCBs are dredged from New York Harbor and that a maximum of 31 percent of the PCB load at Troy enters New York Harbor, the average PCB concentration in the harbor sediments would decline by approximately 2 ug/g by the year 2000. (If it were assumed that 100 percent of the PCB load at Troy enters New York Harbor, the average PCB concentration in the harbor sediments would double to approximately 6.0 ug/g (ppm) by the year 2013.) The average PCB concentration in Albany turning basin sediments is higher than in New York Harbor sediments. Much of the PCB load at Troy settles in the turning basin, causing the PCB concentrations to continue to increase until the year 2013. The bioassay matrix presently used by

Table 2-2

PCB Transport: No-Action Alternative
(with Navigational Dredging and Volatilization)[1]

Period	Average Annual PCB Load at Troy[2] kg/yr (lb/yr)	Condition
1977 to 1978	3,600 (8,000)	Before remnant deposit actions
1979 to 1994	3,270 (7,200)[3]	16 years to exhaust supply above Lock 7
1995 to 2013	1,950 (4,300)	19 years to exhaust supply between Lock 7 and Troy
After 2013	0 (0)	Supply exhausted above Troy
1981 to 2013: 82,800 kg (182,000 lb) of PCBs transported into estuary.		

Notes: 1. Assumes volatilization rate of 680 kg/yr (1,500 lb/yr) of PCBs from upper Hudson River. This rate is the average volatilization between 1981 and whatever year no PCBs remain in the upper Hudson River, or 1/2 the current volatilization rate.

Assumes routine navigational channel maintenance dredging of 1,100 kg/yr (2,500 lb/yr) of PCBs. This removal rate is the average rate between 1981 and whatever year no PCBs remain in the upper Hudson River, or 1/2 the current removal rate.

2. Loadings do not reflect yearly fluctuations of river discharges and variations of the PCB mass transported.

3. Assumes contribution from remnant deposits is negligible.

EPA and the USACOE for determining the viability of ocean disposal of PCB-contaminated sediments suggests that 4 ug/g (ppm) may be the highest acceptable PCB level for ocean disposal (Curll, Save Our Ports, March 24, 1981). PCB hot spots also contain high levels of certain heavy metals which would further interfere with ocean disposal of dredge spoils.

Most PCB transport occurs during short duration high flows, not average flows. (For quantitative analysis of high flows, see section 2 of this chapter.) During very high upper Hudson River flows, substantial loadings of PCB will move rapidly downstream. Although the LMS model (and the refinements of it presented in Table 2-2) considers short duration high flows, it does not consider the effects of uneven downstream deposition of PCB sediments. Deposition near a potable water intake could threaten that supply. Deposition on a spawning ground could threaten a species. Deposition in a navigational channel or docking area could prevent disposal of dredge spoils in the ocean and require additional upland containment sites for upper and lower Hudson River maintenance dredging activities.

A problem that exists under any alternative until the fishery is reopened is the health risk posed by illegal commercial fishing and subsistence fishing. The no-action alternative would leave all the PCB sediments in the river, from which fish will accumulate PCBs. When the commercial fishery is legally reopened, PCDFs in cooked fish may continue to pose a substantial health risk. PCDFs, which may be more concentrated in cooked fish than in raw fish, are 200 to 500 times more toxic than PCBs (FDA, 1979).

The no-action alternative described above does not require a containment site. However, this does not preclude the possible need for containment sites in the future to dispose of PCB contaminated sediments from maintenance dredging operations if dredging were to continue.

1B. <u>No-Action Alternative (Assuming That Routine Channel Maintenance Dredging Will be Halted)</u>

This alternative corresponds to the no-action alternative presented in the draft SEQRA EIS (MPI, 1980d) and in the Upper Hudson River PCB No-Action Alternative Study (LMS, 1978). It assumes that routine channel maintenance dredging in the upper Hudson River will be halted.

Adjusting the LMS model presented in the draft SEQRA EIS for a 50-yr average annual volatilization rate of 680 kg/yr (1,500 lb/yr) of PCBs from the upper Hudson River, the no-action alternative would result in the transport of 112,000 kg (247,000 lb) of PCBs into the estuary over the next 48 years, where they would be essentially unrecoverable (Table 2-3). During this period, 325,600 kg (72,000 lb) of PCBs would be volatilized from the upper Hudson River. The average PCB concentration in New York Harbor sediments would not increase, but the levels in Albany turning basin sediments would continue to increase until the year 2028.

This analysis indicates that if dredging were halted, 36 percent more PCBs would be transported into the estuary than if dredging continued. In addition, if dredging were halted, PCB transport would continue until the year 2028 rather than the year 2013. This alternative will have greater negative impacts than the preceding no-action alternative. In addition to the adverse impacts resulting from PCB-contaminated sediments remaining in the river, substantial adverse impacts on the regional economy will result if routine maintenance dredging is halted.

2. CONTROL OF RIVER FLOWS

Evaluation of the no-action alternative indicated that resuspension of PCB-contaminated sediments and migration of PCB hot spots occur repeatedly during high river flows and that such movements of PCBs pose long-term risks to (1) potable water supplies downstream, (2) the commercial fishery, (3) aquatic and wetland biota, (4) the population of shortnose sturgeon, an endangered species, and (5) future disposal of channel maintenance dredge spoils from the estuary. This conclusion suggested an alternative that had not been considered in the draft SEQRA EIS (MPI, 1980d) or in the rescoping report (Appendix B): control of high river flows. The new alternative entails controlling upper Hudson River flows from one source, the Great Sagandaga Lake at the Conklingville

Table 2-3

PCB Transport: No Routine Maintenance Dredging
(with Volatilization)[1]

Period	Average Annual PCB Load at Troy[2] kg/yr (lb/yr)	Condition
1977 to 1978	3,600 (8,000)	Before remnant deposit actions
1979 to 1994	3,270 (7,200)[3]	16 years to exhaust supply above Lock 7
1995 to 2028	1,950 (4,300)	34 additional years to exhaust supply between Lock 7 and Troy
After 2028	0 (0)	Supply exhausted above Troy
1981 to 2028: 112,000 kg (247,000 lb) of PCB transported into estuary.		

Notes: 1. Assumes volatilization rate of 680 kg/yr (1,500 lb/yr) of PCBs from Upper Hudson River. This rate is the average volatilization between 1981 and whatever year no PCBs remain in the upper Hudson River, or 1/2 the current volatilization rate.

2. Loadings do not reflect yearly fluctuations of river discharges and variations of the PCB mass transported.

3. Assumes contribution from remnant deposits is negligible.

Dam, where a substantial flow enters the upper Hudson River. However, the major water source of the Hudson River enters from Lake Luzerne at Hadley. Additional inflows from runoff, creeks, and groundwater enter the river between the Sagandaga-Hudson confluence and Fort Edward. Table 2-4 compares the flow contributions from these sources during average flows and during the 100-year flood that occurred on April 2, 1976.

Since 1977, the USGS has operated PCB monitoring stations at Glens Falls, Rogers Island, Schuylerville, Stillwater, and Waterford. Data from these monitors indicate that PCB concentrations in the waters of the upper Hudson River are flow-dependent. As shown in Figure 2-1, relatively high PCB concentrations occur at low flows of less then 200 cubic meters per second (cu m/s) (7,000 cubic feet per second [cfs]) between Schuylerville and Stillwater. The concentrations are reduced in the moderate flow range and then increase again in the high flow range, greater than 340 cu m/s (12,000 cfs) (MPI, 1980d). The average flow between Schuylerville and Stillwater is 140 cu m/s (5,000 cfs); 10 percent of the time the flow exceeds 340 cu m/s (12,000 cfs); and 1 percent of the time the flow exceeds 765 cu m/s (27,000 cfs). However, if the data from Figure 2-1 are converted to load of PCBs in the river water column, rather than concentration, it becomes apparent that all flows less than 340 cu m/s (12,000 cfs) between Schuylerville and Stillwater carry very low loads of PCBs (Table 2-5). Therefore in order to avoid substantial resuspension and migration of PCBs it would be necessary to prevent flows from exceeding approximately 340 cu m/s (12,000 cfs) over the hot spots.

Based on the above analysis, it appears that the regulation of water flow over the Conklingville Dam could not substantially contribute to achieving this goal because flows greater than 340 cu m/s (12,000 cfs) occur 10 percent of the time between Schuylerville and Stillwater (LMS, 1978). If the Board of the Hudson River-Black River Regulating District were to develop an implementable program that would reduce flows to less than 340 cu m/s (12,000 cfs), that program would almost certainly conflict with its responsibilities to generate hydroelectric power, to maintain navigable flows, and to protect the recreational value of Great Sagandaga Lake. Therefore, this new alternative could only be

Table 2-4

Comparisons of Flow Contributions

Location of Source	Average Flows[a]			100-Year Flood (April 2, 1976)[b]		
	cu m/s	(cfs)	Percent of Flow at Fort Edward	cu m/s	(cfs)	Percent of Flow at Fort Edward
Lake Luzerne, Hadley	81	(2,850)	71.0	883.6	(31,200)	78
Conklingville Dam	32	(1,130)	28.0	229.4	(8,100)[1]	20
Other inflows	1	(20)	1.0	20	(700)	2
Fort Edward[2]	114	(4,000)	100	1,133	(40,000)	100

Notes: 1. The maximum discharge from Conklingville Dam since its construction in 1930 occurred on July 1, 1968, with a release of 377 cu m/s (13,300 cfs)(USGS, 1975).

2. Ten percent of the time the flow exceeds 280 cu m/s (10,000 cfs). One percent of the time the flow exceeds 590 cu m/s (21,000 cfs) (LMS, 1978).

Sources: a. USGS, 1975; LMS, 1978.
b. USGS, 1980.

Table 2-5

Average PCBs in the River Water Column between Schuylerville and Stillwater[1]

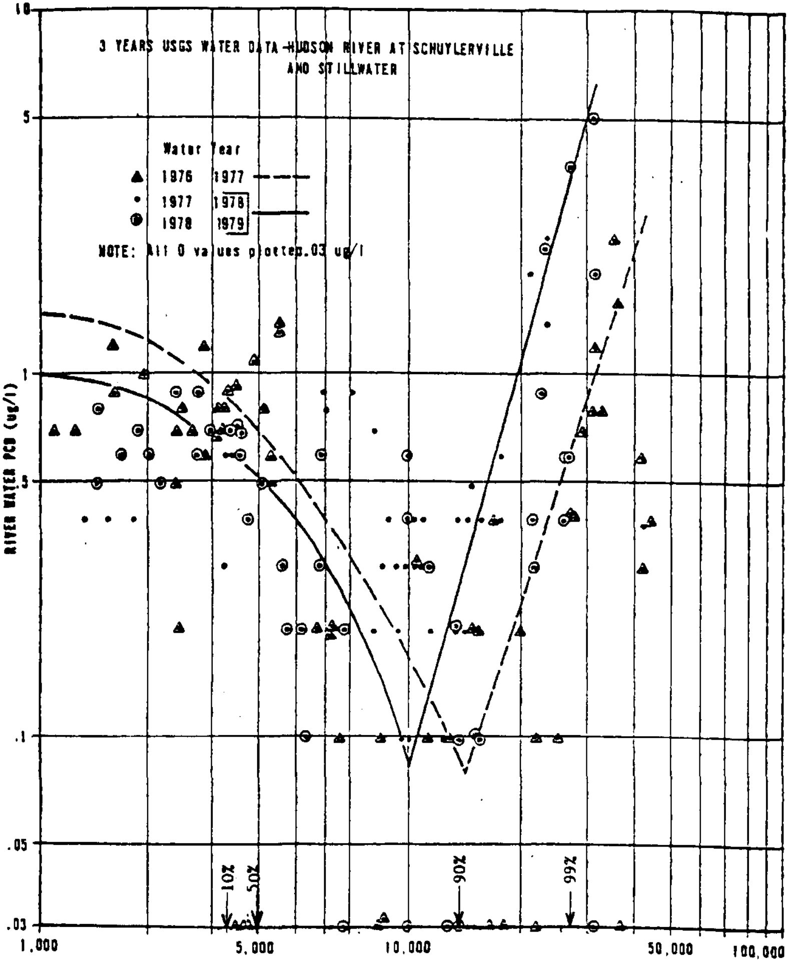
Flow		PCB Concentration[2]		PCB Load	
cu m/s	(cfs)	ug/l	(ppb)	kg/d	(lb/d)
28	(1,000)	1.0	(1)	2.4	(5.3)
57	(2,000)	0.7	(0.7)	3.4	(7.6)
142	(5,000)	0.5	(0.5)	6.1	(13.5)
198	(7,000)	0.3	(0.3)	5.2	(11.4)
283	(10,000)	0.07	(0.07)	1.7	(3.8)
340	(12,000)	0.3	(0.3)	8.8	(19.3)
425	(15,000)	0.5	(0.5)	18.2	(40.1)
566	(20,000)	1.0	(1.0)	48.6	(107.1)
708	(25,000)	3.0	(3.0)	182.3	(402.0)
849	(30,000)	5.0	(5.0)	364.9	(804.5)

Notes: 1. October 1977 through October 1979.

2. From Figure 2-1.

Figure 2-1

River Flows and PCB Concentrations



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Note: Arrow (↓) indicates percent (%) of time flow not exceeded
Source: MPI, 1980d

used as a short-term mitigating measure that would not eliminate the adverse impacts of leaving the PCB hot spots in the upper Hudson River. In summary, control of river flow is not a feasible long-term alternative.

3. IN-RIVER DETOXIFICATION

Alternatives discussed under this heading include:

- degradation by ultraviolet ozonation
- chemical treatment
- bioharvesting
- activated carbon adsorption

3A. Degradation by Ultraviolet Ozonation

Ultraviolet (UV) ozonation is commonly used for end-of-pipe treatment for the water column. Although new uses for UV ozonation are being studied (Valentine, 1981), they are still at the laboratory stage and are being developed for end-of-pipe water treatment. This alternative does not seem feasible for in-river treatment of sediments, but it should be assessed for treatment of runoff from the proposed containment site.

3B. Chemical Treatment

In-river chemical treatment of PCB-contaminated sediments has received little attention. The draft SEQRA EIS indicates that this alternative is infeasible (MPI, 1980d).

3C. Bioharvesting

Both Horstman (1977) and MPI (1980d) conclude that bioharvesting is not a feasible alternative. The technique involves harvesting all the aquatic organisms in the Hudson River that have accumulated high PCB concentrations and disposing of them in an environmentally acceptable manner. Estimates project that this method would require anywhere from 100 to 10,000 years to complete.

3D. Activated Carbon Adsorption

Activated carbon has an affinity for organic molecules and a large surface to volume ratio that lends itself to effective removal of PCBs. Activated carbon processes are widely used in treatment of industrial wastewaters and drinking water. Most of these systems, however, consist of a column containing the activated carbon through which the wastewater is passed.

The alternative for removal of PCBs from the Hudson River involved a proposal to utilize a granular magnetized activated carbon media that would be applied to the bottom sediments as a slurry. The retrieval would be accomplished with a continuous belt-type collection device similar to those employed in magnetic separators attached to a barge.

The cost for PCB removal utilizing this alternative was estimated to be in the range of $122/ha to $1,215/ha ($300/a to $3000/a). This cost is very reasonable when compared to other alternatives. However, this cost does not include costs for storage or destruction of the contaminated carbon. In addition, this alternative has never been tested in-river. Little is known about its effectiveness or technological feasibility (Horstman, 1977).

4. DREDGING ALTERNATIVES--THE FULL-SCALE PROJECT

The original project presented in the draft SEQRA EIS by NYSDEC included six major components. One component specified the dredging of all 40 hot spot areas in the river bed and containment of the spoil in a secure, upland site. The dredging was to take place over a two-year period. During the first year, the 20 hot spots in the Thompson Island Pool were to be dredged either by hydraulic or by clamshell methods, and remnant deposit areas 3 and 5 were to be completely or partially removed by truck. At the end of the first season, the used portion of the containment area would be covered. During the next year, the lower pools were to be dredged (clamshell dredging/hydraulic pumpout unloading), and the remainder of the containment area was to be covered and sealed. In addition, the temporary earthen basins on the containment site would be demolished and these areas regraded. The full-scale alternative will remove approximately 44 to 49 percent of the PCBs from the river and will result in the transport of 47,500 kg (104,800 lb) of PCBs into the estuary over the next 21 years (Table 2-6).

5. DREDGING ALTERNATIVES--THE REDUCED-SCALE PROJECT

A preliminary review of the costs associated with the original proposal indicated that, in order to meet the federal funding limitation imposed by Congress, major elements of the original project would have to be deleted. Accordingly, NYSDEC and its consultants proposed a reduced scale project that modified the original project by reducing the number of hot spots to be dredged and reducing the capacity of the containment site (Appendix B). The Thompson Island Pool was selected as the first pool to be dredged because the cost analysis indicated that this pool had the lowest transportation and treatment costs per pound of PCBs removed. In addition, PCB locations and concentrations have been studied to a greater detail in this pool than in any other.

Under the reduced scale project, final selection of the hot spots to be dredged in the lower pools would await the results of the proposed probing and sampling program to be implemented in 1981. It appears at this time that between 119,000 to 203,000 cu m (155,000 to 265,000 cu yd) of contaminated material could be dredged in the lower pools within the budget constraints.

This volume can be better defined after the first season of Thompson Island Pool dredging. The reduced scale alternative will remove approximately 30 to 35 percent of the PCBs from the river and will result in the transport of 61,200 kg (135,000 lb) of PCBs into the estuary over the next 28 years (Table 2-7).

The original project deferred final selection of the dredging methodology until after the competitive bidding for the dredging. However, the reduced scale project cost constraints may dictate the use of a clamshell dredge with hydraulic pumpout systems in the Thompson Island Pool in order to ensure that sufficient funds remain to allow construction and amortization of special equipment that would be required for lower pools.

Table 2-6

PCB Transport: Full-Scale Alternative[1]

Period	Average Annual PCB Load at Troy[2] kg/yr (lb/yr)	Condition
1977 to 1978	3,600 (8,000)	Before remnant deposit actions
1979 to 1983	3,270 (7,200)[3]	5 years until full-scale action is completed
1984 to 1985	3,270 (7,200)[3]	2 years additional to exhaust supply above Lock 7
1986 to 2001	1,950 (4,300)	16 years additional to exhauat supply between Lock 7 and Troy
After 2001	0 (0)	Supply exhausted above Troy
1981 to 2001: 47,500 kg (104,800 lb) of PCB transported into estuary.		

Notes: 1. Assumes 45 percent removal of PCBs from river by full-scale action.

Assumes volatilization rate of 680 kg/yr (1,500 lb/yr) of PCBs from the upper Hudson River before full-scale action is completed. This rate is the average volatilization between 1981 and whatever year no PCBs remain in the upper Hudson River, or 1/2 the current volatilization rate.

Assumes volatilization rate of 375 kg/yr (825 lb/yr) of PCBs after full-scale action is completed.

Assumes routine channel maintenance removal of 1,100 kg/yr (2,500 lb/yr) of PCBs before full-scale action is completed. This removal rate is the average rate between 1981 and whatever year no PCBs remain in the upper Hudson River, or 1/2 the current removal rate.

Assumes routine channel maintenance removal of 625 kg/yr (1,375 lb/yr) of PCBs after full-scale action is completed.

2. Loadings do not reflect yearly fluctuations of river discharges and variations of the PCB mass transported.

3. Assumes contribution from remnant deposit is negligible.

Table 2-7

PCB Transport: Reduced-Scale Alternative[1]

Period	Average Annual PCB Load at Troy[2] kg/yr (lb/yr)	Condition
1977 to 1978	3,600 (8,000)	Before remnant deposit actions
1979 to 1983	3,270 (7,200)[3]	5 years until reduced-scale action is completed
1984 to 1985	3,270 (7,200)[3]	2 years additional to exhaust supply above Lock 7
1986 to 2008	1,950 (4,300)	23 years additional to exhaust supply between Lock 7 and Troy
After 2008	0 (0)	Supply exhausted above Troy
1981 to 2008: 61,200 kg (135,000 lb) of PCB transported into estuary.		

Notes: 1. Assumes 30 percent removal of PCBs from river by reduced-scale action.

Assumes volatilization rate of 680 kg/yr (1,500 lb/yr) of PCBs from the upper Hudson River before reduced-scale action is completed. This rate is the average volatilization between 1981 and whatever year no PCBs remain in the upper Hudson River, or 1/2 the current volatilization rate.

Assumes routine channel maintenance removal of 1,100 kg/yr (2,500 lb/yr) of PCBs before reduced-scale action is completed. This removal rate is the average rate between 1981 and whatever year no PCBs remain in the upper Hudson River, or 1/2 the current removal rate.

Assumes volatilization rate of 475 kg/yr (1,050 lb/yr) of PCBs after reduced-scale action is completed.

Assumes routine channel maintenance removal of 795 kg/yr (1,750 lb/yr) after reduced-scale action is completed.

2. Loadings do not reflect yearly fluctations of river discharges and variations of the PCB mass transported.

3. Assumes contribution from remnant deposit is negligible.

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6. BANK-TO-BANK DREDGING PROJECT

Bank-to-bank dredging of sediments from the upper Hudson River would require a much greater amount of equipment operating over several more years than would the full-scale and reduced-scale proposals. Bank-to-bank dredging would also require a much larger containment site or several containment sites. These requirements would make the design difficult to implement and would interfere with procedures intended to avoid or mitigate adverse environmental impacts. Much of the dredging effort would be needlessly expended in removing uncontaminated sediments and disturbing productive wetlands. In addition, bank-to-bank dredging is estimated to cost over $250,000,000. Based on these concerns, bank-to-bank dredging is not regarded as a feasible alternative.

II. ALTERNATIVE COMPONENTS

The following sections of this chapter present a discussion of the components to the major action alternatives. The alternative for in-river containment is considered to be applicable to certain hot spots where costs and environmental conditions may make it more desirable than dredging. The remnant deposit alternatives do not involve dredging, but would be implemented in conjunction with dredging of the hot spots. Contaminated material removed from the remnant deposits would be disposed of at the dredge spoil containment site. The other alternative components, in-river dredging mechanisms and dredge spoil disposal, are related to the complete or partial removal of remnant deposits and/or hot spots.

1. IN-RIVER CONTAINMENT

While the removal of PCBs from the river system is the only permanent remedy for the presently threatening situation, insufficient funds are available to remove all the hot spots from the river by dredging. Additionally, the dispersed state of the material and the practical limits of existing technology inhibit complete removal of the total PCB contaminated river bed material. In-river containment--the isolation of shallow areas of PCB-contaminated sediment from the main flow of the river--is proposed as a way to control as great an amount of PCBs as possible with the funds available. This alternative is intended to be used in conjunction with a dredging program that would concentrate on the less stable PCB hot spots.

The PCB hot spots are unevenly distributed along the upper Hudson River. Some hot spots are located in the main channel of the river; others are located adjacent to the riverbanks or in protected coves. Only those depositional areas that are not in the main channel of the river are considered for in-river containment.

In-river containment can be accomplished by various methods, including earthen dikes or berms, bulkheads, or sheet piling (Figure 2-2). Dikes or berms are trapezoid-shaped structures that are built parallel to the river bank in waters of suitable depth. The PCB-contaminated river bed material contained between the structure and the shoreline would be isolated from the river. As an added precaution, a clay cap could be placed over the contaminated river bed material. Wetland vegetation would be planted to stabilize the area further. A less costly variation that may be used for wetland hot spots is a spur dike. This method consists of riprapping the upstream face of the wetland, then building a dike off the end of the riprap at an angle to the river flow. This dike would armor the upper one-third of the wetland against strong flow. Riprap should be placed at the downstream end of the dike to prevent scouring (Hudek, USEPA, March 17, 1981). Bulkheading is similar to dikes or berms, except that pilings and sheetings are used. Sheet piling consists of metal sheets driven along the face of the hot spot parallel to the flow direction. The metal sheets interface with one another. Because of the costs, potential navigational hazards, and difficulties involved with the construction of containment structures in a dynamic river system, the maximum water depth at which in-river containment could be used is 2 meters (m) (6 feet [ft]) below mean river stage.

Furthermore, the hot spots selected for such in-river containment must be in areas with a history of deposition, rather than repeated scouring and aggradation. Such areas include (1) backwater or eddy deposits formed behind projecting points of obviously stable land (e.g., with mature tree growth), (2) deposits at the mouths of tributary streams, particularly where they occupy re-entrants in the wall of the presently active stream valley, (3) areas on the inside of meander bends where depositional history indicates stability, and (4) areas where spoil disposal from channel maintenance dredging has resulted in partially restricted water flow conditions.

In selecting areas for stabilization, strong consideration should be given to the positions of the 500-year and 100-year flood levels and the possible configuration of the river under these conditions. The tops of structures built for in-river containment will be at the 100-year flood level. A site should be rejected if it appears to be unstable under extremely high river flow conditions.

Certain drawbacks are associated with the alternative of in-river containment as discussed above. A cost comparison between in-river containment and dredging is presented in Appendix D. Preliminary indications are that costs involved with berms, dikes, bulkheads and/or sheet piling are approximately equal to the costs of dredging. However, the structures would need maintenance, and a long-term water quality monitoring program would be required in the area of the structures. In addition, a majority of the hot spots are located in areas where the mean river stage is above 2 m (6 ft).

Another method of in-river containment would be to cover PCB hot spots in the river (especially deeper pockets) with a plastic liner, silt and rocks. During low and moderate flows the cover materials might prevent resuspension of PCBs; but during high flows, the finer material would be scoured and the plastic liner ruptured, allowing the PCBs to be resuspended.

2. REMNANT DEPOSIT ALTERNATIVES

Remnant deposits are the remains of sediments snd debris that accumulated behind the former dam at Fort Edward. The deposits consist of silt, sand, rock fragments, sawdust, slabs, and other wood mill wastes. These deposits also contain contaminants, including heavy metals and PCBs that accumulated in quiescent areas behind the dam. After the dam was removed in 1973, most of the accumulated sediments were washed downstream. The five deposits that remained

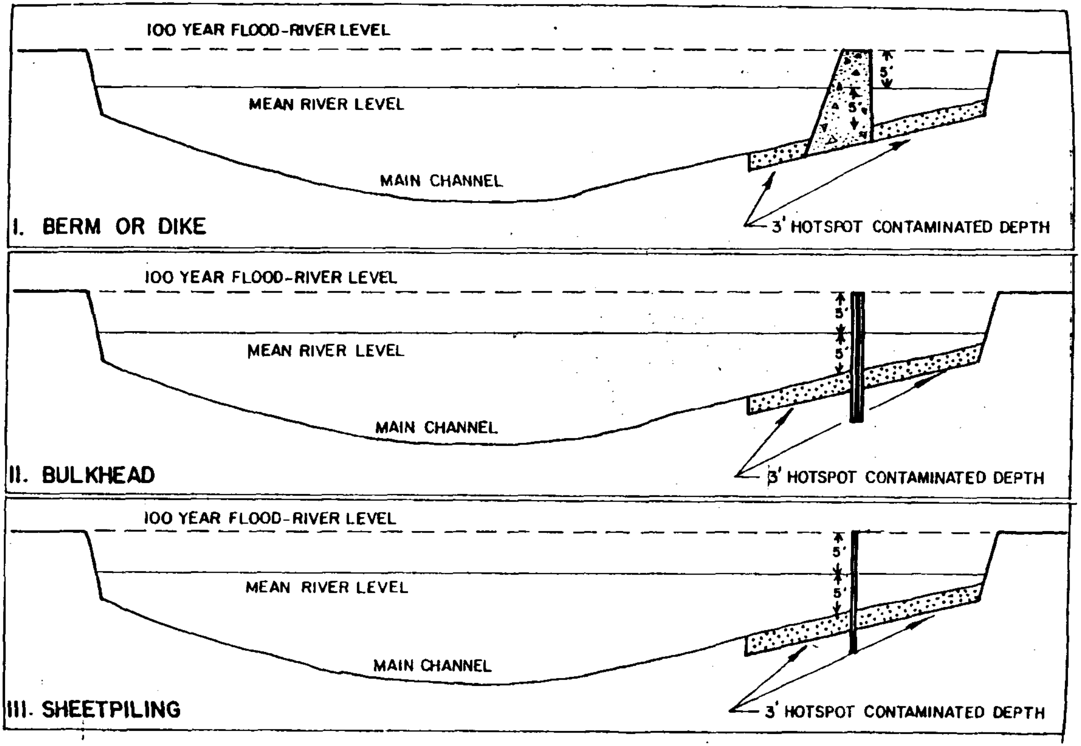

FIGURE 2-2 IN-RIVER CONTAINMENT ALTERNATIVES

were left above normal river levels because removal of the dam substantially reduced water levels (MPI, 1980d). Locations of the five remnant deposits are shown on Plate 2.

From 1974 to 1975, the remnant deposits were subjected to the following remedial measures:

- Work Area No. 1: No action
- Work Area No. 2: Bank shaping and seeding of 730 linear m (2,400 linear ft)
- Work Area No. 3: Bank shaping, placement of rock from timber cribs, and seeding of 600 of 950 linear m (2,000 of 3,100 linear ft) of bank subject to scour
- Work Area No. 4: Bank shaping, placement of rock from timber cribs, and seeding of 600 linear m (2,000 linear ft).
- Work Area No. 5: Bank shaping, placement of dumped rock fill, and seeding of 340 linear m (1,100 linear ft)

During April, 1976, a once in a 100-year flood caused an additional 200,000 cu m (260,000 cu yd) of material to be scoured from the Fort Edward Pool. Remnant deposits 4 and 5 remained intact, but substantial amounts of material were eroded from deposits 1, 2, and 3. In September, 1978, 10,700 cu m (14,000 cu yd) of material were excavated from deposit 3A and moved to the new Moreau landfill. These sediments contained an average PCB concentration of approximately 1,000 ug/g (ppm). Additional bank stabilization measures were employed at deposit 3 (MPI, 1980d).

The remnant deposit sites have been surveyed and sampled by MPI and NYSDEC to determine the degree and extent of PCB contamination. Estimates of the volume of contaminated sediments, PCB concentrations and total PCB mass were made, and the results are presented in Tables 2-8a and 2-8b. The disparity between the two sets of data may be due to different sampling procedures, laboratory techniques, or the possible heterogeneity of the deposits (MPI, 1980d).

Despite the discrepancies between the two sets of data in Tables 2-8a and 2-8b, both sets indicate that remnant deposits 3 and 5 contain the highest concentrations and greatest masses of PCBs. The PCBs in deposits 3 and 5 are

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Table 2-8a

Estimated Mass of PCB in Remnant Deposits (metric measure)

Deposit	Hectares	Contaminated Depth (Meters)	Contaminated Volume (cubic meters)	PCB (ug/gram)	PCB (kilograms)
	Estimates by MPI (1978)				
1	2.0	1.5	30,800	1	30
2	3.3	1.8	59,200	5	310
3	4.9	3.0	148,000	200	30,850
3A[1]	4.5	0.3	17,700	1,000	14,120
4	8.2	0.9	74,000	10	770
5	2.4	3.0	74,000	225	17,340
Total	25.3		399,500		63,420
	Estimates by NYSDEC (1980)				
1	1.6	0.6	9,900	20	200
2	3.2	1.5	49,300	5	260
3	5.4	8.3	123,000	65.3	8,420
3A	2.4	0.3	7,400	1,000	7,720
4	4.9	0.6	29,600	25	770
4A	3.4	0.9	31,400	40	1,320
5	1.6	2.4	39,500	250	10,280
Total	22.5[2]		290,100		28,970
Removed (Area 3A)					7,720
Remaining					21,250

Notes: 1. The actual 3A area and volume removed in the Fall of 1978 was 3.3 ha and 10,700 cu m.

2. Acreage recalculated by NYSDEC to include only areas known to be contaminated.

Source: MPI, 1980d

Table 2-8b

Estimated Mass of PCB in Remnant Deposits (English measure)

Deposit	Acres	Contaminated Depth (Feet)	Contaminated Volume (cubic yards)	PCB (ppm)	PCB (pounds)
	Estimates by MPI (1978)				
1	5	5	40,300	1	70
2	8	6	77,400	5	680
3	12	10	193,600	200	67,950
3A[1]	11	1	17,700	1,000	31,100
4	20	3	96,800	10	1,700
5	6	10	96,800	225	38,200
Total	62		522,600		139,700
	Estimates by NYSDEC (1980)				
1	4.0	2	12,900	20	450
2	8.0	5	64,500	5	570
3	13.3	7.5	160,900	65.3	18,550
3A	6.0	1	9,700	1,000	17,000
4	12.0	2	38,700	25	1,700
4A	8.5	3	41,100	40	2,900
5	4.0	8	51,600	250	22,650
Total	55.8[2]		379,400		63,820
Removed (Area 3a)					17,000
Remaining					46,820

Notes: 1. The actual 3A area and volume removed in the Fall of 1978 was 8.15 a and 14,000 cu yd.

2. Acreage recalculated by NYSDEC to include only areas known to be contaminated.

Source: MPI, 1980d

largely positioned above normal river levels and have concentrations greater than 50 ug/g (ppm). These deposits are therefore fairly suitable for either stabilization or removal. Remnant deposits 1, 2, 4, and 4A contain lower concentrations of PCBs, below 50 ug/g (ppm), and relatively small total masses of PCBs (MPI, 1980d). Remnant deposit 4A is low enough in elevation to be subject to yearly flooding and scouring. Remnant deposit 1 is an island with unstabilized banks and consequently, is subject to erosion. Remnant deposit 2 has had limited bank improvement and may also be subject to erosion (Tofflemire, 1980).

At present, exact quantities of PCBs leaching or otherwise lost to the river from these deposits are unknown. Of the estimated 3,300 kg (7,200 lb) of PCBs currently passing over the Troy Dam each year, the LMS model attributes 730 kg (1,600 lb) to losses from the remnant deposits (LMS, 1979). River monitoring at Rogers Island, immediately below the remnant deposits, indicates an annual downstream PCB transport of 590 to 1,300 kg/yr (1,300 to 2,900 lb/yr), on the same order as the LMS loss projections (MPI, 1980d). MPI (1980d) has estimated that PCB losses from the remnant deposits by means other than volatilization are negligible because they have either been stabilized and are not being scoured, or, as with deposit 1, have a relatively low PCB concentration. MPI (1980d) suggests that an unknown upstream source of PCBs, such as an uncharted dumpsite, a sewage discharge, or a direct industrial discharge, is contributing to the present load of PCBs passing Rogers Island.

Tofflemire' (1980) projected PCB losses of 200 to 460 kg/yr (440 to 1020 lb/yr) from the remnant deposits, primarily from deposits 1, 2, 4 and 4A. Deposits 3 and 5 were considered to be stable, accounting for less than 2.3 kg/yr (5 lb/yr). Tofflemire (1980) estimated that erosion could remove PCBs at rates of 45 to 130 kg/yr (100 to 280 lb/yr) from deposit 1, 60 kg/yr (136 lb/yr) from deposit 2, and 45 to 270 kg/yr (100 to 600 lb/yr) from deposits 4 and 4A. Projections of PCB losses were based on the assumption that the deposits would be eroded in time spans of 5 to 30 years. Currently, some of the sand and wood chips eroded from the remnant deposits may be accumulating on the north tip of Rogers Island, in the east channel adjacent to the island, and in the vicinity of buoy 212. Approximately 75,000 cu m (98,000 cu yd) of material was dredged from the channel in 1979. Thus, according to Tofflemire (1980), sediments from the remnant deposits are still eroding, but it is uncertain which deposit contributes the most PCBs.

To date, NYSDEC has not identified the source of the large quantities of PCBs being measured at Rogers Island. It remains to be determined whether or not the remnant deposits are releasing substantial amounts of PCBs to the river.

PCBs could escape from the remnant deposits by several mechanisms (MPI, 1980d):

- scour during high flows (reduced by bank stabilization measures employed to date)
- precipitation that infiltrates the deposits, desorbs PCBs and subsequently passes into the river as contaminated leachate
- runoff from the surrounding terrain, that infiltrates the deposits and desorbs PCBs, and/or erodes the surface deposits
- regional groundwater movement through the deposits that may desorb PCBs en route to the river
- floods that saturate the deposits and subsequently recede, carrying particle-bound and desorbed PCBs
- Dust-borne transport by wind during dry periods

PCBs are also released from remnant deposits by volatilization. NYSDEC estimates that 130 kg/yr (280 lb/yr) of PCBs volatilize from the five deposits, representing a long-term, low-level source of atmospheric PCBs. Other PCB losses from the remnant deposits may occur by microbial degradation within the contaminated deposits and biological uptake to the terrestrial system (MPI, 1980d).

An additional loss of PCBs from the remnant deposits could occur if a surging dam were constructed at Fort Edward. The Niagara Mohawk Power Company (NMPC) has considered construction of such a dam to produce hydroelectric power. If the Fort Edward Dam is rebuilt and the deposits are inundated, four additional loss mechanisms to the river may occur (MPI, 1980d):

- erosion during the construction phase
- scour of the deposit surfaces during high flow
- biological uptake to aquatic system
- saturation and subsequent drainage of contaminated deposits that are subject to the fluctuating pool levels

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The proposed alternatives for dealing with the remnant deposits are: (1) no action, (2) denial of access, (3) in place cover, and (4) complete or partial removal. The purpose of the action would be to reduce or eliminate possible losses of PCBs from the deposits to the environment. Ongoing PCB losses and potential losses from high-flow periods must be considered.

2A. No-Action

Under this alternative component, no remedial work would be undertaken beyond the bank stabilization, seeding, and material removal already completed between 1975 and 1978. Any present losses of PCBs to the river as well as volatilization of PCBs to the air would continue. There would be no protection against losses from high river flows or long-term erosion. The no-action alternative component is currently proposed as part of the reduced scale project (Appendix B).

2B. Denial of Access

At present, several hot spots are easily accessible to the public from the land, and some are accessible by boat. There is evidence that children occasionally play on some of the deposits and that motorcycles are driven over them. Animals also have free access to the sites. Human and animal activity at the sites may accelerate erosional processes and create a potential health risk. The following measures would be taken under this alternative:

- placement of chain link fences, at least 2 m (6 ft) high, topped with barbed wire, and buried 0.6 m (2 ft) into the ground, on the landward sides of all remnant deposits
- placement of signs facing the water as well as the land at all remnant sites to warn people that the area contains toxic wastes
- continued maintenance of the fence and signs
- seeding of ground disturbed by the work described above and other unvegetated areas with appropriate grasses
- workers would have to take necessary precautions while at the sites, such as the wearing of respirators and protective clothing

This alternative would do little to reduce present losses of PCBs to the water and air and would not prevent potential losses from high flows and long-term erosion.

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2C. In-Place Containment

This alternative would entail further bank stabilization and emplacement of an impermeable cover, such as plastic or clay, anchored by a protective blanket of graded material designed to withstand maximum expected flow velocities during floods (MPI, 1980d). Complete encapsulation would also involve placement of a curtain wall to prevent groundwater infiltration and desorption of PCBs. Total amount of capping material needed, the thicknesses of the impermeable layer, the protective blanket of graded materials, and other construction requirements, as well as costs, are presented in Appendix D.

This alternative component would require extensive construction. Roads would have to be built to the sites for the transport of materials. In-place stabilization and capping of deposits 3 and 5 would require 5,000 to 10,000 truck trips to bring materials to the sites (MPI, 1980d).

Implementation of this alternative component would substantially reduce any possible losses of PCBs to the river. It would also protect against scouring during high-flow periods. Volatilization would be essentially eliminated, as would release through airborne dust and biological pathways.

If a surging dam were constructed at Fort Edward, this alternative would not prevent losses of PCBs once the deposits became submerged. Fluctuations in water levels and water turbulence behind the dam would eventually destabilize the remnant deposits even if they are capped.

This alternative would require a continual maintenance and monitoring program. It would not prevent any long-term erosional changes of the river channel. The remnant deposits would remain a potential, long-term source of PCBs to the river environment.

2D. Complete or Partial Removal

Excavation and upland containment of all remnant sites would entail movement of 280,000 cu m (370,000 cu yd) of contaminated material containing some 21,200 kg (46,800 lb) of PCBs. Transport of this material would require 20,000 to 40,000 truck trips. In-place stabilization would not be attempted. This alternative would be difficult to implement and would include removal of materials with low levels of contamination. This component would not be cost-effective because it would increase sediment removal volume by 74 per cent while increasing PCB removal mass by only 14 percent, as compared with the partial removal alternatives described below (MPI, 1980d).

The advantage of the complete removal alternative is that it would effectively remove an estimated one-seventh of all PCBs believed to be in the Hudson River. It would effectively eliminate all future losses of PCBs from the remnant deposit areas to the river and air, which is especially important if the remnant deposits are the presently unknown source of PCBs in the upper Hudson River.

Complete Removal of Deposits 3 and 5

In the draft SEQRA EIS (MPI, 1980d), NYSDEC proposed to remove approximately 162,500 cu m (212,500 cu yd) of contaminated material, containing roughly 18,500 kg (41,000 lb) of PCBs from deposits 3 and 5. This material would be transported by truck to the PCB containment site located 4.8 km (3 mi) to the south. Approximately 11,000 to 22,000 truck trips would be required to remove the material. NYSDEC proposed no additional remedial measures for deposits 1, 2, and 4, which contain relatively low levels of contamination. However, deposit 4A, containing 1,300 kg (2,900 lb) of PCBs at an average concentration of 40 ug/g (ppm), may be contributing PCBs to the water column, and could be excavated or stabilized further as part of future remedial work in the area. If excavation of area 4A were to be included as a component of the overall project, the removal volume would total roughly 193,900 cu m (253,600 cu yd) (MPI, 1980d).

Removing deposits 3 and 5 under this alternative would be advantageous because:

- they contain the highest concentration and mass of PCBs in the Hudson River
- in place, they represent a potential long-term source of contamination to the lower Hudson River
- substantial volatilization occurs from them
- the cost per pound of PCB removal from the deposits is lowest of any contaminated area in the river

Partial Removal Areas 3 and 5

Two partial removal alternatives for deposits 3 and 5 were considered by NYSDEC and LMS. Under each, removal volumes would be decreased and PCB recovery would be somewhat reduced. The NYSDEC alternative calls for complete removal of deposit 5 to a depth of 2.5 m (8 ft), recovering about 10,300 kg (22,650 lb) of PCBs with 39,500 cu m (51,600 cu yd) of material. At deposit 3, the top 0.5 m (1.5 ft) and/or all material above an elevation of 40 m (134 ft) would be removed, as would all material down to the present water table at the southern 0.6 ha (1.4 a) of the area. Borings taken by MPI at the southern end of deposit 3 indicate that the water table is contaminated in the portion of the deposit. Removal of surface material from 2.5 ha (6.3 a) plus removal of material down to the water table at the southern end would total some 16,700 cu m (21,800 cu yd) and would recover approximately half of the PCBs in deposit 3. A filter fabric and stone blanket could be placed over the entire 5.3 ha (13.3 a) area should conditions warrant (MPI, 1980d).

As consultants to NMPC, LMS has proposed removal of all material above an elevation of 40 m (134 ft) in deposits 3 and 5. Under this proposal, in the portion of depoeit 3 above an elevation of 40 m (134 ft), 7,800 cu m (10,200 cu yd) of material containing 630 kg (1,380 lb) of PCBs would be removed. Contaminated surface materials below an elevation of 40 m (134 ft) would remain unexcavated. Nearly all of deposit 5 lies above an elevation of 40 m (134 ft) and, under this proposal, roughly 26,200 cu m (34,300 cu yd) of material containing 9,400 kg (20,780 lb) of PCBs would be excavated from a 1.6 ha (3.9 a) area. Approximately 3,700 to 7,400 truck trips would be required to remove the material (MPI, 1980d).

The LMS proposal is coordinated with the proposed reconstruction of the Fort Edward Dam by NMPC. If rebuilt, the dam would create a pool that would fluctuate between elevations of 40.5 and 42.6 m (136 and 142 ft). Use of the 40 m (134 ft) level permits a conservative estimate of the area exposed to the rise and fall of the pool. This rise and fall would tend to wash PCBs out of the deposit and into the water. Excavation to an elevation of 40 m (134 ft) would remove all contaminated materials subject to this fluctuation (MPI, 1980d).

The advantages of the partial removal of deposits 3 and 5 are:

- about half of the PCB mass of deposit 3 could be removed by excavating only 13 percent of the contaminated volume
- substantially fewer truck trips are needed to remove the material
- subsequent lining and capping would seal the remaining PCB in place

The amounts of material and PCBs that would be removed by each of the remnant deposit removal alternatives are summarized in Tables 2-9a and 2-9b.

2E. Transportation Alternatives

Trucking seems to be the only feasible method of transporting materials the 2.4 km (1.5 mi) to and from the containment site (MPI, 1980d). Truck access to deposits 3 and 5 would require the use of residential streets. Methods of transport other than by truck are not feasible. Alternative transport systems evaluated include:

- riverside conveyer
- riverside roadway constructed of dumped rock along the bank
- barge transport, hydraulic pumpout
- pipeline with booster stations

A conveyor would require material rehandling and is unsuitable for certain materials found at the remnant deposit sites. Barge transport alone is not feasible because the river is unnavigable above Lock 7. All other alternative means for transporting the remnant deposit materials mentioned above would have associated costs 5 to 20 times those of the proposed transport by truck (MPI, 1980d).

3. IN-RIVER DREDGING MECHANISMS

This section will evaluate the three major dredging/transport systems:

- clamshell dredging/mechanical unloading
- clamshell dredging/hydraulic pumpout unloading
- hydraulic dredging and transport

Table 2-9a

Remnant Deposit Removal Alternatives (metric measure)

Deposit	Complete Removal All Deposits		Complete Removal Deposits 3 and 5		Partial Removal NYSDEC (1)		Partial Removal LMS (2)	
	cu m	kg	cu m	kg	cu m	kg	cu m	kg
1	9,900	200	-		-		-	
2	49,300	260	-		-		-	
3	123,000	8,420	129,900	8,420	16,700	3,760	7,800	630
3A	7,400		(Removed to upland containment (1978))					
4	29,600	1,300	-		-		-	
4A	31,400	1,320	-		-		-	
5	39,500	10,280	39,500	10,280	39,500	10,280	26,200	9,400
Total	290,100	21,780	169,400	18,700	56,200	14,040	34,000	10,030

Notes: 1. Includes removal of the surface 0.5 m (1.5 ft) of material over 2.5 ha (6.3 a) of deposit 3, 0.9 m (3 ft) cut over southern 0.6 ha (1.4 a) of deposit 3, 5.3 ha (13.3 a) of liner and capping material. Complete removal of deposit 5.

2. Includes removal of all material to elevation 40 m (134 ft) in deposits 3 and 5. Does not include additional excavation in deposit 5 for a new hydroelectric dam.

Source: MPI, 1980d.

Table 2-9b

Remnant Deposit Removal Alternatives (English measure)

Deposit	Complete Removal All Deposits		Complete Removal Deposits 3 and 5		Partial Removal NYSDEC[1]		Partial Removal LMS[2]	
	cu yds	lb	cu yds	lb	cu yds	lb	cu yds	lb
1	12,900	450	-		-		-	
2	64,500	570	-		-		-	
3	160,900	18,550	169,900	18,550	21,800	8,275	10,200	1,380
3A	9,700		(Removed to upland containment (1978))					
4	38,700	1,700	-		-		-	
4A	41,100	2,900	-		-		-	
5	51,600	22,650	51,600	22,650	51,600	22,650	34,300	20,780
Total	379,400	46,800	212,500	41,000	73,400	31,925	44,500	22,160

Notes: 1) Includes removal of the surface 1.5 foot of material over 6.3 acres of deposit 3, a 3 ft cut over southern 1.4 acres of deposit 3, 13.3 acres of liner and capping material. Complete removal of area 5.

2) Includes removal of all material to an elevation of 134 ft in deposits 3 and 5. Does not include additional excavation in deposit 5 for a new hydroelectric dam.

Source: MPI, 1980d.

In addition, other dredging systems have been evaluated by MPI (1978b, 1980c) and Gahagan and Bryant (1980) and will be discussed briefly.

The following descriptions of the various major dredging alternatives were obtained from various reports prepared by MPI (1978b, 1980c, 1980d).

3A. Clamshell Dredging/Mechanical Unloading

The clamshell dredging/mechanical unloading system consists of barge-mounted cranes outfitted with suitable clamshell buckets to excavate the bed material (Figure 2-3). The excavated material is loaded on hopper scows for transport to a rehandling area. At the rehandling area, the material is unloaded from the scows utilizing crawler-mounted clamshell buckets and loaded on sealed-body dump trucks for transport to the containment site (Figure 2-4). Alternatively, a belt conveyor system could be used to transport the sediments from the rehandling area to the containment site. However, the conveyor would have to be protected from the weather, and spillage may be a problem. The water treatment plant at the containment site is sized for 3,785 cubic meters per day (cu m/d) (1 million gallons daily [mgd]) and will treat runoff from the site and any rainwater that falls on the site. In addition, runoff rainwater from the rehandling area will be treated.

Because of the quantity of material that will be hauled to the containment site, approxiately 400 15.3-cu m (20-cu yd) truckloads per day will be required. Hauling will be a continuous, 24-hr a day operation, and the traffic-routing problems and environmental impacts will be substantial. In addition, the cost associated with this system is greater than the other major dredging alternatives. Difficulties associated with handling mud and fine-grained material in the dredged sediment will hamper the unloading operation. None of the dredging contractors contacted were interested in unloading the barges mechanically (MPI, 1980d). Consequently, this system was eliminated from further consideration.

3B. Clamshell Dredging/Hydraulic Pumpout Unloading

This system, shown in Figure 2-4, utilizes the same equipment in the river as described above for the clamshell dredging/mechanical unloading alternative. At the rehandling area, however, a barge-mounted hydraulic pumpout system will be used to unload the hopper scows. The pumpout plant can be operated as a once-through process or as a recycle system. River or recycled water from the disposal site would be mixed with the sediment in the hopper scows to an average 15 percent slurry. The slurry is then pumped to the disposal area. The water treatment plant is sized for approximately 37,850 cu m/d (10 mgd) in a once-through system and 3,785 cu m/d (1 mgd) if pumpout water is recycled. At the disposal area, the position of the slurry-pipeline discharge and the layout of the interior dikes would be arranged to facilitate the mixing of fine and coarse-grained sediments.

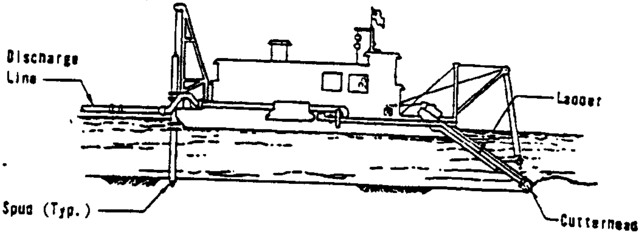
The factors that affect the excavation of material from shallow areas with a clamshell dredge include the weight and configuration of the clamshell bucket, material stratification and characterization, and caving of the cutting face, as well as the placement of the bucket and general skill of the operator. If soft material is encountered, the clamshell bucket can readily penetrate the layers. The bucket will generally scrape across compacted layers of material that lie below the contaminated sediments in the hot spots.

The clamshell bucket design can be modified to provide more efficient excavation and recovery of PCBs. Some modifications that should be considered in the dredging design phase of the project are:

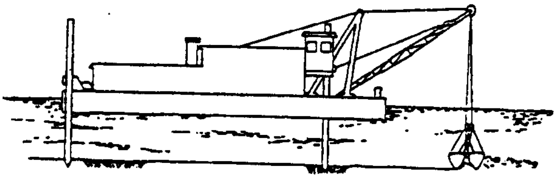
- lateral digging bucket
- special seals on the bucket lips
- buckets that close completely
- shrouded or hooded buckets that would prevent washout of material during hoisting

Clamshell dredges are readily available and have been used for many years (Gahagan and Bryant, 1980). Hydraulic pumpout plants have been used both in this country and in Europe. This system is implementable, and competitive bids could be submitted because several local contractors are equipped to do the work.

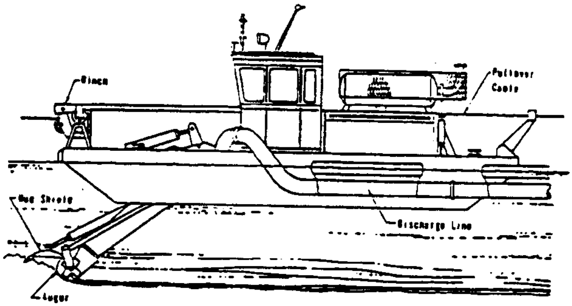
The estimated PCB losses from dredging with this system are presented in Table 2-10. The total loss is dependent on the magnitude of return water flow. If pumpout water is recycled and the return water flow is treated by sedimentation and coagulation, PCB losses from this system are approximately 0.01 percent. In a once-through process, the return water flow is estimated to be 37,850 cu m/d



HYDRAULIC CUTTERHEAD DREDGE



CLAMSHELL DREDGE



MUD CAT DREDGE

Figure 2-3 Dredge Illustrations

Source: MPI, 1980d

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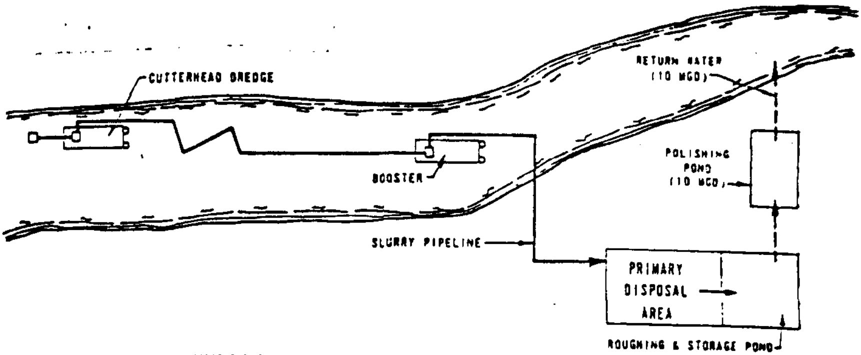
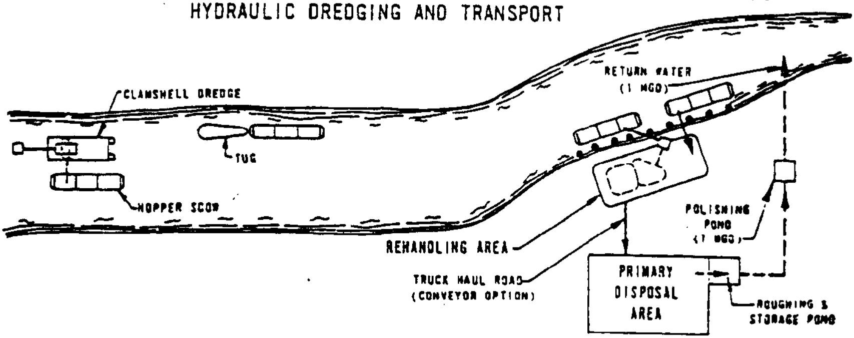
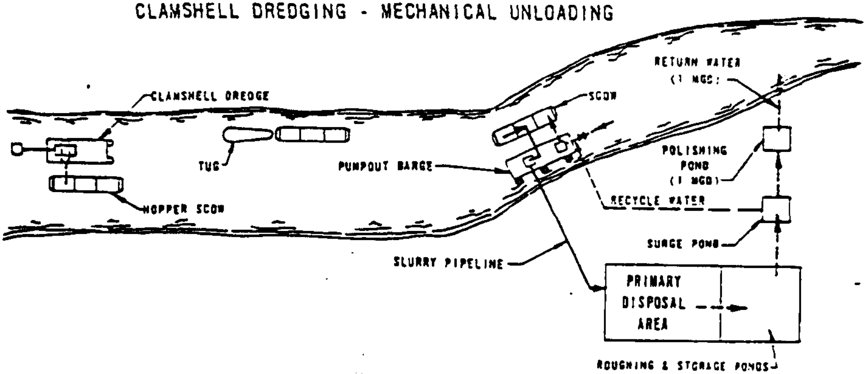


HYDRAULIC DREDGING AND TRANSPORT



CLAMSHELL DREDGING - MECHANICAL UNLOADING



CLAMSHELL DREDGING - HYDRAULIC PUMPOUT

Figure 2- 4 Alternative Dredging Systems
Source: MPI, 1978 b

Table 2-10

PCB Losses Clamshell Dredging/
Hydraulic Pumpout Unloading

Loss Mechanism	PCB Loss (percent)
Missed during dredging	5
Lost in dredging progress[1]	0.8-4
Lost in return water flow at (10 ug/l)[2]	0.01-0.1

Notes: 1. If the PCB lost in the dredging process does not resettle in downstream hot spot areas, the total loss from this mechanism could be 4 percent. However, if 20 percent of the PCBs desorb and the remaining PCBs resettle in hot spots to be dredged, the loss from this mechanism could be only 0.8 percent.

2. Treatment by coagulation and sedimentation.

Source: MPI, 1980a.

(10 mgd), and PCB losses are 0.1 percent. The total PCBs recovered are estimated to range between 90.9 and 94.2 percent for Thompson Island Pool dredging with this system. It is believed that these losses will not be exceeded if the dredging and disposal operations are carefully controlled. Lab work is currently underway to determine more accurately the effluent PCB concentrations to be expected with sedimentation-coagulation treatment.

3C. Hydraulic Dredging and Transport

The equipment utilized in a hydraulic system would be a conventional cutter head suction dredge assisted by boosters, tugs, barges, and miscellaneous equipment (Figure 2-3). Material would be transported by floating or submerged pipeline to the shoreline (Figure 2-4). A channel trench for sections of submerged pipe might be necessary to avoid any obstruction to navigation. A hydraulic dredging operation in the Thompson Island Pool would require one booster station. Removal of lower pool hot spots by this method would require a number of booster stations and an unwieldy pipeline system. Because of high costs associated with booster stations and long pipelines, this system is applicable only to work in the Thompson Island Pool.

The slurry would be pumped on land from the river to the containment site. It would be necessary to install the pipeline beneath U.S. Route 4. At the disposal area, the slurry discharge and dikes would be arranged as described for the clamshell pumpout alternative to facilitate mixing of fine and coarse-grained material. The water treatment plant would be sized for approximately 37,850 cu m/d (10 mgd).

Equipment required would include one 40-cm (16-in) hydraulic cutter head dredge, one derrick barge, two 40-cm (16-in) booster pumps, two bulldozers, one small tug, one tender tug, one fuel barge, one work barge, pipeline, and miscellaneous machinery (Gahagan and Bryant, 1980).

This system offers the advantage of one-time handling of the material between the dredging operation and the disposal area. For the Thompson Island

Pool, the system is economically competitive with a clamshell dredging/hydraulic pumpout system. Hydraulic dredges of this nature are in regular use on the Hudson River by the NYSDOT and others, and no difficulty is expected in securing equipment of this type.

The design of hydraulic dredges must be modified to improve PCB recovery efficiency by:

- installation of a shroud to enclose the top portion of the cutter
- use of sensor devices to control depth of cut over an uneven bottom
- modification of the conventional cutterhead dredge by installing a dustpan-type head

These modifications will be considered and incorporated as appropriate in the dredging design phase of the proposed project.

The estimated PCB losses expected with the hydraulic dredging and transport system are presented in Table 2-11. For hydraulic dredging, the loss from return water flow is larger than for the clamshell dredging/pumpout system with recycle of return water because of the larger flow requiring treatment. For Thompson Island Pool dredging, the average return water flow will be 37,850 cu m/d (10 mgd) as compared to 757 cu m/d (0.2 mgd) with the pumpout recycle system. The loss in return water flow with sedimentation and coagulation treatment is estimated at 0.1 percent and is not significant when compared to the other loss mechanisms. Therefore, the total PCBs recovered are estimated to range between 95.9 and 97.5 percent. It is believed that these losses will not be exceeded if the dredging and disposal operations are carefully controlled. As stated previously, lab work is underway to define more clearly the effluent PCB concentrations with sedimentation-coagulation treatment.

3D. <u>Other Dredging Systems</u>

Several other dredging systems have been evaluated by MPI and Gahagan and Bryant, and the difficulties with these alternative systems, including the reasons for their rejection as primary dredging systems, are summarized below:

Table 2-11

PCB Losses: Hydraulic Dredging and Transport

Loss Mechanism	PCB Loss (percent)
Missed during dredging	2
Lost in dredging process[1]	0.4-2
Lost in return water flow at (10 ug/l)[2]	0.1

Notes: 1. If the PCB lost in the dredging process does not resettle in downstream hot spot areas, the total loss from this mechanism could be 2 percent. However, if 20 percent of the PCBs desorb and the remaining PCBs resettle in hot spots to be dredged, the loss from this mechanism could be only 0.4 percent.

2. Treatment by coagulation and sedimentation.

Source: MPI, 1980a.

- Mud cat dredge: low capacity, limited pumping distance, and inability to deal with large debris. This dredge is illustrated in Figure 2-3. Although not applicable to the whole project, it does have advantages for limited work in shallow areas.

- Dustpan type dredge: difficulty with large debris, ineffective with an uneven bottom, and requires use of water that might cause PCB dispersion. Not presently available, although a conventional hydraulic dredge could be modified to operate as a dust pan. The Norfolk (Virginia) District of the USACOE proposed to carry out a demonstration project with a converted dredge in 1981.

- Pneumatic dredge: limited pumping distance, limited capacity, difficulties with large debris, limited availability, and poor fuel economy. Reported capacities of approximately 60 cu m/hr (2,000 cu ft/hr) for one proprietary type would quadruple cost of dredging.

- Backhoe or dragline dredge: difficulties with bucket roll that could cause displacement of PCBs, imprecise control of dragline bucket, and turbidity.

- Cable excavator: requires extensive operations on the shoreline, is difficult to control, and causes turbidity and dispersion of PCBs.

- Pumping into scows: poor economically because of large volume of water to be transported and rehandled.

- Buckat ladder dredge: not available; causes dispersion of sediments.

These systems may be applicable for hot spots in shallow areas or other inaccessible locations.

4. DREDGE SPOIL DISPOSAL

Associated with any dredging alternative is disposal of the dredge spoil.

Two alternatives are considered for the disposal of the contaminated material. One alternative involves the ultimate disposal of the dredge spoil through a detoxification method. The other option is land disposal in a secure containment facility. NYSDEC screened 40 potential sites in the upper Hudson River area and selected a tract of land located 4.0 km (2.5 mi) south of the Village of Fort Edward. On this site an earthen structure will be built to contain the contaminated sediments. This site is intended for temporary disposal of the dredge spoil until an economical ultimate disposal method is developed. The criteria used for site selection assumed indefinite long-term storage to ensure site safety.

4A. Detoxification

Alternatives evaluated under this section included:

- physical destruction through incineration
- chemical treatment
- biodegradation

Currently, physical destruction through incineration is the most effective and best understood means of ultimately destroying liquid PCBs. Most of the systems used, however, remove PCBs in the liquid phase and are not suitable for PCB-contaminated sediments. The systems require high temperatures (1,148°C [2100°F]) and carefully calculated detention times in order to minimize impacts to air quality.

During research of different alternatives, GE, with the assistance of NYSDOT, collected contaminated sediments and sent them to a pyrolysis system in New Jersey. The conclusion of this study (Nichols Engineering and Research Corporation, 1978) were as follows:

- PCB-contaminated Hudson River bottom sediment can be decontaminated by heating the solids in a multiple-hearth furnace to a temperature of about 537°C (1,000°F).

- Both incineration and pyrolysis are successful methods of decontamination.

- Pyrolysis is preferred over incineration for toxic heavy metals retention in the solid phase. Scrubbers are relatively ineffective for reducing the air pollution discharges of heavy metals, particularly cadmium and lead, from incinerator stacks (Farrell and Wall, 1981).

- Afterburner temperatures between 871° and 982°C (1600° to 1800°F) will be required to destroy the volatilized PCBs.

The cost for this type of incineration of PCB-contaminated dredge spoils has been estimated to be approximately $130/cu m ($100/cu yd), including construction of dewatering equipment and an incinerator (MPI, 1980d). Because of the large volume of materials that would have to be processed, incineration of contaminated Hudson River sediments is economically infeasible. Incineration costs for dredge spoils, not including dredging and transportation costs, would exceed $200,000,000 for the full-scope plan and $80,000,000 for the revised plan. The cost for pyrolysis is comparable to the cost for incineration.

Other systems capable of incinerating PCBs exist. The Wright Malta Corporation (1979) claims to have developed a bench-scale steam gasification process that may potentially convert PCBs into relatively innocuous by-products such as fuel gas and salt. However, this process has been demonstrated to be applicable to PCB-contaminated sediments on a laboratory basis, and the effectiveness and economics of this system have not yet been justified.

Rollins Environmental Services in Deer Park, Texas, and Energy Systems Company in El Dorado, Arkansas have received permits to incinerate waste containing PCBs as of April, 1981 (Jordan, Rollins Environmental Services, February 26, 1981). At present, their system will handle only liquid wastes, and costs have been estimated to range from $0.06 to $0.99/kg ($0.03-$0.45/lb) of waste.

Currently, chemical and biological degradation of wastes are not well proven and remain at the laboratory stage. Chemical degradation has been successful with pure PCBs in laboratory studies (MPI, 1980d), but large-scale degradation has not yet been proven feasible. A chemical process has been developed by the Goodyear Tire and Rubber Company (Goodyear, 1980) that reacts sodium metal with

PCBs at high temperatures (350°C [662°F]). The process is slow and is carried out in an autoclave. It is still in the laboratory stage and is not feasible for the Hudson River sediment at this time.

Biological degradation of some PCBs (the lower aroclors) has been found to be successful by GE. Five types of microorganisms demonstrated the ability to degrade PCBs. Much work, however, is still required before a suitable microorganism is found that can degrade PCBs in a reasonable time span.

Sunohio has developed a process called PCBX that has been demonstrated to detoxify typical transformer oil and may be suitable for other PCB-contaminated oils (Sunohio, 1980). This process is not designed to detoxify PCB-contaminated river sediments.

4B. Containment in Upland Disposal Site

Because of the limitations associated with dredge spoil detoxification, a site for a secure containment facility was sought (MPI, 1980a). MPI evaluated the regional geology, hydrology, soils, land use, and development patterns in the upper Hudson River Valley in an attempt to find a suitable location for a containment facility. A screening methodology was developed that incorporated federal and state regulations for secure land burial facilities, the nonavailability of mineral resources that may be mined at some future date and site preparation requirements to achieve acceptable conditions in an economical manner. The process used in applying this methodology and the site screening criteria are described in various MPI reports (1978b, 1978b, 1980d).

Initial screening resulted in 40 potential parcels that were subsequently reduced to 12 sites. Field inspection further reduced the number of potential sites to 4. After detailed screening of the environmental and socioeconomic factors present at each site, one site was selected. This site is identified as Site 10 and is located 4.0 km (2.5 mi) south of the Village of Fort Edward. The tract consists of three parcels totaling approximately 100 ha (250 a) bisected by a north-south oriented power line right-of-way. Access to the property is from Route 4 to the west. Elevations at the site range from 55 m (180 ft) in the northwest to 40 m (130 ft) in the southeast along Dead Creek. Most of the site is at elevations between 44 and 47 m (145 and 155 ft). Detailed comparisons of the final 4 candidate sites are contained in various MPI reports (1978b, 1980a, 1980b).

Upon selection of Site 10 as the location for the containment facility, a detailed geotechnical and environmental study was performed on the site (MPI, 1980a). The field investigation indicated that subsurface conditions were adequate to prevent leachate from migrating off-site. Soils found at Site 10 are characteristically deep, moderately well drained to poorly drained fine-textured soils. The underlying clays are proglacial lake beds consisting of varved clays. Laboratory and field tests indicate that the clays are very poorly permeable. Permeability of the clays ranged from 2.5×10^{-7} to 5.88×10^{-6} cm/s (9.8×10^{-8} to 2.3×10^{-6} in/s). Additional investigations included 26 borings, four resistivity traverses, and 19 test pits. Information provided by these surveys indicates that the site is adequate for the secure land disposal of PCB-contaminated sediments.

With the selection of Site 10 as the land disposal site, a secure containment facility was designed to encapsulate the contaminated sediments. MPI has designed engineering structures and control systems to prohibit leachate movement and provide continuous monitoring during the placement of the dredge spoils and after closure.

All of the containment dikes, berms, and permanent cap will be constructed primarily of the silty clay and silty clay loam soils present on the site. Engineering studies on the soils at the site indicate that this material will form dikes that are stable if built to design specifications. A seepage analysis of the dike material indicates that flow would be on the order of 2.5×10^{-6} cu m/d/m (3×10^{-4} cu ft/d/ft). It is estimated that water within the containment area would require in excess of 1,000 years to reach the outside face of the dike (MPI, 1980b).

When placed in the proposed containment site, the dredged material will contain substantial quantities of interstitial water remaining as a result of the hydraulic transport process. The rate at which this liquid can be drained is a function of the permeability of the dredged material, and drainage will take from 1 to 2 years at the maximum. It is estimated that this will produce 344,435 cu m (91,000,000 gallons [g]) of interstitial water over the 1 to 2 year period.

An alternative method of dewatering the dredge spoils is to use hydrocyclone separators, diaphragm presses, or other mechanisms. The dewatering spoils would be deposited in an upland containment site and the water would be discharged to the Hudson River after receiving necessary treatment. This conceptual alternative is more energy intensive than the alternative to dewater by gravity, but impacts associated with volatilization of PCBs during dewatering probably would be substantially less using mechanical methods. However, the engineering feasibility and design of mechanical dewatering have not been determined. Nevertheless, applying currently available dewatering processes, such as hydrocyclone separators or diaphragm presses, preliminary estimated indicate that mechanical dewatering would cause additional costs of more than $5,000,000 (Richard Thomas, Project Manager, MPI, April 21, 1981). Therefore, mechanical dewatering is presently regarded as not cost-effective.

Long-term rainfall infiltration through the cover could continue to generate a leachate, estimated to be approximately 8,377 cu m/yr (2,200,000 gal/yr) (MPI, 1980b). A leachate collection system has been designed by MPI for the containment facility and consists of the following components:

- sloped bottom of containment area
- gravel-filled collection trenches wrapped with filter fabric
- perforated drainage piping in the collection trenches
- collection and sampling wells on the containment area perimeter connected to the drainage piping
- piping system to connect the drainage system to a discharge point at the Hudson River
- flow metering and monitoring system

The leachate collecting system would be valved. Discharge to the Hudson River would be permitted only if leachate quantities and concentrations observed will have no adverse impact on the river.

Stormwater runoff collection would entail the use of one collector drainage channel, constructed at the toe of the containment dikes, to convey all off-site and on-site drainage to the Hudson River. After closure, additional channels would be constructed both along the south dike and on top of the closed containment areas. All flow from these channels would be conveyed to the collector drainage channel by means of drop pipes constructed at various locations around the containment areas.

All flow from the collection channel, as well as effluent from the treatment plant, would be conveyed to the Hudson River under Route 4 and the Champlain Canal by means of a closed conduit (MPI, 1980b).

During each dredging season, the proposed site would receive spoil from the dredging operations. At this time, the rate at which the dredged material dewaters will dictate how quickly the cap will be placed. The higher the percentage of fine-grained sediments, the slower the material will drain. Recent data from probings in the Thompson Island Pool indicate that the material will dewater within two or three weeks of placement. Based upon this initial assumption, the capping material will be spread over the dredged material as dredging progresses throughout the summer. This will minimize volatilization.

At the end of the second season, the site will be permanently capped. The cover will consist of a 46-cm (18-in) thick layer of clay overlain by gravel and topsoil. Clay material for the cap will be obtained on-site. The cap will be designed to withstand deterioration by freezing, thawing, and drought. At the time of permanent closure, all return water treatment structures will be removed and permanent long-term monitoring and control structures will be installed.

Under the full-scale project, the containment area was designed for a capacity of 1,728,000 cu m (2,260,000 cu yd) of contaminated material. Under the reduced-scale project, the required containment volume was reduced owing to deletion of remnant deposit relocation and containment, deletion of provisions for NYSDOT spoil area containment, and reduction in hot-spot dredging. For these reasons, the required containment capacity of the reduced-scale project is estimated to be 841,000 cu m (1,100,000 cu yd) (Appendix B).

III. SELECTION OF THE RECOMMENDED ACTION

1. RECOMMENDED ACTION

Based on public health, environmental, cost, and engineering evaluations carried out by EPA and its environmental consultants, the EPA recommends that the action alternative be implemented if contingency/mitigation measures ensuring public safety are developed (Table 2-12).

Resolution of these issues will ensure that minimal risk to public health, safety, and welfare will result from the implementation of this project Modifications and contingencies developed will be submitted for public comment before a NEPA decision is reached.

EPA recommends that a project to dredge and/or stabilize all known PCB hot spots be implemented. After carefully evaluating both the original full-scale proposal and reduced-scale proposal submittted by NYSDEC, EPA recommends funding a modification of the original full-scale project since greater potential benefits will be realized. However, if additional funding is not available, the reduced-scale project is also recommended, although with reduced potential benefit, because it will provide for demonstration of river recovery and indefinite storage while not endangering public health, safety, and welfare.

The authorization by Congress under Section 10 of the CWA Amendments is $20,000,000. If the action alternative is approved, the recommended action is to undertake the originally proposed $40,000,000 full-scale project with the required modifications. Additional funds from either federal, state, or perhaps outside sources will be required to implement the full-scale project, while affording protection of the public health and the environment. Although not as desirable as the full-scale project, it is recommended that the $26,700,000 reduced-scale project could be undertaken along with the aforementioned project modifications.

Table 2-12

EPA Recommended Program

Full- Scale	Reduced-Scale
Dredging or in-river containment of all 40 hot spot areas in the river bed with containment in a secure upland site.	Reduction of the number of hot spots to be dredged or contained in-river
Design and construction of a secure upland containment site capable of indefinite long-term isolation of contaminated material	Same, except for a reduction in capacity at the containment site
Deletion of remnant deposit removal and upland containment; instead, provision of secure cap and top dressing,and further bank stabilization if necessary	Same
Elimination of provision for the containment of PCB-contaminated material from dumpsites in the Fort Edward area.	Same
Provision for containment of contaminated materials from three NYSDOT dredge spoil sites (212, 13 and 204 Annex)	Same
Provision for dredging and containment operational standards and procedures, mitigation measures, monitoring programs, and contingency plans necessary to safeguard public health and agricultural resources	Same
Provision for research studies/environmental monitoring programs necessary to demonstrate the improvement in the rate of recovery of the river and storage of contaminated material	Same

2. FINDINGS

1. Disposal of PCB-contaminated dredge spoils in a landfill would provide a higher standard of protection of the public health, safety, and welfare than disposal of such pollutants by other methods including, but not limited to, incineration or a chemical destruction process. The basis of the above conclusion is that alternative disposal methods are either infeasible or highly speculative and would render the entire project economically infeasible within the amounts of money available for the "rescoped" project (i.e., $26.7 million).

2. The proposed containment site, incorporating the modifications and safeguards described below, is environmentally sound for indefinite storage of PCB-contaminated sediments. The storage of contaminated sediments at the proposed containment site will not have significant long-term adverse environmental impacts to the surrounding communities.

3. The proposed dredging operation, incorporating the modifications and safeguards described below, will not have significant short- or long-term adverse effects on the surrounding community, downstream water supplies or the ecology of the Hudson River.

4. Removal and in-river containment of substantial quantities of PCB-laden sediments should demonstrate an improvement of the rate of recovery of the Hudson River.

5. Removal and in-river containment of PCBs from the upper Hudson River will also reduce the risk of:

   - contaminating downriver water supplies caused by high flow conditions
   - public health threats due to excessive volatilization from the river bank areas
   - public health threats due to the consumption of contaminated fish
   - the necessity to close the Hudson River fishery due to high flows after projected reopening
   - permanent closure of the striped bass fishery
   - conducting environmentally unsound maintenance dredging and upland disposal of contaminated sediment from the upper Hudson River and estuary
   - closing navigable waterways both in the upper and lower Hudson River due to the inability to provide adequate upland containment of containment dredge spoil
   - endangering aquatic species, in particular the shortnosed sturgeon.

6. Removal and in-river containment of PCBs from the upper Hudson River is not expected to significantly reduce PCB sediment concentrations in the New York Harbor.

7. As presently proposed by NYSDEC, PCB volatilization caused by the discharge of contaminated dredged sediment into the containment site could exceed the New York State Department of Health (NYSDOH) recommended maximum allowable 24-hour average ambient air PCB concentration at nearby residences and at other sensitive receptors under worst case dissolved PCB concentrations and meteorological conditions. However, the analysis conducted by EPA shows that with mitigation measures presented below, the 1 ug/cu m ambient air guideline should not be exceeded.

3. MODIFICATIONS

The modifications to the original project, as well as to the reduced-scale project referenced above, include changes in the design, operational standards, contingencies, and long-term monitoring and maintenance. These recommendations are consistent with the Congressional intent of Section 10 of the CWA Amendments. The purpose of these modifications is to provide a higher standard of protection for public health, safety, and welfare during dredging and disposal operations and throughout the life of the containment site. Prior to the NEPA decision and granting of federal funds to undertake site construction and dredging, the modifications described below must be fully developed, submitted for public comment, and approved by EPA.

Since neither the original or reduced-scale project contains the specific provisions to carry out financial assurances, contingencies, long-term monitoring, operational standards and procedures, operation and maintenance, or land acquisition, the NYSDEC must obtain firm commitments for additional funding for these provisions from either state or other federal sources prior to project approval. Federal or state matching funds currently appropriated for this project are not sufficient to be used for these purposes. These current funds are to be used only for dredging, site construction and closure, and a monitoring program for only the duration of the project operations. Although there are a substantial number of modifications and additions to the original full-scale and reduced-scale projects, most are directed toward long-term elements subsequent to containment site closure, the costs of which are to be borne by New York State. Therefore, the modified project should not substantially reduce the material planned to be removed from the river.

The recommended modifications to the project are specified below under the separate categories of "Dredging, In-River Containment, and Stabilization", "Disposal", "Long-Term Storage", and "Water Quality Monitoring".

Dredging, In-River Containment, and Stabilization

1. Study and make recommendations to maximize in-river containment of hot spots where feasible and cost effective. (This will be studied in detail during the 45-day draft NEPA EIS review period).

2. Cap/in-place stabilization and denial of access of remnant deposits 3 and 5 as an immediate measure.

3. Maximize upriver flow regulation at Sagandaga Dam as a flood control measure during the dredging operation.

4. Develop operational standards and procedures, mitigating measures, monitoring programs, and contingency plans to eliminate excessive volatilization and resuspension of PCB-contaminated sediments to protect workers, residents, agricultural resources, and water supplies.

Disposal

1. Modify disposal operations at the containment site including the provision for smaller containment cells, addition of PCB adsorbents, and possible cell cover during loading operations to minimize volatilization.

2. Develop operational standards and procedures, contingency plans, and monitor program surrounding the proposed containment site for the duration of the disposal operations to assure the NYSDOH 1 ug/cu m ambient air guideline is met, as well as the 0.2 ug/g (ppm) standard for crops set by the FDA

3. Develop specific contingency plans for additional treatment of the supernatant from dewatering prior to discharge if permit limits (to be established) are exceeded.

Long-Term Storage

1. Development of long-term maintenance and monitoring programs for a minimum of 30 years with periodic program review by EPA and NYSDOH.

2. Contingency plans for (a) long-term leachate collection and treatment, (b) landfill cap maintenance, (c) excessive PCB volatilization or methane generation, and (d) alternate water supply should monitoring indicate failure of containment site.

3. The development of grievance and arbitration procedures and the investigation of the feasibility of liability insurance for any claims arising in connection with the public health aspects of the project.

4. Provision for specific funding mechanisms by NYSDEC to assure implementation of long-term contingency plans, operation, maintenance, and monitoring.

5. Redesign of the containment site leachate collection and storage system to improve operations and to avoid clogging and buildup of leachate within the site.

6. Provision for storage of NYSDOT maintenance dredging materials from sites 212, 13, 204 Annex from Washington County only (if removal is deemed necessary), under the condition that the state bear the incremental costs associated with disposal and long-term storage.

Water Quality Monitoring

1. Develop a long-term monitoring program to evaluate the improvement of the recovery rate of the river and fisheries.

2. Develop a long-term monitoring and maintenance program if in-river containment is implemented to determine leaching of PCBs back into the river.

3. Develop a downstream public water supply monitoring program for PCBs and heavy metals to be implemented before, during, and after dredging operations, especially during and shortly after high flows. Contingency plans to provide additional water treatment or alternate water supplies also should be developed.

4. Develop a short-term monitoring program for air quality, water quality, and biota during dredging and disposal operations.

4. CITIZEN INVOLVEMENT

It is also recommended that if either the full-scale or the reduced-scale project is undertaken, the CAC and the Settlement Advisory Committee (SAC) be continued at least through the operational phase of the project, and beyond if so desired by the respective committees. The committees would serve as a community focal point for the distribution of project information and data and, at the same time, provide oversight and local and technical liaison between the affected communities and the operational and regulatory agencies, including EPA.

The CAC has raised two issues of public concern which should be considered by New York State.

1. NYSDOT should develop a comprehensive PCB dredge spoil disposal plan for the upper Hudson River, also within the same time frame as this proposed project.

2. NYSDEC should consider providing assurances that neither the proposed containment site nor the surrounding land acquired by New York State will be used for the future disposal of any hazardous waste generated from either within or outside Washington County.

CHAPTER 3

AFFECTED ENVIRONMENT (EXISTING CONDITIONS)

This chapter presents descriptions of the natural and man-made environmental resources that may be affected by the alternatives under consideration.

1. EARTH RESOURCES

1a. Regional Geological Setting

Bedrock Geology

Geological units in the region are composed of both consolidated and unconsolidated materials. The area is underlain predominantly by shales with minor occurrences of slate and graywacke. Blue-black to gray clayey shale layers (a few inches to several feet thick) and some sandstone layers (rarely more than 8 cm [3 in] thick) make up the shales. These bedrock formations, as observed in outcrops and borings in the area, dip toward the southeast. In areas of jointing and fracturing, many fractures are tightly sealed with calcium carbonate. However, the remaining open joints and fractures allow the migration of water.

Surficial Geology

In most places, the bedrock is overlain by unconsolidated glacial materials and more recently deposited materials ranging in depth from a few inches at rock outcrops to more than 60 m (200 ft). The identifiable unconsolidated sediments are: (1) glacial till, (2) glacial outwash, (3) ancient lake deposits, (4) recent river deposits, and (5) modern dredge spoils.

The glacial deposits are the result of the Wisconsin Age glacial advancement that eroded and smoothed the bedrock surface during the Pleistocene Epoch.

Glacial till deposits, which cover approximately 10 percent of the upper Hudson basin are highly variable assortments of rock materials ranging in size from clay particles to rock fragments and boulders. The till usually occurs as ground moraines of varying thickness. Generally, the till is not stratified but local pockets of sand, gravel, silt, and clay do occur within the till mass. Deep till deposits tend to be more compact and dense than shallow deposits that have been weathered more completely (MPI, 1978a).

Glacial outwash deposits consist of sand and gravel sorted by glacial melt water. These deposits are generally younger than, and commonly rest on, till. Valley-fill deposits were formed in lakes or stream channels where spillways were formed by ice or glacial debris. Approximately 25 percent of the upper Hudson River area is overlain by glacial outwash. Outwash deposits occur in most stream valleys tributary to the Hudson River. The thickness of the deposits is influenced by the shape and original bedrock of the valleys. These highly variable sediments are usually stratified, consisting of gravel, coarse through fine sand, and clay. Deltaic deposits are fan-shaped outwash formations that were generated at points where streams laden with large rock debris entered the still waters of proglacial Lake Albany. Deltaic deposits are composed of materials ranging in size from coarse gravel to fine sand and silt (MPI, 1978a).

Ancient lake sediments, which occupy up to 60 percent of the upper Hudson area, were deposited on the bottom of proglacial Lake Albany. This lake extended from Rensselaer County to Essex County some 10,000 to 15,000 years ago. These deposits were laid down in the quiet water of the glacial lake and were eventually exposed as flat terraces or bottomlands when the lake drained, near the end of the Pleistocene Epoch. Today, the formations are found along the Hudson River as terraces, covering flat to gently rolling valley floors. The lower beds are predominantly fine-grained bluish clays grading to yellowish-red silts (MPI, 1978a).

Recent river deposits, known as alluvium and consisting of sediments of various textures deposited along streams, occupy less than five percent of the upper Hudson area. These deposits are usually located on the floodplains within 790 m (2,600 ft) of the banks of the Hudson River and certain tributaries.

Canal dredging spoils has been deposited along the Hudson River as a result of human activity within the study area. These deposits are generally coarse grained, consisting of quartz-feldspar sands, cinders, and shale cobbles, mixed with wood fragments ranging from sawdust to pieces several feet long (MPI, 1978a).

Seismic History

Seismic events recorded in and around the upper Hudson River Basin have been moderately common, although not excessively damaging. Earthquakes in the area indicate that movements are associated with known or closely related faults. The area is listed in the Zone 2 (moderate damage) seismic risk area. Algermissen and Perkins (1976) estimate that there is approximately a ten percent chance that the bedrock units in the area will undergo horizontal acceleration (shaking) that exceeds nine percent of the force of gravity at least once in a 50-year period.

Soils

Most of the soils within the upper Hudson River Valley have been formed in mineral material deposited by the Wisconsin Age glacial advancement, the most recent glacier of the Pleistocene Epoch. Some soils, however, have been formed in more recent deposits of alluvium or dredge spoils.

Shallow soils developed in glacial till over bedrock are rare in the area and are usually found on undulating to hilly uplands. Drainage of these soils ranges from moderately well drained to somewhat excessively drained. A dense subsurface soil layer, low in organic matter and slowly permeable, called a fragipan, is often encountered in these soils. Fragipan may seriously impede drainage and result in localized elevation (perching) of the groundwater table. Shallowness of soil to bedrock or a fragipan, as well as numerous rock outcrops, are the main limitations for farm and nonfarm uses (MPI, 1978a).

Soils that have been developed in glacial lake sediments occur quite extensively on lake plains and valleys within the upper Hudson River Basin. These deep soils, found on slopes ranging from nearly level or depressional to very steep, are classified as somewhat poorly drained to well drained. The wetness of these clayey and silty deposits increases with depth; water contents as high as 60 to 70 percent have been reported (U.S. Department of Agriculture, Soil Conservation Service, [USSCS] 1975). These clayey and silty deposits are highly susceptible to frost action and their sticky and plastic character makes them difficult to work when wet.

The soils formed on plains, terraces, and glacial outwash deposits in the valleys are deep, and somewhat excessively drained, and moderately coarse textured. Many of these soils are underlain by lenses of silt and clay that impede their drainage. Droughtiness and the large number of coarse fragments are the main limitations for farm uses.

Soils that have formed in recent alluvium on floodplains are usually deep, medium textured (high in silt and very fine sand), and characterized by drainage classes ranging from very poorly to well drained. These soils are all subject to annual or more frequent periods of overflow, except along the Hudson River where the flow is regulated. The water tables in these soils fluctuate and are determined to a large extent by the water level of adjoining streams. Flooding is the main limiting factor for use of these soils.

1b. Containment Site Geology

The following is a brief discussion of the bedrock, surficial geology, and soils at the containment site. For more detailed discussions of field investigations and environmental conditions at the containment site, the reader is referred to MPI (1978b, 1980a, and 1980b).

Bedrock Geology

The bedrock that underlies the site and outcrops adjacent to the site is part of the Snake Hill Formation. This rock is a dark gray, fissile (capable of being split along closely spaced parallel planes), unweathered, moderately jointed to broken, calcareous shale. There are a number of springs discharging along the slopes and at the base of the rock outcrop south of the site. Depth to bedrock varies greatly at the site, from just below the ground surface in the southeast and southwest corners to approximately 23 m (75 ft) below ground surface in the northeast corner (MPI, 1980a).

Surficial Geology

The unconsolidated material overlying the bedrock at the containment site consists of fine-grained sediments deposited in glacial Lake Coveville. The clays are typically varved (layered) and were deposited during the retreat of the Wisconsin Age glacier, approximately 13,000 years ago.

The varved clay begins between 89 to 167 cm (35 to 66 in) from the ground surface and extends to a depth of 10 m (30 ft). The varves are a result of seasonal sedimentation and consist of alternating laminae (thin layers) of dark grayish-brown clay (from 0.5 to 3.8 cm [0.2 to 1.5 in] thick) and silty material (less than 0.2 to 2.5 cm [0.1 to 1.0 in] thick). Occasionally, lenses of very fine send are found between the clay layers, but they do not appear to be continuous. Deposits of calcium carbonate are identifiable 61 to 91 cm (24 to 36 in) below the surface. The carbonate usually occurs in discontinuous vertical seams, but at a few locations pockets of carbonate exist that are 8 to 10 cm (3 to 4 in) thick. The pockets of carbonate (lime) are generally found 1.2 to 1.5 m (4 to 5 ft) below the surface and contain irregularly shaped carbonate nodules that are 0.63 to 2.5 cm (0.25 to 1.0 in) in diameter. The major clay minerals present are illite, montmorillonite, chlorite, and vermiculite with some trace kaolinite and smectite (MPI, 1980a).

Analysis performed on the borings by the engineering firm of Muser, Rutledge, Johnston, and Desimore (MRJD) (Richards, MRJD, April 22, 1980) indicates that the unconsolidated material overlying the bedrock is variable in thickness. In the northern and central parts of the containment site, the thickness of the clay material ranges from 10 to 23 m (35 to 75 ft). Along the southern portion of the site, bedrock is closer to the surface and the thickness of the clay varies from 0.6 to 12 m (2 to 40 ft). In the south central portion of the site, the bedrock outcrops and the overlying clay thins significantly. The actual containment facility will not extend to this portion of the site (MPI, 1980b).

The clay material at the site may be divided into two basic types. The upper layer, identified by MRJD as stratum C_1, is basically a stiff, brown to graybrown clay, varved with trace layers and pockets of silt to clayey silt with occasional fine sand seams. The natural water content for this material ranges from 29 to 38 percent of dry weight. Below this stratum is C_2, a softer clayey material with an average water content that varies between 33 and 45 percent of dry weight. Because C_2 material has a higher water content and is softer, C_1 material is more suitable for use in the construction of containment dikes and the clay cover (MPI, 1980a).

Laboratory and field tests were performed on the unconsolidated material to determine the engineering, physical, and hydrologic characteristics of the material. Tests of the permeability of the lake bed material indicate a range from 2.5×10^{-7} to 5.88×10^{-6} cm/sec (8.2×10^{-9} to 1.92×10^{-7} ft/sec). New York State regulations on hazardous waste deposits require a clay seal at the site having a hydraulic conductivity of not greater than 1×10^{-5} cm/sec (3.3×10^{-7} ft/sec) and EPA requires an overall in-place permeability of not greater than 1×10^{-7} cm/sec (3.3×10^{-9} ft/sec). Physical analysis of the varved clay indicates that 90 percent of the particle sizes are finer than No. 200 sieve size. An Atterberg Limit Test run on both pure clay samples and clay varved with silt indicated that the Liquid Limit is greater than 30 and a Plastic Index greater than 15 (MPI, 1980a).

Soils

The predominant soil type found in approximately 53 percent of the containment site is the Kingsbury silty clay. Other similar soils found at the site are the Covington silty clay loam and the Vergennes silty clay loam, which account for about 20 and 21 percent of the area, respectively. A minor portion of the site (6 percent) is Nassau shaly silt loam, a shallow, medium-textured soil that formed in glacial deposits. Properties of these soils are presented in Table 3-1. The Kingsbury soil occupies the nearly level portions of the site, while the Vergennes soils have formed on the more sloping sections. Covington soils are found along drainways and at the base of slopes (USSCS, 1975).

Table 3-1

Characteristics of Soils within the Containment Site

Soil Series	Area Occupied Percent of Total	Depth to Bedrock[1] (m)	Depth to Bedrock[1] (ft)	Depth to Seasonal High Water Table (m)	Depth to Seasonal High Water Table (ft)	Drainage	Land Use Capability	Agricultural Suitability
Kingsbury silty clay	53	>1.1	>3.5	0-0.6	0-2.0	Somewhat poorly to poorly	Severe limitations due to periodic standing water	Soils have severe limitations that reduce choice of plants
Vergennes silty clay loam	21	>1.1	>3.5	0-0.6	0-2.0	Moderately well	Very severe limitations due to risk of erosion	Majority have severe limitations that reduce choice of plants
Covington silty clay loam	20	>1.1	>3.5	0-0.6	0-2.0	Somewhat poorly to poorly	Very severe limitations due to periodic standing water	Soils have severe limitations that reduce choice of plants
Nassau shaly silt loam	6	0.3-1.1	1-3.5	0.5-1.1	1.5-3.5	Somewhat excessively well to well	Very severe limitations due to risk of erosion	Soils have severe limitations that reduce choice of plants

Note: 1. These depths are for typical soils. It may vary significantly depending on the location.

Source: MPI, 1980a.

The agricultural potential for Site 10 is limited. The majority of soils fall within agricultural suitability Classes III and IV. These are defined as having severe agricultural limitations, primarily due to excessive wetness and slow permeability, that reduce the choice of plants and/or require special conservation practices. Kingsbury soils are estimated to yield 27 to 36 metric tons (t)/ha (12 to 16 short tons [tn]/a) per year of corn for silage, or 5.6 to 9.0 t/ha (2.5 to 4.0 tn/a) per year of forage mixture. Vergennes soils are estimated to yield 27 to 40 t/ha (12 to 18 tn/a) per year of corn for silage, 4,350 to 6,960 liters (l)/ha (50 to 80 bushels [bu]/a) per year of corn for grain, or 5.6 to 11.2 t/ha (2.5 to 5.0 tn/a) per year of forage mixture. Covington soils are estimated to yield 4.5 to 7.8 t/ha (2.0 to 3.5 tn/a) per year of forage mixture. Nassau soils are estimated to yield 4.5 to 6.7 t/ha (2.0 to 3.0 tn/a) per year of forage mixture (Newton, March 28, 1981). Therefore, on the proposed containment site the potential yields are estimated to be 20 to 27 t/ha (9 to 12 tn/a) per year of corn for silage, 870 to 1,390 l/ha (10 to 16 bu/a) per year) of corn for grain, or 5.4 to 9.0 t/ha (2.4 to 4.0 tn/a) of forage mixture. At present the proposed containment site is not active farmland. The current property owner is neither a farmer nor a resident of the area (Newton, March 28, 1981).

1c. River Bed Materials in Upper Hudson River

The sedimentary deposits within the upper Hudson River in the area between Glens Falls and Troy are characterized by geographically and temporally intermittent distributions, caused by varying hydraulic regimes and sediment sources. In areas of moderate velocity, bottom materials consist primarily of sands and gravels in combination with concentrations of coarse-grained organic debris including wood chips, sawdust, and lath. Within low velocity backwater areas, sediments become progressively finer as the coarser materials are replaced by silts and clays (LMS, 1978). Sediments with a grain size ranging from medium to very fine sand can be eroded at the lowest velocities and, therefore, tend to accumulate in the more protected areas. Both clays and gravel require much higher velocities to be eroded. The clays are held in place by cohesive forces, while the gravel is held in place by its weight (Vanoni, 1977).

Numerous sampling programs of the upper Hudson River bed material have been carried out as part of this study. The most extensive program was carried out by Normandeau Associates from 1976 to 1977. Cores of river bed deposits were obtained from Lock 7 at the Troy Dam and were analyzed for PCB concentrations, sediment grain-size distribution, sediment/PCB relationships, and distribution of PCBs within the river channel. Detailed discussions of the results of this and other river surveys can be found in Tofflemire (1976), Tofflemire and others (1979), Tofflemire and Quinn (1979), and MPI (1978a, 1980c). The following is a brief summary of the findings.

The majority of the Thompson Island Pool samples had average grain sizes that ranged from fine to very fine sand. Overall, the median grain size of the hot spots fell within the very fine sand range. Approximately 21 percent of the samples had average grain sizes greater than 2 millimeters (mm) (0.08 in), and a large portion of the gravel-sized material consisted of wood chips.

Samples obtained along the length of the river were extremely variable, but indications are that finer textured materials were more common closer to the shoreline and in slack water deposits. In general, the Thompson Island Pool deposits had a coarser texture than those found in the downstream pools. Average organic and clay contents of bed deposits are presented in Table 3-2.

Organic materials within the bed deposits ranged from colloidal size humus to wood fragments several feet in length. Organic matter has been shown to adsorb PCBs from waters, thereby largely affecting PCB concentration and distribution within the bed deposits.

Total volatile solids within the deposits ranged from 0.6 to 92.7 percent by weight in the Thompson Island Pool and from 0 to 93.1 percent by weight south of the pool. The average content of volatiles for the total study reach was approximately 7.0 percent by weight. The high percentages of volatile solids within the deposits are due to wood fragments. Most of the volatile solids within the material were associated with the gravel-sized fraction (MPI, 1978a).

PCB values tend to be high in coarse sand-sized particles, low in sand-sized particles, and high again in the silt- and clay-sized particles. The coarse

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Table 3-2

Bed Deposit Properties

Pool	Percent Clay	Percent Volatile Solids (by weight)	Number of Samples
Thompson I	5.82	7.5	211
Lock 5	7.53	11.8	118
Lock 4	4.01	4.36	293
Lock 3	7.27	10.07	36
Lock 2	3.96	3.76	9
Lock 1	0.74	2.23	4
Total Reach	5.34	6.96	671

Source: MPI, 1978a.

fraction contained a significant higher percentage of volatile solids (largely wood chips), thus accounting for the high PCB content. PCBs also adsorb to clays and fine silts (Tofflemire and others, 1979; Tofflemire and Quinn, 1979).

The greatest quantities of PCBs are located immediately downstream from the former discharge points in the remnant deposits and in the Thompson Island Pool. Estimates of PCBs in the remnant deposits range from 29,000 kg (64,000 lb) (Tofflemire and others, 1979) to 63,500 kg (140,000 lb) (MPI, 1978a), and in the Thompson Island Pool from 53,500 kg (118,000 lb) to 60,600 kg (133,700 lb) (MPI, 1978a). The entire upper Hudson River, including the remnant deposits, is believed to contain between 148,800 to 178,700 kg (328,200 to 394,000 lb) of PCBs.

The average level of PCBs exceeds 50 ug/g (ppm) in the Thompson Island Pool and Lock 5 pool, but is lower in the remaining pools (MPI, 1978a). Concentrations generally decrease with distance downstream, although the Lock 4 pool levels are low in comparison with those of the Lock 2 and 3 pools.

PCB levels in the center of the river and along the eroding bank are typically in the range of 5 to 20 ug/g, (ppm) while levels along the depositional shore may range from 50 to 1,000 ug/g (ppm) in fine grained sediments. Statistical analyses in the Thompson Island Pool and Lock 5 and 6 pools showed significantly higher PCB levels along near-shore areas of the river, in comparison to the middle third of the river. The differences among the Lock 1, 2, and Troy Dam pools were not significant (Tofflemire and Quinn, 1979).

NYSDEC has prepared a summary tabulation of average PCB concentration with depth of sediment core (Tofflemire and Quinn, 1979). The cores were taken principally in the soft near-shore sediments. Cores registering less than 6 ug/g (ppm) PCBs were not included. Above Lock 7 and in the Thompson Island Pool, peak PCB levels of approximately 130 ug/g (ppm) were generally found at depths of 30 to 45 cm (12 to 18 in). Further downriver from the Lock 6 pool to the Troy Dam, the PCB peak typically occurred at between 8 to 30 cm (3 and 12 in) deep. The peak PCB strata averaged about 150 ug/g (ppm) in the Lock 5 and 6 pools, and decreased to approximately 50 ug/g (ppm) in the remaining downstream pools (Tofflemire and Quinn, 1979).

Sediment samples taken in a variety of locations in the upper Hudson River show elevated levels of chromium, lead, and zinc in addition to PCB. Sediments from behind the original Fort Edward Dam that were examined in 1970 contained lead and zinc in very high levels, up to 3,630 and 2,950 ug/g (ppm), respectively (Clarkson and Clough, 1970). Limited samples taken in the remnant deposits following the removal of the dam in 1973 showed very high levels of lead, up to 5,600 ug/g (ppm) (MPI, 1978b). Elevated sediment levels of chromium, lead, and zinc were found at the Thompson Island Pool (Tofflemire, 1976) and at the confluence with the Moses Kill (GE, 1977). Representative grab samples taken by NYSDOH throughout the upper Hudson River showed the following mean values: chromium, 705 ug/g (ppm); lead, 387 ug/g (ppm); and zinc, 217 ug/g (ppm) (Tofflemire and Quinn, 1979).

Statistical analysis indicates that of the metals sampled, the distribution of lead most closely approximates the distribution of PCBs. (The correlation coefficient of log lead versus log PCBs is 0.609.) This observation is based on grab samples taken to depth of six inches, which are, therefore, likely to consist of recently deposited sediments. The correlation suggests that lead levels should be closely monitored during any remedial dredging (MPI, 1980d).

1d. River Bed Materials in Lower Hudson River

The estuarine portion of the river below the Federal Dam is estimated to contain 75,700 kg (167,000 lb) of PCBs (Bopp, 1979; Bopp and others, 1981). The following depositional areas in the lower Hudson River have higher concentrations of PCBs: Albany turning basins (River Mile 109.5), Kingston area (River Mile 85 to 93), Haverstraw Bay and the Tappan Zee, New York Harbor, and other coves and bays. Among these areas, New York Harbor has the greatest mass of PCBs, 23,100 kg (51,000 lb), at an average concentration of 3 ug/g (ppm) (MPI, 1980d). Bopp (1979) estimates that 70 to 75 percent of the PCBs in New York Harbor originated from discharges to the upper Hudson River.

2. WATER RESOURCES

2a. Surface Water

Hudson River Basin

The Hudson River Basin covers 34,615 square kilometers (sq km) (13,365 square miles [sq mi]), 27 percent of New York State. From the Hudson-Sacandaga River junction south to Fort Edward, there is a series of seven dams and three natural waterfalls that are used to generate hydroelectric power. From south of Fort Edward to the Federal Dam at Troy, the Hudson River is regulated by a series of eight dams. In addition to these dams, there are seven locks that are part of the Champlain Canal System. The Hudson River from Albany to New York Harbor is a tidal estuary (MPI, 1980d).

The drainage area of the Hudson River varies from 7,299 sq km (2,818 sq mi) at Fort Edward to 20,953 sq km (8,090 sq mi) at the Federal Dam at Troy. To maintain navigation and power generation, flows are regulated to a minimum of 85 cu m/sec (3,000 cfs). The minimum depth of 3.6 m (12 ft) is maintained for navigation.

Several reservoirs above Glens Falls affect flow levels in the upper Hudson River. The Sacandaga Reservoir is a 940 million cu m (247,650 million gal) impoundment on the Sacandaga River, which joins the Hudson River at Hadley. Flows from the reservoir are regulated during low flow to maintain navigation, water quality, and power generation downstream. Flows from the reservoir are regulated to control flooding during high flows. Water is released from this reservoir to maintain a minimum of 85 cu m/s (3,000 cfs) at Spier Falls (MPI, 1980d). Other reservoirs that affect flows in the upper Hudson River are Indian Lake, Piseco Lake, Spier Falls Reservoir, and Sherman Island Reservoir.

Low flows are generally observed between July and October of each year and have been recorded at 14 cu m/sec (500 cfs). April and May are annual high flow periods when rates over 280 cu m/sec (10,000 cfs) are common, and a flow of 1,113 cu m/sec (39,319 cfs) was recorded on April 2, 1976, during the 100-year flood.

Water Quality

New York State water quality classifications and standards are listed in Table E-1 (Appendix E). Classifications for the upper Hudson River vary from "A" to "D" and are based on the intended "best use" for these waters. Classification of the river, as reported by MPI (1978a), is as follows:

From Lock 7 downstream to the mouth of the Snook Kill 3.7 km (2.3 mi) the waters are classified 'D': suitable for secondary contact recreation but not for the propagation of fish. From the Snook Kill to Fort Miller 9.0 km (5.6 mi) the classification changes to 'C': intended as suitable for fishing and other uses except water supply and contact recreation. The classification reverts to 'D' downstream to the mouth of the Batten Kill (6.1 km) (3.8 mi), then back to 'B' along the 25.7-km-(16-mi) section south to Lock 3. 'B' waters are intended as suitable for contact recreation and other uses except water supply. The classification is reduced to 'D' betwen Locks 2 and 3, but is upgraded to 'A' below Lock 2, a classification that does not necessarily reflect improved water quality as much as the fact that this section is used as a public water supply for the Village of Waterford.

Water quality data for the Hudson River are collected by NYSDEC, USGS, and NYSDOH. These data are presented in Table E-2 (Appendix E). The data show that, with the exception of mercury, lead, hydrocarbons, and phosphorus, all parameters measured meet state and federal standards. The maximum level for lead that is recommended by EPA is 12 ug/l (ppb) in soft waters.

Point and Non-Point Sources

Glens Falls, Fort Edward, Fort Miller, and Mechanicville discharge municipal and industrial wastes into the Hudson River, causing adverse effects on water quality. The water quality downstream from Mechanicville improves because of dilution and the biological and chemical breakdown of pollutants (MPI, 1978a).

Non-point source (NPS) runoff results primarily from agriculture and can cause increased nutrient levels, turbidity, and erosion. Levels of NPS have not been quantified (MPI, 1978b).

2b. Groundwater

Regional Groundwater

Two main types of groundwater aquifiers occur in the study area: Ordovician-aged consolidated rocks, and Pleistocene-aged unconsolidated sediments. The consolidated rocks generally have low effective primary porosities. However, in many areas, the presence of joints, fractures, and fault zones has significantly increased the permeability of formations. Yields reported for 192 wells drawing from the shale aquifer in Washington and Saratoga Counties ranged from 2.0 to 300 liters per minute (lpm) (0.5 to 80 gallons per minute [gpm]) and averaged about 34 lpm (9 gpm). Water from shale wells is generally hard and may contain hydrogen sulfide (MPI, 1978a).

The unconsolidated deposits yield water of varying quality and at differing rates. Because of its low porosity, glacial till yields water very slowly. The estimated average yield of these deposits is from 4 to 8 lpm (1 to 2 gpm). The more productive wells derive water largely from thin sand lenses in the till. Glacial outwash deposits have high permeabilities. These stratified sands and gravels have average yields of 19 to 38 lpm (5 to 10 gpm). Deltas are the most productive water-bearing glacial outwash formations. Lacustrine deposits of clay and silt yield water very slowly and seldom in usable quantities. The alluvial deposits found in the study area are not coarse enough or thick enough to be important as sources of groundwater.

Containment Site Groundwater

It is difficult to define a true water table at the containment site because of the variable nature of the lake bed sediments and the extremely low permeability of the clays. The slowly permeable clays retard groundwater flow to the point that test pits dug through the silty layers to depths between 1.6 and 2.6 m (5 and 8 ft) accumulated water so slowly that a stable level could not be determined (MPI, 1980a). Water levels were monitored in five piezometers installed across the site and, after several days of monitoring, stable water levels were reached. These water levels varied from 0.9 to 1.2 m (3.0 to 4.1 ft) below the ground surface. In one boring that penetrated the bedrock, artesian conditions were encountered, but the full height was not measured (MPI, 1980a).

The thin lenses of fine sand contain pockets of more mobile groundwater. However, the evidence obtained from systematic boring across the site indicates that the extent these lenses is limited and they are not hydraulically connected to each other or to the Hudson or Dead Rivers. Therefore, the groundwater is immobilized within these lenses and, if contaminated, would remain in the same location (MPI, 1980b).

The existence of a water table less than 3 m (10 ft) from the bottom of the containment facility would prevent New York State regulatory bodies from approving the site as a secure landfill facility. A waiver would be required for construction of the facility.

The site does not recharge any aquifers in the area. Because of the high clay content of the soils and underlying unconsolidated material, most precipitation falling on the site flows into the Hudson and Dead Rivers as surface runoff. The presence of a small wet area in the south part of the site also indicates the poor infiltration capacities of these soils.

Wells in the area of the containment site are used largely for domestic supplies and are located predominantly along Route 4 near the river. These wells vary from 8 to 58 m (25 to 190 ft) in depth and produce up to 76 lpm (20 gpm) of potable water. The formation used is the Snake Hill Shale and the amount of water produced depends on the extent of interconnecting fractures. The formation is recharged where it outcrops approximately 2.5 km (1.5 mi) to the east of the containment site. It is also recharged to a lesser extent by induced infiltrations from the Hudson River. The formation water has a high iron sulfide content and, in some cases, is not potable.

2c. Water Supply

A number of communities obtain drinking water from the Hudson River, including the Village of Waterford, the Port Ewen Water District, the Village of Rhinebeck, the City of Poughkeepsie, and the Highland Water District (MPI, 1980d). In addition, several municipalities and numerous private individuals obtain water from wells adjacent to the river. Stillwater, for example, operates four wells and Green Island draws water from infiltration galleries located on an island in the upper Hudson River. Some homes along the Hudson River also use the river as a supplemental water supply for watering lawns and gardens (MPI, 1980d). In addition, a water intake exists at Chelsea, which may be used to augment water supplies for New York City during drought conditions.

Hudson River water is analyzed by the USGS at five stations on the upper reaches: Glens Falls (above the GE plant), Rogers Island, Schuylerville, Stillwater, and Waterford (Tofflemire, NYSDEC, 1980). Although the Glens Falls PCB levels are usually below the detection limit of 0.1 ug/l (ppb), there are data for Schuylerville and Stillwater for the three water years beginning in October, 1976. The average PCB concentrations for these years were: 0.687 ug/l (ppb) in 1977, 0.568 ug/l (ppb) in 1978, and 0.657 ug/l (ppb) in 1979. Higher levels have been reported for the 1974 to 1975 period at Rogers Island 1.5 ug/l (ppb), and levels as high as 3 ug/l (ppb) were recorded in the Hudson River prior to elimination of GE discharges in 1976.

PCBs in Hudson River drinking waters can be reduced by 40 to 80 percent through treatment (Cranston, City of Poughkeepsie, August 25, 1977). If standard water treatment measures (alum coagulation, settling, aeration, sand filtration, and chlorination) are used, levels of PCBs in finished water can be reduced from the present approximate level of 0.65 ug/l (ppb) to about 0.20 ug/l (ppb). There was no significant difference in the amount of PCBs in the water for the three-year period between 1977 and 1979. These levels probably represent background levels for residents using the Hudson River, and possibly also wells and infiltration galleries near the river, for drinking water. Residents using this water may assimilate approximately 0.3-1.3 ug/day at an average water consumption rate of 2 lpd (0.5 gpd). Monitoring of Hudson River water at Poughkeepsie and Waterford by the USGS indicated PCB levels below the maximum level of 1.0 ug/l (ppb) established by NYSDOH and below the 0.16 ug/l (ppb) level calculated to represent a lifetime cancer risk of one in one million (MPI, 1980d).

NYSDEC data indicate that primary and secondary federal and state drinking water standards are presently being met in finished water at the five water supply intakes along the Hudson River (Appendix E). In addition, the 1 ug/l (ppb) short-term exposure standard for PCBs developed by the NYSDOH is also being met. However, it should be noted that during high flow periods, or 10 percent of the time, the 1 ug/l (ppb) standard for PCBs in finished water may be exceeded at some of the treatment facilities (Figure 2-1).

3. AQUATIC ECOLOGY

The lower Hudson River south of the Troy Dam is an estuarine ecosystem. The river's free connection to the ocean, the mixing of ocean salt water with freshwater from the land, and the resulting salinity gradient below Poughkeepsie are the main factors affecting the flora and fauna of the lower Hudson River.

Extensive development of the shoreline of New York City and cities to the north, as well as the intense use of the river for navigation and industry, have also substantially affected the ecosystem. The estuarine ecosystem of the lower Hudson River is described in An Atlas of the Biologic Resources of the Hudson Estuary (BTI, 1977). A complete listing of the aquatic flora and fauna of the lower and upper Hudson River is given in Hudson River Fish and Wildlife (NYSDEC and USFWS, 1978). (These reports are on file at the five designated depositories as a supporting document to this draft NEPA EIS.)

Above the Troy Dam, the Hudson River is not influenced by the inflow of ocean waters and is a freshwater river ecosystem with corresponding freshwater flora and fauna. The ecology of much of the upper Hudson River between Troy and Hudson Falls has been substantially altered by industrial utilization.

3a. Flora

Aquatic vegetation is abundant in tidal shallows and marshes of the lower Hudson River. In the lower estuary, vegetation tolerant of brackish waters predominates, and freshwater vegetation exists in up-river areas. Submerged aquatic vegetation in the Hudson River includes pondweed, water celery, and water milfoils. Vegetation in freshwater marshes is comprised of cattails, reeds, purple loosestrife, swamp rosemallow, ferns, spike grass, cordgrass, arrow arum, and pickerel weed. Wooded wetlands exist on portions of the river bank and on islands in the river. A complete description of the vegetation of the lower Hudson River is given by the BTI (1977). Typical freshwater wetland species are described by Rawinski and others (1979).

The wetlend and submerged vegetation provides cover and substrate for a wide variety of crustacea, snails, insects, and other fauna. It is also utilized as food for ducks, geese, other waterfowl, and muskrats. Detrital material derived from the vegetation is consumed by filter feeders such as zooplankton, benthic invertebrates, and menhaden (BTI, 1977).

The Hudson River also contains a diverse phytoplankton community, with marine species dominant in the lower estuary. Diatoms, green algae, dinoflagellates, and blue-green algae comprise most of the phytoplankton population (BTI, 1977; Hydroscience, 1979).

3b. Wetlands and PCB Hot Spots

In the upper Hudson River, 8 of the 40 PCB hot spots that have been identified by NYSDEC contain wetlands. A brief description of each is given in Table 3-3. Wetlands are not common in the upper Hudson River; they tend to be located in quiescent, depositional areas behind dams or along the margins of islands and the river bank (MPI, 1980d). Because of this, they also tend to be sites of PCB deposition. These wetlands support extensive marsh vegetation and are locally significant habitats for wildlife, especially nesting and breeding waterfowl (MPI, 1980d). The principal species encountered are black duck, mallard, wood duck, golden eye, scaup, green-winged teal, blue-winged teal, and merganser (MPI, 1978a).

NYSDEC has designated the hot spot wetlands that are particularly valuable as wildlife habitats (Koechlein, NSYDEC, June 5, 1980). Hot spot 35 contains a diverse wetland that is extensively utilized by waterfowl. The wetlands at hot spot 40 and between hot spot 39 and Lock 2 are also especially valuable. These wetlands should be restored following any remedial action involving the hot spots.

The preliminary results of a study of PCB levels in wetland vegetation are available (Buckley, BTI, February 6, 1981). These results indicate that PCB levels in the roots and rhizomes of the marsh plants Pontederia, Leseria, and burr reed (Sparganium eurycarpum) are generally comparable to PCB levels in marsh soils. In the hot spot wetlands, PCB levels in plant roots are high because of the high PCB levels in the soil. Plant portions that are submerged obtain their PCB content from PCBs in the water column. Similarly, PCB levels in plant portions extending above the water derive their PCB content from airborne PCB. Evidence indicates that there is little upward translocation of PCB from roots to leaves in these marsh plants (Buckley, BTI, February 6, 1981). If this is the case, PCB uptake from the soil by these three plant species may not be a significant pathway for release of the contaminant from hot spot deposits.

Table 3-3

Hot Spots and Wetlands

Hot Spot	Mean PCB Concentration ug/g (ppm)	Contaminated Volume cu m (cu yd)	Comments
1-7	39-81	98,150 (128,350)	No wetlands.
8	99	82,850 (108,350)	Shallow water on east side of islands includes limited wetlands. Area judged not to present major conflict. Should additional sampling indicate localized, less contaminated areas, these should remain undisturbed. Many overhanging and fallen trees and shallowness will present some hindrance to dredging.
9-12	28-78	23,400 (30,600)	No wetlands.
13	89	1,550 (2,050)	Southern limit of hot spot is at access road berm, major marsh lies to the south. No conflict with wetlands.
14	279	55,150 (72,150)	No emergent, some floating and submerged species. Not a wetland.
15-17	103-380	46,200 (60,450)	No wetlands.
18	94	11,450 (14,950)	Diverse 9 m (30 ft) wide band of marshland present. Conflict exists.
19,20	83-249	5,950 (7,750)	No significant wetlands.
21-24	75-143	10,650 (13,950)	No significant wetlands.
25	100	10,650 (13,900)	Wetland is present. Southern portion of Galusha Island, no conflict. Northern portion contains diverse marsh community and provides valuable waterfowl habitat. Significant conflict.
26,27	47-53	7,050 (9,200)	No significant wetlands.

Table 3-3 (Continued)

Hot Spot	Mean PCB Concentration ug/g (ppm)	Contaminated Volume cu m (cu yd)	Comments
28	109	36,350 (47,550)	A broad expanse of emergent sedge, pickerel weed, rushes, rice cut grass; offers excellent duck brood habitat. Significant conflict exists.
29-34	51-516	49,450 (67,700)	No wetlands.
35	105	8,700 (11,350)	Valuable wetland used by waterfowl, herons, other shore birds. Diverse mixture of vegetation types. Distribution of PCB in wetland should be verified. Significant conflict exists.
36	51	42,750 (55,900)	No wetlands.
37	116	43,900 (57,400)	Large area of water lilies and water chestnut, used by diving ducks during migration. No major conflict.
38	50[1]	11,300 (14,750)	No wetlands.
39	161	10,050 (13,150)	5 ha (13 a) wetland below hot spot, probably no conflict exists. Sampling is meager, marsh discontinuous. Additional sampling needed.
40	62	26,300 (34,400)	Valuable diverse wetland communities, conflict exists. Recent sampling indicates the area may not be "hot."

Note: 1. Assumed value, no samples in this area at this time.

Source: a. MPI, 1980d.

Water celery (Vallisneria americana Michx.), a submerged aquatic plant sampled from the wetland at hot spot 28, contained high levels of PCB in plant roots and tops. PCB levels in plant tops, roots, and river sediments were 18.94, 51.8, and 41.1 ug/g (ppm), respectively (Buckley, BTI, February 6, 1981). PCBs incorporated into the plant can enter the ecosystem because the plant may serve as food for aquatic birds, especially ducks and geese. Additional PCBs would be absorbed by the organic detritus that is produced when the leaves die, break off, and start to decompose. Upon complete decomposition of the plant parts, the PCBs would be released again into the sediments and water column. A small portion of the detritus would enter the food chain (Buckley, BTI, March 12, 1981).

Loss of PCBs from wetland hot spots may occur from volatilization from marsh soils. However, these hot spots also contain large amounts of organic materials, which tend to adsorb PCB and inhibit the release of the contaminant to the atmosphere (MPI, 1980d).

Scouring of wetlands during periods of high river flow can cause resuspension of PCB-laden sediments and their release to the river system. Wetlands tend to be less subject to scouring than other river areas because the vegetative cover tends to hold sediments in place (MPI, 1980d).

Ice that forms on the river during the winter months may also be an important mechanism for release of PCB-contaminated sediments from wetlands. Field studies along the St. Lawrence River have indicated that mats of wetland sediment that are frozen to the underside of ice can be carried away when water levels rise during the spring thaw. In addition, ice floes can scour wetlands and abrade river banks as ice is moved downstream during the spring melt (Marshall, February 26, 1981). The degree to which ice scouring of wetlands occurs on the Hudson River is not known.

The effect of the high PCB levels on wetland vegetation in the hot spots is also unknown. There is limited evidence that submerged aquatic plants are sensitive to elevated PCB levels. Photosynthetic activity in the aquatic plant

Spirodela oligorrhiza has been shown to be greatly reduced by PCB concentrations of 5 ug/g (ppm) in the ambient water (Mahanty and Fineran, 1976).

3c. Fauna

Zooplankton, including copepods, water fleas, larval snails, and other mollusks, are found throughout the Hudson River but are most abundant in the brackish waters of the lower estuary. Zooplankton are important food sources of certain fish, particularly young striped bass, young white perch, and anchovies (BTI, 1977).

Snails are the most abundant mollusks in the Hudson River, but clams and oysters are found in the lower estuary. Crustaceans are represented mainly by copepods and amphipods. Blue crab (an important recreational species) is found in the lower estuary (BTI, 1977). Turtles, frogs, and other reptiles and amphibians are present throughout the Hudson River system, especially in wetlands.

A large variety of fish inhabit the Hudson River and many are commercially and recreationally important (Smith, 1977). A list of fish species recorded in the Hudson River, along with brief descriptions of their origins and habitats, is presented in Appendix F. The lower Hudson River serves as a spawning area for several anadramous fish, including striped bass, American shad, and Atlantic sturgeon. The broad shallow areas of Havertraw Bay are especially productive for spawning and rearing. The lower Hudson River is the second most important propagation area for striped bass on the east coast. Hudson River striped bass comprise a significant portion of the striped bass fishery on the east coast, which generally has a commercial and recreational value of $20,000,000 per year (MPI, 1980d).

Other commercially valuable fish that inhabit the lower Hudson River in their juvenile stages include bluefish, weakfish, and winter flounder. Bay anchovies are abundant in brackish water, and the species is a major food source for larger fish (BTI, 1977). The shortnose sturgeon, a species that is on the federal list of rare and endangered species, also inhabits the lower Hudson River. The species will be discussed in section 5 of this chapter.

Freshwater fishes that inhabit the Hudson River include shiners, goldfish, carp, white sucker, brown bullhead, white catfish, white perch, yellow perch, blue gill, pumpkinseed, black crappie, darters, walleye, chain pickerel, northern pike, largemouth bass, and smallmouth bass. The American eel is abundant throughout much of the Hudson River (BTI, 1977; Smith, 1977).

Additional information on the aquatic ecosystem of the upper Hudson River is given by MPI (1978a).

3d. Hudson River Fishery

In 1976, much of the Hudson River fishery was closed by NYSDEC because many fish were found to have PCB levels that exceeded the FDA temporary tolerance level of 5 ug/g (ppm). The NYSDEC regulations that have been enacted are:

> Title 6 of the Official Compilation of Codes, Rules and Regulations of the State of New York.
>
> Section 12.19 Regulations for the taking of fish and American eel in the Hudson River and their sale or offer for sale:
>
> (a) All fishing and taking of American eel is prohibited in the Hudson River, and its tributary waters upstream from the River to the first falls or barrier impassable by fish, from Fort Edward downstream to the Troy Dam.
>
> (b) In the Hudson River, and its tributary waters upstream from the river to the first falls or barrier impassable by fish, from the Troy Dam downstream to the mouth of the river at the Battery, New York City, until November 30, 1981, no person shall:
>
> (1) Take or possess American eel.
>
> (2) Fish commercially except for Atlantic sturgeon greater than four feet in length, goldfish and American shad. For the purposes of this subdivision, commercial fishing shall include, but not be limited to, the possession, setting, tending, operation and maintenance of nets or other devices for which a license is required pursuant to Section 11-1503 of the Fish and Wildlife Law and the sale, offering for sale or possession of fish taken in any of the foregoing nets or devices.
>
> (3) When commercial fishing, take or possess striped bass, or fail to immediately return striped bass to the water.
>
> (4) Set gill nets from December 1 through March 14.

(c) The sale, or offer or exposure for sale, of any American eel or any fish, except for Atlantic sturgeon greater than four (4) feet in length, goldfish and American shad, taken in the Hudson River, or its tributary waters upstream from the River to the first falls or barrier impassable by fish, from Fort Edward downstream to the mouth of the River at the Battery, New York City, is prohibited.

In 1971, NYSDEC also issued an advisory against eating more than 230 g (0.5 lb) of fish per week from any New York State waters because of mercury contamination. This advisory was subsequently extended because of PCBs, and it remains in effect today (Sloan, NYSDEC, March 10, 1981).

Despite the regulations and advisory, illegal fishing, especially sport and subsistence fishing, and consumption of contaminated Hudson River fish continues (MPI, 1980d). Illegal commercial fishing of striped bass occurs in the lower Hudson River because the fish has a relatively high market value. NYSDEC enforcement officials have intercepted sizeable quantities of Hudson striped bass ready for shipment to markets in New York City (Sloan, NYSDEC, March 10, 1981; Blumenthal, New York Times, April 3, 1981).

PCB Levels in Fish

When widescale testing for PCBs in fish began in 1977, it was found that PCB contamination was extensive (MPI, 1980d). Uptake of PCBs by fish probably occurs primarily by diffusion of contaminated water through gills, skin, and other tissues. PCBs accumulate in fatty tissues and can be biomagnified through the food chain. Possible biological pathways of PCB movement in the environment have been discussed (O'Connors and others, 1978; Hydroscience, 1979; Armstrong and Sloan, 1980; MPI, 1980d).

PCB levels in Hudson River fish were found to vary greatly according to species. Studies done in 1978 by NYSDEC revealed that 93 percent of all fillets from striped bass (a large predatory species) contained concentrations of PCBs over 5 ug/g (ppm), with median and mean concentrations of 10 and 18 ug/g (ppm), respectively. PCB levels in fish that are full-time residents of the Hudson

River, such as the largemouth bass, were also very high. Resident fish such as eels, catfish, goldfish, and carp were found to have especially high PCB levels primarily because these species have high fat content. Minnows and anadramous shad and herring had low PCB levels, generally much less than 5 ug/g (ppm). The blue crab had low PCB levels (around 0.5 ug/g [ppm]) in its muscle tissue, but the hepatapancreas had considerably higher levels (over 5 ug/g [ppm]) (Armstrong and Sloan, 1980).

Analysis of fish sampled since 1977 has shown a substantial drop in PCB levels in many species. PCB levels in American shad caught at Poughkeepsie, for example, decreased by 40 percent from 1977 to 1978, and by 50 percent from 1978 to 1979 (Armstrong and Sloan, 1980; MPI, 1980d). The 1980 data also indicate a decline in PCB levels in striped bass. The trend in striped bass has not been as apparent because the striped bass population in the Hudson River is comprised of fish that are full-time residents of the river and fish that move into the river temporarily to spawn. The two groups have different degrees of PCB accumulation (Armstrong and Sloan, 1980; Sloan, NYSDEC, March 10, 1981).

Various factors may have contributed to the initally high PCB levels found when extensive testing began in 1977 and the decline since then:

- In 1974, the Fort Edward Dam was removed, releasing PCBs to downstream areas and creating high background PCB levels.
- In 1976, a significant flood occurred, resuspending PCB-laden sediments and making the contaminant more accessible to uptake by fish.
- In 1977, active direct discharge of PCBs ended.
- From 1977 to 1979, flows in the Hudson River were relatively low and no major floods occurred, causing minimal release of PCBs from sediments.
- The principal forms of PCBs discharged by GE into the Hudson River and incorporated into fish flesh were Aroclor 1242 and Aroclor 1016, which are lower chlorinated aroclors compared to Aroclor 1254. Lower chlorinated aroclors may be less stable and subject to slightly greater degradation in the environment (Armstrong and Sloan, 1980; MPI, 1980d).

1980 Fisheries Data

NYSDEC continued its monitoring of PCB levels in Hudson River fish through 1980. These data indicate that the decline in PCB levels is continuing primarily because levels of Aroclor 1016 are declining. Levels of Aroclor 1254, however, are declining only slowly, if at all, in Hudson River fish. Sampling in 1981 should clarify this point (Sloan, NYSDEC, March 10, 1981).

The PCB data collected by NYSDEC in 1979 and 1980 are given in Appendix G. For ten species, 1980 PCB levels were compared with levels found in the same species since 1977, as shown in Table 3-4. Only levels in fish sampled from the same river location were compared. No account was made for size or lipid content of the fish in the comparison.

For the five species sampled from the lower Hudson River, PCB levels were lower in 1980. Levels in largemouth bass, white perch, yellow perch, and American eel have declined substantially in the past seven years. The mean PCB level in American shad was approximately 1.5 ug/g (ppm) in 1980, slightly lower than the level for the previous year.

For largemouth bass, yellow perch, brown bullhead, and goldfish sampled from the upper Hudson River at Stillwater, PCB levels were substantially lower in 1980 than in 1977. For the two species for which data are available (brown bullhead and pumpkinseed), there was no significant difference between PCB levels in 1979 and 1980.

Data on the most important commercial and recreational species of the regions, the striped bass, were not included in the comparison because possible sample bias has made data suspect. Data for striped bass caught near the Tappan Zee Bridge are given in Table 3-5. PCB levels in striped bass have declined, but the magnitude of the decline remains unconfirmed because of the unreliability of the data (Sloan, NYSDEC, March 10, 1981).

Of the ten species from the lower Hudson River represented in the 1980 date, four still have mean PCB levels above the FDA tolerance level of 5 ug/g (ppm); these are white perch, eel, walleye, and striped bass. The highest PCB level recorded in the 1980 data for the lower Hudson River was 52.70 ug/g (ppm) for an eel from the vicinity of the Verrazano Narrows Bridge. For the five species

Table 3-4

Means and Ranges of PCB Levels in Hudson River Fish

A. Lower Hudson River

Year	American Shad Poughkeepsie				American Shad Tappan Zee Bridge			
	No. Sampled	Total PCB (ppm)	Range Min (ppm)	Range Max (ppm)	No. Sampled	Total PCB (ppm)	Range Min (ppm)	Range Max (ppm)
1977	33	3.77	1.11	11.45	19	2.40	0.70	8.45
1978	87	2.25	0.30	6.73	77	2.16	0.30	9.36
1979	N	N	N	N	15	<1.37	<0.57	2.51
1980	29	1.42	0.63	3.87	30	<1.55	<0.52	3.94

Year	American Eel Indian Point				Largemouth Bass Catskill			
	No. Sampled	Total PCB (ppm)	Range Min (ppm)	Range Max (ppm)	No. Sampled	Total PCB (ppm)	Range Min (ppm)	Range Max (ppm)
1977	N	N	N	N	N	N	N	N
1978	35	81.83	1.06	263.10	61	100.46	6.18	372.00
1979	N	N	N	N	N	N	N	N
1980	6	<8.61	<1.99	22.41	30	16.71	2.60	46.17

Year	White Perch Troy				Yellow Perch Catskill			
	No. Sampled	Total PCB (ppm)	Range Min (ppm)	Range Max (ppm)	No. Sampled	Total PCB (ppm)	Range Min (ppm)	Range Max (ppm)
1977	N	N	N	N	25	4.91	0.84	10.60
1978	61	100.46	6.18	372.00	N	N	N	N
1979	N	N	N	N	N	N	N	N
1980	30	16.71	2.60	46.17	10	<0.98	<0.30	4.82

Note: 1. N = No data available.
2. ug/g = ppm

Table 3-4 (Continued)

B. Upper Hudson River

Year	Pumpkinseed Stillwater				Largemouth Bass Stillwater			
	No. Sampled	Total PCB (ppm)	Range Min (ppm)	Max (ppm)	No. Sampled	Total PCB (ppm)	Range Min (ppm)	Max (ppm)
1977	N	N	N	N	11	52.41	6.22	140.84
1978	N	N	N	N	17	158.20	20.53	305.50
1979	64	19.91	15.63	25.43	N	N	N	N
1980	75	20.12	14.80	29.48	26	10.16	1.67	66.78

Year	Yellow Perch Stillwater				Brown Bullhead Stillwater			
	No. Sampled	Total PCB (ppm)	Range Min (ppm)	Max (ppm)	No. Sampled	Total PCB (ppm)	Range Min (ppm)	Max (ppm)
1977	30	12.23	1.56	42.69	30	109.57	35.46	242.19
1978	N	N	N	N	N	N	N	N
1979	N	N	N	N	30	<8.97	<0.83	59.79
1980	7	<0.84	<0.33	2.15	30	12.34	3.50	30.11

Year	Goldfish Stillwater			
	No. Sampled	Total PCB (ppm)	Range Min (ppm)	Max (ppm)
1977	10	382.90	736.29	79.69
1978	24	216.05	58.00	658.30
1979	N	N	N	N
1980	30	72.62	11.47	267.61

Note: 1. N = No data available.
2. ug/g = ppm

Source: Hydroscience, 1979; Armstrong and Sloan, 1980; NYSDEC, unpublished data.

Table 3-5

PCB Trends for Striped Bass, Hudson River, 1973-80, Tappan Zee Bridge

Date	No. Fish	Mean Length mm (in)	Total PCB ug/g (ppm)	Ratio of Aro 1016 to Aro 1254
1973a	22	654 (26)	14.75[3]	NA
1975a	6	666 (26)	11.02[3]	NA
1976a	46	543 (21)	8.62	0.80
1977a	5	507 (20)	8.01	0.28
1978a	130	549 (22)	10.33	0.88
1979a	14	456 (18)	5.27	0.31
1980b	30[1]	468 (18)	5.59	NA
1980b	30[2]	515 (21)	6.37	NA

Notes: 1. Sampled 4-14-80
2. Sampled 5-8-80
3. Aroclor 1254 measured only
4. NA = Not available.

Sources: a. Armstrong and Sloan, 1980.
b. NYSDEC, unpublished data.

sampled from the upper Hudson River, all but yellow perch had levels well above 5 ug/g (ppm). The highest levels were found in goldfish, with a mean PCB concentration of 72.62 ug/g (ppm).

Effects of PCBs on Health of Fish

The effects of PCBs on the health of natural fish populations are not well understood. Adverse effects may be greatest for reproductive and larval stages, as indicated by limited laboratory evidence. Spawning of fathead minnow, for example, has been shown to be affected significantly by exposure to 1.8 ug/l (ppb) Aroclor 1254 in the water column (USEPA, 1976a).

Despite the high levels of PCBs that have existed in certain fish species, in-river toxicological effects, such as fish kills, have not been confirmed in the Hudson River. According to MPI (1980d), possible reasons for this are:

(1) The effects on particular segments of the aquatic life cycle are not documented.

(2) Certain organisms may have developed a resistance to PCBs and other Hudson River pollutants as a result of long-term exposure.

Several health effects that may be related to contaminant levels have been observed in the Hudson River (Kuzia, NYSDEC, January 21, 1981). Numerous goldfish collected over a 105-km (65-mi) stretch of the river were found to have extensive skin ulcerations, possibly caused by the bacterium Aeromonas salmonicida. The disease also appears in golden shiners and black bass. Two extensive mortalities of white perch have occurred, but a causative agent was not discovered. A 25 percent incidence of liver tumors reported in Hudson River tomcod may be related to PCB contamination. U.S. Fish and Wildlife Service (USFWS) investigations have determined that striped bass fry and fingerlings contaminated with PCBs have backbones that are considerably weaker than those of fish from other waters. Through its possible effect on backbone strength, PCBs may reduce the ability of the young bass to compete for food and endure the stresses of migration and reproduction. The possible relationship between contaminant levels and fin rot in the endangered shortnose sturgeon will be discussed in section 5 of this chapter.

Potential Value of Fishery

If a full-scale fishery could develop on the Hudson River, it would have substantial regional and local importance. Sheppard (1976) has estimated that the Hudson River has the potential to produce an annual commercial finfish harvest of 560,000 to 890,000 kg (1,240,000 to 1,960,000 lb) with a value of $261,000 to $426,500 (1976 dollars). Sheppard (1976) has estimated that a recreational fishery in the upper Hudson River could support 100,000 man-days of recreational fishing, with a corresponding economic value of $1,250,000 (1976 dollars). Sheppard has assigned an annual value of $1,350,000 (1976 dollars) to the recreational fishery in the lower Hudson River.

4. TERRESTRIAL ECOSYSTEM

Below is a discussion of the terrestrial ecosystem at and around the proposed containment site (Site 10). Additional information on the terrestrial flora and fauna of the upper Hudson region is given in Hudson River Fish and Wildlife Report [NYSDEC and USFWS, 1978]. (This report is on file at the five designated depositories as a supporting document to this draft NEPA EIS.)

4a. Flora

The area of the proposed containment site is mainly agricultural, consisting of planted and abandoned hay fields. Approximately half the site has not been pastured or mowed for four to ten years. The western fields consist mainly of grasses, milkweed, trefoil, three-square sedge, daisies, cow vetch, narrow leaved cattail, and wild strawberries. The eastern portion of the site contains these species, in addition to buttercups, St. John's wort, elm and cherry seedlings, hard hack, and meadow sweet (MPI, 1980a). The northeastern portion of the site has been abandoned long enough to have developed a young stand of slippery elm, aspen and willow. Fence rows are lined with elms, white oak, shagbark hickory, black cherry, ash and grey stemmed dogwood. The largest trees on the site are willows and elms, and several are up to approximately 1 m (3 ft) in diameter (MPI, 1980 d).

Parts of the proposed containment site contain wet soils and are considered to be wetlands under the New York State definition. Wetlands present on the site include:

- A 1.2 ha (3 a) seasonally wet grove of slippery elm
- Linear wetlands totalling over 5 ha (12.34 a) in area along drainage ditches, with wet meadow species such as rushed, sedges and cattail
- A 1.2 ha (3 a) marsh at the foot of the shale ridge on the southeast portion of the site, containing a diverse assortment of wetland shrubs, sedges, ferns, rushes and mosses (MPI, 1980d).

The soils at the site have serious limitations for agricultural production because they have low permeability and tend to be excessively wet. The rooting depth of crops is usually limited to the upper 25 to 50 cm (10 to 20 in) of soil because of a seasonal high water table and slowly permeable subsoil. Because of the soil conditions, the site is more suited for the production of hay and pasture mixtures that tolerate wetness than for the production of row crops. The gently sloping areas of the site are subject to erosion, and the use of pasture crops controls the loss of surface soil (MPI, 1980a).

Lands in the region of the proposed containment site are agricultural and mainly utilized for production of dairy cattle. Corn, hay, and other crops for use as animal feed are also grown in the area. Additional information on the dairy industry of the region is given in section 4d of this chapter.

4b. PCB Levels in Terrestrial Flora

Terrestrial plants are known to absorb PCBs from the atmosphere. Background atmospheric PCB levels resulted in detectable PCB concentrations in all the foliage analyzed by Buckley (1980) in Washington and Saratoga counties. Concentrated sources of PCBs, such as PCB dumpsites, increase uptake by foliage in surrounding vegetation within a radius of 500 to 700 m (1,600 to 2,300 ft). PCB levels measured in foliage around PCB dumpsites are given in Table 3-6 and Table

3-7. At the Fort Miller dumpsite, PCB levels of 58 ug/g (ppm) were found in leaves adjacent to the site, and levels decreased to background levels, below 0.3 ug/g (ppm), approximately 700 m (2,300 ft) distant from the site. Elevated PCB levels also exist around some roadways in the region. The PCBs may have been derived from dredge spoil material that was used to sand roads in winter. PCB levels also tend to be higher within a 2,000 to 4,000 m (2,200 to 4,400 yd) wide margin on each side of the upper Hudson River (Buckley, 1980).

Levels of PCBs in roots tend to be comparable to levels in soil if the soil is sandy and low in organic matter. PCBs are retained by organic matter and clays, making the contaminant less accessible to uptake by plant roots (Buckley, 1980). If PCB-contaminated leaves fall to the soil and decay, the PCBs tend to volatilize as the plant matter decays, rather than accumulate in the soil. However, PCBs in leaves that are ploughed or disked into the soil would remain there for several years at plough depth (Buckley, 1980).

There are differences in the degree to which different plant species absorb PCBs. PCB levels derived from background atmospheric sources were found to be 0.03 ug/g (ppm) for alfalfa and 0.29 ug/g (ppm) for golden rod. For root crops, carrots accumulate PCBs from the soil more than sugar beets and radishes. PCBs are accumulated in the outer tissues of carrots and beets so that peeling removes 90 percent of the contaminant. However, PCBs are uniformly distributed in radish (Buckley, 1980).

PCB levels in forage crops in Saratoga and Washington Counties are generally well within the 0.2 ug/g (ppm) limit set by the FDA for PCBs in animal feeds. PCB levels in forage crops grown near PCB sources, such as landfills and roads, have been found to exceed the limit (Buckley, 1980). Additional information of PCB crops of the region is in section 4d of this chapter.

Terrestrial plants are apparently able to tolerate high levels of PCBs in surrounding soils and in their tissues. Native plants growing in 10,000 to 30,000 ug/g (ppm) PCBs at the Fort Miller dump site show no visible symptoms of

Table 3-6

Increases in Foliage PCB Levels

Location	Maximum Distance of Foliage from Original PCB Source m (yd)	Range of Foliage Concentrations Within Area of Elevated PCB ug/g (ppm)	FDA Standard for Forage Crops ug/g (ppm)
Fort Miller Dump Site	700 (770)	0.1 to 58	0.2
Caputo Dump Site	400+ (440+)	0.1 to 51	0.2
Bouy 212 Dredge Spoil Site	150 (170)	0.1 to 3	0.2
Moreau Dredge Spoil Site (Old Moreau Site)	200 (220)	0.1 to 1.4	0.2

Source: Buckley, 1980.

Table 3-7
Foliage PCB Levels Near fort Miller Dumpsite

Distance from Dumpsite m (yd)	Mean Weekly PCB Concentration in Air ug/cu m	Corn, Grain and Cob[1] ug/cu m	Corn, including Stem, Leaves, Ears and Tassle[1] ug/g (ppm)	Alfalfa[1] ug/g (ppm)	Red Clover[1,2] ug/g (ppm)	Timothy[1,2] ug/g (ppm)
73.5 (80.4)	0.19	0.13	0.91	1.35		3.2
89.0 (97.4)	0.14	0.14	0.67	0.95		2.4
132.1 (144.5)	0.08	0.06	0.40	0.56		1.4

Note 1. FDA standard for forage crops is 0.2 ug/g (ppm)
2. Estimates based on data for other crops

Source: Buckley, BTI, March 24, 1981.

stress except those usually expected from water and nutrient deficiencies (Buckley, 1980). Reduced plant growth, however, has been documented in a crop species (soybeans) growing in soils containing 1,000 ug/g (ppm) Aroclor 1254 (Weber and Mrozek, 1979).

4c. Fauna

The terrestrial fauna at the proposed containment site consists of a variety of birds and small mammals common to woodlots and fields. Likely inhabitants of the area include opposum, racoon, porcupine, cottontail rabbit, whitetail deer, several species of field mice, rats and moles, and numerous species of birds. Burrowing animals that may be present include woodchucks, red fox, skunk, muskrat, and weasel (MPI, 1980a). Because the land is not significantly wooded, the area is not a preferred habitat for most of these animals, except woodchucks, mice, rats, moles, and birds.

4d. Agriculture

Dairy farming is a major industry in the upper Hudson River region and 180 active farms are located within a 16-km (10-mi) radius from the proposed PCB containment site. The dairy farms are small to moderately sized and are predominantly family owned. The approximate total investment for farm operation is $4,000 to $5,000 per cow. Replacement costs per cow are estimated at $1,000 to $3,000 (Beaty, CAC, March 28, 1981).

Most of the crops grown in the region, such as corn, alfalfa, clover, and other forage crops are used to feed dairy cows. The selling value of these crops is estimated at $18 to $23/t ($20 to $25/tn) for corn silage and $54/t ($60/tn) for grass hay. Cost to the farmer from a dealer is estimated at $32 to $41/t ($35 to $45/tn) for corn silage and $54 to $73/t ($60 to $80/tn) for hay (Beaty, CAC, March 28, 1981). The proposed containment site could yield 20 to 27 t/ha (9 to 12 tn/a) per year of corn for silage, or 5.4 to 9.0 t/ha (2.4 to 4.0 tn/a) per year of forage mixture. Such yields would sell for $370 to $740/ha ($150 to $300/a) per year.

The pasture season, when the cows consume pasture forage, usually lasts from May to October. During the remainder of the year, the cows eat winter rations of corn silage and hay. The feed allowance for each mature Holstein is approximately 4.5 to 6 t (5 to 7 tn) of good hay-equivelent during the winter season and 5.5 to 7.5 t (6 to 8 tn) of good hay-equivalent during the pasture season. (One unit of good hay is equivalent to three units of silage, or two units of haylage.) A dairy cow generally remains in the herd for less than seven years. Each cow has one lactation per year and produces 6,300 to 7,300 kg (14,000 to 16,000 lb) of milk per year. A lactating cow drinks approximately 150 l (40 gal) of water per day to produce milk that is approximately 87 to 90 percent water (Newton, February 27, 1981).

As previously discussed, low levels of PCB are found in forage crops in Washington and Saratoga counties. Measured PCB levels occasionally exceed the FDA limit of 0.2 ug/g (ppm) in animal feed. There has been concern that milk from cows consuming contaminated forage might exceed the FDA limit of 1.5 ug/g (ppm) for PCBs in dairy products, especially because PCBs are known to concentrate in milk. Aroclor 1254 accumulates in milk by a factor four to five times greater than the levels of 1254 in feed. But it has been determined that milk produced in the region does not contain PCBs over the FDA limit, as indicated by the following paragraph (MPI, 1980d).

> The New York State Department of Agriculture and Markets has periodically sampled milk produced in Washington and Saratoga Counties for PCB contamination. Most recently, potentially contaminated farming areas were delineated by the State Department of Health (NYSDOH), and milk on eight farms in these areas was tested for PCB on June 12, 1979. All eight milk samples measured less than 0.2 ug/g total PCB on a fat basis, well below the FDA standard of 1.5 ug/g ...

In addition to dairy products, poultry products, calves, heifers, pure bred cattle, and relatively small quantities of cash crops are produced in the region (Slocum, February 9, 1981; Stork, February 9, 1981).

5. THREATENED OR ENDANGERED SPECIES

A substantial population of endangered shortnose sturgeon exists in the

Hudson River estuary. Most of the population probably occurs between Esopus Meadows (River Mile 87) and the Troy Dam (River Mile 154). This reach of the Hudson River encompasses the spawning area, the major overwinter area, the important nursery area for young-of-the-year fish, and a substantial portion of the summer feeding ground. Young-of-the-year shortnose sturgeon feed extensively on benthic species between River Mile 140 and Kingston (River Mile 92) (Dovel, Oceanic Society, February 23, 1981).

The vitality of the shortnose sturgeon population is probably more susceptible to harm from toxic chemicals introduced into the upper Hudson River than any other species of fish inhabiting the estuarine ecosystem, including the commercially valuable American shad and striped bass. The extreme vulnerability of the sturgeon may be attributed to its occurrence and spawning in a highly polluted 12.4-km (20-mi) segment of the estuary immediately south of the Federal Dam at Troy (Dovel, Oceanic Society, February 23, 1981).

Approximately 75 percent of adult shortnose sturgeon over 75.0 cm (29.5 in) in total length have fin rot. In some cases, this fin rot is very severe, but the agent that causes the disease has not been positively identified. However, high prevalence of fin rot has been shown to be associated with ecologically degraded coastal areas (Murchalano, 1980). It is possible that toxic substances in the water column lower the natural immunity of shortnose sturgeon to infestations of a fungus, tentatively identified as Leptolegria caudata. For example, PCBs have been shown to increase the number of virus infections in the pink shrimp of the Gulf of Mexico (Murchelano, 1980). The fin rot common on adult shortnose sturgeon in the Hudson River seems to be sublethal, but the disease probably imposes a substantial stress on affected individuals (Dovel, Oceanic Society, February 23, 1981).

The apparent low survival of newly fertilized eggs may be a critical factor limiting the size of the shortnose sturgeon population in the Hudson River. In 1979 and 1980, the hatching success of laboratory-reared eggs was greatly impaired by the fatal penetration of fungus (Dovel, 1979). Eggs held in Hudson River water became totally overwhelmed by the fungus in less than 24 hours, whereas eggs held in spring water remained generally free of the fungus for a much longer period.

There seem to be substantial sublethal and lethal impacts on the shortnose sturgeon that may indirectly result from a deterioration of the natural water chemistry due, in part, to the presence of toxic chemicals, especially PCBs (Dovel, Oceanic Society, February 13, 1981). A sturgeon with a concentration of 998 ug/g (ppm) PCBs in fatty tissue around the brain was alive when caught (Dovel, 1980). However, there is no way to measure the sublethal stress experienced by such contaminated fish. It is fairly obvious that the shortnose sturgeon of the Hudson River is a bioaccumulator and bioconcentrator of PCBs and probably other toxic chemicals, such as pesticides and heavy metals. The present condition of the shortnose sturgeon population is unknown; it could be stable or approaching collapsa (Dovel, Oceanic Society, February 23, 1981).

No other rare or endangered species are known to inhabit the Hudson River, and none are known to inhabit or frequent the area of the proposed containment site. Protected species, such as the osprey and northern bald eagle, may pass over the region during migrations through the Hudson River valley.

6. ENVIRONMENTALLY SENSITIVE AREAS

Areas that are classified as being environmentally sensitive include prime agricultural soils, wildlife refuges, critical habitats of rare or endangered species (as designated by USFWS), aquifer recharge areas, scenic or recreational areas, floodplains, wetlands, cultural resources, and steep slopes.

Most of these categories either do not exist in this area or are not affected by any of the alternatives under consideration. Wetlands and the habitats of rare or endangered species have been discussed in section 3 of this chapter. Prime agricultural soils are not present on the property proposed to be acquired for a containment facility. Cultural resources, scenic and recreational areas, and floodplains will be discussed below.

6a. Cultural Resources

In conformance with federal and state laws and implementing regulations, a preliminary cultural resource investigation (Stage I) was conducted for the PCB containment facility at Site 10 in the Township of Fort Edward. The purpose of the investigation was to identify historic and archaeological properties on, or eligible for listing on, the National Register of Historic Places.

The Stage I cultural resources study was conducted in the Township of Fort Edward at the proposed containment site. The study was divided into two components: a literature search (Stage Ia) and a field investigation (Stage Ib). The literature search consisted of a detailed review of existing site files, interviews, deed research, examination of histories and maps, a walkover, and drive-around the area. As a result of the literature search, the following resources were identified within the project's proposed impact area:

- trolley line (Hudson Valley Railroad right-of-way),
- the Old Champlain Canal, a property listed on the National Register of Historic Places,
- old barn complex, and
- house and barn complex.

The literature search also provided the data for the derivation of a historic and prehistoric sensitivity model. From this preliminary inspection and research, it was determined that a field investigation (Stage Ib survey) was needed to identify prehistoric and historic archaeological site locations.

To locate archaeological sites, shovel test pits were placed at varying intervals at selected locations within the project area. This sampling methodology was based on the derived sensitivity models.

Table 3-8 summarizes all cultural resources identified during the Stage I study. No further work is recommended for those resources that do not appear to meet the eligibility criteria for the National Register of Historic Places. The archaeologically sensitive Dead Creek is outside the project impact zone and will be avoided. Mitigation plans are presently being developed for the Champlain Canal area. For the remaining eight cultural resources, further investigation will be conducted in early spring. Historic structures will be evaluated by a qualified architectural historian in consultation with New York State Historic Preservation Office (SHPO). Subsurface testing will be conducted

Table 3-8

Summary of Cultural Resources Identified at Site 10

Cultural Resource	Description	Recommendation
1. Historic Dump 1	historic, surface	no further work
2. Historic Dump 2	historic, surface	no further work
3. Old Barn Complex	historic structure	further identification
4. Garage or Equipment Shed	historic structure	further identification
5. New Barn Complex	historic structure	further identification
6. House	historic structure	further identification
7. Hudson Valley Railroad	historic, destroyed	no further work
8. Champlain Canal	National Register Site historic structure	develop mitigation plan
9. Concrete Foundation	historic	further identification
10. Stone and Concrete Foundation	historic	further identification
11. Hudson South	prehistoric	further identification
12. Hudson North	prehistoric	further identification
13. Dead Creek Bank	prehistoric?	avoidance

at the identified archaeological sites to evaluate their potential eligibility for the National Register of Historic Places (Stage II).

6b. Scenic and Recreational Areas

Water quality classificatons for the upper Hudson River vary from "A" to"D." These classifications are based on the "best use" intended for these waters (Appendix E). Except for the stretch of water from the mouth of the Batten Kill to Lock 3 ("B"), and the section below Lock 2 ("A"), these waters are intended for secondary contact recreation, primarily boating and fishing. However, since 1976, commercial and recreational fishing have been prohibited in the upper Hudson River between Fort Edward and the Troy Dam because of the high PCB concentrations in fish (greater than 5 ug/g [ppm] PCBs). It has been estimated that the annual value of the recreation fishery in the upper Hudson River would be $1,250,00 (in 1976 dollars) (Sheppard, 1976). The waters of the upper Hudson River continue to be used by recreational boaters.

Recreational fishing is permitted in the lower Hudson River below the Troy Dam. The taking ot American eel, however, is prohibited. Sheppard has assigned an annual value of $1,350,000 (in 1976 dollars) to the recreational fishery in the lower Hudson River. These waters are suitable for secondary contact recreation.

6c. Floodplains and Wetlands

The Hudson River betwéen Troy and Glens Falls is bordered by terraced proglacial lake deposits and bedrock cliffs. The floodplain of the upper Hudson River in the area is long and narrow, confined largely to areas adjacent to the river. The 100-year flood last occurred on April 2, 1976.

A small creek (Dead Creek) crosses the southeast corner of the containment site property. The extent of floodplain for this creek varies between 75 and 150 m (250 and 500 ft) from the center of the stream bed. Neither the Hudson River floodplain nor the Dead Creek floodplain will infringe on the containment facility. Wetlands are found on the containment site and are described in section 4a of this chapter.

Several wetlands along the upper Hudson River have been designated as hot spots. A discussion of these areas and their location is represented in section 3b of this chapter. Because of their value as wildlife habitats, several of these wetlands should be retained, or restored, irrespective of any remedial action involving the hot spots.

7. AIR RESOURCES

7a. Climate

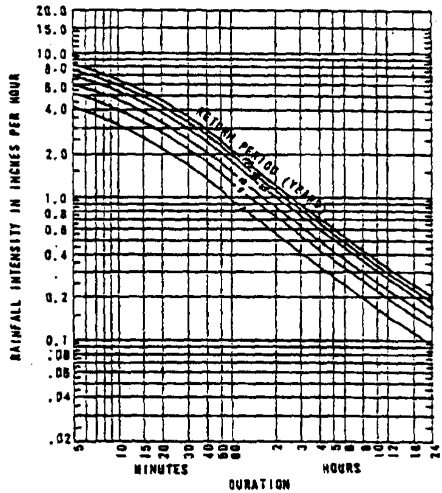
The following section is an adaptation of Dredging of PCB-Contaminated River Bed Materials, Upper Hudson River, New York (MPI, 1978a). The climate of the upper Hudson River Valley from Glens Falls to the Troy-Albany area is generally a humid continental type. Specifically, cold winters and warm, sometimes humid, summers are typical. Mean minimum temperatures in January for Glens Falls and Troy are $-12^{o}C$ ($10^{o}F$) and -9C ($16^{o}F$), respectively. July mean maximum temperatures for the same two locations are $30^{o}C$ ($86^{o}F$) and $28^{o}C$ ($83^{o}F$) (United Stated Department of Commerce [USDC], 1974). Average annual temperatures in 1976 for Glen Falls and Troy, were about $6^{o}C$ ($43^{o}F$) and $8^{o}C$ (47'F), respectively. The length of the freeze-free period for Glens Falls in 1976 was 135 days, extending from mid-May to the end of September. The freeze-free period in Troy covered the period from mid-April to mid-October, for a total of 182 days (USDC, 1976).

Precipitation in the Hudson River region is uniformly distributed throughout the year. The minimum precipitation usually occurs during the winter months, and the maximum during the summer months. For Glens Falls, mean annual precipitation, calculated over a period of 20 years, is approximately 100 cm (40 in). Mean annual precipitation for Troy ranges around 90 cm (36 in) (USDC, 1976). A rainfall intensity-duration-frequency curve for Albany is depicted in Figure 3-1 (USDC, 1955). This curve indicates the frequency, in years, of a rainfall of a given intensity in inches per hour and a given duration in minutes or hours.

The Hudson Valley generally has a continuous snow cover from mid-December to mid-March, with maximum depths occurring in February. Mean total snowfall in both Glen Falls and Troy is approximately 150 cm (60 in) per season (USDC, 1974).

Figure 3-1

Rainfall Intensity-Duration-Frequency Curve[1] for Albany, New York (1903-1951)



Note: 1. Frequency analysis by method of extreme values, after Gumbel.

Source: a. MPI, 1978a

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Within the Hudson River region, average pan evaporation and lake evaporation have been calculated to be about 90 cm (35 in) and 70 cm (27 in), respectively (USDC, 1959).

Wind speed and direction data for Glen Falls and Rensselaer are given in Tables H-1 and H-2 (Appendix H). Winds at the containment site are affected by local topography and other conditions. However, local meteorlogical data for the containment site is not available.

7b. Air Quality

The following is an adaptation and update of Dredging of PCB-Contaminated River Bed Materials, Upper Hudson River, New York (MPI, 1978a).

Total suspended particulates were monitored with high volume air samplers at five stations in the general vicinity of the study area. These stations included two in Glens Falls and one each in Fort Edward, Mechanicville, and Troy. At one Glens Falls station and in Fort Edward, Mechanicville and Troy, both the annual geometric means for 1975 through 1979 and the 24-hr average concentrations of total suspended particulates were well under the state and federal standards (Table 3-9). While the federal standard is uniform, state standards vary, depending on the economic development and associated land uses of the region. The other Glens Falls station did exceed the standard for the annual geometric mean in 1975. The 1976 mean showed an improvement and subsequently, this site was in compliance with the state standard of 55 ug/cu m for each successive year through 1979. The 1979 24-hour maximum averages at all sites listed in Table 3-9 were well below the 250 ug/cu m standard (NYSDEC, 1979). Settleable particulates are monitored in Glens Falls and Troy with the use of 30-day dustfall jars. These results are summarized in Table 3-10 (NYSDEC, 1979).

A PCB air sampling study has been undertaken at five locations in the upper Hudson Valley. This program involves simultaneous sampling at each of the sites every six days for 24 hours. Data in this program collected between January and August, 1977 are presented in Table 3-11. The stations in Glens Falls and Warrensburg recorded the lowest PCB values with readings generally less than

Table 3-9

Total Suspended Particulates from High Volume Air Samplers at Selected Stations, Upper Hudson River, 1979

Station	Federal Standard ug/cu m	NYS AAQS Geometric Mean		Annual Geometric Mean (ug/cu m) (not to exceed AAQS G.M.)					24-hour Avg ug/cm m (not to exceed 250 ug/cu m)[1]		
		Level	ug/cu m	1975	1976	1977	1978	1979	1st Max[2]	2nd Max	3rd Max
Glens Falls	75	II[3]	55	63[4]	45	41	34	37	90(0)	72	71
Glens Falls	75	III	65	49	43	45	41	45	134(0)	133	116
Fort Edward	75	II	55	NA[5]	36	33	33	36	144(0)	92	78
Mechanicville	75	II	55	NA	45	39	39	44	110(0)	106	105
Troy	75	III	65	46	39	36	33	36	71(0)	68	65

Notes: 1. New York State standard for 24-hr average is 250 ug/cu m; federal standard is 260 ug/cu m.

2. 1st, 2nd and 3rd maximum averages measured during 1976. The number in parentheses indicates number of times 24-hr max was exceeded.

3. The state is divided by air quality priorities into four levels: level I, denoting areas of least pollution to level IV, areas of heaviest pollution. The two Glens Falls stations are located in areas with different levels, thus the difference in the AAQS values.

4. Denotes a violation of Ambient Air Quality Standards.

5. NA = Not Applicable.

Source: NYSDEC, 1979.

Table 3-10

Settleable Particulates from 30-Day Dustfall Jars Annual Averages 1976 to 1979 and Monthly Averages in 1979 at Selected Stations, Upper Hudson River

	NYS Annual Standard	NYS AAQS[1] Geometric Means and 50/84		Annual Arithemtic Mean ($mg/cm^2/mo$)				Monthly (30-day) Avg.-1979[2] ($mg/cm^2/mo$)		
Station	Level	$mg/cm^2/mo$	$mg/cm^2/mo$	1976	1977	1978	1979	Max	2nd Max	3rd Max
Glens Falls	II	0.30	0.30/0.45	0.39	0.26	NA	0.23	0.66	0.24	0.21
Troy	III	0.40	0.40/0.60	0.33	0.23	NA	NA	0.47	0.34	0.27

Notes: 1. 50th percentile value/84th percentile value.

2. Under monthly average 1979, the 1st, 2nd, and 3rd maximum 30-day averages were measured from January 1 to December 31, 1979.

3. NA = Not Available. Insufficient data were available to formulate an annual arithmetic mean.

Source: NYSDEC, 1979.

Table 3-11

PCB Air Sampling by the New York State Department of Health

nannogram/cu m

Date	Stations				
	Glens Falls 5601-4	Warrensburg 5660-02	Hudson Falls 5726-01	Fort Edward I 5755-01	Fort Edward II 5755-02
1/1/77	R	R	R	R	<30
1/7/77	R	LA	40	R	R
1/13/77	R	R	<or=190	1020	<or=60
1/19/77	LA	<30	LA	530	<20
1/25/77	R	<40	R	1800	R
1/31/77	<20	<20	R	1000	<30
2/6/77	<20	<20	50	STB	<20
2/12/77	<20	<20	80	500	20
2/18/77	<20	<20	130	360	40
2/24/77	R	<20	<20	870	280
3/2/77	<50	<30	<20	<or=600	80
3/14/77	<20	<20	190	<or=60 [1]	560 [1]
3/20/77	R	<20	<20	<or=320	<or=70
3/26/77	<20	<20	<20	140	240
4/1/77	<20	<20	<20	100	130
4/7/77	<20	NR	100	1250	<20
4/13/77	<20	<20	120	1180	160
4/19/77	<20	<20	160	740	200
4/28/77	<20	<20	260	3060	<20
5/3/77	<20	<20	30	330	210
5/13/77	<20	<20	<20	850	120
5/19/77	<20	<20	<20	580	100
5/25/77	R	<20	200	1140	130
5/31/77	<20	<20	100	970	<20
6/6/77	<20	<20	30	R	320
6/12/77	<20	<20	20	130	30
6/18/77	R	R	R	90	R

Table 3-11 (continued)

Date	Stations				
	Glens Falls 5601-4	Warrensburg 5660-02	Hudson Falls 5726-01	Fort Edward I 5755-01	Fort Edward II 5755-02
6/24/77	R	<20	R	R	30
6/30/77	<20	<20	110[2]	3260[2]	<20
7/6/77	<20	<20	140[2]	150[2]	70
7/12/77	<20	<20	50	290	<20
7/18/77	<20	<20	50	350	<20
7/24/77	<20	<20	100	520	<20
7/30/77	<20	<20	30	590	<20
8/5/77	R	<20	120	R	<20
8/11/77	R	<20	R	R	R
8/17/77	<20	<20	R	480	<20

5601-04 = Continuous Air Monitoring Station, Glens Falls
5660-02 = DEC Region 5 Suboffice, Warrensburg
5726-01 = Main Street School, Hudson Falls
5755-01 = Washington County Office Building, Fort Edward
5755-02 = Fort Hudson Nursing Home, Fort Edward

1 nannogram = 1,000 micrograms
R = Reject
LA = Lab Accident
STB = Sampling Train Broken
NR = Not Run

Notes: 1. = Appear to have been switched but cannot be verified.
2. = Results are inconsistent with each other: 5726-01 is usually ten percent of 5755-01.

Source: NYSDEC, 1977 b.

The Hudson Falls and two Ford Edward stations recorded higher PCB levels, perhaps because of proximity to the GE facilities in Ford Edward. One Fort Edward station, immediately northeast of the GE plant, recorded the highest concentrations of the five stations, with values ranging from around 0.06 ug/cu m to a maximum of 3.26 ug/cu m during the eight-month period. The other nearby Fort Edward sampling station registered a maximum PCB value of 0.56 ug/cu m. The mean PCB levels at this station were the second highest of the five stations. Hudson Falls followed with monitoring results indicating PCB concentrations significantly greater than Glens Falls and Warrensburg but less than the two Fort Edward stations (NYSDEC, 1977).

Thirty-day dustfall jar tests, which are used to measure settleable particulates, have also been conducted for three stations in Fort Edward, Glens Falls, and Warrensburg (NYSDEC, 1977). Samples were collected monthly from February to July 1977, and the results expressed as a total amount of PCBs per jar, PCBs per gram of particulate matter, and amount of particulate matter per unit area.

In the two categories related to PCBs, the Fort Edward station was markedly higher than the Glens Falls or Warrensburg stations.

Values of PCBs were less than 0.02 ug/cu m for each reading at Glens Falls and Warrensburg, but ranged between 0.13 and 0.93 ug/cu m for the Fort Edward station. Similarly, the micrograms PCB per gram particulate matter ranged from less than 0.6 to less than 3.0 ug/cu m for Glens Falls and Warrensburg, but from 8 to 29 ug/cu m at Fort Edward. The accumulation of particulate matter, however, was only slightly greater at Fort Edward than at Glens Falls, while both stations had considerably higher levels than Warrensburg.

These results indicate that settleable solids are more prevalent at Fort Edward than Glens Falls and have much higher associated PCBs. Settleable solids at Warrensburg are both reduced in quantity and less contaminated with PCBs. The Fort Edward station is, again, located immediately northeast of the the GE plant. It should also be noted that the above results are unpublished and subject to revision.

The following includes new information not previously reported in Dredging of PCB-Contaminated River Bed Materials, Upper Hudson River, New York (MPI,1978a).

A field study was performed by NYSDEC (Tofflemire, 1981) on PCB concentrations at site 10 near the Delong Farm and the Lock 6 dam at the Cottrell Paper Company (Table 3-12). The highest concentrations of PCBs were found at the Lock 6 Dam site for Aroclor 1016. The NYSDEC measured PCB concentrations outside the Washington County Office Building in Hudson Falls, New York from November 1976 to December 1977 (Figure 3-2). As evidenced by the figure, the average PCB concentration dropped from approximately 1 ug/cu m to about 0.3 ug/cu m after the cessation of PCB use at the GE plant in July, 1977.

NYSDEC measured PCB concentrations in air at several sites in the Fort Edward and Hudson Falls area (Table 3-13). As indicated by the table, it appears that the highest PCB concentrations occurred at the Caputo Dump site. However, some discrepancies in sampling method and duration have been noted and as a result, these data may not be appropriate for the purpose of comparisons.

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Table 3-12

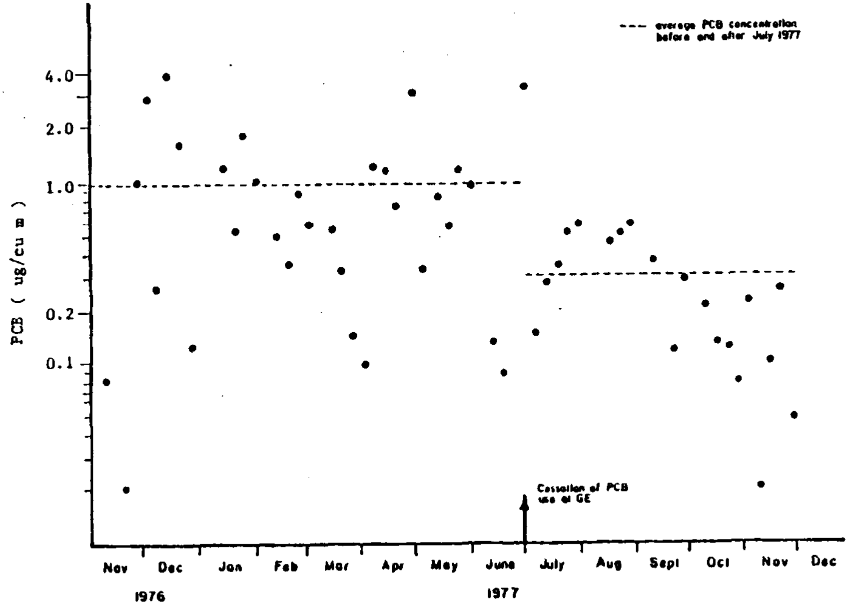
Ambient PCB Levels at Site 10 and Lock 6 Dam

Site	Date	Hrs. of Sampling	PCBs ug/cu m Aroclor		
			1016	1221	1254
Site 10 by Delong Farm	8/25/80 8/26/80	19 1/2	<.02	<.02	<.02
Site 10 by Delong Farm	9/05/80 9/07/80	48	<.01	<.01	<.01
Lock 6 Dam at Cottrell Paper	8/25/80 8/27/80	48	<.11	<.01	<.01
Lock 6 Dam at Cottrell Paper	9/05/80 9/07/80	48	<.52	<.01	<.01

Source: Tofflemire, NYSDEC, March 11, 1981

Figure 3-2

PCB CONCENTRATIONS IN AMBIENT AIR AT WASHINGTON COUNTY OFFICES



-sample collection by NYS DEC
-PCB analysis by NYS DOH

Table 3-13

Summary Tabulation of Air PCB Data by NYSDEC Division of Air Resources

Data taken at Temperature of 18 to 29 ° (65 to 85°F)

Site	Comment	Air PCB ug/cu m	Sediment ug/g (ppm)
Caputo Dump	Max	300	10,000-50,000
Caputo	Avg	130	10,000-50,000
Fort Miller Dump	Max	35	5,000-15,000
	Avg	24	5,000-15,000
Remnant Area	Max	10	1,000-2,000
	Avg	9	1,000-2,000
Moreau site with excavated 3A material	Max	15	600-1,000
	Avg	5.6	600-1,000
Buoy 212 site Summer 1979	One Sample 29° (85°F)	0.7	50-100
Old Moreau Site Summer 1979	Avg	0.3	20-50

CHAPTER 4

ENVIRONMENTAL CONSEQUENCES OF FEASIBLE ALTERNATIVES

This chapter presents a discussion of the environmental impacts of the feasible alternatives proposed to address the PCB problem that exists in the Hudson River. The evaluation will draw on the alternatives presented in Chapter 2 and the scientific evaluations presented in Chapter 3 of this document. However, the environmental impacts of all the options discussed in Chapter 2 are not presented because some were found to be infeasible and/or ineffective. Specific alternatives, including Control of River Flows, In-River Detoxification, Physical Treatment/Destruction of Dredged Spoils, and Bank-to-Bank Dredging were found to be infeasible because of costs and technical considerations and are not analyzed further.

The remaining altarnatives, including No-Action (with and without routine maintenance dredging), Dredging Alternatives (the Full-Scale Project and Reduced-Scale Project), In-River Containment of Hot Spots, Remnant Deposit Alternatives, Dredging Mechanism Alternatives, and Dredge Spoil Disposal Alternatives, were evaluated for potential beneficial and adverse, short- and long-term impacts under normal river flow as well as high-flow conditions. By definition, primary impacts are those adverse or beneficial impacts that are associated with the construction and operation of a proposed project. Secondary impacts are those adverse or beneficial impacts that are induced or result indirectly from the proposed project. The major factors considered in the assessment of primary and secondary impacts are:

- Public Health

  - Protection of downstream water supplies
  - Reduction of volatilization from remnant deposits and dredge spoil areas
  - Reduction of containment site volatilization
  - Reduction of exposure through the ingestion of contaminated fish
  - Protection of groundwater in the area of the containment site

- Fisheries and Aquatic Biota

  - Permanent reopening of the commercial and recreational fisheries
  - Protection of endangered species (shortnosed sturgeon)
  - Reduction of the bioaccumulation of PCBs through the food web
  - Protection of wetlands

- Maintenance Dredging and Navigation
  - Mitigation of future maintenance dredging and disposal problems in the upper Hudson Basin as well as the estuary
  - Evaluation of impacts to future hydroelectric dam construction and usage

- Agriculture
  - Reduction of volatilization from remnant deposits and dredge spoil areas
  - Reduction of containment site volatilization
  - Protection of groundwater in the area of the contaminant site
  - Protection of crops and livestock in the area of the containment site

The recommended action is comprised of the following alternatives:

- Full-Scale Project, Major Alternatives section 4 (if funding becomes available)

- Reduced-Scale Project, Major Alternatives section 5

- In-River Containment, Alternative Components section 1 (wherever cost-effective)

- Containment Site, Alternative Components section 4

I. MAJOR ALTERNATIVES

1. The No-Action Alternative

1A. No-Action Alternative (Assuming That Routine Channel Maintenance Dredging Will Continue)

1a. Short-term Primary Impacts

Under this alternative, there will not be adverse short-term primary impacts because PCB-contaminated sediments will not be removed from the Hudson River. This alternative does not provide for the stabilization and/or removal of remnant deposits, or the removal of NYSDOT Spoil Site 204 Annex. In short, this no-action alternative would allow the total mass of PCBs to remain in the banks and bed of the Hudson River, except for that removed by maintenance dredging, volatilization and transport downstream. The continued dispersion of PCB in such a way could present long-term adverse impacts, as described below.

The beneficial primary impacts of this alternative include the avoidance of short-term construction related effects such as noise, truck traffic, destruction of wetlands and resuspension of sediments.

1b. Long-term Primary Impacts

Under this no-action alternative, long-term adverse impacts can arise because the total mass of PCBs will remain in the Hudson River system, allowing the continual release of the toxic chemical to the air, water and biota. Routine maintenance channel dredging and volatilization will remove PCBs from the river. Table 2-2 indicates that it would take 33 years from the present date for all the PCBs in the upper Hudson River either to be transported into the estuary, to be volatilized, or to be removed by routine navigational dredging. Under this no-action alternative, 82,800 kg (182,000 lb) would be carried over the Federal Dam at Troy, 22,500 kg (49,500 lb) would be volatilized, and 37,400 kg (82,500 lbs) would be removed by routine maintenance dredging.

The long-term primary impacts that could arise from this no-action alternative include: potential long-term threat to downstream public water supply; continued risk to the public associated with exposure to PCBs from uncontrolled volatilization and direct contact; continued availability of PCBs to the food chain from both the terrestrial and aquatic media; continued threat to the commercial and recreational fisheries of the Hudson River; and a threat to the continuation of routine maintenance dredging operations.

Public Health

An evaluation of the impact of the no-action alternative on public health should include a definition of background levels of PCBs in all media that lead to human exposure and an evaluation of the toxic effects and health impacts associated with such exposure. Routes of exposure include drinking water, inhalation, ingestion, and dermal absorption. Routes and degrees of absorption of PCBs through the skin are unknown, and exposure through this route is unquantifiable, although subjectively estimated to be small relative to other exposure routes. (Appendix A).

As described in section 2 of Chapter 3, background levels of PCBs in the Hudson River are approximately 0.6 ug/l (ppb) and have remained steady through the three monitoring years of 1977, 1978, and 1979 (Tofflemire, NYSDEC, 1980). Water treatment by activated carbon filtration can reduce these levels by 40 to 80 percent (Cranston, City of Poughkeepsie, August 25, 1977), but such treatment is presently not used by Hudson River communities. Residents using treated Hudson River water for consumption would consume about 0.6 ug/day of PCBs (at a consumption rate of 2 liters/day [lpd]). Residents consuming untreated river water, could be exposed to levels of up to 1.2 ug/day. This situation could become worse and actually increase in areal extent under a flood situation where PCB-laden sediments from hot spot areas would be resuspended and carried further downstream.

Based on comprehensive national food surveillance programs from 1971 through 1975, FDA has estimated the average daily intake from all food group composites and the average daily intake from the meat-fish-poultry class (Table 4-1). The decrease in total dietary exposure is due to decreasing levels of PCBs in food packaging materials. The ingestion of PCBs through food should level out (based upon national background levels) and continue at the 1975 level as long as fish remain almost the sole source of dietary PCBs.

The populace in Fort Edward and Hudson Falls is exposed to an outdoor general background PCB concentration of 0.05 to 0.10 ug/cu m (Kerr, NYSDEC, May 8, 1980) and the rural populance is exposed to concentrations of less than 0.01 ug/cu m (Buckley, BTI, April 9, 1981). Residents and livestock in the area of existing PCB dumpsites and dredge spoil disposal sites and remnant sites can be exposed to levels above background levels. For example, at several PCB dump sites in the Fort Edward and Glens Falls areas, concentrations exceeded the NIOSH 8-hour recommendation of 1 ug/ cu m, with levels at the Caputo site of up to 130 ug/cu m during the summer (MPI 1980d). Soil concentrations of PCBs at the Caputo site were 10,000 to 50,000 ug/g (ppm).

As discussed later in this chapter, the general public health risks associated with the no-action alternative are greater than those associated with any of the feasible action alternatives.

Table 4-1

Estimates of Total Daily PCB Ingestion

Fiscal Year	Average Daily Ingestion of PCBs (ug/day)	
	Total Diet	Meat-Fish-Poulty Class
1971	15.0	9.5
1972	12.6	9.1
1973	13.1	8.7
1974	8.8	8.8
1975	8.7	8.7

Source: EPA, 1976b.

Fisheries and Aquatic Biota

Under the no-action alternative, contamination of fish in the Hudson River will continue. Based on 1980 data, most fish species in the upper Hudson River contain PCBs at levels exceeding the FDA tolerance level of 5 ug/g (ppm). A number of species in the lower Hudson River, including striped bass, white perch, and eel, also contain PCBs above the FDA standard (Appendix G). As discussed in Chapter 3, section 3, PCB levels in Hudson River fish have substantially declined since testing began in 1976 and 1977. Collective decreases in total PCBs averaged 38 percent from 1977 and 1978 (Armstrong and Sloan, 1980). The overall decline was mainly caused by decreases in Aroclor 1016, which is less stable in the environment than the more highly chlorinated aroclors. The 1980 fishery data indicate that the decline in fish PCB levels may be leveling off. Aroclor 1016 continued to decline, but Aroclor 1254 declined very little, if at all, from 1979 to 1980 (Sloan, NYSDEC, March 10, 1981).

Under the no-action alternative, it seems likely that PCB levels will not decline to the acceptable limit until the late 1980s at the earliest. For largemouth bass and other resident fish in the upper Hudson River that have PCB levels well above the limit, PCB levels would decline to below 5 ug/g (ppm) in approximately five or six years, assuming that the rate of decline over the past three years continues. In the lower Hudson River, resident fish, such as white perch and some striped bass, would not have acceptable PCB levels until the late 1980s at the earliest. However, the rates of decline that occurred from 1977 to 1980 probably will not continue because the declines were mainly due to the cessation of PCB discharges by GE, the low flow conditions on the river, removal of some contaminated materials by maintenance dredging, and by the removal of remnant deposit 3A, the stabilization of remnant deposits, and the breakdown of the lower chlorinated aroclors. PCB levels in fish may tend to stabilize around a level in equilibrium with levels of PCBs released from river sediments. If a future flood causes extensive resuspension of PCB contaminated sediments, declines in PCB levels in fish could be halted or even reversed. There is evidence that fish can accumulate PCBs from the water column quite rapidly

(Armstrong and Sloan, 1980). A flood event that elevates PCB levels in the Hudson River for one to two weeks could cause increases in fish PCB levels. PCBs accumulated in such a way would persist in the fish indefinitely because of the long retention time of PCBs in fish flesh.

Under the no-action alternative, it is unlikely that PCB levels in fish will reach the FDA limit that would allow the fishery to be reopened during the next ten years. The continued release of PCBs from sediments and the likelihood of floods could combine to keep the fisheries closed. The lowering of the limit to 2 ug/g (ppm), as proposed by FDA, would keep the fishery closed indefinitely. The one exception is American shad. Mean PCB levels in shad were found to be below 5 ug/g (ppm) when testing began in 1976. After significant declines from 1976 to 1978, PCB levels in shad seem to have stabilized around 1.5 ug/g (ppm) (Appendix G).

Contamination of Hudson River fish will continue to impose health risks on the public. Despite the ban on fishing, illegal commercial fishing, sport fishing and subsistence fishing do take place on the Hudson River, and consumers are eating fish with PCB levels exceeding the FDA limit (Blumenthal, New York Times, April 3, 1981).

Since FDA data collected in 1975 indicate that the meat-fish-poultry food category is primarily responsible for dietary intake of PCBs, suspension of the ban on fishing in the upper Hudson River must be considered for its effects on local population dietary exposure to PCBs. For people along the Hudson River that do not consume fish taken directly from the river, exposure to PCBs through the ingestion of food would be at least 9 ug/day, the national background level (USEPA, 1976b). Consumption of Hudson River fish with PCB levels at the FDA action level of 5 ug/g (ppm) would increase this level to approximately 900 ug/day, based upon an average daily consumption of 200 grams (0.4 lbs) of fish (USFDA, 1979).

Agriculture and Terrestrial Biota

The no-action alternative would allow the continued volatilization of PCBs from remnant deposits, from the banks and bed of the Hudson River, and from existing dredge disposal sites. This situation poses a potential threat to the dairy industry immediately adjacent to these uncontrolled disposal sites through the volatilization process. Forage crops contaminated with PCBs could be ingested by dairy cows, increasing the risk that milk could be contaminated with PCBs. Another agricultural concern associated with the no-action alternative regards the potential risk of using Hudson River water (without treatment) for dairy herds.

Volatilization from existing PCB sources will also continue to contaminate adjacent flora and fauna, allowing biomagnification of PCBs to occur in the terrestrial ecosystem.

Maintenance Dredging and Navigation

The USACOE requires toxicity testing of dredge spoils before permitting ocean disposal. Such tests have indicated that PCB concentrations greater than 4 ug/g (ppm) in dredge spoils would likely preclude ocean disposal, especially if heavy metals and other toxic contaminants are present (Curll, Save Our Ports, March 24, 1981). There are sediments in areas of the lower Hudson River which are not now suitable for ocean disposal. PCB levels in the Albany turning basin are expected to continue to increase until the year 2013 under this alternative. This would preclude ocean disposal of these dredge spoils. At present the average PCB concentration in New York Harbor is 3 ug/g (ppm) with some areas exceeding 4 ug/g (ppm) (Bopp, 1981). The average PCB concentation in New York Harbor sediments is expected to increase under the no action alternative, but local increases in PCB concentrations are likely to occur.

A beneficial impact associated with the no-action alternative (assuming that routine maintenance channel dredging will continue) is that, although the removal of PCB-contaminated sediments as proposed by the NYSDEC would not be implemented, future routine maintenance dredging operations would inadvertantly remove PCB contaminated sediments from the channel. In effect this will remove approximately 37,400 kg (82,400 lbs) of PCBs from the ecosystem. However, this could present the potential adverse effects from disposal practices involving multiple upland containment sites.

1c. Secondary Impacts

The no-action alternative will have several adverse secondary impacts. The continued contamination of Hudson River fishes and the partial closing of the fisheries will cause a continued loss of income and employment for the region that would occur if the commercial fishery were fully opened. Closure of the recreational fishery in the upper Hudson River also represents a loss of income that would otherwise be generated by the sale of fishing equipment, bait, gasoline and other expenditures by sportfishermen.

The contamination of drinking water supplies with PCBs to unacceptable levels during a flood event will also have adverse secondary impacts under the no-action alternative. The costs of additional water treatment measures, such as activated carbon filtration, or costs of providing alternative supplies of water, would be an economic burden to communities or private individuals if such contamination occurs.

If dredge spoils from the lower Hudson River cannot be disposed of in the ocean, substantial economic hardship would be imposed on port areas because alternative methods, such as land disposal, are much more costly. Maintenance dredging in the upper Hudson River could also become much more costly if highly contaimnated dredge spoils must be held in a safe containment facility instead of a usual dredge spoil site.

The no-action alternative could have secondary impacts on agriculture if contamination of forage crops leads to excessive PCB levels in milk, rendering it unmarketable. This is not a likely impact of this alternative, however, because contamination of forage crops probably will not become worse in the future. PCB levels in milk from the region have not exceeded FDA tolerance limits.

The no-action alternative could have adverse secondary impacts on the development of hydroelectric power in the region. Under the no-action alternative, loss of PCBs from remnant deposits would be greatly accelerated if a surging dam were constructed at Fort Edward by NMPC, as discussed in section 2 of Alternative Components, Chapter 2. All or some of the remnant deposits would have to be removed or adequately stabilized before construction of a surging dam. This would represent a possible impediment to the development of hydroelectric power in the Fort Edward region.

1d. Unavoidable Adverse Impacts and Steps to be Taken to Minimize Harm

The no-action alternative poses substantial risks to the fishery, to disposal of dredge spoils from the estuary, and to public health. The only possible mitigating measure is to control the flow in the upper Hudson River to reduce the resuspension and transport of PCBs. This could be done with very limited effect-
iveness at the Conklingville Dam and is not recommended for addressing the existing PCB problem in the Hudson River.

1e. Contingency Plans

In the event that a potable water supply were contaminated with PCBs at concentrations greater than 1 ug/l (ppb), a filtration system or alternate sources of water would be necessary.

1f. Monitoring

Monitoring of the PCB levels in fishes of the upper and lower Hudson River will be necessary to know when to reopen the fishery. Monitoring PCB concentrations in sediments prior to dredging will enable dredging to occur before those concentrations preclude ocean dumping. Monitoring programs must be established during flood conditions to protect water supplies for down-river communities utilizing the Hudson River for municipal water.

1B. No-Action Alternative (Assuming That Routine Channel Maintenance Dredging Is Halted

Primary and secondary environmental impacts for this scenario of the no-action alternative are similar to those discussed under the no-action alternative, Chapter 4, section I.1A. Table 2-3 indicates that 112,000 kg (247,000 lb) of PCBs would be transported into the estuary over 48 years. This can be compared with 82,800 kg (182,000 lb) of PCB transported into the estuary over 33 years for the no-action alternative assuming that maintenance dredging will be continued.

Table 2-3 indicates that, if routine channel maintenance of the upper Hudson River were to cease, it would take 48 years from the present date for all the PCBs in the upper Hudson River either to flow into the estuary, or to volatilize. Under this scenario 112,000 kg (247,000 lb) would be carried over the Federal Dam at Troy, and 33,300 kg (73,500 lb) would be volatilized. Both no-action alternatives (with and without routine channel maintenance) have similar impacts, except that it is more likely that an adverse event will occur under the no-action alternative without maintenance dredging. Routine channel maintenance in the upper Hudson River is likely to be halted unless a containment area is available for dredge spoils with concentrations greater than 50 ug/g (ppm) of PCBs. The cessation of maintenance dredging could create a significant economic hardship on upper Hudson River communities because alternative transportation systems would be more costly.

The mitigating measures, contingency plans and monitoring requirements discussed under section I.1A of this chapter would also apply to this no-action alternative.

2. Control of River Flows

This alternative was found to be infeasible, as discussed in Chapter 2.

3. In-River Detoxification

This alternative was found to be infeasible, as discussed in Chapter 2.

4. Full-Scale Project

The full-scale project involves the removal of hot spots by hydraulic or mechanical means, the disposal of the dredge material in the containment area, the in-river stabilization of selected hot spots, and mitigative actions at the remnant deposits. Impacts will occur with each aspect of the full-scale project. To avoid repetition, short-term impacts associated with the various dredging methods that could be used in the full-scale project are discussed in section II of this chapter (Alternative Components). Similarly, the impacts associated with the containment of the dredge spoils and the remnant deposit alternatives are also discussed in section II. Only the long-term impacts arising from the removal of PCBs from the Hudson River under the full-scale project will be discussed in this section.

4a. Short-term Primary Impacts

The primary impacts of the full-scope project are short term impacts related to the dredging methods, remnant deposit actions and other alternative components utilized in the project. These impacts will be discussed in section II of this chapter.

4b. Long-term Impacts

Public Health

The full-scale project will have beneficial long-term impacts on public health. The quality of drinking water for communities utilizing the Hudson River water will improve. Although the current PCB drinking water guideline (1 ug/l) is presenlty being met, removal of contaminated sediments will further reduce present concentrations. A corresponding reduction in health risks will follow.

Volatilization of PCBs from the river, remnant deposits and other sources will be signficantly reduced. Direct contact of the public with PCB-contaminated deposits, particularly at the remnant deposits, will be reduced. The risks associated with exposure to PCBs by the public will therefore decrease.

As discussed below, removal of PCBs from the Hudson River under the full-scale project will reduce the amount of PCBs available for uptake by fish. A reduction of PCB levels in fish would have a beneficial impact on public health because it would reduced the dietary uptake of PCBs by the public.

Fisheries and Aquatic Biota

Monitoring by NYSDEC from 1976 to 1980 indicates that PCB levels in Hudson River fish have declined. If the trend continues, it is possible that PCB levels below the FDA tolerance limit of 5 ug/g (5 ppm) could be achieved by the end of the 1980s and that the fishery could eventually be opened completely. However, if contaminated sediments were resuspended by a major flood event, PCB levels could remain high and the fishery would remain closed. Under normal flow conditions, the full-scale project has the potential to accelerate the decline in PCB levels and the recovery of the fishery. The project also has the potential to reopen the fishery permanently even under future flood conditions.

The full scope project may also directly benefit fish populations in the Hudson River. There is limited evidence indicating that PCB-contamination has adverse effects on the survival and reproduction of certain fish species, including striped bass.

The endangered shortnose sturgeon could benefit by a reduction of PCB contamination in the river. Damage from PCBs has been linked to susceptibility of the shortnose sturgeon popoulation to fin rot disease.

Some PCB hot spots are in wetlands and their removal would have adverse effects on food chain relationships and breeding habitats. Several wetland areas containing hot spots may be affected if these areas are diked or stabilized in place. This action may initiate a succession of the vegetation from shallow to deeper rooted plants, thus changing the aquatic and terrestrial fauna. Removal of PCB-contaminated sediments would have the favorable impact of reducing the bioaccumulation of PCBs through the wetland food web.

Agriculture and Terrestrial Biota

Under the full-scale project, removal of PCBs from the river bed and banks will decrease volatilization and the resulting contamination of adjacent terrestrial flora, including forage crops. Contamination of forage crops represents a potential risk to the dairy industry because PCBs tend to concentrate in cows and milk. The full-scale project will decrease this risk. A reduction in volatilization will also decrease the extent of biomagnification of PCBs through terrestrial food chains.

Maintenance Dredging and Navigation

The full-scale project will result in an overall beneficial impact on maintenance dredging and navigation.

In the upper Hudson River, continued maintenance dredging will be assured if concentrations in dredged material can be reduced to less than 50 ug/g (ppm). A piecemeal approach to the disposal of dredge spoils from maintenance dredging will be prevented by providing secure and localized containment for a substantial portion of contaminated sediments. Continued maintenance dredging will also ensure that future navigation is maintained in the upper Hudson River. The full-scale project will also reduce the chance that the PCB content of sediments in the lower Hudson River, especially in the Albany turning basin, will increase to levels that would require upland containment of dredge spoils.

4c. Secondary Impacts

The full-scale project will have beneficial secondary impacts. The project has the potential to reduce PCB contamination of Hudson River fish and to hasten the complete reopening of the fisheries. Complete reopening of the commercial and recreational fisheries would have significant economic benefits by creating additional employment and income for residents and businesses of the area.

The full-scale project will also have the beneficial impact of ensuring that maintenance dredging will not be halted because of excessive contamination of sediments in the upper Hudson River. The economic hardships that would occcur if segments of the river system presently used for barge and other boat traffic became unnavigable would not occur. In addition, the economic hardships that could result from a halt of ocean disposal of dredge spoils from the lower Hudson River may also be avoided.

The full-scale project will facilitate the construction of a hydroelectric dam at Fort Edward. The costs of removing the remnant deposits will no longer be an impediment to construction of the dam and development of hydroelectric power.

4d. Unavoidable Adverse Impacts and Steps to be Taken to Minimize Harm

Except for the maintenance of a containment facility for dredge spoils, the long-term impacts of the full-scale project will be mainly beneficial and mitigating measures are not needed. If valuable wetlands are destroyed by removal or containment of hot spots, however, a mitigating measure would be the restoration of the wetland. Restoration of a wetland through the planting of wetland vegetation and other reconstruction measures would be especially important if the wetland is a valuable wildlife habitat or breeding and nesting area for waterfowl.

Mitigating measures applicable to the construction and operation of a containment facility are discussed under Alternative Components, section II.4. of this chapter. Mitigating measures for the adverse impacts of the dredging components will also be discussed in section II, as will the mitigating measures associated with the remnant deposit alternative.

4e. Contingency Plans

The full-scale project will substantially reduce the risk that drinking water supplies derived directly or indirectly from the Hudson River could become contaminated by PCBs after a major flood. However, contingency plans should provide for alternate supplies of water or adequate purification systems for residents if PCB levels were to exceed acceptable limits in water supplies.

Contingency plans for the operation of a containment facility for the dredge spoils will be discussed in section II of this chapter. Short-term contingency plans for the dredging and remnant deposit components of the full-scale project will also be discussed in section II.

4f. Monitoring

Extensive monitoring will be required during the construction and operation of the containment facility (section II, Chapter 4).

Long-term monitoring of river water for PCBs and heavy metals must be performed downstream of removed hot spots to determine the effectivenss of the removal operation. PCB levels in vegetation adjacent to the upper Hudson River, particularly near dams and locks, should also be monitored at least at yearly intervals. Particular attention should be given to forage crops. PCB levels in Hudson River fish must also be monitored to determine if PCB levels have declined enough to permit the reopening of the fishery.

5. Reduced-Scale Project

The reduced-scale project involves the removal of selected hot spots by hydraulic or mechanical means, the disposal of the dredge spoils in the containment area, and mitigative actions at the remnant deposits. To avoid repetition, short-term impacts associated with the various dredging components that could be used in the reduced-scale project are discussed in section II of this chapter. Similarly, the impacts associated with the containment of the dredge spoils and the remnant deposit alternative are also discussed in section II.

5a. Short-term Primary Impacts

The short-term primary impacts of the reduced-scale project are impacts related to the dredging methods, remnant deposit actions and other alternative components utilized in the project. These impacts will be discussed in section II of this chapter.

5b. Long-term Primary Impacts

The long-term impacts associated with removal of contaminated sediments from the upper Hudson River under the reduced-scale project are essentially the same as those of the full-scale project. The reduced scale project will have beneficial impacts on public health, fisheries and aquatic biota, agriculture and terrestrial biota, and maintenance dredging and navigation. However, the magnitude of these impacts will be less under the reduced-scale project because the amount of contaminated sediment removed from the river system will be less.

The long-term adverse impact on wetlands discussed under the full-scale project will not occur under the reduced-scale project. Under the reduced-scale project, hot spots in valuable wetlands will not be removed.

5c. Secondary Impacts

The reduced-scale project will have beneficial economic impacts associated with the Hudson River fisheries, maintenance dredging, and ocean disposal of dredge spoils. The secondary impacts of the reduced-scale project will be essentially the same as those for the full-scale project (section I.4 of this chapter). The magnitude of the impacts, however, will not be as large because the amount of PCBs removed from the river system will be less under the reduced-scale project.

5d. Unavoidable Adverse Impacts and Steps to be Taken to Minimize Harm.

Mitigating measures for the reduced-scale project are the same as those for the full-scale project, with the exception that restoration of wetlands will not be necessary since the reduced-scale project would avoid dredging of the wetland hot spots.

5e. Contingency Plans

Contingency plans for the reduced-scale project are the same as those for the full-scale project.

5f. Monitoring

The monitoring program for the reduced-scale project will be identical to that for the full-scale project.

6. Bank-to-Bank Dredging

This alternative was found to be infeasible, as discussed in Chapter 2.

II. ALTERNATIVE COMPONENTS

1. In-River Containment

The in-river containment alternative involves isolation of selected hot spots with dikes, bulkheads and backfilling. The purpose of in-river containment is to prevent erosion of the hot spots and reduce the release of PCBs to the river.

1A. Short-term Primary Impacts

Public Health

The in-river containment alternative will expose workers at the work site to potential health risks. Air concentrations of PCBs at the hot spots could be greater than 1 ug/cu m, the NIOSH 8-hour recommendation, but well below the 500 ug/cu m OSHA standard. The health effects of exposure to airborne PCBs are discussed in Appendix A.

Short-term health risks could be imposed on the public if construction activities cause an increase in releases of PCBs to the air or water. Releases of PCBs are likely to occur through the following processes:

- Construction of containment structures such as dikes will require dredging of PCB-laden sediments in order to prepare a firm substrate as a base. The dredged sediments must be either transplanted to the in-river contained area or to an upland containment site. Dredging will resuspend sediments and cause release of PCBs to the river and air. The impacts of dredging are discussed in section II.3 of this chapter.

- Erosion and scouring of PCB-contaminated sediments could increase during the construction phase because vegetation and sediments will be disrupted by machinery, boat movements and other construction activities.

- Other construction related activities, such as the movement of tug boats in shallow water, will resuspend sediments and PCBs.

- During the construction phase, volatilization of PCBs will increase as previously buried hot spot sediments are exposed to the air or water.

Releases of PCBs to the water and air from construction should be low and of short duration, so public health effects should be minimal.

The construction equipment required for in-river containment will create substantial noise that may disturb nearby residential areas. The equipment will also produce minor amounts of air pollution. These impacts will be of short duration and should not create any significant public health problems.

Fisheries and Aquatic Biota

Releases of PCBs to the river from construction activi will make the contaminnment available for accumulation by fish. Because the releases are expected to be small and of short duration, the effects on fish of in-river containment should not be significant. Benthic organisms in close proximity to construction activity, however, may be harmed or killed by local siltation.

Existing wetland vegetation and wildlife habitats at and adjacent to areas where containment structures are to be placed will be destroyed.

Agriculture and Terrestrial Biota

The construction equipment will create substantial noise and disrupt nearby wildlife habitats. Such impacts will be localized and of short duration.

No short-term impacts on agriculture are expected from in-river containment of hot spots.

Maintenance Dredging and Navigation

Barges, boats and other equipment needed in construction activities will create a hinderance to normal traffic on the river. Siltation and erosion patterns in the river will be altered in the vicinity of the contained area. Placement of containment structures could hinder navigation on the river.

1B. <u>Long-term Primary Impacts</u>

Public Health

In the long term, in-river containment will stabilize hot spots and prevent erosion of PCB-contaminated sediments. In-river containment will also minimize the release of contaminated material from ice rafting. Decreases in PCB releases will decrease the health risks associated with PCB-contamination of the Hudson River. However, health risks could reoccur if containment of hot spots fails. Major damage to containment structures could occur from high flow periods, ice jams, or boat collisions. Gradual weakening of containment structures could arise from normal, long-term river processes.

Fisheries and Aquatic Biota

In-river containment will benefit the fisheries in the long-term because it will decrease the amount of PCBs readily available for uptake in aquatic ecosystems. This could help to reduce the PCB content of fish to levels below the acceptable tolerance limit. A failure of the containment structures, however, would cause the release of PCBs to the aquatic ecosystem.

In-river containment will have long-term impacts on contained wetlands. Silt transported in runoff from the land will accumulate in the contained areas, covering PCB-laden sediments. This will have the beneficial impact of stabilizing the contained area and encouraging the growth of more deeply rooted vegetation. This process will further stabilize the hot spot and decrease volatilization of PCBs.

Containment of wetland hot spots will substantially alter drainage patterns within the wetland. This may have adverse effects on the nature of the vegetation and wildlife habitat. Containment will reduce the exchange of water, causing greater extremes in temperature of contained surface waters. Reduced circulation will also decrease oxygen levels of contained surface waters, particularly during warm weather. The value of the wetland as a wildlife habitat will probably decrease.

Containment, stabilization and backfilling of presently shallow hot spots may create additional wetlands. This would have the beneficial impact of creating new wildlife habitats in the river system.

Agriculture and Terrestrial Biota

In-river containment will reduce volatilization of PCBs and therefore reduce the amount of PCBs availabe for uptake by terrestrial ecosystems. This beneficial impact, however, may not be large because only a small number of hot spots are suitable for in-river containment under the full-scale project.

Maintenance Dredging and Navigation

By stabilizing PCB hot spots, in-river containment will help prevent further contamination of down-river sediments. This will help prevent PCB levels from reaching such high levels that dredge spoils from maintenance dredging would require costly upland containment.

Siltation and erosion patterns in the river would be altered in the vicinity of the contained area, possibly creating navigational problems. Placement of containment structures could hinder navigation on the river.

1C. Secondary Impacts

Because in-river containment will help to reduce the release of PCBs from hot spots to the river system, the in-river containment alternative will have beneficial effects, with corresponding beneficial secondary impacts, on the fisheries, maintenance dredging in the upper Hudson River and ocean disposal of dredge spoils from the lower Hudson River. Secondary impacts of this alternative will be similar in nature to those that will occur from removal of hots spots, as described in section I.4 of this chapter (full-scale project). The secondary impacts attributable to in-river containment of hot spots, however, will not be large because only a small number of hot spots are suitable for in-river containment.

1D. Unavoidable Adverse Impacts and Steps to be Taken to Mininize Harm

Unavoidable adverse impacts can be mnimized by implementing the following measures:

- All work on the hot spots should be performed during the dry season, between May and September. Low rainfall and low flows will minimize erosion and scouring, and decrease chances of flood flows occurring while the work is still incomplete, thus minimizing release of PCBs to the river.

- Only vegetation that poses a direct hindrance or hazard to work on the hot spots should be removed.

- Protective clothing, including respirators, should be provided to all workers at the site to minimize health risks.

- The public should not have access to the hot spots and surrounding area during the work phase.

- Work which generates excessive noise should only be conducted during normal working hours to minimize disturbance to the public.

- Public access to contained hot spots should be discouraged by posting of warning signs. If feasible, access should be prevented by placement of fences.

- Hot spots should be cqvered to a height above the 100- or 500-year flood level to reduce the risk of erosion during major flood events. However, this would eliminate the wetland character of the hot spot.

1E. Contingency Plans

Major damage to the containment structures may occur during high flow periods, ice jams, or boat collisions. If containment structures are damaged, repair would have to be made immediately. NYSDEC will have the authority to make arrangements for immediate repairs.

Contingency plans discussed under the full-scale project (section 4, Chapter 4) should also apply under this alternative.

1F. Monitoring

Short-term monitoring should accompany construction of the containment structures and consist of air and water sampling. Water sampling for turbidity, Cs^{137}, lead and PCBs should be done at regular intervals downstream of construction activity. Air quality should be sampled everyday at four locations representing the major compass directions.

Long-term monitoring will consist of periodic water and air sampling. Water samples should be taken downstream of each in-river contained hot spot and should be analyzed for PCBs and heavy metals. Samples should be taken once every two months. Air samples should be taken and analyzed for PCBs. Additionally, samples of the vegetation should be analyzed for PCB levels once every year.

2. Remnant Deposit Alternatives

After the dam at Fort Edward was removed in 1973, most of the contaminated sediment originally contained behind the dam that was not transported downstream remained as exposed deposits along the river bank at five locations. Of these five remnant deposit areas only two, deposits 3 and 5, are presently considered to be a significant source of PCB to the environment. The most highly contaminated remnant area, 3A, was removed to the new Moreau NYSDOT site in 1978.

2A. Remnant Deposit No-Action Alternative

2a. Short-term Primary Impacts

Under the no-action remnant deposit alternative, there will not be adverse primary impacts because the PCB-contaminated deposits will not be removed or contained. No-action would permit the continued release of PCBs from the remnant deposits. Such PCB releases could present long-term adverse impacts, as described below.

The beneficial primary impacts of no-action include the avoidance of short-term construction related effects such as noise, truck traffic, and other disruptions to the public.

2b. Secondary Impacts

Public Health

Under the remnant deposit no-action alternative, the main long-term impact will be the continued release of PCBs to the Hudson River and surrounding air and the public health risks associated with PCB contamination of the Hudson River.

The amount of PCBs being released from the remnant deposits to the Hudson, however, has not been adequately determined. There is a substantial flow of PCBs, 590 to 1315 kg/yr (1300 to 2900 lbs/yr), in the Hudson River at Rogers Island (MPI, 1980d). The source of this flow has not been identified, and it has not been determined to what extent the remnant deposits are contributing to this flow. As discussed in section II.2 of Chapter 2, deposits 1,2,3 and 4A are subject to erosion, especially during high flows. These deposits, however, contain relatively low levels and small total amounts of PCBs (Tables 2-8a and 2-8b). Remnant deposits 3 and 5 contain high concentrations and substantial total amounts of PCBs, but remedial measures have been taken to stabilize them. Under the no-action alternative, the short-term impacts of the remnant deposits on water quality and public health cannot be fully assessed until the unknown source of PCBs in the upper Hudson River is determined and the stability of deposits 3 and 5 is confirmed.

Under the no-action alternative, continued release of PCB through volatilization is also a potential health risk. The remnant deposits, especially those on the east side of the river, are in fairly close proximity to residential areas. Some of the remnant deposits are accessible by the public, creating an additional risk to public health. The health hazards of exposure to PCB in air are discussed in Appendix A.

A potential long-term impact of the remnant no-action alternative is the release of large quantities of PCBs if the deposits undergo extensive erosion during a high flow period, as occurred in 1976. Erosion of deposits 1,2, 4 and 4A is possible during high flows because little or no stabilization measures have been taken on them. Erosion of these deposits would not have a great impact because they do not contain large quantities of PCBs. Erosion of deposits 3 and 5 would release substantial quantities of PCB to the Hudson River, causing a substantial reduction in water quality, increased contamination of fish and other biota, the formation of new hot spots in downstream areas of deposition, and risks to public health. The chances of large scale erosion of deposits 3 and 5, however, are not great because stabilization measures, including rip-rapping, have been taken.

Fisheries and Aquatic Biota

The continued release of PCBs from remnant deposits could make substantial amounts of the contaminant available for uptake by the aquatic ecosystem. Such releases, depending on their magnitude, may be contributing to the PCB contamination of Hudson River fish. The remnant deposit no-action alternative may lengthen the time required for fish PCB levels to decrease to levels low enough for the fishery to be reopened.

Agriculture and Terrestrial Biota

Under the remnant deposit no-action alternative, volatilization of PCBs from the remnant deposits, estimated to be 130 kg (280 lb), will continue, causing locally reduced air quality and contamination of adjacent vegetation. Agricultural products grown within 700 m (2300 ft) of remnant deposits may have PCB concentrations above background levels. Volatilization from remnant deposits represents a route by which PCBs can enter terrestrial ecosystems and bioaccumulate in exposed organisms.

Maintenance Dredging and Navigation

The no-action alternative does not provide protection against large-scale scouring of remnant deposits during future flood events. Such scouring could lead to the formation of new PCB hot spots in the river, impairing the ability to dispose of dredge spoils from the upper and lower Hudson River. Large-scale erosion of remnant deposits with the consequential release of PCBs to the river could contribute to PCB contamination of downstream sediments. As discussed in section I.1 of Chapter IV (No-Action Alternative), sediments could become contaminated with PCBs to such an extent that spoils from maintenance dredging could no longer be disposed of in usual manners, eventually resulting in a halt to maintenance dredging and closing of some navigational channels. Although long-term impacts under the no-action remnant deposit alternative would most likely not be as great as those associated with large-scale movement of hot spot sediments, they could be significant because of the large quantity of PCBs presently contained in the remnant deposits.

2c. Secondary Impacts

The no-action remnant deposit alternative may have adverse secondary impacts similar to those discussed for the no-action alternative (section I.1 of this chapter). The potential large-scale release of PCBs from the remnant deposits to the Hudson River could have adverse economic impacts associated with the continued closure of the fisheries, the contamination of downstream water supplies, and the halting of maintenance dredging. Adverse secondary impacts are less likely to result from the remnant deposits than from PCB hot spots in the river because the remnant deposits are more stable and less subject to scour than the hots spots. In addition, there are less PCBs contained in the remnant deposits than in all the hot spots.

Volatilization of PCBs from remnant deposits could contaminate nearby agricultural crops, especially private garden crops, with unacceptable amounts of PCBs. This would cause an economic loss to farmers or garden owners if their crops became unmarketable or inedible.

The no-action remnant deposit alternative would also have secondary impacts on hydroelectric power generation at Fort Edward. If the NMPC constructed a surging dam for the generation of electric power at the old Fort Edward dam site, as the company has proposed, the remnant deposits would be resubmerged, and release of PCBs to the river would be accelerated. Therefore, the remnant deposits would have to be removed or effectively stabilized before construction of the dam. This would represent a possible impediment for development of the dam and hydroelectric power.

2d. Unavoidable Adverse Impacts and Steps to be Taken to Minimize Harm

Control of river flow by the Conklingville Dam would prevent scouring of the remnant deposits during a flood event. As discussed in section I.1 of Chapter IV, the dam has very limited potential for such use.

No other mitigative measures are considered under the remnant deposit no-action alternative.

2e. Contingency Plans

Contingency plans are necessary if a future flood event causes further destabilization of remnant deposits and substantial loss of PCBs to the river. Measures should be taken to re-establish stability and prevent unrestrained scouring of the deposits, especially deposits 3 and 5, through bank reinforcement and other erosion control measures. Contingency plans must provide for the protection of public health if scouring of remnant deposits sharply increase PCB levels in the river. Such an increase poses a potential threat to downstream fishery resources and public drinking water supplies. The same contingency plans that apply under the no-action alternative, discussed in section I.1 of Chapter IV, should also apply to the remnant deposit no-action alternative.

2f. Monitoring

Monitoring of PCB levels in water under the remnant deposit no-action alternative must be conducted so that any changes in the amounts of PCBs flowing downstream at Fort Edward can be detected. Such an increase could indicate that destabilization of remnant deposits has occurred. Monitoring of water PCB levels must be intensified during and several weeks after any significant high flow events.

In addition to the monitoring program, a careful sampling program must be initiated as soon as possible in the upper Hudson River to identify the presently unknown source of PCBs above Fort Edward. Series of water samples should be taken starting at Rogers Island and extending upstream several miles. Samples should be taken over a range of seasonal and flow conditions. If PCBs are entering the river from a fairly concentrated source, such as an undiscovered landfill, wastewater discharge, or the remnant deposits, PCB levels should decrease fairly abruptly upstream of the vicinity of the input. Absence of such a drop in PCB levels would indicate the existence of a source of PCBs further upriver or non-point sources. Confirmation of whether or not the remnant deposits are presently a substantial source of PCB contamination of the Hudson River is critical for determining the proper course of action for the remnant deposites and for determining the relative priorities of dredging lower river hot spots and removing remnant deposits.

Monitoring of PCB levels in air around the remnant deposits and around residential areas nearest the deposits should also be undertaken. Monitoring should be done under various seasonal and meteorological conditions so that PCB levels under worst case conditions can be assessed.

2B. Denial of Access

2a. Short-term Primary Impacts

The denial of access alternative will have impacts related to construction activities. Because this alternative only involves limited constuction activity (erection of fences, placement of warning signs and seeding of bare ground), these impacts should be minor.

Public Health

The denial of access alternative will impose a slight health risk to workers implementing the actions of the alternative. Air concentrations of PCBs at the remnant deposits could be over 1 ug/cu m, the NIOSH 8-hour recommendation, but well below the 500 ug/cu m OSHA standard. The health effects of exposure to airborne PCBs are discussed in Appendix A.

Materials will have to be trucked to the sites through residential neighborhoods, causing slight disruption to inhabitants. Because the amount of materials needed is not large, such impacts will be small and for a short duration. There will be noise impacts from the machinery needed to implant the fences. Noise impacts should not be great because heavy machinery is not needed and the duration of activity will be short.

Fisheries and Aquatic Biota

This alternative may have slight impacts on aquatic biota by causing small releases of PCBs to the Hudson River during the construction phase. The removal of vegetation in the path of the fence and the digging of a trench and post holes for emplacement of the fence may increase erosion and cause slight increases in PCB losses to the river. The increases should not be large enough to affect fish or other aquatic biota.

Agriculture and Terrestrial Biota

This alternative will have no primary impacts on agriculture. Noise from construction activities may disturb local fauna.

Maintenance Dredging and Navigation

This alternative will have no short-term primary impacts on maintenance dredging and navigation.

2b. Long-term Primary Impacts

The denial of access alternative will have the same adverse long-term impacts as described for the remnant deposit no-action alternative (section II.2A of this chapter) because this alternative has no provisions for stabilization or removal of remnant deposit material. The denial of access alternative, however, will have an additional beneficial impact on public health. Public health risks will be slightly reduced because people will no longer have access to the deposits, thus eliminating direct exposure to the contaminated material.

2c. Secondary Impacts

The adverse secondary impacts that could occur under this alternative are the same as those discussed for the remnant deposit no-action alternative (section II.2A. of this chapter).

2d. Unavoidable Adverse Impacts and Steps to be Taken to Minimize Harm

Mitigating measures that should be taken to minimize unavoidable adverse impacts are described below.

- Reseeding of all disrupted soils should be undertaken as quickly as possible to establish a vegetative cover and prevent erosion.

- Work should be carried out during the dry season so that chances of rainfall are minimized, thus decreasing the potential for erosion of distrubed soils. River flows will also be lowest during the dry season, thus diminishing chances of flood flows that could easily erode disturbed soils.

- Work and trucking of materials should be done during working, daytime hours as much as possible to minimize inconvenience and disturbance for nearby residential areas.

- Protective clothing, including respirators, should be provided to workers on the site to minimize their health risks.

2e. Contingency Plans

Because the denial of access alternative does not stabilize the remnant deposits, the contingency plans discussed under the remnant-deposit no-action plan also apply to this alternative. These plans include the restabilization of the deposits in the event they are scoured by a flood event, and plans to safeguard health of the public if enough scouring of deposits and release of PCBs occur to threaten downriver drinking water supplies and fishery resources.

2f. Monitoring

The monitoring described under the remnant deposit no-action plan should also be applied to this alternative.

2C. Remnant Deposit In-Place Containment

2a. Short-term Primary Impacts

The in-place containment alternative involves the stabilization of remnant deposits by placement of an impermeable cover and by reinforcement of the river bank. The short-term primary impacts are related to construction activities.

Public Health

The in-place containment alternative could expose workers at the work site to health risks. Air concentrations of PCB at the remnant deposits could exceed 1 ug/cu m, which is the recommended NIOSH 8-hour standard, but will be well below the 500 ug/cu m OSHA standard. The health effects of exposure to airborne PCBs are discussed in Appendix A.

Short-term health threats could be imposed on the public if construction activities cause an increase in releases of PCBs to air or water during the construction phase. Such releases should be low and of short duration, so health effects should be minimal.

Trucking of materials to the remnant deposits will cause severe disruption of residential areas near the remnant deposits because of the noise, traffic and air pollution that will result. The transport of materials needed for in-place containment of deposits 3 and 5 will require 5,000 to 10,000 truck trips, depending on truck capacities (MPI, 1980d). Noise and air pollution created by the machinery needed at the work sites will also disrupt nearby residents.

In-place containment would also preclude the removal of the contaminated material which would release significant quantities of PCBs to the air and water during excavation. Also there would be an increase in the number of truck trips for removal.

Fisheries and Aquatic Biota

Destruction of vegetation and disruption of soils during the construction phase could temporarily increase erosion and destabilize river banks, consequently increasing loss of PCBs to the river. The impacts of such PCB losses to the water should not be large.

Agriculture and Terrestrial Biota

In-place containment of remnant deposits will have no significant short-term impacts on agriculture. Noise from construction activities may distrub local fauna. In addition, existing vegetation on and adjacent to the remnant deposits and the paths of needed access roads will be destroyed.

Maintenance Dredging and Navigation

In-place containment of remnant deposits will have no significant short-term impacts on maintenance dredging and agriculture.

2b. Long-term Primary Impacts

Public Health

Stabilization and cover of remnant deposits would decrease public health risks by reducing volatilization of PCBs to the air and by reducing any present losses of PCBs to the river. In the long term, however, any failure of the containment measures could result in releases of PCBs to the environment and a reoccurrence of public health risks. Health effects of exposure to PCBs to the public are discussed in Appendix A. Because PCBs are not removed from the river system under this alternative, any long-term erosional patterns of the river could weaken containment measures and cause PCB contamination of the river. Continuous maintenance of the cover and bank reinforcements would be necessary to minimize this threat.

Fisheries and Aquatic Biota

In-place containment of the remnant deposits would decrease risks to the fisheries by reducing PCB losses to the Hudson River by erosion and other processes. However, if containment of remnant deposits failed and PCB-contaminated sediments were released to the river, risks to the fishery would reoccur.

Maintenance Dredging and Terrestrial Biota

Containment of remnant deposits will decrease the amounts of PCBs entering sediments of the Hudson River. This would partially prevent dredge spoils resulting from maintenance dredging of the upper Hudson River from becoming too contaminated with PCBs to be disposed of in usual manners. The chances of lower Hudson River sediments becoming too contaminated for ocean disposal also may be reduced.

2c. Secondary Impacts

In-place containment of remnant deposits will reduce PCB contamination of the Hudson River, and help to avoid the adverse secondary impacts that could arise from the continued closure of the fisheries, the halting of maintenance dredging and the ocean disposal of dredge spoils, and the contamination of downstream drinking water supplies, as discussed under the remnant deposit no-action alternative (section II.2A of this chapter). In-place containment of remnant deposits, however, may not adequately stabilize the deposits if a surging dam is constructed at Fort Edward. The costs of additional stabilization methods or removal of the deposits could be an impediment to development of the dam and hydroelectric power at Fort Edward.

2d. Unavoidable Adverse Impacts and Steps to be Taken to Minimize Harm

Unavoidable adverse impacts can be minimized by implementing the following measures for the in-place containment of remnant deposits:

- To control erosion, all work on the remnant deposits should be performed during the dry season, between May and September. Low rainfall and low flows will minimize erosion of disturbed soils and decrease chances of flood flows occurring while the work is still incomplete, thus minimizing release of PCBs to the river. Disturbed soils should be reseeded as quickly as possible to stabilize soils and prevent erosion. Only vegetation that poses a direct hindrance or hazard to work on the remnant deposits and access roads should be removed.

- To minimize the risk of eroding the remnant deposits during floods, the cover should be brought to a grade level above either the 100 or 500-year flood level.

- Protective clothing, including respirators, should be provided to all workers at the site to minimize health risks for them.

- The public should not have access to the remnant deposits during the work phase.

- To reduce noise impacts, mufflers and engines should be properly maintained to minimize noise levels, with the use of additional mufflers, silencers, and/or baffle structures as necessary. Work performed near homes which generates especially loud noise should be scheduled within normal working hours. Night work should be minimized to the greatest extent possible (MPI, 1980d).

- The contractor should not wash vehicles, change engine oil, or repair hydraulic lines near the working area or the river. Petroleum compounds must not leak into the deposit areas or directly into the river because such compounds will desorb PCBs from debris and sediments. In addition, all vehicles should be well maintained to minimize exhaust emissions (MPI, 1980d).

- Trucks enroute to the work area carrying uncontaminated sediments should have their cargo covered, as required by Section 380-a, Chapter 418 of the Laws of 1975, and 17 NYCRR Part 158 (MPI, 1980d).

- Paved roads used by construction traffic should be kept in a broom-cleaned condition to minimize wind-blown dust. If fugitive dust becomes a problem at remnant deposits or access roads, a light spray of water or other appropriate agent should be applied (MPI, 1980d).

- Signs, warning lights and/or flagmen should be employed along routes where heavy truck traffic is anticipated, particularly at busy intersections. Roads which are damaged by truck activity should be repaired to at least their original condition (MPI, 1980d).

- When the project has been completed, the area should be landscaped, including the planting of trees, to make the area visually attractive.

2e. Contingency Plans

A contingency plan must be established to re-stabilize the remnant deposits if containment measures fail. If a flood event erodes the capping layer on a remnant deposit and PCB-laden sediments begin to escape to the river, measures must be taken as soon as possible to repair the situation.

There must also be contingency plans to safeguard public health if containment does fail and large quantities of remnant deposit materials are washed into the Hudson River during a flood or other unusual event. Measures would have to be taken to ensure the public would be protected from increases of PCB levels in downstream areas of the Hudson River. Contingency plans similar to those discussed for the remnant deposit no-action alternative (section II.2A, Chapter 4) would be required.

2f. Monitoring

Under the in-place containment alternative, PCB levels in water downstream of the remnant deposits will have to be monitored. PCB levels will have to be monitored frequently in areas several hundred yards downstream of the remnant deposits when construction is in process to ensure that the activity does not cause a significant release of PCBs to the river. Levels of PCBs in the air should also be monitored at the worksite and also in nearby residential areas to ensure that PCB levels do not increase above acceptable levels while the work is in process.

Long-term monitoring of PCB levels in the water downstream of the remnant deposits and in vegetation adjacent to remnant deposits is necessary to make certain that containment is effective.

2D. Remnant Deposit Complete and Partial Removal

A complete or partial removal of remnant deposits will mainly have short-term primary impacts directly related to the excavation and hauling away of remnant deposit material. Complete and partial removal alternatives would have similar impacts. Complete removal would have impacts of greater magnitude and longer duration. The long-term impacts of remnant deposit removal are beneficial.

Under the complete removal alternative, 290,000 cu m (380,000 cu yds) of remnant deposit material would have to be removed, requiring approximately 40,000 truck trips, as discussed in Section II.2 of Chapter 2 . Removal of deposits 3 and 5, as proposed by NYSDEC, would involve 56,000 cu m (73,400 cu yd) and 7,400 truck trips (MPI, 1980d).

Under partial removal plans, remnant deposits which are not removed could be contained in-place as described in section II.2 of Chapter 2. Impacts of in-place containment of remnant deposits are discussed in section II.2 of Chapter 4.

2a. Short-term Primary Impacts

Pubic Health

Removal of remnant deposits will have adverse short-term impacts on public health.

During the removal process, health risks will be imposed on workers. Excavating the deposits will temporarily increase volatilization and levels of PCB in the air at and around the work site. Air concentrations of PCBs could be over 1 ug/cu m, the NIOSH 8-hour recommendation, but well below the 500 ug/cu m OSHA standard (MPI, 1980d). The health effects of exposure to airborne PCBs are discussed in Appendix A.

Excavation of remnant deposits will increase volatilizatin of PCBs, increasing contamination of surrounding vegetation and imposing health risks on nearby residents. During dry or windy conditions, PCB-laden particles will be lost to the air.

The earth moving equipment will create substantial noise pollution and contribute to local air pollution in nearby residential areas.

Noise, traffic congestion and air pollution resulting from the large number of truck trips needed to remove contaminated material will severely disrupt residential areas in Fort Edward. Trucking of contaminated materials away from the remnant deposits creates the potential for contamination of roads and roadside areas if proper containment procedures are not followed on every truck trip.

The public health implications of upland disposal of PCB contaminated materials are discussed in section II.4 of this chapter.

Removal of the remnant deposit material nearest the river will result in resuspension of PCB-contaminated materials and their loss to the river. Destruction of vegetation and disruption of soils at and around the remnant deposits will temporarily increase erosion of PCB-contaminated material into the river. Such releases of PCBs to the river will be small and of short duration, and impacts on the fish and other aquatic biota should be minimal.

Agriculture and Terrestrial Biota

Vegetation at and adjacent to the remnant deposits and the paths of needed access roads will be destroyed. Noise from trucks and escavation equipment will disturb fauna in the vicinity of the remnant deposits and trucking routes. Increased volatilization of PCBs during escavation may slightly increase contamination of adjacent vegetation. Removal of remnant deposits will not have significant short-term impacts on agriculture.

Maintenance Dredging and Navigation

Removal of the remnant deposits will have no significant short-term impacts on maintenance dredging and navigation.

2b. Long-term Primary Impacts

Public Health

Removal of remnant deposits will have beneficial long-term impacts. Removal will significantly decrease potential health threats by stopping PCB losses from the deposits to the air and river. This will be especially significant if the remnant deposits are the presently unidentified source of PCBs in the Hudson River. The public health risks of exposure to PCBs in water, food and air are discussed in Appendix A. Removal of remnant deposits will also eliminate the chance that future erosion, particularly during a flood event, could release large quantities of contaminated remnant deposit material to the river.

Fisheries and Aquatic Biota

Removal of remnant deposits will reduce the amount of PCBs entering the Hudson River. Removal will also eliminate the chance that future erosion during a flood event could release large quantities of PCBs to the river. Elimination of this source of PCBs will partially reduce PCB-contamination of Hudson River fish.

Agriculture and Terrestrial Biota

Removal of remnant deposits will substantially reduce volatilization of PCBs and therefore reduce contamination of nearby vegetation, including agricultural crops. This will eliminate a possible pathway for PCBs to enter terrestrial food chains and bioaccumulate in terrestrial fauna.

Maintenance Dredging and Navigation

The beneficial impact of remnant site removal will be the elimination of this particular source of PCBs as a potential constraint on dredging and disposal should these deposits be scoured during a flood and transported down-river.

2c. Secondary Impacts

Removal of remnant deposits will reduce existing and future PCB releases to the Hudson River, and help to avoid the adverse secondary impacts that could arise from the continued closure of the fisheries, the halting of maintenance dredging and ocean disposal of dredge spoils, and the contamination of downstream drinking water supplies, as discussed for the remnant deposit no-action alternative (section II.2A of this chapter). Under the removal alternatives, the remnant deposits will no longer represent a possible impediment to the construction of a hydroelectric dam at Fort Edward.

2d. Unavoidable Adverse Impacts and Steps to be Taken to Minimize Harm

Unavoidable adverse impacts can be minimized by implementing the same measures discussed for the remnant deposit in-place containment alternative (section II.2c of this chapter). The following measures should also be taken under this alternative:

- Excavation should be done by highly experienced personnel so that the deposits can be removed as quickly, efficiently, and neatly as possible. This will help to reduce risks of any unnecessary losses of contaminants to the air or river.

- To prevent loss of material to the river, escavation should begin in the center of the deposit, leaving an outer perimeter of material to act as a protactive earthen dike. Should floating solids result from dredging, a floating boom would be employed downstream from the dredge site (MPI, 1980d).

- Trucks enroute to the disposal area should have their cargo covered, as required by Section 380-a, Chapter 418 of the Laws of 1975, and 17 NYCRR Part 158 (MPI, 1980d). It is imperative that the trucks strictly adhere to the regulations and that they be tightly covered. It is also important that they not be overloaded. In addition, the trucks should be cleaned before leaving the containment site to minimize the tracking of contaminated material onto the roadways and into the residential areas.

- Completely contained trucks or trailers could be useful if there is the risk of contaminated water running off trucks transporting wet sediment.

- The NYSDOH and local authorities, in conjunction with NYSDEC, must carefully oversee all operations of this alternative, particularly the trucking of the contaminated material, to safeguard the safety of the public and workers. State or local police should also be on site and frequently inspect the trucks involved to make sure that they meet motor vehicle safety requirements.

2e. Contingency Plans

Contingency plans must provide for public safety in the event that the removal operation causes unacceptably high losses of PCBs to the air or river. Cessation or revision of the operation and evacuation of local residents could be necessary. Contingency plans regarding downstream drinking water supplies in the event of additional PCB contamination of the river could also apply.

2f. Monitoring

Throughout the removal operation, PCB levels downstream of the operation must be frequently monitored so that any significant increase in PCB losses to the river can be detected. Two sampling wells should be installed near each downstream perimeter of the remnant deposit to monitor the movement of PCBs with groundwater through the deposits and into the water column (MPI, 1980d). PCB levels in the air at the worksite and in adjacent residential areas must also be monitored.

After the removal operation is complete, PCB levels in the river downstream of the former remnant deposits must also be monitored to ensure that substantial amounts of contaminated deposits were not left behind. Such deposits could continue to release PCBs to the river.

3. <u>In-River Dredging Mechanisms</u>

This section of the EIS will discuss the primary environmental impacts of the feasible dredging alternatives available for physically removing PCB contaminated sediments from the Hudson River. In-river dredging mechanisms are components of the full-scale and reduced-scale projects. As a result of excessive costs and other technical considerations, mechanical unloading of dredge spoils and dredging systems discussed under "Other Dredging Systems" in chapter 2, except for the mud cat, were found to be infeasible and will not be considered further. The mud cat might have limited application in shallow hot spots.

Hydraulic dredging and transport, and clamshell dredging with hydraulic pumpout and unloading are the main feasible alternatives, and they will be evaluated for potential adverse and beneficial, short-term environmental impacts.

Environmental analysis of the dredging and transport mechanisms will be discussed as they affect the major primary assessment objectives outlined at the beginning of this chapter with special emphasis on the following parameters:

- Water Quality
- Public Health
- Fisheries and Aquatic Biota
- Maintenance Dredging and Navigation

The long-term primary impacts and secondary impacts of the full-scale and reduced-scale projects, which include in-river dredging components, in-river containment and remnant deposit alternative components, have already been discussed in Sections I.4 and I.5 of this Chapter.

3A. Short-Term Primary Impacts

3a. Hydraulic Dredging

Water Quality

The most critical environmental factor that may be affected by dredging activities is water quality. The impacts are a result of (1) continued effects of PCBs left in place after dredging; (2) PCBs lost downriver in the dredge plume; and (3) PCBs recycled to the river in the return water. The magnitude of these losses, as projected by MPI (1980d), are summarized in Table E-3 (Appendix E).

PCB losses to the water column from a hydraulic dredgehead occur when bottom material disturbed by the rotating and laterally moving dredgehead is stirred up but is not drawn into the hydraulic pipeline. MPI (1978b, 1980d) estimates, based on the assumption that the bed material is predominantly sand and gravel, that 2 percent of the total material dredged will escape to the water column. Laboratory testing conducted by MPI demonstrated that in a suspension approximating a dredge plume, about 20 percent of the PCB does not readily resettle, while the remaining 80 percent would settle downstream from the dredge. The suspended PCB contaminated sediment may or may not resettle in downstream hot spots and it is possible that 100 percent of the plume could be lost (MPI, 1980d). If a flow of 85 cu m/s (3,000 cfs) is assumed, the estimated average PCB increase above ambient levels immediately downstream of the dredgehead could be 0.2 ug/l (ppb) for the hydraulic dredge. The NYSDEC standard for ambient levels of PCB downstream from a dredging operation is 0.5 ug/l (ppb) (MPI, 1978a). Dredgehead losses from the hydraulic dredge alternative are within this standard (MPI, 1978a). If this standard were exceeded, dredging operations would be stopped.

Tofflemire (1979) evaluated the dredgehead losses from a hydraulic dredge and clamshell dredge operating adjacent to each other. The objective was to try to compare the two types of dredging where all variables were equal. He attempted to relate suspended solids, turbidity and PCB losses from the dredge plume. Readings taken 60 m (200 ft) downstream of the hydraulic dredge indicate very little turbidity and little increase in PCB concentrations in the water column. However the transmissometer used to measure turbidity malfunctioned and there was difficulty in establishing a correlation between suspended solids and turbidity. Though these problems may have altered the data, the overall conclusion that a dredge plume developed by the hydraulic dredgehead will disperse and resettle within 1.6 km (1 mi) downstream is valid. However, both background levels and anticipated increases are several orders of magnitude above the EPA criterion for the protection of freshwater life, which is 1 part per trillion or 0.001 ug/l (MPI, 1978a).

In addition to loss of PCBs in the dredgehead plume, certain amounts will be missed during dredging, due to inherent imprecision in dredge positioning, depth control, and difficulties with obstructions in the river. MPI (1978a, 1980d) estimates that a hydraulic dredge would miss 2 percent of the hot spot material. This includes a dredging pay limit set at 91 cm (36 in.). Based on the 2 percent loss, it is estimated that 950 kg (2,100 lbs) will be left in the Thompson Island Pool. However, this estimate for PCBs missed during dredging may be low. Tofflemire (1979) estimates that hydraulic dredging of PCB hot spots consisting of sediments whose grain size composition averages between 50 to 60 percent silt, will miss 13 percent of the sediments. Factors critical to control of contaminated layer removal are boom swing speed, position of the dredge, amount of overlap, depth of dredge cut, and operator experience. Further evaluation of dredgehead placement and the amount of PCB contaminated material missed by the dredgehead is necessary before a full evaluation of impacts is possible.

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Under the hydraulic dredging alternative, the average return water flow will be 37,800 cu m/d (10 mgd). This water is mixed with the dredged material at the dredgehead and used to transport the sediments by pipeline to the containment site. At the containment site, the sediment and water will flow through a series of settling lagoons to produce a nearly sediment-free water. At this point it will enter a water treatment plant to remove suspended particulates with PCBs. The plant will have a capacity of 49,200 cu m/d (13 mgd) and consist of coagulation, flocculation, and sedimentation units. For hydraulic dredging of the Thompson Island Pool, an estimated 70 kg (160 lbs) of PCBs would be lost via the return flow per year. Such a loss would result in an increase above ambient of 0.1 ug/l (ppb), assuming complete dilution of the effluent in 85 cu m/s (3,000 cfs). As estimated previously, dredgehead losses would raise the ambient PCB levels of 0.2 ug/l (ppb). The total calculated PCB increase attributable to the hydraulic dredge, without carbon absorption, would be 0.3 ug/l (ppb) (MPI, 1980d). This increase would occur during the 20-hour work day. Background levels measured at Schuylerville and Stillwater during low flow between June and September 1977 averaged approximately 0.7 ug/l (ppb). While this average may be atypically high, it will be used here as a worst case (MPI, 1978a). The estimated PCB increase in combination with the background level would result in a total of PCB concentration of approximately 1.0 ug/l (ppb).

The potential loss of heavy metals to the water column from dredgehead disturbance of the bottom and return flow concentrations is important due to the toxicity of many metals to aquatic life and the effect on down river public water supplies. Such losses are dependent on the efficiency of the dredge, the metal levels encountered in bed materials (Table E-4, Appendix E) and the ability of the return water treatment process in removing metals along with the PCBs. The majority of heavy metals in the upper Hudson River are bound to the organic and fine grained particulate matter. Additionally, metals may also be present in the interstitial water or as part of the crystalline structure. Upon disturbance from the dredgehead, the interstitial component is immediately released to the water columns, while the fraction that is attached to the particulate matter releases to the water column at various rates, depending upon ambient conditions such as pH, redox potential, and the presence of complexing chemicals which would act to precipitate dissolved metals. Because of the diversity of factors affecting the release of heavy metals, it is highly difficult to predict water column interactions (MPI, 1978a). However, a conservative best-estimate is possible based on bed material concentrations.

MPI (1978a) has estimated dredgehead losses for hydraulic and clamshell dredging. Using existing information for the Thompson Island Pool, assumptions regarding the position of elevated metal levels in the sediment column and data on settling rates gathered from jar tests, an initial increase above ambient was determined from dredgehead losses (Table E-5, Appendix E). Ambient heavy metal values at Waterford between April 1975 and July 1976 were used.

As Table E-5, (Appendix E) indicates, for the majority of heavy metals, neither dredging alternatives will create a significant increase. However, background concentrations in lead are frequently three to ten times higher than NYSDEC dredging certification standards and suspension of lead concentrated riverbed materials may cause significant increases in lead levels adjacent to the dredgehead. Mercury levels in the river bed sediment were small, but background levels are high when compared to the NYSDEC standard. This metal requires monitoring during dredging due to its high toxicity.

To a large degree, heavy metal losses at the dredgehead are based on dredge plume losses for hydraulic (2 percent) and clamshell (4 percent). Subsequently, heavy metal loss rates for the clamshell dredgehead are expected to be greater than hydraulic dredgehead. While most increases in heavy metals will be minor, lead and mercury increases will be significant.

In addition to dredgehead losses, heavy metals will be added to the water column from the return flow. The treatment process proposed for the return water is coagulation and sedimentation. It is difficult to estimate the heavy metal losses, but a rough approximation can be made based on jar tests of sediment samples collected from the Thompson Island Pool, Buoy 214 and Route 4 Bridge at Northcumberland. With the exception of cadmium, heavy metal levels in the unfiltered supernatant were within NYSDEC standards. The high cadmium concentrations may reflect a greater tendency for cadmium to desorb from sediments into the water.

Using the NYSDEC standard as a worst case situation, MPI (1978a) has estimated the return flow increases over the ambient metal levels in the upper Hudson River. Table E-6, (Appendix E) summarizes these increases and the dredgehead increases discussed earlier. Because hydraulic dredging return flow is larger than clamshell, relative increases in heavy metals are an order of magnitude higher. However, all of the anticipated heavy metal increases, with the possible exception of cadmium, are within the previously established NYSDEC certification standards. In combination with background heavy metal levels, however, the levels may equal or exceed the standards, particularly for cadmium, lead and mercury (MPI, 1978a).

Public Health

NYSDEC has determined that the plume caused by resuspension of river sediments will extend up to 1.6 km (1.0 mi) downstream of the dredging activity. The nearest water supply intake (for Stillwater) would be located 3.2 km (2.0 mi) downstream from the nearest dredging operations (at hot spot 36). The water supply intake for Waterford would be located 12.1 km (7.5 mi) downstream from the nearest dredging operations (at hot spot 40).

The draft SEQRA EIS (MPI, 1980d) reports:

> In the Thompson Island Pool, total PCB increases above ambient are estimated as: hydraulic dredge 0.3 ug/l; clamshell dredge, hydraulic pumpout with recycle 0.7 ug/l; clamshell dredge, hydraulic pumpout without recycle 0.8 ug/l. These estimates are based on the following assumptions: 3,000 cfs [85 cu m/s] river flow; 114 day project period for the hydraulic dredge, 81 days for the clamshell; and PCB loss rates as discussed previously. Recent background levels for comparable flows at Schuylerville and Stillwater range from 0.5 to 1.0 ug/l [Tofflemire and Quinn, 1979].
>
> Clamshell dredging would be employed exclusively below the Thompson Island Dam. The ambient PCB increases shown for the Thompson Island Pool represent a "worst case", in that the estimated overall sediment PCB concentrations in the lower pools are approximately one-half that of the Thompson Island Pool (45 ug/g versus 96 ug/g including overcut). River flows average water column PCB increases for clamshell dredging below Thompson Island should be comparable to hydraulic dredging in the Thompson Island Pool.

Therefore, under the worst case scenario, dissolved PCB levels would increase by 0.8 ug/l (ppb) immediately downstream from the dredging operation at the Thompson Island Pool. The resulting ambient concentrations of PCBs at Stillwater could possibly increase during the dredging operations. The NYSDOH recommended guidelines for short-term exposure to PCBs in drinking water is 1.0 ug/l (ppb).

Dredging of hot spots, particularly those in shallow water, will increase PCB concentrations in the air. Health risks will be greatest for workers involved in the dredging operation. Air concentrations of PCBs could exceed the recommended NIOSH 8-hour standard of 1 ug/cu m but will probably be well below the 500 ug/cu m OSHA standard. PCB air levels at homes in the vicinity of hot spots being dredged will also be elevated, but such increases are not expected to exceed safe levels. Noise levels of the hydraulic dredge will be fairly constant, but not particularly high. Dredging operations will probably continue for 24 hours a day. People living near the river will be affected, especially at night.

Fisheries and Aquatic Biota

Impacts on biota from dredging operations will originate from two sources: destruction of benthic organisms and their habitat; and reductions in water quality.

The removal of benthic organisms, which are food sources for fish, will vary significantly depending on the extent of dredging. While hydraulic or clamshell dredging will result in a similar disturbance of substrate, the level of effort for the dredging will dictate the extent of overall disturbance and loss of habitat. Dredging of all 40 hot spots will disturb eight percent of the river bottom in the eight pools, while just dredging the hot spots in the Thompson Island Pool would disturb four percent of the river bottom. Organism recolonization would be hindered by removal of parent stock and radical alternation of the substrate, but migration from adjacent undisturbed areas should recolonize the dredged area in one to two seasons after dredging (MPI, 1980d).

Under the full-scale project, hot spots in wetlands will be removed. Removal of the hot spot will destroy part or all of the wetland, possibly causing a substantial loss of wildlife habitat, loss of breeding and nursery areas for fish and other fauna, and alterations of food chain relationships.

The principal water quality problems which will affect aquatic organisms are increased levels of PCBs and heavy metals. Although the expected increases in PCB concentrations from the dredging activities are expected to be below the acute and chronic toxicity levels of most adult fish, the increases may be significant to sensitive species (MPI, 1978a). For example, spawning of the fathead minnow, a species known to inhabit the upper Hudson River, is affected by Aroclor 1242 at levels as low as 1.8 ug/l (ppb) (USEPA, 1976a). The hydraulic dredge in combination with background levels could equal or exceed this level (MPI, 1978a).

Increases in PCB levels in the water will increase PCB levels in exposed fish. The amount of increase would depend on the fraction of entrained, biologically active PCBs which is capable of moving across fish gill membranes. After dredging is complete and entrainment ceases, some of the bioconcentrated increment would be metabolized. However, the more chlorinated hydrocarbons are resistant to such breakdown. The impact of the PCBs on fish would be reduced with distance downstream (MPI, 1978a).

The estimated increases in heavy metals, particularly cadmium and lead, may have adverse effects on certain sensitive fish species. For soft waters such as the upper Hudson River where dredging will occur, the EPA recommended criteria for cadmium are 0.4 ug/l (ppb) for cladocerans and salmonids, and 4.0 ug/l (ppb) for other aquatic forms (MPI, 1978a).

Lead background levels as high as 300 ug/l (ppb) have been measured at Waterford. Where lead levels are high in the bottom material, dredge-related entrainment could augment the background levels and aggravate existing adverse conditions (MPI, 1978a).

Similarly, background mercury levels approach or exceed the EPA creterion of 0.05 ug/l (ppb) for aquatic life. Increases against this background are not large but could exceed threshold values under existing conditions (MPI, 1978a).

Suspended solids may cause sublethal effects on foraging ability and respiration of fish immediately within the plume. Because of their mobility, however, fish can avoid such turbid areas. Dredging conducted during the months of April and May would interfere with spawning, at least immediately downstream from the dredge (MPI, 1978a).

Invertebrates could also be affected by increases in PCBs and heavy metals in the river during dredge operations. Invertebrate populations immediately downstream from the dredge site could encounter increases in ambient PCBs demonstrated to be toxic in laboratory experiments. For example, a three-week exposure to 1.3 ug/l (ppb) Aroclor 1254 was observed to cause 50 percent mortality in populations of the water flea Daphnia (MPI, 1978a). It should be noted that benthic and planktonic organisms in the upper Hudson River already inhabit a highly contaminated environment, with background PCB levels which occasionally exceed 1 ug/l (ppb) (MPI, 1980a).

The invertebrate situation with regard to heavy metals is similar to that of the fishery. Increases in cadmium could exceed the tolerance range of sensitive species. Increases in mercury and lead may not be substantial, but may have significant effects in combination with high background levels. Increases in PCB and heavy metals in aquatic organisms would be transferred via the food chain to waterfowl and other organisms of higher trophic levels (MPI, 1978a).

Agriculture and Terrestrial Biota

Dredging of hot spots, particularly those in shallow water, will increase PCB contamination in the air, causing increased contamination of nearby terrestrial vegetation. Such contamination will be localized and at low levels.

Operation of the dredge equipment and resulting noise will temporarily disrupt nearby wildlife habitats and possibly interfere with feeding, breeding and nesting.

Hydurаulic dredging will not have any significant short-term impacts on agriculture.

Maintenance Dredging and Navigation

Dredging activities will have adverse short-term effects on navigation in the river. Floating pipelines, and other dredging apparatus may hamper the passage of barges and other river traffic. If barges are used to transport dredge spoils, they would also block river traffic, especially at the locks. Each operating dredge would generate four barge trips per day, and each barge trip would require 30 minutes of lock time (round-trip) in each lock upstream of dredging operations. Therefore, a single dredge would add two hours of lock time at each lock daily; two dredges, four hours; three dredges, six hours; and so forth. Depending on the amount of river traffic, these increases may result in occasional delays (MPI, 1978a).

3b. Clamshell Dredging

Water Quality

The clamshell dredging operation loses sediment during the raising and lowering of the bucket. The greater the water depth, the more sediment is lost from the bucket. Additionally, it is difficult, but not impossible, for the operator to overlap each bite of the bucket, resulting in a bottom with mounds and holes. However, this can be minimized by careful positioning of the clamshell bucket during operation.

MPI (1978a) estimated dredgehead losses from a clamshell dredge to be 4 percent of the total material dredged. This is twice the material lost from the hydraulic dredge. If relative rates of removal are considered, then total losses for the clamshell dredging will be 1.5 times greater than the hydraulic dredge. Monitoring of side-by-side operation of a clamshell and hydraulic dredge indicates that the clamshell tends to suspend more material than the hydraulic dredgehead (Tofflemire and others, 1979). However, problems developed with the testing equipment, as discussed under the previous section. Assuming that the amount of material to be dredged from the Thompson Island Pool is 840,000 cu m (1.1 million cu yd) and the average PCB concentration in this material is 50 ug/g (ppm), MPI (1978a) has estimated that the total amount of PCBs lost to the water column from the dredgehead is 235 kg (520 lbs). If an average flow of 85 cu m/s (3,000 cfs) is assumed, the estimated average PCB increase above ambient levels immediately downstream from the dredgehead is 0.4 ug/l (ppm). These increases would occur over a 20-hour work day.

Because clamshell dredging will cause a larger dredge plume than hydraulic dredging, it will also suspend more heavy metals at the dredgehead (Table

E-5, Appendix E). However, return flow for clamshell dredging is less than hydraulic, producing less total loading of heavy metals to the river. Based on estimates which include loss from the dredgehead and return flow, clamshell dredging appears to minimize heavy metal losses to the water column in comparison to the hydraulic dredge. However, the return flow concentrations were not empirically determined and may bias the calculations against the hydraulic dredge. It is therefore not possible to favor conclusively either dredging alternative with respect to heavy metals (MPI, 1978a).

MPI (1980d) estimates that the clamshell dredge would miss about 4 percent of the PCB contaminated sediment in the hot spots. However, Tofflemire and others (1979) estimates that 13 percent of the PCB will be missed during accurate dredging. This is a large difference and could have significant effects on PCB desorbtion and water column concentrations. Further investigations are necessary to evaluate this discrepancy.

The volume of return flow for the clamshell dredging operation will be 20 times less than that for the hydraulic dredge because the water would be recycled back to the pumpout barge. The estimated increase in PCBs in the upper Hudson River caused by return water is 0.1 ug/l (ppm) (MPI, 1978a). The total increase above ambient level due to the dredge plume and recycling of the pumpout water is 0.7 ug/l (ppb) (MPI, 1980d).

Clamshell dredging would be employed exclusively below the Thompson Island Pool. The ambient PCB increases shown for the Thompson Island Pool represent a "worst case", in that the estimated overall sediment PCB concentrations in the lower pools are approximately one-half that of the Thompson Island Pool (45 ug/g [ppm] versus 96 ug/g [ppm] including overcut). River flows would be higher due to increased drainage basin area. Hence, average water column PCB increases for clamshell dredging below Thompson Island should be comparable to hydraulic dredging in the Thompson Island Pool.

Public Health

The impacts of clamshell dredging on the quality of downstream drinking water supplies will be similar to those discussed in Section 3a (Hydraulic Dredging) of this chapter. However, the impact of clamshell dredging may be slightly greater because it may result in slightly higher concentrations of PCBs in the river water.

Air quality effects associated with clamshell dredging will be slightly more substantial than for the hydraulic system. With the clamshell dredge, excavation may generate septic odors as the spoil is placed in the receiving barge. In addition, the agitation caused by the bucket entering and leaving the water surface, or water draining from the closed bucket may result in the entrainment of pathogens associated with contaminated sediments in airborn droplets. Volatilization of PCBs will occur when the contaminated material is placed on the receiving barge and during the towing of the barge to the containment site.

Noise levels from mechanical dredges are slightly higher than those from hydraulic dredges. In addition there would be noise from the tugs that transport the barges and the pumpout barge. Operations are scheduled for 24 hours a day and may effect people living near the river.

Fisheries and Aquatic Biota

The clamshell dredge will have a slightly larger effect on aquatic biota than the hydraulic dredge. The increased concentrations of PCBs that may occur downstream from the dredgehead would increase biological PCB uptake within the areas of the dredge plume. Additionally, heavy metals placed into the water column by disturbance of river bed material could be incorporated into the food chain.

As with hydraulic dredging, the full scope clamshell dredging program calls for removal of hot spots that are wetlands. Removal of such hot spots will result in the destruction of wetlands and subsequent loss of habitat space. Additionally, any benthic communities associated with hot spots will be destroyed.

Agriculture and Terrestrial Biota

The impacts of clamshell dredging on nearby vegetation will be similar to those discussed for hydraulic dredging. PCB contamination of vegetation may be slightly higher with clamshell dredging, however, because more PCBs may be volatilized by clamshell dredging than hydraulic dredging. Clamshell dredging will also create more noise, causing greater disruption of nearby wildlife habitats.

Clamshell dredging will not have significant short-term impacts on agriculture.

Navigation

Clamshell dredging will have adverse short-term impacts on navigation in the river. During the removal of hot spots, dredging apparatus may block river traffic. If barges are used to transport dredge spoils, they would also hamper river traffic, especially at the locks. Each operating dredge would generate four barge trips per day, and each barge trip would require 30 minutes of lock time (round trip) in each lock upstream of dredging operations. Therefore, a single dredge would add two hours of lock time at each lock daily; two dredges, four hours, and three dredges, six hours, and so forth. Depending on the amount of river traffic, these increases may result in occasional delays (MPI, 1978a).

3c. Other Dredging Systems

Various other dredging systems were evaluated in the alternative discussions. Presently the mud cat dredge seems to be the only minor dredging option that seems feasible for this project.

The mud cat dredge operates by using two augers that loosen and feed the sediment to a suction pipe located beneath the dredge. The head is 2.5 m (8.0 ft) wide and can take as little as a 0.5 m (1.5 ft) thick cut.

Water quality effects from operation of the mud cat would be similar to the hydraulic dredge. Because the mud cats would be used for limited work in shallow areas, effects would be proportional to its use.

3B. Long-term Primary Impacts

The long-term primary impacts associated with the removal of PCBs from the Hudson River under the full-scale project and reduced-scale project have been discussed in Sections I.4 and I.5 of this chapter.

3C. Secondary Impacts

The secondary impacts associated with the removal of PCBs from the Hudson River under the full-scale project and reduced-scale project have been discussed in Sections I.4 and I.5 of this chapter.

3D. Unavoidable Adverse Impacts and Steps to be Taken to Minimize Harm

Unavoidable adverse impacts from the dredging mechanisms are: (a) suspension of PCB-contaminated material at the dredgehead of the various dredging units; (2) missed PCB-contaminated material; and (3) PCBs returned to the river in the return water flow.

Measures to limit adverse environmental effects and maximize the efficiency of the PCB removal, as given by MPI (1980d), are:

Dredging

- Hot Spot Delineation--Additional PCB sediment samples will be taken for lower pools prior to any remedial dredging to better define the depth and areal extent of contamination. The existing sediment PCB data base is accurate enough for planning, but not implementation of a hot spot dredging program. The data are fairly complete for the upper pools, but become more intermittent with distance downstream. Additional data are desirable to define more precisely the hot spots to insure accurate removal of contaminated material.

- Scheduling--Dredging would take place during the low-flow period between May 15 and September 15 (or until higher flows resume in the fall) to minimize downstream PCB losses.

- Operation Precautions, Hydraulic Dredge--PCB losses from the hydraulic dredge would be minimized by contractual control of the cutter and swing speed.

- Operation Precautions, Clamshell Dredge--PCB losses from the clamshell dredge would be reduced by limiting the hoisting speed through the water column, and by positioning the dredge and receiving barge so as to minimize the length of bucket swing above the water.

- Hydraulic Dredge Modifications--The feasibility of placing a shroud over the top of the cuter in order to increase suction efficiency and limit the escape of suspended material will be examined carefully.

- Clamshell Dredge Modifications--Tight seals on the bucket lips will be required. The feasibility of placing a shroud over the top of the bucket or completely enclosing the bucket to reduce washout during hoisting will be assessed in the design phase.

- Floating Boom--When dredging results in a floating scum, a floating boom would be positioned downstream from the work site. The employment of such a boom should not impede navigation and would be dependent on favorable current conditions. The boom would be cleaned at least daily, and the trapped material placed in the disposal site.

- Silt Curtain--Where dredging results in an extensive surface plume a silt curtain may be required. The curtain would extend from the water surface to a point midway in the water column.

- Marsh Restoration--If it is determined that the benefits of dredging a particular contaminated marsh hot spot outweigh the adverse impacts of habitat loss, and one or more wetlands are removed, marsh restoration may be a feasible mitigating measure. Garbish (1979) has outlined the steps required for marsh requirement following dredging, which are summarized below:

  -- Dredged areas filled with uncontaminated sediments to predetermined above-grade elevation.

  -- Following settling and consolidation, areas filled and/or graded to final elevation.

-- Upstream structures may be required to minimize scour; downstream silt screens may be needed to minimize sediment loss.

-- After final grading, nursery grown stock or sprigs from nearby marshes transplanted, maintained for at least one season.

Garbish (1979) notes that replacement plants must be set out at the same elevations that pre-existing or nearby plants of the same species are established. Avoidance of areas subject to high velocity and scour is necessary in achieving successful restoration. Garbish reports successful regeneration of wetlands with Peltandra virginica (arrow arum), Pontederia cordata (pickerel weed), Sagittaria latifolia (duck potato), Scirpus americanus (American three square), Typha sp. (cattaila), and Leesia oryzoides (rice cut grass). All of these species are found in the existing upper Hudson River marshes.

- Shoreline Conditions--During the dredging design phase detailed field studies and analyses will be undertaken to minimize interference with overhanging trees and to avoid river bank instability.

Dredged Material Transport

- Hydraulic Dredge Pipeline--Where navigation may be impeded it would be necessary to submerge the pipeline.

- Pipeline Leaks--While small leaks are inevitable, operation would be stopped immediately if a major leak or a break occurs.

- Hydraulic Pumpout of Barges--In order to reduce leakage, welded connections would be used in the pipeline construction, and a check valve would be installed at the pumpout station to prevent backflow.

- Loading of Barges--Sufficient freeboard must be maintained inside the barge to prevent overflow or spillage during transport. Alternatively, a splashboard could be installed around the top of the barge, permitting complete filling and thereby maximizing productivity.

3E. Contingency Plans

Monitoring will be ongoing during the dredging operation in order to have continuous information on the water quality effects resulting from disturbances of the river bottom. If levels exceed standards, the dredging operation will be halted.

If PCB and heavy metal concentrations in the water column near public water supply intakes exceed safe limits additional treatment or alternative water supplies will be required.

3F. Monitoring

In the design phase, provision of an on-site laboratory for analysis of PCB samples taken ahead of the dredge will be evaluated. An abbreviated technique would suffice which should measure total PCBs as being either less or greater than 50 ug/g (ppm). The extraction technique developed by GE, which has an approximate turn-around time of 1 hour, will be investigated. Materials which tend to occur with PCB, such as cesium 137 and lead, could also be monitored. The distribution of cesium 137, a nuclear testing fallout product, is closely correlated with PCB, and the analysis procedure for cesium may be simpler than that for PCBs. Lead is slightly less closely correlated with PCBs.

Sufficient samples should be taken to document any water quality impact of hot spot dredging, and to ensure compliance with certification standards established by NYSDEC. A minimum program should include sampling for PCBs, lead, chromium, suspended solids and turbidity.

Monitoring for airborne PCBs should be conducted at the dredge sites.

Intensive monitoring would be conducted during early phases of excavation or dredging of materials with high concentrations of PCBs. If air PCB concentrations are acceptable at these areas, monitoring would be reduced during excavation or dredging of less contaminated areas.

4. Containment Site

Disposal of the contaminated dredge spoils by any means other than upland containment in a secure landfill is considered infeasible at this time. Spoil biodegradation and physical destruction are not cost-effective when dealing with the volumes of spoil that will be generated by this project. Other potentially feasible processes are not yet operational on a large scale. Therefore, the need for a secure containment facility is an important part of any dredging alternative for removal of PCB-contaminated sediments from the upper Hudson River.

4A. Short-Term Primary Impacts

Primary impacts associated with the containment site are the disturbances caused by construction activities, water quality changes resulting from discharge to the Hudson River of the return flow, air quality changes resulting from volatilization of PCBs from the dredge spoil, and effects to groundwater caused by infiltration of leachate.

Public Health

The protection of public health from volatilization of PCBs of the dredge spoils during placement of the spoils in the containment facility, discharge of PCB-contaminated return water to the Hudson River, infiltration of leachate to the groundwater and disturbance from the construction processes is of paramount importance in the operation of the proposed project. With the inclusion of specific mitigating measures outlined in section 4d of this chapter potential environmental impacts will be minimized.

In order to comply with the NYSDOH recommendation that PCB concentrations in the air at residences not exceed 1.0 ug/cu m for any 24-hour period (Appendix I), mitigating measures may be necessary to reduce volatilization from the site during placement of the dredge spoils (Appendix J). If the dissolved concentration of PCBs in the containment area exceeds 28 ug/l (according to WAPORA), or 43 ug/l (according to MPI) during the dredging operations, and adverse meteorological conditions occur as well, then it has been computed that the NYSDOH air quality recommendation could be violated at the nearest residence (Appendix J). However, under normal meteorological conditions it is predicted that the NYSDOH guideline will not be exceeded with any regularity.

However, it has been demonstrated that PCBs do volatilize from the water column of the Hudson River and from PCB-contaminated sediments in the remnant deposits and river bed. Tofflemire (1980) has estimated that 1,360 kg/yr (300 lb /yr) of PCB is presently being released from existing contaminated land fills and dumpsites in the upper Hudson Basin. Elevated ambient PCB levels have been observed at several contaminated dumpsites and concentrations exceeding the NIOSH 8-hour recommendation have been recorded at dumpsites in the Fort Edward and Glens Falls areas.

Additionally, the BTI (1978) sampled plants near the Fort Miller dumpsite in order to determine a relationship between foliar PCB levels and distance from a source of PCB volatilization. From their sampling program at the Fort Miller dumpsite and PCB contaminated dredge spoil disposal sites they determined the following:

- At the Fort Miller dumpsite elevated foliar PCB levels were obtained at distances as far as 700 m (2300) ft from the dump.
- Measurable increases in foliar PCB levels were apparent within 100 m (330 ft) of the Buoy 212 dredge spoil disposal site.
- Elevated foliar PCB levels were apparent within 200 m (640 ft) of the old Moreau dredge spoil disposal site and are expected to approach the limits of detection (i.e. undistinguishable from background levels) as far as 300 m (980 ft) from the site.

These examples illustrate the volatile nature of PCBs and the potential environmental effects from atmospheric losses while the dredge spoils are being placed in the containment site.

Under the hydraulic dredging alternative, the average return water flow will be 3,780 cu m/d(10 mgd). This water is mixed with the dredged material at the dredgehead and used to transport the sediments by pipeline to the containment site. At the containment site, the sediment and water will flow through a series of settling lagoons to produce a nearly sediment-free water. At this point it will enter a water treatment plant to remove suspended particulates with PCBs. The plant will have a capacity of 49,200 cu m/d (13 mgd) and consist of coagulation, flocculation and sedimentation units. For hydraulic dredging of the Thompson Island Pool, an estimated 70 kg (160 lb) of PCBs would be lost via the return flow per year. Such a loss would result in an increase above ambient of 0.1 ug/l (ppb), assuming complete dilution of the effluent in 85 cu m/s (3,000 cfs).

In addition to heavy metal dredgehead losses, heavy metals will be added to the water column from the return flow. The treatment process proposed for the return water is coagulation and sedimentation. It is difficult to estimate the heavy metal losses that will occur, but rough approximation can be made based on jar tests of sediment samples collected from the Thompson Island Pool, Buoy 214 and Route 4 Bridge at Northcumberland. With the exception of cadmium, heavy metal levels in the unfiltered supernatant were within NYSDEC standards. The high cadmium concentrations may reflect a greater tendency for cadmium to desorb from sediments into the water compared to other heavy metals.

Using the NYSDEC standard as a worst case situtation, MPI (1978a) has estimated the return flow increases over the ambient metal levels in the upper Hudson River. Table E-5 (Appendix E) summarizes these increases and the dredgehead increases discussed earlier. Because hydraulic dredging return flow is larger than that for clamshell dredging, relative increases in heavy metals are an order of magnitude higher. However, all of the anticipated heavy metal increases, with the possible exception of cadmium, are within tha previously established NYSDEC certification standards. In combination with background heavy metal levels, however, the standards may be equaled or exceeded, particularly for cadmium, lead and mercury (MPI, 1978a).

The volume of return flow for the clamshell dredging operation will be 20 times less than that for the hydraulic dredge, because the water would be recycled back to the pumpout barge.

A leachate will develop as a result of the drainage of the interstitial water in the dredge spoil. MPI (1980b) has estimated that 344,000 cu m (91 million gal) of interstitial water will be entrained in the dredge spoil. The substratum at the site will form an effective barrier to the downward migration of this leachate. The substratum consists of a very poorly permeable clay with a permeability that ranges from 2.5×10^{-7} to 5.88×10^{-6} cm/s (9.8×10^{-8} to 2.3×10^{-6} in/s). At present the thickness of this material varies from 1.3 m (4.5 ft) in the south to 17 m (57 ft) in the west. The site will be graded to approximately 43 m (144 ft) above sea level. On the average, approximately 9 m (30 ft) of clay will remain beneath the site once it is completed. EPA and NYSDEC regulations regarding the siting of secure landfills requires a minimum of 3 m (10 ft) of relatively impermeable material be above bedrock. This site will satisfy these requirements. Migration of leachate from the base of the site is estimated to occur at the rate of 2.4×10^{-4} m/d (8.0×10^{-4} ft/d). It is expected to take 600 years for the leachate to travel a distance or 60 m (200 ft) to the property line (MPI, 1980d). The nearest well is approximately 500 m (150 ft) west of the exterior dike of containment structure. Additionally, PCB and heavy metal movement would be further retarded by adsorption onto the clay particles, possibly reducing their movement 100 to 10,000 times below the water flow rate (MPI, 1980d). Groundwater impacts from leachate generated at the containment site are expected to be minimal.

The clay material at the site will not only serve as the base of the containment facility, but will also provide soil to form the exterior and interior dikes. It is estimated that for water within the containment facility to seep to the outside face of the dike it would take in excess of 1,000 years (Richards, April 22, 1980).

Noise levels in the area around the containment site will increase temporarily during construction of the facility and placement of the dredge spoil. Construction noise will originate from heavy earth moving equipment, increased traffic and other construction related activities. During placement the site will operate 20 hours a day, generating noise from pumping stations, earth moving equipment and increased traffic.

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Fisheries and Aquatic Biota

Discharge of return flow to the Hudson River will effect water quality in the river. Return flow generated from the containment site during operation would contain some PCBs and would be treated prior to discharge to the river. The treatment process will consist of sedimentation, flocculation, and coagulation and will only remove PCBs adsorbed to the solid material. Since the treatment process will remove the solid material, effluent PCBs will be primarily those dissolved in the water. Based on an average PCB concentration in the hot spot material of 120 ug/g (ppm) and a maximum concentration of 1,516 ug/g (ppm), the following effluent PCB concentrations are predicted (MPI, 1980d):

- Average: 10 to 20 ug/l (ppm)
- Maximum: 100 ug/l (ppm)
- Minimum: 4 ug/l (ppm)

Based on these projections, it is estimated that 70 kg (160 lb) of PCBs will be lost to the river with hydraulic dredging of the Thompson Island Pool hot spots. With clamshell dredging and hydraulic cycle pumpout unloading, 9 kg (20 lb) of PCBs will be lost for each year's dredging. If the pumpout water were not recycled, an estimated 68 kg (150 lb) would be lost during the first year and 59 kg (130 lb) during the second year (MPI, 1980d). Impacts to the fisheries and aquatic biota will be less with clamshell dredging and hydraulic pumpout unloading than with hydraulic dredging.

Site dewatering will produce an additional 344,000 cu m/d (91 mgd), which will drain through a collection system to the river. At an estimated PCB concentration of 10 ug/l (ppb), this drainage water would contain some 3.4 kg (7.6 lb) of PCBs (MPI, 1980d). Effects to aquatic biota and fisheries would be minimal.

Agriculture and Terrestrial Biota

The area around the containment site is used for growing of certain crops and grazing of cows. Volatilization of PCBs from the dredge spoils will increase levels in crops and grazing forage for fields near the site. Based on the PCB volatilization and dispersion models (Appendix J), the PCB levels in the various crops (including corn with cob and ear only; corn with stem, ear, cob, tassle, and leaf; alfalfa; red clover; and timothy) should be monitored at approximately 100-m (330-ft) intervals to a distance from the containment site at which all foliar PCB levels are below the FDA maximum allowable level of 0.2 ug/g (ppm) for forage. Based on work by Buckley (1980) it is expected that corn, with cob and ear only, will be less contaminated with PCBs than corn with stem, ear, cob, tassles, and leaves; corn with stem, ear, cob, tassles, and leaves will be less contaminated than alfalfa; alfalfa will be less contaminated than red clover; and red clover will be less contaminated than timothy. Therefore, vegetation should be monitored before cattle are permitted to graze within 2,000 m (6,600 ft) of the containment site.

Wildlife habitat at the site of the containment facility will be destroyed. In addition, noise from construction activity will disrupt nearby wildlife habitats and interfere with normal feeding, breeding, and nesting activities.

Maintenance Dredging and Navigation

Disposal of contaminated dredge materials will not have significant impacts on maintenance dredging and navigation.

4B. Long-Term Primary Impacts

Public Health

Leachate will be collected by an underdraining system consisting of (1) gravel filled collection trenches, wrapped with filter fabric; (2) perforated drainage piping in the collection trenches; (3) collection and sampling well along the containment area perimeter; (4) piping system connecting the drainage system to a discharge point at the Hudson River and 5) flow meterizing and monitoring system.

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The leachate collection system consists of gravel filled collection trenches that have a potential for clogging if a large portion of fine grained sediment is contained in the dredge spoil. If this happens, the interstitial water will be unable to drain and the water will remain within the containment facility. Although the capping material is very poorly permeable, MPI (1980c) estimates that long term infiltration through the cover will be 3.1 cm (1.25 in) per year. If this input is unable to drain out, it may develop a hydraulic head within the closed containment facility that could lift the clay cover at a low point.

MPI (1980d) estimates that total annual leachate will be approximately 8,320 cu m/yr (2.2 million gal/yr). At 10 ug/l (ppb), this leachate would discharge 0.08 kg (0.2 lbs) per year to the river. At present, leachate will be drained to the river untreated, but options for leachate treatment are available. However, estimates of leachate quantity and concentration indicate that effects to the river will be minimal from the untreated leachate (MPI, 1980d).

Stormwater management controls are described in MPI (1980d). All site drainage will be conveyed to the Hudson River during construction and after closure. PCBs and sediment concentrations in the drainage may be elevated during emplacement, but should decrease significantly after closure. Effects to water quality in the Hudson are expected to be minimal. Additionally, the clay cover will effectively prevent long-term migration of PCBs into the groundwater.

The shale bedrock underlying the containment site will bear the additional weight of the filled and closed containment structure without rupturing or collapsing. Presently, there is 9 to 22 m (30 to 75 ft) of saturated clay overlying the shale. The addition of the dredge spoil to the clay overburden will not effect the shale's ability to bear the weight of both the clay and filled containment facility.

Once the contaiment area is stabilized and permanently capped, the volatilization of PCBs will decrease markedly. An important factor in any long-term impact assessment would be which of the two options presently being considered for the cap is chosen. One option included in the plan is the installation of a capped continuous venting and control system. The other option is to install a capped venting system immediately, but to wait and see if monitoring data show that significant amounts of PCBs are being volatized before installing a control system. Either of these options appear acceptable as long as the funding for any future control system is set aside and available if necessary. In addition, it appears that the second option may be most cost-effective as it is quite possible that emissions from the covered containment site will be minimal.

4C. Secondary Impacts

The presence of a hazardous waste containment facility may lower market values for adjacent property. In addition, state acquisition will remove real property from the tax rolls and reduce the property tax revenues for the local school district and local governments.

Use of the property as a containment facility will reduce the amount of land available for development. This will not result in a significant shortage of land for development because of the anticipated low rate of growth, current lack of development pressure, and the already large supply of vacant land in the region.

4D. Mitigating Measures

Unavoidable adverse impacts will originate largely from volatilization of PCBs at the containment site during emplacement of dredge spoils. Mitigating measures may be necessary to reduce the volatilization from sections of the containment site nearest the local homes (section numbers 13, 14, 15, 16 and 17 indicated on Figure 4-1). After capping volatilization will decrease significantly.

Mitigating measures that may be taken to minimize potential environmental impacts from the containment site are:

- Protective clothing would be available for operators and other personnel at the dredging and containment sites. This would include respirators and protective gloves. PCB air concentrations at the containment site will exceed the NIOSH 8-hour recommendation (1 ug/cu m), but they will be well below the OSHA 8-hour standard (500 ug/cu m). Therefore, use of the protective clothing would not be required.

- A six-foot security fence should surround the active disposal area from the initiation of site use (MPI, 1980d).

- The containment site could be divided into smaller cells thereby reducing total emissions at any given time during the disposal operations. High surface tension monomolecular films and adsorbents should be studied to determine if their use would substantially reduce volatilization. Less contaminated dredge spoils should be placed in those containment cells nearest the occupied residences.

- The clay cover should be put in place as soon as a given containment site cell is filled and dewatered enough to support the weight of construction equipment (MPI, 1980d).

- Adequate topsoil, fertilizer, seed, and water will be applied to establish a thick vigorous cover. Over time the vegetation would be allowed to revert to a mixture of pasture plants. The cover should be mowed a minimum of once per year to prevent growth of deep-rooted plants (MPI, 1980d).

- The cover surface would be inspected regularly for slope failure, cracks, holes, and depressions. These would be filled and reseeded to maintain an even surface. Lime would be applied periodically (MPI, 1980d).

- Burrowing animals, such as woodchucks, which may inhabit the site, would be controlled by trapping (MPI, 1980d).

4E. Contingency Plans

Despite the precautionary measures taken in the design, construction, and operation of a containment facility, there still is some potential for accidental failure of the containment area. Although this possibility is considered remote, such an event would be likely to contaminate local groundwater supplies. This would require New York State to obtain alternate water supply sources or treat the contaminated supplies.

4F. Monitoring

Monitoring at the containment site will concentrate on PCB levels in groundwater, leachate, stormwater runoff and air quality.

The groundwater monitoring network for the containment site consists of six monitoring points adjacent to the active disposal portions of the site. Each monitoring point will have three observation/monitoring wells:

- A 3-m (10-ft) section; 3.8 cm (1.5 in) in diameter, schedule 80 PVC pipe with 1 m (3 ft) of 10 slot screen;
- A 6-m (20-ft) section; 3.8 cm (1.5 in) in diameter, schedule 80 PVC pipe with 1 m (3 ft) of 10 slot screen;
- A 9-m (30-ft) section; 10 cm (4 in) in diameter, schedule 40 PVC pipe with 1.5 m (5 ft) of 10 slot screen.

These cased wells with friction type couplings will be installed by the chopping and wash method. Each well will be backfilled with clean, well sorted sand around and 0.6 m (2 ft) above the top of the screen. The remainder of the hole will be filled with a bentonite grout and surrounded by a 1.5-m (5-ft) protective sleeve with a locking cap.

When bedrock is encountered within the 9-m (30-ft) depth, the 10-cm (4-in) in diameter well will be set 1.5 m (5 ft) into the bedrock (MPI, 1980a).

Leachate will be sampled periodically through the collection and sampling wells connected to the drainage pipe. Storm water runoff will be collected and sampled periodically (MPI, 1980a).

A system of gas sampling and venting wells will be installed in the containment area cover. These outlets will be valved to prevent the escape of PCBs through volatilization. Gas pressure and compositon will be monitored regularly and the valves will only be opened if necessary to prevent breaching of the cap. If significant quantities of gas are generated, and if the gas does not contain appreciable levels of PCBs, then the valves will be left open. If gas does contain high levels of PCBs, appropriate provisions for collection and disposal will be implemented (MPI, 1980a).

Volatilization during emplacement of the contaminated dredge spoil can cause significant release of PCBs. The surrounding air quality and vegetation will be continuously monitored for elevated PCB levels.

FEDERAL, STATE, LOCAL AND OTHER SOURCES
FROM WHICH COMMENTS HAVE BEEN REQUESTED

Federal Agencies:

Army Corps of Engineers
Council on Environmental Quality
Coast Guard
Department of Agriculture
Department of Commerce
Department of Health and Human Services
Department of Housing and Urban Development
Environmental Protection Agency
Executive Office of the President
Fish and Wildlife Service
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State Agencies:

Department of Agriculture and Markets
Department of Commerce
Department of Environmental Conservation
Department of Health
Department of Transportation
Great Lakes Basin Commission
Power Authority

County Agencies:

Dutchess County Environmental Management Council
Rockland County Department of Health
Washington County Board of Supervisors
Washington County Planning Department

Local Agencies:

Town of Greenwich Planning Board

Groups and Organizations:

Citizens Advisory Committee
Conservation Board, Town of Pound Ridge
Council of Agricultural Organizations, Inc.
Environmental Affairs Groups
Federation of Dutchess County Fish and Game Clubs, Inc.
Friends of Long Island
National Resources Defense Council
New Rochelle Environmental Impact Advisory Commission
Scenic Hudson Inc.
Settlement Advisory Committee
Sierra Club, Atlantic Chapter
Yonkers Environmental Impact Advisory Commission

ABBREVIATIONS USED

a	acre
BTI	Boyce Thompson Institute
bu	bushel
°C	Celcius
cfs	cubic feet per second
cm	centimeters
cu ft	cubic foot
cu m	cubic meter
cu yd	cubic yard
CWA	Clean Water Act
d	day
DEIS	Draft Environmental Impact Statement
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
°F	Farenheit
FDA	United States Food and Drug Administration
ft	foot
gal	gallon
g	gram
GE	General Electric Corporation
gpd	gallons per day
gpm	gallons per minute
ha	hectare
in	inch
kg	kilogram
km	kilometer
l	liter
lb	pound
LMS	Lawler, Matusky and Skelly Engineers
lpd	liters/per day
lpm	liters per minute
m	meter
mgd	million gallons/day
mg	milligram
mi	mile

mm	millimeter
MPI	Malcom Pirnie, Inc.
MRJD	Juser, Rutledge, Johnston and Desimore, Consulting Engineers
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
NMPC	Niagara Mohawk Power Company
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPS	non-point source
NYSDEC	New Yorl Policy Act
NIOSH	National Institute for Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPS	non-point source
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOT	New York State Department of Transportation
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated biphenyl
PCFD	Polychlorinated dibenzofuran
ppb	parts per billion
ppm	parts per million
s	second
sq km	square kilometer
sq m	square mile
SEQRA	State Environmental Quality Review Act
SHPO	State Historic Preservation Office
USACOE	United States Army Corps of Engineers
USDASCS	United States Department of Agriculture Soil Conservation Service
USDC	United States Department of Commerce
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USSCS	United States Soil Conservation Service
uv	ultraviolet
ug	microgram
yr	year

Metric	English
celcius (^{o}C)	Farenheit (^{o}F)
centimeter (cm)	inch (in)
cubic meter (cu m)	cubic yard (cu yd) cubic foot (cu ft) gallon (gal)
gram (g)	pound (lb)
hectare (ha)	acre (a)
kilogram (kg)	pound (lb)
kilometer (km)	mile (mi)
liter (l)	gallon (gal)
meter (m)	yard (yd) foot (ft)
metric ton (t)	ton (tn)
microgram per gram (ug/g)	part per million (ppm)
microgram per liter (ug/l)	part per billion (ppb)[1]
milligram per liter (mg/l)	part per million (ppm)[1]
millimeter (mm)	inch (in)

Note: 1. an approximate equivalent

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APPENDIX A

Human Exposure and Risk Assessment for Residents in the Vicinity of Operations Associated with the Dredging of the Upper Hudson River

The material in Appendix A was compiled by WAPORA, Inc. principally from the following references:

United States Environmental Protection Agency. 1976b. Review of PCB levels in the environment, EPA-560/7-76-001, PS-253-735.

World Health Organization. 1976. Environmental health criteria 2: Polychlorinated biphenyls and zerphenyls, Geneva, Switzerland.

Appendix A

HUMAN EXPOSURE AND RISK ASSESSMENT FOR RESIDENTS IN THE VICINITY OF OPERATIONS ASSOCIATED WITH THE DREDGING OF THE UPPER HUDSON RIVER

1. HEALTH EFFECTS OF PCB EXPOSURE

A 1976 study by the World Health Organization (WHO) indicates that man appears to be the species most sensitive to PCBs. The monkey is the only experimental species in which effects qualitatively and quantitatively approaching those in man have been observed; this has been attributed to metabolic differences leading to a slower elimination than that observed in other species tested.

Conclusions concerning the specific effects of PCBs on different species are confused by uncertainty arising from the presence of toxic impurities. Rice oil that caused an outbreak of severe disease in Japan was contaminated with PCBs containing relatively high amounts of tetrachlorodibenzofuran, but the sample used in the monkey experiments had low concentrations of these impurities, so it is not clear whether PCBs alone were responsible for the incident in Japan. Further uncertainty arises from reports from Finland of high PCB concentration in blood and body fat of occupationally exposed workers with no indication of adverse effects, while at similar tissue concentrations Japanese workers showed skin lesions (WHO, 1976).

Commercial PCBs are not sold on a composition specification, but on their physical properties. Impurities known to be present in commercial PCBs are chlorinated dibenzofurans and chlorinated naphthalenes. Chlorinated dibenzofurans have been found at 0.8-3.0 mg/kg (ppm) in samples of the Aroclor 1248-1260 series, but none in Aroclor 1016, and at levels of 8.4 mg/kg (ppm) in Clophen A60 and 13.6 mg/kg (ppm) in Phanoclor DP-6. Chlorinated dibenzofurans have also been found at levels of 1 mg/kg (ppm) and 18 mg/kg (ppm) in different batches of Kanechlor 400 (WHO, 1976).

A species-specific toxic manifestation that can probably be attributed to toxic impurities is the abdominal edema and hydropericardium seen in birds affected by some commercial PCB mixtures (WHO, 1976)

Mink is another species with a high sensitivity to PCBs. Deaths have been produced with diets containing PCB levels of 30 mg/kg (ppm); no information is available on any species-specific metabolic pathway in the mink that would account for this susceptibility (WHO, 1976).

The following is a summary of data concerning the relationship between mammalian toxicity and dose. Approximate calculations of the daily dose in mg/kg body weight derived from the dietary concentration are given in parentheses. When no food consumption figures were available from the experimental studies, the following factors were used to transform mg/kg (ppm) in the diet to mg/kg body weight: mouse (7), rat (20), guinea-pig (25), mink (10), rabbit (33), monkey (25) (WHO, 1976).

1a. Body Weight

Body weight was reduced in rats from 8 months of dietary intake of Aroclor 1254 and 100 mg/kg (corresponding to 5 mg/kg body weight); no effects were observed at 20 mg/kg in the diet (corresponding to 1 mg/kg body weight) (WHO, 1976).

Dose-dependent retardation of weight gain was observed in mink after 4 months of dietary intake of Aroclor 1254 at 5 and 10 mg/kg (corresponding to 0.5 and 1.1 mg/kg body weight respectively) (WHO, 1976).

1b. Effects on Liver

Liver Weight

Dose-dependent increase in liver weight was observed in rats receiving Aroclors 1242, 1254 and 1260 at concentrations of more than 20 mg/kg in the diet (corresponding to >1.4 mg/kg body weight). Male rats were more sensitive than female rats; no effects were observed with Aroclors 1254 and 1260 at concentrations lower than 20 mg/kg in the diet (corresponding to < 1.4 mg/kg body weight). Effects were less marked with the lower chlorinated PCBs (WHO, 1976).

Liver Changes

Smooth endoplasmic reticulum proliferation with fat droplet inclusions were observed in the liver tissue of rats after 8 months of dietary intake of Aroclor 1254 at 20 mg/kg (corresponding to 1 mg/kg body weight). Liver damage was observed with Aroclors 1242 and 1254 in rabbits receiving 14 weekly oral doses of 150 mg/kg body weight; no effect was observed with Aroclor 1221 (WHO, 1976).

Liver Enzyme Activity

Increase in microsomal enzyme activity was observed in male rats after 8 months of dietary intake of Aroclor 1254 of 20 mg/kg (corresponding to 1 mg/kg body weight). No effect was observed at 2 mg/kg in the diet (corresponding to 0.1 mg/kg body weight). Effects were less marked in female rats. Increased activity was also observed with Aroclors 1242 and 1016 in male rats receiving 21 daily oral doses of 1 mg/kg body weight (WHO, 1976).

Liver Porphyria

Effects were observed in rats after several months of dietary intake of Aroclor 1254 at 100 mg/kg (corresponding to 5 mg/kg body weight); dose-dependent effects were observed in female rats after 21 daily oral doses of Aroclor 1252 at 20 and 100 mg/kg (corresponding to 1 and 5 mg/kg body weight); no effects were noted at less than 1 mg/kg body weight (WHO, 1976).

Liver Vitamin A

Reduction of hepatic vitamin A was observed in rats receiving Aroclor 1242 at the rate of 100 mg/kg in the diet (corresponding to 5 mg/kg body weight) (WHO, 1976).

Liver Tumors

Hepatocellular carcinomas were observed in mice after one year of dietary intake of Kaneclor 500 at 500 mg/kg (corresponding to 75 mg/kg body weight); no carcinomas were observed with Kaneclor 500 at 250 mg/kg in the diet (corresponding to 36.5 mg/kg body weight), or with Kaneclor 300 and 400 at 500 mg/kg in the diet (corresponding to 75 mg/kg body weight).

Hepatomas were observed in mice after 10 months of daily intake of Aroclor 1254 at 300 mg/kg in the diet (corresponding to 49.8 mg/kg body weight).

Hepatocellular carcinomas were observed in rats after 21 months of daily intake of Aroclor 1260 at 100 mg/kg in the diet (corresponding to mg/kg body weight) (WHO, 1976).

1c. Reproduction

Effects on reproduction were observed in mice at a daily oral dose of 0.025 mg Clophen A60 and in the rat at a dietary level of Aroclor 1254 of 20 mg/kg (corresponding to 1 mg/kg body weight) with the effects decreasing with higher chlorinated PCBs; in the mink at a dietary level of Aroclor 1254 of 5 mg/kg (corresponding to 0.5 mg/kg body weight); and in the monkey at a dietary level of Aroclor 1248 of 2.5 mg/kg (corresponding to 0.1 mg/kg body weight).

1d. Immunosuppression

Immunosuppression effects were observed in the guinea-pig at a dietary level of Clophen A60 or Aroclor 1260 of 50 mg//kg (corresponding to 2 mg/kg body weight) (WHO, 1976).

1e. Skin Effects

In man, symptoms of disease were observed at a dietary level of 4.2 mg/day of PCBs (corresponding to 0.7 mg/kg body weight/day for a 60-kg person). A value of 0.50 g was estimated as the quantity of PCBs consumed over approximately 120 days above which toxic symptoms were evident. Similar effects were observed in the monkey at a dietary level of Aroclor 1248 of 2.5 mg/kg (corresponding to 0.1 mg/kg body weight) after several months (WHO, 1976).

1f. Nondetected Effect Levels

The assessment of non-detected effect levels for toxic effects is complicated by the different activities of the component PCBs and by the presence of impurities, in addition to the influence of inter-and intraspecies variation, age, sex, and length of exposure. Moreover, many of the available experimental studies do not include a non-detected effect level (WHO, 1976).

The most sensitive species appears to be man, and effects have been observed at intake rates of 4.2 mg/day. This may have been influenced by the intake of impurities more toxic than PCBs, but similar effects have been produced in monkeys at the same order of dosage with a product containing little of these impurities. At this dosage level, no effects may be expected on growth, liver enlargement, and liver enzyme activity in less sensitive species such as the rat. Although non-detected effect levels are not available for effects on immunosuppression and reproduction, and for certain biochemical effects on the liver, it seems unlikely that these effects would be apparent at intake rates of 6 mg/day. Carcinogenic effects have been observed in rats and mice at dosages two orders of magnitude greater than this, but there is not epidemiological evidence to suggest that PCBs cause turmors in man. Rats fed a PCB diet at the rate of 2 mg/kg (equivalent to about 0.1 mg/kg body weight) showed PCB levels of 8 mg/100 ml in blood and 26.1 mg/kg in body fat. However, values much higher than these have been observed in men occupationally exposed to PCBs without evidence of any toxic effects (WHO, 1976).

2. HUMAN EXPOSURE TO PCBs IN THE VICINITY OF DREDGE AND DISPOSAL OPERATIONS

2a. Drinking Water

Residents along the upper Hudson River can be exposed to PCBs through contaminated drinking water. Hudson River water is analyzed by the US Geological Survey at five stations on the upper reaches; Glens Falls (above the General Electric Plant), Rogers Island, Schuylerville, Stillwater, and Waterford (Tofflemire, 1980). Although the Glens Falls PCB levels are usually below the detection limit of 0.1 ug/l (ppb), there are considerable data for the Schuylerville and Stillwater sampling areas for the three years beginning in October 1976. Average PCB concentrations for these years were .687 ug/l (ppb) in 1977, .568 ug/l (pb) in 1978, and .657 ug/l (ppb) in 1979. Higher levels have been reported for the 1974-1975 period at Rogers Island (1.5 ug/l) and levels as high as 3 ug/l (pb) were recorded in the Hudson prior to elimination of General Electric discharges in 1976.

PCBs in Hudson River drinking waters can be reduced through treatment (Tofflemire, NYDEC, 1980). If treatment is used by commmunities using the Hudson as a source of drinking water, levels of PCBs in finished water could be reduced from the present approximate level of .6 ug/l to about .3 ug/l. The drinking water standard for PCB is 1.0 ug/l. Since there was no significant difference in the amount of PCB in the water for the three-year period between 1977 and 1979, these levels probably represent background levels and residents using the Hudson for drinking water, including wells and infiltration galleries near the river, may assimilate approximately .3-1.0 ug/day at an average water consumption rate of 2 l/day. Residents with alternative drinking water supplies will be exposed to PCBs from atmospheric rain-out and fall-out into reservoirs and drainage basins, but the extent of this exposure is currently unknown. There is no evidence to indicate that these levels will exceed those in the Hudson River.

Ambient water PCB levels would increase due to return flow from the containment site and from the dredge plume (Malcolm Pirnie, 1980). In a "worst case" scenario based upon clamshell dredging with hydraulic pumpout without recycle, PCB levels would increase by .8 ug/l immediately downstream from the operation. The resulting ambient concentration of approximately 1.3 ug/l would yield a treated drinking water concentration of .65 ug/l and an average daily body burden of 1.3-2.6 ug/day for residents using the Hudson as a drinking water supply. This increased body burden would also apply to the modified hot spot dredging alternative although the period of chronic exposure would be reduced.

2b. Food

Comprehensive human food monitoring data on levels of PCBs are not available for the Hudson River area. However, the Food and Drug Administration (FDA) conducts a comprehensive food surveillance program yearly to determine pesticide residues, PCBs, heavy metals, and other contaminants in the diets of consumers in the United States. These studies, conducted since 1969, indicate that PCBs are most commonly found in fish, both freshwater and marine, although they have also been detected in other foodstuffs (USEPA, 1976b). An FDA total diet study based on FY 70 and FY 71 data showed composite food samples containing PCB residues of up to .36 ppm. The positive readings were found in meat, fish, poultry, dairy, and grain and cereal composites.

FDA's FY 73 study included thirty market basket samples from representative areas of the United States consisting of the total 14-day diet of a 15-20 year old male (USEPA, 1976b). About 117 individual food items were analyzed. Most of the PCB levels were trace amounts. The most frequent occurrences were in the meat-fish-poultry and grain-cereal products groups. The range of concentrations encountered was trace to 0.73 ppm.

In the FY 74 study, there were positive findings of PCBs in two food groups: sugar and adjuncts, and meat-fish-poultry (USEPA, 1976b). Only 3% of the samples in the first group were positive, while 45% of the second group had detectable levels of PCBs, with fish as the usual source of contamination. Data for 1975 indicated PCB contamination in 40% of the meat-fish-poultry samples and no positive findings in any other food groups.

Based upon these data, FDA has estimated the average daily intake from all food group composites and the average daily intake from the meat-fish-poultry class (Table 1). The decrease in total diet exposure is due to decreasing levels of PCBs in food packaging materials. The ingestion of PCBs through food should level out (based upon national background levels) and continue at the 1975 level as long as fish remain almost the sole source of dietary PCBs.

Table 1. Estimates of Total Daily PCB Ingestion (FDA, 1979).

	Average Daily Ingestion of PCBs (ug/day)	
Fiscal Year	Total Diet	Meat-Fish-Poultry Class
1971	15.0	9.5
1972	12.6	9.1
1973	13.1	8.7
1974	8.8	8.8
1975 (1st half)	8.7	8.7

The FDA studies are based upon national data and do not reflect actual conditions along the upper Hudson River although food levels in the dredge area could not be expected to be below national averages. Monitoring of foliage near dump sites indicated PCB levels of from .1 to 58 ppm (USEPA, 1976b). Background levels were recorded beyond 700 meters from the dump sites. Since cows fed diets containing 10 ppm and 100 ppm PCBs produced milk containing 6.27 ppm and 75.4 ppm PCBs (WHO, 1976), dairy herds grazing on foliage at 58 ppm would produce milk containing between 36 ug/l and 43 ug/l PCBs, far above the FDA limit of 1.5 ug/l. The WHO study (1976) reports that these PCBs survive processing into dairy products, and most was located in milk fat. Foliage levels at the Moreau dredge spoil site did not exceed 1.4 ppm.

Given the potential contamination of grazing land and residences near the containment site, volatilization and aerosol contamination by PCBs should be minimized prior to capping with a clay seal.

Since 1975 FDA data indicate that the meat-fish-poultry food category is primarily responsible for dietary intake of PBCs, suspension of the ban on fishing in the upper Hudson River must be considered for its effects on local population dietary exposure to PCBs. The FDA data on fish concentrations ranged from trace to .05 ppm (USEPA, 1976b) while data on PCB levels in upper Hudson River fish indicate levels ranging from 20 ppm to greater than 500 ppm (Thomann and St. John, 1979). Recent trend analyses on levels of PCBs in upper Hudson River fish indicate that a 5 ppm level may be reached by the mid-1980s without dredging and possibly sooner if contaminated sediments are removed (Armstrong and Sloan, 1980). Temporary elevations in tissue PCB levels can be expected from increases in PCB levels in the Hudson that result from dredging activities.

For populations along the Hudson that do not consume fish taken directly from the river, exposure to PCBs through the ingestion of food would be at least 9 ug/day, the national background level (USEPA, 1976b). Consumption of Hudson River fish with PCB levels at the FDA action level of 5 ppm would increase this amount one-hundred fold to approximately 900 ug/day (0.9 mg/day). These exposure levels would apply equally to the no action, hot spot dredging, and re-scoped hot spot dredging alternatives. Since effects on humans have been observed at 4.2 mg/day, a diet that includes up to 1 mg PCBs/day could not be considered safe for sensitive individuals in the local population, particularly since inhalation and drinking water exposures would increase the daily body burdens.

2c. Inhalation

Exposure to vapor phase or aerosol PCBs will be greatest for workers involved in the dredging and containment operations and nearby residents, and of less significance for the general population in the vicinity of the upper Hudson River. At several PCB dump sites in the Fort Edward and Glens Falls area, concentrations exceeded the NIOSH 8 hour recommendation of 1 ug/m^3, with levels at the Caputo site of up to 130 ug/m^3 during the summer (MPI 1980d). Sediment concentrations of PCBs at the Caputo site were 10,000-50,000 ppm. Workers at the Monitoring data taken near Buoy 212 during dredging in the Fall of 1979 indicated atmosphere levels of .5 ug/m^3. The populace in Fort Edward and Hudson Falls is exposed to a general background concentration of .05 ug/m^3. In addition, average indoor kitchen air has been reported to be 0.32 ug/m^3 (USEPA, 1976b).

At an average working inhalation rate of 0.05 m^3/min, workers at the dredge sites could be exposed to up to 12 ug/8-hour shift (.05 m^3/min) (.5 ug/m^3) (60 min/hr) (8 hr/shift) = 12 ug/shift) and workers at the containment sites could be exposed to 3,12 ug/8 hour shift ((.05 m^3/min) (13 ug/m^3) (60 min/hr) (8 hr/shift) = 3,120 ug/shift) The potentially excessive exposures for containment site workers can be mitigated by personal protective equipment or by engineering controls. Residents in the vicinity of the upper Hudson will be exposed to from 0.7 ug/day to 4.6 ug/day, calculated upon inhalation of atmospheric background levels of .05 ug/m^3 and indoor levels of .32 ug/m^3.

2d. Summary

In man, symptoms of disease were observed at dietary levels of PCBs of 4.2 mg/day (WHO, 1976). Similar effects were seen in rhesus monkeys administered the same dose. Effects on liver function, reproduction, immunosuppression, skin health, and incidence of hepatocarcinomas have also been noted in various species. There are insufficient data to calculate dose-response relationships for humans, and a non-effect level cannot be determined.

Common contaminants associated with PCBs include chlorinated dibenzofurons and benzodioxins (WHO, 1976). A single oral dose of chlorinated dibenzofurans of .5-1.0 mg/kg body weight caused severe and often lethal liver necrosis in rabbits. This corresponds to a single human dose of 33-65 mg for a 65 kg human. Chlorinated dibenzofurons have been calculated to be approximately one order of magnitude less toxic the chlorinated benzodioxins.

If the PCBs in the Hudson are not removed, total daily exposure to PCBs will be approximately .010-0.15 mg (9 ug from food, .3 ug from drinking water, and .7-4.6 ug inhaled). This level will not change significantly during and after dredging provided the dredge spoil containment area and dredge spoil barges are covered to prevent atmospheric losses of PCBs. Without precautions, workers at the containment area could be exposed to up to 0.3 mg/day, and cows feeding on forage near the containment site could be contaminated to levels in excess of FDA limits. If the ban on fishing in the upper Hudson River is rescinded and these fish become a part of this local diet, another .9 mg/day would be added to the diet.

In addition to the recommended engineering controls, monitoring of the Hudson River and foliage and milk in the vicinity of the dredge and containment areas should be implemented. In addition to analyses for total PCBs, the levels of PCB contaminants such as chlorinated benzodioxins and dibenzofurans should be monitored. Since the sediments are also known to contain high levels of cadmium, chromium, lead, and zinc (MPI, 1980d), analyses for these toxic metals should be included. The analyses should not be limited to raw river water but should be extended to include finished drinking water from treatment plants with intakes on the Hudson as well as groundwater and infiltration gallery sources of drinking water downstream of dredging and containment operations.

It is unlikely that human exposure to PCBs will increase if no action is taken to remove contaminated Hudson River sediments, provided the sediments are not disturbed by natural or anthropogenic scour. If the sediments are resuspended, increases in atmospheric, fish, and drinking water levels can be expected although there are insufficient data to quantify the increases and resultant human exposure. Dredging and containment operations would not increase human exposure significantly beyond background levels if the additional engineering controls are implemented. Reopening of the fishery would increase human exposure to consumers of the fish by 100 fold.

Ref. 45

An Assessment of Risk Associated with the Human Consumption of Some Species of Fish Contaminated with Polychlorinated Biphenyls (PCB's)

June, 1979

Requested by: Donald Kennedy
Commissioner, FDA

Prepared by: PCB Risk Assessment Work Force
Joseph Rodricks, Chairman
Deputy Associate Commissioner
for Health Affairs (Science)

An Assessment of Risk Associated with the Human Consumption of Some Species of Fish Contaminated with Polychlorinated Biphenyls (PCB's)

INTRODUCTION

The risk assessment reported in this paper was conducted in connection with a pending Food and Drug Administration (FDA) rulemaking proceding involving proposed reductions in the tolerance levels for PCB's in various categories of food, including fish and shellfish (Docket No. 77N-0080). FDA has proposed, inter alia, to reduce the tolerance for fish and shellfish from 5 ppm to 2 ppm (see the Federal Register of April 1, 1977, 42 FR 17487). Most of the toxicity data on PCB's has already been presented in this proposal. However, the available data were not utilized for performing a human risk assessment under the conditions of various, possible tolerances; i.e., no tolerance, 5 ppm, 2 ppm, or 1 ppm PCB tolerance for fish and shellfish. Furthermore, certain data relevant to assessment of the levels of PCB exposure and the toxicity of PCB during reproduction and lactation have been reported since the proposal was published; these data are also reviewed. The purpose of this risk assessment is to assist the agency in its estimation of the degree to which risk to consumers would be reduced by the proposed reduction of the tolerance for PCB's in fish.

The term PCB's refers to a complex mixture of chlorobiphenyls. Commercial PCB products, manufactured in the United States exclusively by the Monsanto Company, are identified by the trade name "Aroclor," and the particular PCB as, for example, Aroclor 1254 or Aroclor 1260. The first two digits refer to the fact that the biphenyl is made up of 12 carbon atoms, and the second two digits refer to the approximate percentage by weight of the chlorine content in the mixture. Thus, Aroclor 1254 contains 12 carbon atoms and approximately 54 percent chlorine, while Aroclor 1260 contains 12 carbon atoms and approximately 60 percent chlorine.

PCB's were reportedly first synthesized in 1881, but they were not commercially available until 1930 (DHEW, 1976). By late 1971, the widespread, uncontrolled use of PCB's in a variety of industrial applications had resulted in their becoming a persistent and ubiquitous environmental contaminant.

One consequence of this environmental contamination with PCB's has been the contamination of certain foods, including fish and shellfish. Though human exposure to PCB's occurs to a limited extent through the air and water, the most significant exposure now appears to be from dietary sources, especially from consumption of freshwater fish from contaminated waters. Human breast milk is another source of these substances.

The risk assessment reported here uses toxicity data from animal studies, human exposure data, and a mathematical extrapolation model to arrive at estimates of risks posed by exposure to PCB's assuming the imposition and enforcement of three possible tolerance levels--5 ppm, 2 ppm, and 1 ppm. This paper will first discuss some of the toxicity data available on PCB's. Following that will be a discussion of the calculations made regarding human exposure to PCB's through fish consumption and, finally, the results of the risk assessment.

Toxicity of PCB's

A. Human Data

Considerable scientific interest has centered on the Yusho incident in Japan in 1968, involving human intoxication with Kanechlor 400 (a brand of PCB's manufactured in Japan). The incident occurred as a result of the consumption by Japanese families of rice oil ("Yusho" oil) that had been contaminated accidentally with Kanechlor 400.

The typical clinical findings of "Yusho" disease included chloracne and increased pigmentation of the skin, increased eye discharge, transient visual disturbances, feeling of weakness, numbness in limbs, headaches, and disturbances in liver function. Most of the babies born to mothers with the Yusho syndrome were small and had skin discoloration that slowly regressed with age. Adult Yusho patients had protracted clinical disease with a slow regression of symptoms and signs, suggesting a slow metabolism and excretion of PCB's in humans, probably resulting from a long biological half-life. A total of 1291

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Yusho disease cases have been reported up to May, 1975 (NIOSH, 1977).

Originally, the effects seen in the Yusho incident were attributed exclusively to PCB's, which had been thought to be the sole contaminant of the rice and had been identified in the blood and tissues of Yusho patients. In the review by Kuratsune et al. (1975), a new factor was introduced: the canned rice oil was shown to be contaminated also with polychlorinated dibenzofurans (PCDF's) to the extent of 5 ppm. In addition, Kuratsune presented data of Nagayama et al. (1975) showing PCDF's to be present in the liver and adipose tissue of Yusho patients, while none was found in that of a control group. The ratio of PCB's to PCDF's in the Yusho oil (containing "used" Kanechlor 400) was 200:1, whereas the ratio of PCB's to PCDF's in "unused" (unheated) Kanechlor 400 is 50,000:1. Thus, with respect to PCB's, the ratio of PCDF's in Yusho oil to PCDF's unused Kanechlor 400 is 250:1. Also, the toxicity of PCDF's ranges from 200 to 500 times that of PCB's (Cordle et al., 1978). Thus, for equal amounts of rice-oil and pure Kanechlor 400, the toxicity of the rice oil would range from 2 to 3.5 times that expected from its PCB content alone.

Uncertainty about the confounding of effects between PCB's and PCDF's makes it difficult to determine from the Yusho data exactly what effect(s) exposure to only PCB's could have on humans. Detailed records of the 1291 Yusho patients have been maintained in an effort to detect possible long-term effects. At least 9 out of the 29 deaths that occurred as of May, 1975 have been attributed to malignant neoplasms (NIOSH, 1977), but a causal relationship between PCB's and cancer cannot be inferred because of the confounding introduced by the presence of PCDF in the oil. The Yusho study, nevertheless, can lead to two important observations: first, PCB's can be transferred from mother to fetus and from mother to child through breast feeding; and second, highly chlorinated PCB compounds are excreted more slowly from the body than the less chlorinated ones (NIOSH, 1977).

Finally, in a study of chemical workers (Bahn et al., 1976, 1977), two malignant melanomas were diagnosed in 31 workers exposed heavily to Arochlor 1254 (and also exposed to other chemicals that could possibly cause cancer). It was estimated that .04 malignant melanomas would have been expected from this group of individuals. Among 41 other workers also exposed to Aroclor 1254, but less heavily, one additional melanoma was diagnosed.

Data from Lifetime Animal Feeding Experiments

A number of studies have evaluated the neoplastic potential of PCB ingestion (Ito, 1973, Linder et al., 1974, Kimbrough et al., 1973, 1974, 1975, Calandra, 1976, NCI, 1978). Each of these studies provides some evidence that neoplastic lesions can be induced by PCB exposure. However, only three of these were of sufficient duration to be of value in assessing the lifetime carcinogenic risk of PCB's. These three studies are the following:

1) Effect of Aroclor 1260 on Female Sherman Rats (Kimbrough et al., 1975)

In this study, 200 Sherman strain female rats were fed a diet containing 100 ppm of Aroclor 1260 for approximately 21 months, and treatment was discontinued for 5 weeks before the animals were sacrificed at 23 months. A group of 200 untreated female rats served as controls. All animals were observed daily; moribund animals were sacrificed and subjected to gross and microscopic pathological examination, as were the animals sacrificed at the end of the experimental period. A total of 184 dosed rats and 173 controls survived to the end of the experiment. The authors concluded that Aroclor 1260, when fed in the diet, had a hepatocarcinogenic effect in these rats. No significant differences could be observed between experimental and control animals with regard to the incidence of tumors in other organs.

Although this study provides strong evidence of the carcinogenic potential of PCB's, certain prtocol design elements preclude this study from being considered adequate by today's standards. These deficiencies include the use of only female rats; lack of in utero exposure in the light of evidence that suggests in utero effects; sacrificing the animals at a relatively early time of 23 months, considering the expected life span of 25-30 months; and continuing dosing only up to 21 months. However, these shortcomings would, if anything, tend to mask or understate the true carcinogenic potential of PCB's.

2) National Cancer Institute (1978) Bioassay of the Carcinogenic Effect of Aroclor 1254 in Fisher 344 Rats

In a bioassay of Aroclor 1254 (National Cancer Institute, 1978), groups of male and female Fisher 344 rats (24 of each sex per group) were administered the test compound in the diet at 25, 50, and 100 ppm for a period of 104-105 weeks. Matched controls consisted of groups of 24 untreated rats of each sex. All animals were observed daily for signs of toxicity and palpated for tissue masses at each weighing. Moribund animals were observed daily for signs of toxicity and palpated for tissue masses at each weighing. Moribund animals were sacrificed and subjected to gross and microscopic pathological examination, as were the animals sacrificed at the end of the experimental period. It was concluded that "under the conditions of this bioassay, Aroclor 1254 was not carcinogenic in Fisher 344 rats; however, a high incidence of hepatocellular proliferative lesions in both male and female rats was related to the administration of the chemical. In addition, the carcinomas of the gastrointestinal tract may be associated with the administration of Aroclor 1254 in both males and females."

Although Aroclor 1254 was not shown to be carcinogenic by the NCI bioassay, it must be kept in mind that this was a relatively small experiment utilizing only 24 animals per dose group per sex. To provide statistical sensitivity for detection of cancer, the usual number of animals per group for an NCI bioassay is 50. A likely reason this bioassay is smaller than most may be because this study was part of a larger study designed to assess the combined effects of a group of chemicals. Overlooking for the moment the fact that the protocols were different than those used for a standard cancer bioassay and different Aroclors were tested, the results of the NCI bioassay and the Kimbrough study are not entirely inconsistent. Both studies indicate that the liver is the target organ for toxicity, and a high incidence of proliferative lesions occurs in both studies. Furthermore, if the same percentage of animals exhibited carcinomas in the NCI study as in the Kimbrough (1975) study, the high dose (100 ppm) group in the NCI study would exhibit only 3 carcinomas out of the 24 animals/sex used in this study. (This compares closely to the 2 carcinomas the NCI study found in this dosage group.)

Nevertheless, due to the small number of animals in the NCI study, it is not presently possible from the NCI bioassay data to support either a carcinogenic or noncarcinogenic response with PCB's in Fisher 344 rats.

3) Industrial Bio-Test Experiment (1971) with Charles River Rats

This experiment was performed by Industrial Bio-Test Laboratories (1971), and a summary of results was presented at the National Conference on Polychlorinated Biphenyls (Calandra, 1976). One thousand Charles River strain albino rats were placed into 10 treatment groups. One hundred rats (50 male and 50 female) served as controls and 100 rats (50 male and 50 female) were assigned to each of nine treatment groups which were fed diets containing 1, 10, and 100 ppm of Aroclors 1242, 1254, and 1260, respectively. Dosage started when the animals were about 4-6 weeks old and continued for 24 months. The liver slides from this study have been examined twice by pathologists, once in the original report (Industrial Bio-Test Laboratories, 1971) and in a later report (Monsanto, 1975). The diagnoses in these two examinations were disparate, e.g., for animals dosed at 100 ppm, the first examination diagnosed one hepatoma and two animals with nodular hyperplasia, whereas the later examination diagnosed eleven animals with hepatomas and twenty-eight animals with nodular hyperplasia.

For unexplained reasons, there was also unusually high mortality among the rats in the experiment, and the numbers of rats were further reduced by interim sacrifices during the course of the experiment. For example, only 6-21 animals out of the initial 100 in each treatment/sex subgroup fed 100 ppm survived to the terminal sacrifice. The FDA has found many such abnormalities with work conducted by Industrial Biotest Laboratories and has disqualified this study as a valid carcinogenic study and considers the findings unreliable. Nevertheless, re-diagnosis of the liver pathology indicated a significant tumorigenic effect. The incidence of nodular hyperplasia was significantly elevated in the group fed 10 ppm Aroclor 1260 over the incidence in the control group. There are a total of 9 hepatomas in the groups fed 100 ppm of one of the three Aroclors, but none in the groups fed lesser concentration of PCB's. Because this study is considered unreliable by the agency, it will not be used for estimating risk, but is presented as supportive data only.

Examination of the literature available on PCB toxicity indicates various types of toxicity other than carcinogenicity.

These toxicities include teratogenesis, reproduction effects, behavior effects, skin disturbances, edema, etc. This report is not ignoring these effects but is addressing only estimated human lifetime risks to cancer and not each of the other reported toxicities. Certainly, data for all types of toxicity will be considered in assessing the overall safety of PCB's in the diet.

4) Additional Toxicity Data

A recent presentation of Barsotti et al. (1979) indicates that female Rhesus monkeys exposed to PCB's exhibit reproduction and neonatal toxicity in their offspring even after PCB exposure has been discontinued for over a year. Details of this study were provided to us by Dr. J. R. Allen (1979) in the form of a draft scientific paper.

Aroclor 1248 (PCB) was fed to eight female Rhesus monkeys at levels of 2.5 and 5.0 ppm in the diet. After six months, they were mated to control males. Six of eight females fed at 5.0 ppm conceived but only one was able to carry to term. Most of the abortions occurred during the first 45 days of pregnancy. All of the animals fed at 2.5 ppm conceived and five gave birth. During nursing, milk PCB levels were 3.85-9.9 ppm (on a fat basis). Within two months following birth, the infants had facial acne and edema, swelling of the eyelids, loss of facial hair including eyelashes, and hyperpigmentation of the skin. Three of the six infants died during their first year of life due to PCB intoxication (Allen and Barsotti, 1976).

To evaluate the prolonged effects of PCB's on adult female primates, the PCB-containing diets were discontinued for approximately one year and the females were again mated to control males. No control female to control male matings were performed. All the females conceived. Four of the seven 5 ppm animals gave live births while seven of the eight 2.5 ppm females gave live births and one had an abortion. At birth, the infants from the 5.0 ppm group were generally smaller than the historical control infants.. The 2.5 ppm infants showed considerable weight variation.

During the four months of nursing, the infants of both groups developed hyperpigmentation about their hairline. Analysis of the milk that the infants were consuming at the time they were weaned revealed PCB levels of from 0.9 to 1.25 ppm (on a fat basis) compared to 3.35-9.3 ppm previous to discontinuing PCB treatment. Two infants from each group died following weaning. Prior to death, these infants became anoretic, lost weight, and developed swollen eyelids, loss of eyelashes, scaly skin, acne and alopecia (all signs of PCB poisoning).

It can be concluded that one and a half years after exposure to PCB's and with the milk PCB levels considerably reduced from previous levels, there was enough PCB in the milk to increase the body burden in the infant and cause PCB poisoning. It should be noted that during the time the females were off the PCB diet there had been a dramatic decrease in the PCB content of the subcutaneous fat of the adult animals. Nevertheless, when these animals were lactating, the PCB content of the milk fat had changed less dramatically than expected from adipose tissue levels. These data suggest that during lactation, PCB's are concentrated in the milk fat and accumulate in infants to levels higher than in their mothers.

A study by Kuwabara et al. (1978) presents convincing human evidence that brest-fed, children of mothers exposed to PCB's have much higher blood PCB levels than controls. Furthermore, the blood levels in children who breast feed for greater than three months were higher than their mothers. A correlation between duration of breast feeding and blood levels was shown. These data are presented in more detail under a subsequent section of this document on Human Milk Exposure to PCB's.

In conclusion, these newly reported data present the agency with a difficult task in protecting the unborn and newborn young. At the present time, we are unable to assess the long-term risk from increased exposure to PCB's during a relatively short part, e.g. (six months to one year) part of the total lifespan of an individual. Ordinarily, adequate protection from such effects can be attained for children and adults if a level of toxicant producing no observable adverse effects, is determined; however, the data available do not permit establishment of such a "no-effect" level in monkeys. Furthermore, because the infant is undergoing tremendous growth and differentiation during this period, it is possibly even more susceptible to PCB intoxication than is the adult.

Estimated Human Exposure Levels

A. FDA Total Diet Program

Using the FDA Total Diet Program data (Johnson and Manske, 1977), an estimate of PCB exposure from all dietary sources for 1974-1975 was compiled (Jelinek and Corneluissen, 1976). These values, which are listed in Tables 1 and 2, must be viewed as only crude estimates since in order to obtain them numerical values had to be assigned to trace observations. Those levels that were reported as trace were considered to be at one-half the quantitative lower level of detection, i.e., .025 ppm. Examination of Tables 1 and 2 indicates that the predominant food class in which PCB's were detected from 1974 to 1977 was meat, fish, and poultry. The majority of these positive findings are due to PCB's in fish samples. It appears from Tables 1 and 2 that the average daily PCB intakes from the meat, poultry, and fish category have remained fairly stable (7.9 - 9.1 [g/day) since 1972, while levels in other foodstuffs have decreased to nondetectable levels.

B. PCB Levels In Fish

As pointed out in the previous section, the most significant exposure to PCB's in food is through fish, Tables 1, 2. The distribution of total commercial fish consumption can be calculated from the Seafood Consumption Study (National Marine Fisheries Service, 1976), but the distribution of consumption of other freshwater sportsfish species is not available. Moreover, the concentration of PCB's in fish is highly variable, both among species and within a single species. Fish caught further offshore tend to have smaller amounts of PCB's than estuarine fish, and freshwater fish caught in areas of high PCB pollution tend to have the highest concentrations of PCB's. Furthermore, sports fishermen would consume varying amounts of fish. The activities of sports fishermen are not and cannot be regulated by the FDA.

1) Estimate of Human Exposure to PCB's Through Commercial Fish Consumption

In order to determine human exposure to PCB's through commercial fish, it is necesary to know the levels of PCB residues in the edible portions of fish consumed by the population. Information has been compiled by the National Marine Fisheries Service-NOAA (1976) on the most important types of fish in the U.S. diet and on the mean daily amount of each type consumed by those who actually consumed that type. This study included 25,947 eaters selected as a sample representing all fish eaters in the United States.

Information from the survey shows that some twenty species comprise 95% of all the fish products eaten. Although 93% of the U.S. population (197 million) eat fish, the average annual per capita consumption of fish is small: 15.0 lb/year. A major portion of total consumption consists of "unclassified" fish, ranking just below tuna in importance. This "unclassified" fish consists of a variety of species, each of which considered separately would make up only a minor portion of the diet. Freshwater species, led by trout, bass, and catfish, comprise about 9% of our total fish diet.

Table 3 lists the 12 fish categories of interest, i.e., the 11 species of fish found in the FDA 1978-1979 survey to have the highest PCB residue levels and all other species grouped under "all other," and gives the mean PCB levels in these species assuming the absence of an FDA tolerance and assuming the imposition of tolerances of 5 ppm, 2 ppm, and 1 ppm. A rough approximation of the effect of a given tolerance on mean PCB levels for each species was arrived at by eliminating samples with PCB levels above the assumed tolerance and recalculating the mean.

Table 4 lists estimated human exposure levels corresponding to no tolerance, and tolerances of 5 ppm, 2 ppm, and 1 ppm for those 3939 persons who ate the species of interest. Because analytical methods for regulatory purposes are not presently available for PCB levels below 1 ppm in fish, (i.e., due to analytical limitations, it would not now be possible to impose a tolernce at levels less than 1 ppm) no exposure estimates were made for levels below 1 ppm. The estimated daily exposure levels were arrived at by multiplying the consumption per day of each of the species of interest (at both the 50th and 90th percentile consumption levels) by the mean PCB level for each type of fish assuming no tolerance and tolerance levels of 5 ppm, 2 ppm, and 1 ppm. The figures in Table 4 reflect the total estimated daily exposure from the 12 species of interest. The risks estimated on the basis of these exposure levels can be extrapolated to the 15.2% (3939/25947) of the total U.S. population expected to consume the species of interest.

The estimation of mean PCB levels in fish assuming no tolerance and tolerances of 5 ppm, 2 ppm, and 1 ppm is a key element of the exposure estimates and may be the most uncertain part of the entire risk assessment. The effect of a given tolerance on the mean PCB levels depends to a large degree on the actual distribution of PCB levels before a tolerance is instituted. The data used here consisted of 892 samples collected in 1978 and 1979 from all of the FDA districts. This sampling may not have been sufficiently representative or extensive to provide a reliable estimate of the distribution of PCB levels in each species. It should be noted that the mean PCB levels based on an assumption of no tolerance may not reflect all PCB levels occurring in fish because the 1978-1979 survey was carried out when a tolerance of 5 ppm was in effect. Thus, the effect of going from no tolerance to a tolerance of 5 ppm may be greater than shown here.

2) Estimated Sports Fisherman Exposure to PCB's from Sports Fish Consumption

The National Fish and Wildlife Monitoring Program has followed PCB levels in freshwater fish for many years. Walker, 1976, summarized these findings as follows:

"Geographically, the higher concentrations appear to be associated with certain river systems having industrial activity.... PCB residues expressed as Aroclor 1254 were found in five major river systems in the Atlantic coastal region, with residues exceeding 5 mg/kg. Four of these stations had residues exceeding 10 mg/kg during the last 5 years. Fish in four of the Great Lakes stations had PCB concentrations exceeding the 5 mg/kg level and all stations reported concentrations exceeding 0.5 mg/kg. In the

Mississippi River system, the Allegheny and Ohio were the hot spots, with seven out of the eight stations reporting residue concentrations in excess of 5 mg/kg. Thirty-one of thirty-five stations in this river system reported residues in excess of .15 mg/kg in the 1970-73 sampling programs. The highest residues, often exceeding 10 mg/kg, were found in the Allegheny, Kanawha, Cumberland, Tennessee, and Ohio Rivers along with stations on the Mississippi River at Memphis, Tennessee, and the Missouri River at Herman, Missouri. Other monitoring stations that were found to have residue levels exceeding 5 mg/kg during the sampling periods 1970-73 included: the Williamette River on the Columbia system; the Rouge River in the Pacific coastal drainage; the Sacramento River in California; the Chena River tributary of the Yukon in Alaska; and the Rio Grande, Alabama, and Mississippi Rivers in the Gulf States region. Only in two sample periods of 1972-73 and in the current monitoring samples, which are still yet to be fully analyzed, has there been a downward trend, but this occurs only in those samples where residues are not being detected. The stations where high residues have been noted in the past still remain relatively contaminated with PCB. Unlike the decline of DDT in Great Lakes fish, PCB concentrations do not show significant changes and may trend upward in salmonids, ..."

Both the Hudson River (Spagnoli and Skinner, 1977) and Lake Michigan (Humphrey et al., 1976) have exhibited PCB levels in their sportsfish that were very high and in some cases still increasing.

The Michigan Department of Public Health recently completed a study (Humphrey, H.E.B. et al., 1976) which attempted to assess some of the consequences of human exposure to PCB's from the consumption of sportsfish caught in different areas of Lake Michigan. The study included exposed and control subjects from five areas of Michigan bordering on Lake Michigan. Exposed study subjects were those individuals who consumed at least 24 to 25 lbs of Great Lakes fish per year. Control subjects were those individuals who consumed less than 6 lbs of Great Lakes fish per year. An assessment of the findings in the study indicates that the most frequently recorded quantity of fish consumed by the study participants was in the 24-25 lb/yr range. The highest recorded fish consumption over the two-year period of the study was 180 lb/yr, and the highest single-season consumption was 260 pounds.

Mean PCB levels in whole lake trout are reported as 18.93 ppm in 1973 and 22.91 ppm in 1974; and in coho salmon, as 12.17

ppm in 1973 and 10.45 ppm in 1974. However, comparisons of PCB levels in raw vs. cooked fish indicated that actual human exposure to PCB's from fish consumption was less than might be expected from the raw fish data. This is because preparation (trimming away fatty tissue) and cooking result in a decrease in the amount of PCB's remaining in the fish at the time it is consumed. For example, the PCB level in cooked lake trout consumed by the study participants ranged from 1.03 ppm to 4.67 ppm; in cooked salmon from 0.48 ppm to 5.38 ppm; and in other cooked fish from 0.35 ppm to 2.06 ppm. These levels are decidedly lower than the level of PCB contamination reported in raw trout and salmon.

PCB's were found in all blood specimens collected from the 182 study participants during the study period, including controls. The values ranged from a mean of 0.007 ppm in blood in the control group to a mean of 0.366 ppm in the exposed group. Although there was a wide range of blood values for each quantity of fish consumed, there was a highly significant correlation between the reported quantity of Lake Michigan fish consumed and the concentration of PCB's in the blood of study participants.

No annual variation in PCB blood levels in humans could be demonstrated. The mean PCB blood values for the control and exposed groups did not appear to change markedly from 1973 to

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1974. In addition, abstinence from Lake Michigan fish consumption for a period of 90 days or more did not change the PCB blood levels significantly. PCB blood levels over the abstaining period show variations, but no steady decline. In fact, more subjects showed no change or a rise in PCB blood levels than showed a decline during the period of abstinence.

The calculated quantity of PCB's ingested by eating Lake Michigan fish averaged 46.5 mg/yr and ranged from 14.17 to 114.31 mg/yr. The calculated mean daily dose received by the exposed group in the study was 1.7 µg/kg/day and ranged from 0.09 to 3.94 µg/kg/day. PCB ingestion for each individual was determined by proportioning his/her reported annual fish consumption by frequency of species eaten and the cooked fish PCB levels for those fish. The community average for cooked fish was used in instances where cooked fish determinations were not available for a study participant. Because fish consumption was found to vary from year to year, the average annual consumption for each individual for the two baseline years of study was used in each case.

The exposed group experienced no observable adverse health effects or symptoms as a result of their exposure. Though this study suggests that the PCB consumption and blood levels observed in the study are not high enough to trigger the adverse effects experienced by the Yusho population, it does not preclude the possibility that such levels caused effects too subtle to detect or effects whose latency periods exceed the period of the study. One subject in this study gave birth to a normal child in January, 1976. A milk specimen from this individual contained 4 ppm PCB (on a fat basis), whereas the blood PCB level was 0.053 ppm.

C. PCB Exposure From Human Milk

A nationwide survey for levels of PCB's in human milk covering 44 States was conducted by Savage (1977). He examined 1038 samples and detected PCB's in all but 9 of the samples. Of the positive samples, 720 had trace amounts and 309 had levels that ranged from 0.03 ppm to 16.92 ppm (fat basis). A total of 81 samples (7.8%) had PCB levels that were in excess of the present 2.5 ppm (fat basis) temporary tolerance used by FDA for commercial milk. The mean PCB concentration for all the samples was estimated to be in the range of 1.00-1.10 ppm (fat basis).

Although only one data point is available for PCB's in human milk from a Michigan fish consumer, this level is quite high (4 ppm on a fat basis). It seems reasonable to assume that since this woman was an average sports fish consumer, a sizable number of the women in

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Michigan who consume sports fish could produce milk that has four times (4 ppm vs. 1 ppm) the averge U.S. levels of PCB's. The same may be true for other states in which sports fish consumption is similar to that of Michigan.

A recent study (Kuwabara et al., 1978) examined the relationship between breast feeding and PCB levels in the children of mothers occupationally exposed to PCB's. The children had ingested their mothers' milk for 0 to 3 years. The age of the children was 0-13 years. Control subjects, Yusho patients, and occupationally exposed mothers were studied for PCB blood levels and had 2.5 ± 1.2, 4.2 ± 1.9, and 36.8 ± 21.5 ppb, respectively. The children of the occupationally exposed mothers had PCB blood levels of 14.3 ± 18.1 ppb. Thus, these children had PCB blood levels that were at least 3 times higher than were blood levels in Yusho patients. Close examination of 59 of these children indicates that the determining factor in the children's blood level was the length of time that the child breast fed and not the age of the child when the blood levels were determined. Thus, blood levels in children who fed on artificial milk is much lower than that of their mothers' (mothers 45.3 ± 23.5, children 5.8 ± 5.8); children who breast fed less than three months had moderate blood levels (mothers 35.5 ± 19.8, children 12.6 ± 6.9 ppb); and children who breast fed for greater than three months had higher blood levels than their mother (mothers 21.9 ± 13.4, children 32.8 ± 33.3 ppb). These results suggest that the PCB blood levels in children are much more a function of PCB from mothers' breast milk than placental transport during gestation. The authors further estimated that the expected

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exposure for adults having no occupational exposure was 20 μg/day (0.33 μg/kg/day) while children of occupationally exposed mothers would have been exposed to 500 μg/day if their mothers' milk had 0.5 ppm PCB's and they consumed 1 kg milk/day. No overt toxicity was reported in the children.

RISK ASSESSMENT

Because of the lack of sufficient human data, risk assessments for potential long-term toxic effects of PCB's must be made on the basis of animal experiments. In the absence of contradictory kinetic or metabolic data, animal data are appropriately used to estimate potential human risks. Because the numbers of animals used in tests are limited, doses above the human exposure levels are used in animal studies to increase the probability of detecting potentially toxic chemicals. Thus, it is necessary to estimate the risks to humans at low doses by use of statistical extrapolation. Because of the inability to observe the low end of the dose-response curve with precision, the Interagency Regulatory Liaison Work Group on Risk Assessment (1979) has recommended the use of linear (or when necessary, one-hit) extrapolation from high to low doses. Of the available methods that appear to be consistent with what is known about the biological mechanism of carcinogenesis, the linear method is the least likely to underestimate risk. Also, linear extrapolation is the limiting case for the multi-stage model of carcinogenesis at low doses. Because the shapes of dose-response curves at low doses are unknown, actual estimates of risk are not possible. But, based on plausible assumptions, it generally is possible to place upper bounds on potential human risk by use of linear extrapolation based on animal data. The linear method is used here. Upper 99% confidence bounds on the animal response data are used to eliminate the effect of sample size so that comparisons between experiments can be made. Use of such upper bounds adds an additional degree of conservatism to the estimate.

The extent to which these estimated risks reflect true human risk is always uncertain. In the case of PCB's, the uncertainty is greatly compounded by the absence of toxicity data on the particular set of PCB's that occur as residues in fish. Due to environmental transformation, the PCB residues found in fish are of a chemically different composition than any of the industrial PCB products, though a typical PCB residue in fish resembles the Aroclor 1254 mixture more closely than it does other Aroclors (Zitke et al., 1972; Veith, 1975). All the animal toxicity data represent the effects of one of the industrial PCB products; no toxicity studies have been performed using the PCB residue that actually occurs in fish. For this reason, it is uncertain that the available toxicity data accurately represent the toxicity of the PCB mixture ingested by humans who consume fish. The fairly close resemblance of such residues to Aroclor 1254 permits some reliance to be placed on data derived from studies of that PCB product, but the chemical difference between even that product and actual fish residues introduces an additional element of uncertainty into the risk assessment.

Data from the NCI bioassay program in which Aroclor 1254 was fed to Fisher rats are presented in Table 5 to show the numbers of total malignancies, liver carcinoma plus adenomas, and hematopietic effects in males and females at various feeding levels. Similar data are also presented in Table 5 for the feeding studies of Kimbrough using female Sherman rats fed 100 ppm Aroclor 1260.

Based on the toxicity data in Table 5 and the exposure data in Table 4, the upper confidence limits (99%) on lifetime risks for cancer in eaters of the 12 fish species of commercial interest at the 50th and 90th percentiles of consumption have been calculated and are presented in Table 6. In addition, the lifetime risk for consumers of sportsfish in Lake Michigan at the 50th and 90th percentile of consumption are presented. These risks would probably approximate those of sportsfish consumers in other areas of the country having PCB contamination, but for which residue data are not available. Upper limits on estimated risks have been computed from the NCI data on total malignancies for males plus females, liver carcinoma plus adenomas in males plus females, and on hematopietic in males plus females. Estimated risks similarly computed from the Kimbrough data are also presented in Table 6. The various estimated risks shown are based on mean PCB levels in commercial fish, assuming no tolerance, a tolerance of 5 ppm, 2 ppm, and 1 ppm. Risk for sports fishermen was only calculated assuming no tolerance, because tolerances have no relevance to such exposures. Because the relative susceptibilities of humans and test animals to the chronic effects are unknown, it is not certain whether the data in Table 6 over- or underestimate human risks. The data do show, however, remarkable agreement, indicating that the various rat strains used react similarly to PCB carcinogenic insult. The relative effects of exposure reduction can be seen and increased risk associated with sportsfish consumption in Michigan (and, presumably, in other areas having similar contamination problems) is apparent.

Multiplication of the size of the population at risk by the risk estimates found in Table 6 yields the number of extra cases of carcinoma per year; these data are presented in Table 7. The assumption was made that the risk is evenly distributed over a 70-year lifetime. A tolerance of 5 ppm appears to reduce cancer risk about 8-10% from that expected with no tolerance; a tolerance of 2 ppm appears to reduce risk about 32-38%, and reducing the tolerance to 1 ppm appears to reduce risks to 55-61% of the cancer risk expected in the absence of any tolerance. Furthermore, the Lake Michigan sports fish consumers have a 12-14 fold increased risk compared to the general U.S. population.

It should be noted that the possible human risks due to the effects of PCB's on the reproductive system and offspring cannot be ignored. Exposure to PCB's from human milk also imposes an additional burden on the infant, which burden has yet to be assessed. Certainly, the infant who is breast feeding will consume higher levels of PCB's/kg/day than the general population. Added to the nationwide human milk PCB burden would be the increased levels of PCB's that would occur in the milk of consumers of sportsfish.

Estimating risk from exposure during gestation and neonatal growth is very difficult. The toxicological data have not been developed, and the methodologies for computing life-time risks from exposure to a substance only during a short period of life have not been developed. It is reasonable to predict that children exposed in such a fashion may suffer an increased cancer burden from PCB's, especially if dietary contamination continues after childhood and throughout life; thus, the risk estimates shown in Table 6 may underestimate risk in years to come.

Table 1: Total Diet Studies-American Teenage Male

Fiscal Year	Dairy products	Meat, fish & poultry	Grain & cereal products	Potatoes	Legume vegetables	Root vegetables	Garden & fruits	Oils, fats shortening	Sugars and adjuncts
	Percent of composites containing PCB's								
	Food class composites								
1971		47	13						
1972	6	46	6		6	3	3	17	6
1973	10	33	17	3				3	
1974		43							3
1975 (1st half)		40							

Source: Jelinek and Corneliussen (1976)

Table 2: Estimates of Daily PCB Intakes

(Total Diet Study-Teenage Male)

	Average Daily Intake of PCB's[a]	
Fiscal year	Total diet (ug/day)	Meat-fish-poultry food class (ug/day)
1971	15.0	9.5
1972	12.6	9.1
1973	13.1	8.7
1974	8.8	8.8
1975*	8.2	8.2
1976*	8.5	7.9
1977*	8.7	8.1

[a]Lower limit of quantitative reporting = 0.05 ppm with analytical method employed.

*Jelinek (1979) personal communication.

Table 3: Mean PCB Levels in FDA 1970-1979 Domestic Survey by Species of Interest

Species of Interest	Assuming No Tolerance*		Assuming 5 ppm Tolerance		Assuming 2 ppm Tolerance		Assuming 1 ppm Tolerance	
	Mean (ppm)	N	Mean (ppm)	N	Mean (ppm)	N	Mean (ppm)	N
Carp	1.10	54	0.90	52	0.68	46	0.54	38
Catfish	1.70	295	1.19	281	0.73	219	0.38	150
Buffalo	0.50	36	0.50	36	0.43	35	0.30	31
Freshwater Trout	1.36	87	1.28	85	0.76	58	0.37	40
Sea Trout	0.56	10	0.56	10	0.56	10	0.27	8
Bass	1.28	15	1.28	15	0.77	11	0.27	10
Chubs	1.14	19	1.14	19	0.96	17	0.58	9
Bluefish	0.53	23	0.53	23	0.44	22	0.37	20
Scup (Porgy)	0.72	10	0.72	10	0.72	10	0.53	8
Drum	0.49	12	0.49	12	0.49	12	0.32	10
Mackerel	0.53	21	0.53	21	0.53	21	0.28	17
All Others	0.26	206	0.26	206	0.24	204	0.22	201

*For assumed tolerances, PCB values exceeding the tolerance were elimintcd in calculating the mean.

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Table 4: Intake of PCB's from Fish for Eaters of Species of Interest (3939/25,947)

	Assuming* No Tolerance	Assuming Tolerance = 5 ppm	Assuming Tolerance = 2 ppm	Assuming Tolerance = 1 ppm
Intake at 50th percentile - ug per day	8.46	7.57	5.59	3.30
PPM of diet**	.0056	.0051	.0037	.0022
ug per kilogram of body weight	.12	.11	.08	.05
Intake at 90th percentile - ug per day	22.1	20.1	14.9	9.22
PPM of diet	.0147	.0135	.0099	.0061
ug per kilogram of body weight***	.32	.29	.21	.13

* For assumed tolerances, PCB values exceeding the tolerance were eliminated

** Assumed 1500 grams daily intake

Table 5: Animal Data Used for Risk Extrapolation to Humans

Animal Studies	Dose of Aroclor fed in ppm			
	0	25	50	100
NCI Bioassay - Fischer Rats fed Aroclor 1254				
Total Malignacies				
Males	5/24	2/24	9/24	12/12
Females	4/24	13/24	8/24	9/24
Combined	9/48	15/48	17/48	21/48
Liver Carcinoma & Adenomas				
Males	0/24	0/24	1/24	2/24
Females	0/24	0/24	1/24	2/24
Combined	0/48	0/48	2/48	4/48
Males	3/24	2/24	5/24	0/24
Females	4/24	[illegible]	6/24	6/24
Combined	7/48	[illegible]	11/48	[illegible]/48

Kimbrough - Female Sherman Rats fed Aroclor 1260 Hepatocellular Carcinomas	1/173			26/184

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Table 6: Upper Confidence Limits (99%) on Lifetime Risks* of Cancer in Eaters of Fish Species of Interest

Animal Studies on which risks are based	50th Percentile Eaters: Assuming No Tolerance, USA	50th Percentile Eaters: Assuming No Tolerance, Lake** Michigan	50th Percentile Eaters: Assuming Tolerance = 5 ppm	50th Percentile Eaters: Assuming Tolerance = 2 ppm	50th Percentile Eaters: Assuming Tolerance = 1 ppm	90th Percentile Eaters: Assuming No Tolerance, USA	90th Percentile Eaters: Assuming No Tolerance, Lake** Michigan	90th Percentile Eaters: Assuming Tolerance = 5 ppm	90th Percentile Eaters: Assuming Tolerance = 2 ppm	90th Percentile Eaters: Assuming Tolerance = 1 ppm
Kimbrough - Rats Liver Carcinoma	1.3	18.4	1.2	0.8	0.5	3.4	41.4	3.1	2.3	1.4
NCI Bioassay - Total Malignancies for Male & Female	4.1	58.0	3.7	2.7	1.6	10.6	129.2	9.8	7.2	4.4
NCI Bioassay - Liver Carcinoma & Adenomas for Male & Female	0.9	12.75	0.9	0.6	0.4	2.5	30.5	2.3	1.7	1.0
NCI Bioassay Hematopietic for Male & Female	2.7	38.25	2.4	1.8	1.1	7.0	85.3	6.5	4.7	2.9

All risks are lifetime risks computed as rates per 100,000 of the population at risk.

*Risk calculated for Lake Michigan sportsfish eaters who consume an average of 1.7 μg/kg/day PCB or 3.9 μg/kg/day at the 90th percentile. Risks in other areas having similar sportsfish consumption and PCB contamination are probably similar.

Table 7: Upper Confidence Limits (99%) on Number of New Cancers per Year in Eaters of Fish Species of Interest

Animal Studies on which risks are based	50th Percentile Eaters: Assuming No Tolerance USA	50th Percentile Eaters: Assuming No Tolerance Lake** Michigan	50th Percentile Eaters: Assuming Tolerance = 5 ppm	50th Percentile Eaters: Assuming Tolerance = 2 ppm	50th Percentile Eaters: Assuming Tolerance = 1 ppm	90th Percentile Eaters: Assuming No Tolerance USA	90th Percentile Eaters: Assuming No Tolerance Lake** Michigan	90th Percentile Eaters: Assuming Tolerance = 5 ppm	90th Percentile Eaters: Assuming Tolerance = 2 ppm	90th Percentile Eaters: Assuming Tolerance = 1 ppm
Kimbrough - Rats Liver Carcinoma	6.2	10.4	5.8	3.8	2.4	16.3	23.4	14.7	10.0	6.7
NCI Bioassay - Total Malignancies for Male & Female	19.6	32.8	17.6	12.9	7.6	50.6	73.1	46.8	34.3	21
NCI Bioassay - Liver Carcinoma & Adenomas for Male & Female	4.3	7.2	4.2	2.9	2.0	12.0	17.3	10.9	8.0	4.7
NCI Bioassay Hematopoietic for Male & Female	12.9	21.6	11.4	8.66	5.3	33.4	48.3	31.0	22.5	13.8

* All risks are the increased number of cancers per year for the population at risk (15.2% of U.S. population) considering a 70 year life span.

**Risk calculated for Lake Michigan sportsfish eaters who consume an average 1.7 μg/kg/day PCB or 3.9 μg/kg/day at the 90th percentile. (4,000,000 people assumed exposed) Risks should be similar for sportsfish eaters in other areas; but data not available to make estimate.

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APPENDIX B

PCB Hot Spot Dredging Program

Upper Hudson River, New York, Rescoping Report

MPI, February, 1981. Draft PCB Hot Spot Dredging Program, Upper Hudson River, New York, Rescoping Report. Submitted to New York State Department of Environmental Conservation, Albany, New York.

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WAPORA N. Y.
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To: 211 East 43rd Street
New York, NY
10017

Attention: Mr. Howard Schwartz

Date: March 31, 1981

Re: Hudson River PCB Reclamation Project
Scoping Report

GENTLEMEN:

We are sending you ☒ Enclosed ☐ Under separate cover via ☒ Express Mail ☐ Messenger, the following items

☐ shop drawings ☐ prints ☐ data sheets ☒ Report
☐ specifications ☐ sketches ☐ brochures ☐ ______

Our action relative to items submitted for approval has been noted on the drawings.

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1	MPI		FINAL DRAFT OF THE SCOPING REPORT
			DATED MARCH, 1981

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Remarks: This report is to be substituted for the draft forwarded yesterday. There have been no further changes to the Figures, so the originals sent yesterday are to be used.

Thank You,

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Very truly yours
MALCOLM PIRNIE, INC.
by Judith A. Bedard

Copies to: RE Thomas

HUDSON RIVER PCB RECLAMATION PROJECT
SCOPING REPORT

MARCH 1981

BACKGROUND

This rescoping of the PCB hot spot dredging project has been prompted by the limited funding available to undertake the work. The cost of the original 40 hot spot dredging program, including construction of the containment site and removal of remnant deposit areas 3 and 5 (remains of the former Fort Edward Pool deposits above Fort Edward) was an estimated $40 million. Total funds available for the project at this time are $26.7 million, and the purpose of this review is to identify the most beneficial and cost-effective combination of project elements which can be completed for this amount.

This report briefly describes the original hot spot dredging program as evaluated in the Draft Environmental Impact Statement, New York State Environmental Quality Review (Draft EIS, New York SEQR), as well as associated actions which include relocation and containment of contaminated New York State Department of Transportation (DOT) dredge spoil material and nearby dumps. It then presents a discussion of discrete elements of the $40 million project, criteria for a rescoped project, a proposed reduced scale program.

BRIEF DESCRIPTION OF ORIGINAL PROJECT

The original project, as presented in the Draft EIS, included six components directed toward reducing the impact of PCB on the Hudson River, its biota, and the surrounding Hudson River Valley. These components were:

- o Dredging of 40 hot spot[1] areas in the river bed with containment in a secure upland site.
- o Design and construction of a secure upland containment site capable of long-term isolation of contaminated material.
- o Excavation of remnant deposit areas 3 and 5, located above the former Fort Edward Dam site, and removal to the upland containment site.
- o Provision for containment of material from three PCB-contaminated dump sites in the Fort Edward area - Old Fort Edward, Fort Miller and Caputo - should removal be found more suitable than in-place containment.
- o Provision for containment of contaminated material from three DOT dredge spoil areas - Spoil Area 13, Site 212 and Site 204 Annex.
- o Destruction of the recovered PCB at such time as a technically and economically feasible procedure becomes available.

If relocation of the above mentioned dump and spoil area material were to take place in conjunction with the dredging of all 40 hot spots and the removal of remnant deposit areas 3 and 5, almost half of the PCB estimated to be in the Hudson River and adjacent land areas would be permanently contained. (See Table 5.) However, this figure includes the movement of DOT spoil areas and highly concentrated dump materials, and therefore does not represent the reduction of PCB in the river itself. Dredging of the 40 hot spots and excavation and movement of all of remnant deposit areas 3 and 5, would result in a 54 percent reduction in the mass of PCB contained in the bed and banks of the Upper Hudson. The bed and banks of the Hudson River, as defined here, include all of the hot and cold areas in the Upper Hudson River (bed) and the remnant deposits

[1] Hot spots have been defined as areas of PCB contamination equal to or greater than 50 μg per g.

(banks). Dredging all of the 40 hot spots would alone result in a 49 percent reduction in the mass of PCB in the bed of the Upper Hudson River and a 33-35 percent reduction in the mass of PCB in the bed and banks of the Upper Hudson River. A reduction in the scope of this project would result in a corresponding reduction in the amount of PCB removed from the river. This relationship is not linear, and the revised project will be designed to recover the greatest mass of PCB potentially subject to loss to the water column for the funds available.

Table 1 presents an estimate of the cost of the original 40 hot spot project. The $40 million cost indicated was based on construction of the containment site in 1981, and a two year dredging program in 1982 and 1983.

ORIGINAL PROJECT

General

The proposed program was to have a three year duration. The first year included site construction and probing and sampling of lower pools. The second year included dredging the 20 hot spots in the Thompson Island pool, removal by truck, partially or completely, of the Area 3 and 5 remnant deposits, and subsequent covering of the required portion of the containment area. In the third year, the lower pools were to be dredged, and the remainder of the containment area covered and sealed. In addition, the nonpermanent earthen basins on the site were to be razed and these areas regraded.

In this section each element of the program will be described. The cost associated with each is presented in Table 1. A location map is presented in Plates 1 and 2.

Data Used

The quantities of contaminated volumes to be removed and associated PCB masses for each of the hot spots are those computed by Malcolm Pirnie, Inc. (MPI 1978).

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TABLE 1

ESTIMATED COSTS FOR ORIGINAL 40 HOT SPOT DREDGING PROGRAM
(All costs in thousand dollars)

Phase	1981 (3)	1982 (4)	1983 (4)	Total by Phase
Site Construction (1)	$4770			$ 4770
Cover Costs		$ 789	$ 868	1657
Site Modifications After Closure (2)			429	429
Thompson Island Pool Dredging (5)		6534		6534
Remnant Deposits Removal		1670		1670
Lower Pool Hot Spots Dredging				
Lock 6 -			844	844
Lock 5 -			2826	2826
Lock 4 -			1329	1329
Lock 3 -			1371	1371
Lock 2 -			1457	1457
Material Rehandling		221	199	420
Sub-Total	$4770	$9214	$9323	$23,307
Contingencies	480	2525	2624	5629
Engineering Design	278	930	1018	2226
Field Engineering & Construction Administration	384	1062	1493	2939
Legal & Administrative	69	257	293	619
Totals By Year	$5981	$13,988	$14,751	$34,720
Three Year Total				$34,720
Scientific, Engineering, Monitoring & Administrative Costs 9/76-3/80				3,480
Scientific, Monitoring & Administrative Estimated 4/80-3/83				1,800
Project Total				$40,000

Notes:

(1) Includes site work costs for all phases, except site modifications after closure and cover costs.

(2) Includes south dike channel, additional swale drops, and razing and regrading the roughing & storage pond, surge pond and the treatment plant basins.

(3) Escalated 13.2 percent from third quarter 1980 to mid-1981.

(4) Escalated 24 percent from 1979 to 1980, and 10 percent/year from 1980.

(5) Includes site acquisition costs.

Related Studies

More detailed descriptions of each of the project elements and their costs can be found in the following previous reports:

- Phase I Engineering Report, Dredging of PCB Contaminated Hot Spots, Upper Hudson River, NY, Malcolm Pirnie, Inc. (December 1978).
- Design Report, PCB Hot Spot Dredging Program Containment Site, Malcolm Pirnie, Inc. (September 1980).
- Dredging System Report, Program Report No. 2, PCB Hot Spot Dredging Program, Upper Hudson River, NY, Malcolm Pirnie, Inc. (September 1980).
- Draft Environmental Impact Statement, PCB Hot Spot Dredging Program, Upper Hudson River, NY, Malcolm Pirnie, Inc. (September 1980).

Containment Site

The containment site, referred to as Site 10 in earlier reports, is situated on a 250 acre parcel of land located approximately 2.5 miles south of the Village of Fort Edward, in the Town of Fort Edward, in Washington County, New York. (See Plate 3).

The site's major components are:

- Containment Area
- Roughing and Storage Pond
- Surge Pond
- Water Treatment Plant
- Pump Station
- Leachate Collection System
- Access Road
- Storm Water Drainage System
- Chemical Feed System
- Appurtenances

Containment Area - The containment area is an earthen basin bisected by a cross dike. It occupies approximately 63 acres at its maximum water surface and its total containment volume at the maximum water surface is 2,260,000 cu yds. This volume is sufficient to hold all of the 40 hot spots, remnant deposit areas 3 and 5 and the DOT spoil areas.

The containment area is designed for long term encapsulation of PCB-contaminated materials, and will therefore be capped with a clay cover during each season of dredging.

Roughing and Storage Pond - The roughing and storage pond (R&SP) is an earthen basin with a maximum water surface area of approximately 12 acres.

After the slurried dredge material is pumped into the containment area, weir overflow is transported via pipeline to the R&SP. The primary purpose of this basin is to ensure efficient sedimentation near the end of each dredging season as the effective overflow rate in the containment area decreases. The R&SP also provides protection for the subsequent treatment units from any upsets in the containment area which might lead to transient escape of dredged material.

A small portable dredge will be operated to recycle settled dredged material back into the containment area.

The R&SP is not a permanent containment unit. At the end of the dredging program, all of the contaminated material in the R&SP will be relocated to the containment area and the pond will be filled in and regraded.

Surge Pond - The surge pond is an earthen basin with a maximum water surface area of 2.4 acres. This pond receives weir overflow from the R&SP. Its purpose is to buffer the treatment plant units from surges in the dredging process and to provide a convenient, sediment-free point for treatment feed and recycle supply pump suctions if a recycle dredging procedure is implemented. A detailed discussion of dredging options is presented in the Containment Site Design Report.

Water Treatment Plant - The water treatment plant consists of two earthen basins, the flocculation basin and the settling basin, with maximum water surface areas of 0.1 and 1.0 acres, respectively. The plant has a capacity of 13 million gallons per day (mgd) and consists of coagulation, flocculation and sedimentation units. The purpose of the water treatment plant is to reduce PCB concentration in the dredge return flow before discharge to the river.

The water treatment plant is expected to achieve effluent suspended solids less than 4 milligrams per liter and turbidity less than 10 NTU with proper chemical doses. The average PCB concentration in the discharge is expected to be in the 10-20 microgram per liter range.

Pump Station - The pump station consists of three mixed-flow pumps each with a capacity of 4500 gallons per minute (gpm). One of the three pumps functions as a standby. The pump station's function is to provide a reasonably constant influent feed to the water treatment plant.

Leachate Collection System - The leachate collection system is a network of perforated drainage piping laid in gravel-filled, filter-cloth-lined collection trenches at the base of the containment area. The bottom of the containment area is sloped to transmit flow towards the trenches.

The leachate collection system will be utilized in two phases: short-term dewatering and long-term percolation.

A piping system connects the drainage system to a discharge point at the Hudson River.

Valves, collection and sampling wells, and a flow metering and monitoring manhole are provided to determine the quantity and concentration of PCB in the leachate. Discharge to the Hudson River will only be permitted if the observed leachate quantities and concentrations will have no adverse impact on the River. If river discharge proves unacceptable, the leachate will be stored in-place and periodically collected and treated.

Stormwater Drainage System - The stormwater drainage system will intercept and convey stormwater runoff that would have directly affected the containment site. Precipitation falling on the containment site, and on the watershed north of the containment site, will be transported by the drainage system to the Hudson River.

The components of the drainage system include a combination of swales, open channels, and closed conduits.

Access Road - An access road will be provided between Route 4 and the chemical feed building. This roadway will permit access to tank trucks delivering bulk chemicals, as well as access and parking for contractor, engineer and DEC personnel.

Chemical Feed System - The pumps, piping, tanks and dilution water needed for the chemical feed system for the treatment of the dredged slurry will be housed in a chemical feed building.

Appurtenances - Also including in the construction site requirements are electrical services, fencing, seeding, clearing and grubbing of wooded areas and monitoring wells.

Thompson Island Pool

The Thompson Island Pool is located between the Thompson Island Dam and Rogers Island. The areas to be dredged are the 20 identified hot spots (including four above Lock 7) with a volume of approximately 645,500 cu yds and 105,800 lbs of PCB (see Table 2).

Under the original program, the Thompson Island Pool hot spots were to be dredged in the first dredging season.

Lower Pools

Under the original program, the second season was to consist of dredging the five lower pools:

- Lock 6 pool
- Lock 5 pool
- Lock 4 pool

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TABLE 2

REMOVAL VOLUMES AND MASS OF PCB
PROPOSED FOR MOVEMENT TO CONTAINMENT SITE
UNDER THE ORIGINAL PROGRAM

Hot Spot Number	Location	Volume to be Removed (cubic yards)(1)	PCB Mass (pounds)	PCB Concentration in Dredged Material (μg/g)
1-4	Above Lock 7	22,800	900	24
5-20	Thompson Island Pool	622,700	104,900	96
21-27	Lock 6 Pool	88,900	4,900	31
28-35	Lock 5 Pool	296,700	33,700	65
36	Lock 4 Pool	134,200	5,000	21
37	Lock 3 Pool	137,800	11,700	48
38-40	Lock 2 Pool	149,600	8,800	33
Total		1,452,700	169,900(2)	average=67(1)
Remnant Deposits (maximum removal volumes)				
Area 3		160,900	18,500	66
Area 5		51,600	22,700	250
Total		212,500	41,200	average= 110
Dumps (Non-secure Landfills)				
Old Fort Edward		1,000	208,000	
Fort Miller		7,400	119,000	
Caputo		200	1,130-10,000	
		8,600	328,100-337,000	
DOT Spoil Areas				
Spoil Area 13		191,000	25,000	
Site 212		77,000	10,000	
Site 204 Annex		3,000	300-700	
		271,000	35,300-35,700	
Total		1,944,800	574,500-583,800	

(1) The dredged material volume and concentrations are calculated using a 36 inch removal depth which includes an overcut of essentially uncontaminated material. Contractual incentives to limit depth of cut to 24 inches could reduce removal volumes and increase concentrations.

(2) The total mass of PCB in the bed of the Upper Hudson River is estimated to be 347,200 lb. The remaining 177,300 lbs of PCB are present in "cold areas" with PCB concentrations less than 50 μg/g.

Sources: Weston (1978) MPI (1978) DEC (March 1980)
Estimates rounded to nearest 100 cubic yards or pounds

- Lock 3 pool
- Lock 2 pool

The removal volumes and associated masses of PCB for each of these pools is listed in Table 2.

Remnant Deposits

The remnant deposits are PCB-contaminated areas adjacent to the Hudson River upstream of the former Fort Edward Dam. These areas are the remains of 150 years of deposition behind the dam, exposed as dry land following dam removal in 1973. Much of the deposited material has washed downstream; those areas which remain have been designated remnant deposits.

Under the original project remnant deposit areas 3 and 5 were to be partially or completely removed and placed in the containment site during the first season of dredging. Area 3 has a complete removal volume of 160,900 cu yds containing an estimated 18,500 lbs PCB. Area 5 has a complete removal volume of 51,600 cu yds containing an estimated 22,700 lbs of PCB.

DOT Spoil Areas

Three DOT spoil sites, containing a total of 271,000 cu yds of material and approximately 35,000 lbs PCB (average concentration 50-100 μg per g) were proposed for movement to the containment site under the original program. This is material that has already been removed from the river, top dressed and seeded. The containment site was designed to have capacity for this material, though its movement was neither evaluated in the draft EIS, nor considered to be a part of the hot spot dredging program.

Dump Sites

Seven dumps in the Fort Edward area contain capacitor wastes and other concentrated PCB materials. Under the original program, an area was to be provided for the contents of the Old Fort Edward, Fort Miller and Caputo dumps (total 8,600 cu yds; 328,100 - 337,000 lbs PCB) in a segregated cell at the containment site. Movement of the dumps was not a component of the hot spot dredging program, was not evaluated in the draft EIS, and was not included in the cost estimates for the hot spot dredging project.

CRITERIA FOR RESCOPING

General

A preliminary review of the cost summary for the original 40 hot spot project shows that in order to meet the budget constraints major elements of the project will have to be deleted. Therefore, a set of criteria for inclusion in the rescoped project were defined. The major criteria discussed in this section are:

- o Maximization of PCB removal from the Hudson River
- o Program Performance
- o Cost-Effectiveness
- o Wetlands Avoidance
- o Flexibility

Maximization of PCB Removal from the Hudson River

The main objective of the project is tc stabilize the maximum amount of PCB-contaminated material thereby minimizing its uncontrolled migration. Because the remnant deposits, DOT spoil areas and dumps are more stabilized than the in-river PCB-contaminated material, this objective will be best realized by maximizing the PCB removal from the hot spots in the Hudson River.

Program Performance

The rescoped project maintains the same level of control on performance of the dredging and return flow treatment systems, and containment site design criteria as was incorporated in the original hot spot dredging program. Cost reductions have been achieved through elimination of specific project elements. The quality of design and operational controls has not been relaxed.

Cost-Effectiveness

The priority of pools for dredging has been evaluated by developing an associated cost per pound of PCB removed per pool for the dredging, transport and treatment required. Pools are prioritized for removal beginning with those which have the lowest unit cost for PCB removal and containment. This results in concentrating dredging efforts on the most readily accessible and most highly contaminated pools.

Wetlands Avoidance

PCB which is contained in wetland sediments is, in effect, stabilized in place by root systems, and is, therefore, less subject to flood scour losses, though ice scour may result in some erosion of contaminated material. Wetlands in the river did not experience significant erosion during the 100-year flood in 1973. Some sediment PCB may be dislodged or taken up by burrowing organisms, but this mechanism occurs throughout the Upper Hudson. Recent sampling of hot spot 28, the most highly contaminated wetland in the river, found above-ground leaves and stems of wetland plants to average 1-4 parts per million PCB (Buckley 1981). Though contaminated to some degree, wetlands in the river offer cover, brooding areas, and food for a variety of resident and migratory wildlife species. Biologists from DEC, MPI and the Boyce Thompson Institute have noted the biological value of these wetlands, and recommended that they not be removed. Dredging efforts will be concentrated on the less stable, and less biologically productive hot spots. Using this criteria, hot spots 25, 28, 35 and 40

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have been identified as containing significant wetlands and hence have been given a low priority for removal.

THE RESCOPED PROJECT

General

Using the above stated criteria the following modifications were made to the original project.

- o Deletion of remnant deposit relocation.
- o Provision of top dressing and fencing for remnant deposit Areas 3 and 5.
- o Elimination of provision for the containment of PCB contaminated dumps.
- o Reduction of number of hot spots to be dredged.
- o Reduction of capacity at the containment site, resulting from the above reductions in volumes of material to be encapsulated, as well as a better definition of materials handling requirements at the site.
- o Reduction in the scope of research studies.

This section will discuss these modifications, and detail the elements of the rescoped project.

Remnant Deposits

Until it is demonstrated that the remnant deposits are indeed leaching PCB, these deposits will be considered more stable than the hot spots. No remnant deposit removal is recommended at this time.

Top dressing and fencing of Areas 3 and 5 has been suggested as a means to minimize volatilization and public access.

It should be noted that a proposal to reconstruct the Fort Edward Dam is under consideration. Reestablishment of the Fort Edward Pool may affect the stability of the remnant deposits requiring consideration of capping or other measures at that time.

DOT Spoil Areas

The USEPA (1981) has advised that not all of the DOT spoil areas have been covered properly in accordance with the Toxic Substances Control Act. Although funding is not included in this program for the removal and transport of these areas to the containment site, the containment area has been designed under the rescoping project with an excess capacity that could be used to accommodate the DOT spoil areas.

Dump Sites

Under the September 23, 1980 agreement between DEC and the General Electric Co., responsibility has been delegated to General Electric and others for the remediation and long-term maintenance of these dumps. Therefore, all provisions for these dumps have been eliminated under the rescoped project.

Hot Spot Dredging

The reduced budget for the hot spot dredging program introduces increased importance to the selection of a dredging system for the Thompson Island Pool. The original program defers final selection of either a hydraulic or clamshell/pump-out system until the competitive bidding for the dredging. At that time the cost-performance characteristics of the systems could be based upon conclusive cost data.

With a reduced scope program significantly less funds will be available for the second season dredging of the lower pools. If a clamshell/pumpout system is not used at Thompson Island pool remaining funds may not allow construction and amortization of special equipment that would be required for the lower pools. The impacts of this situation should be evaluated in detail in the upcoming pre-design studies for Thompson Island Pool. Results of these studies may indicate that hydraulic dredging of Thompson Island is not feasible in the total rescoped program.

Although not evaluated in this report, the reduced hot spot dredging will tend to reduce contaminant mass emission rates resulting from project operations during the life of the program.

Thompson Island Pool - The Thompson Island pool is a clear choice for inclusion in the rescoped program. Cost analysis indicates that the dredging, transport and treatment cost per pound of PCB removed in this pool is $62. This is the lowest unit cost for any of the pools. In addition, probing and sampling programs have been more detailed in this pool than in any other, permitting confidence in the PCB location and concentration data used. Studies have also shown that the river bed materials in this pool are subject to scour, and that there is no significant conflict with wetlands in the hot spots in this pool. Finally, this pool is located closest to the containment site, facilitating transport.

Lower Pools - Based on a range of costs per cubic yard for dredging, transport and treatment, between 160,000 and 265,000 cu yds of material could be dredged in the lower pools within the budget constraints of the rescoped project.

Using the MPI estimates of contaminated volumes and PCB masses listed in Table 2, and applying the criteria discussed previously to each of the lower pools, results in the prioritization of hot spot dredging by pool as shown in Table 3.

Incorporating the range of lower pool dredging - 160,000 to 265,000 cy yds - with the volumes listed in Table 3 yields the following. Using the lower range value of 160,000 cu yds only hot spots 29-34 in the Lock 5 Pool will be dredged. Using the higher range value of 265,000 cu yds, both hot spots 29-34 in the Lock 5 Pool and approximately 80 percent of hot spot 37 in the Lock 3 Pool will be dredged. Table 4 details the hot spots to be dredged under the rescoped program.

TABLE 3

PRIORITIZATION OF HOT SPOT DREDGING BY POOL

Priority Number	Location	Hot Spots to be Dredged	Volume to be Removed (cu yds)	PCB Mass (lb)	Cost per lb PCB Dredged, Transported and Treated (1983 dollars)
1	Lock 5 Pool	29-34 (1)	155,350	22,530	$100-170
2	Lock 3 Pool	37	137,800	11,680	$180-290
3	Lock 2 Pool	38-39 (2)	67,000	5,020	$200-330
4	Lock 4 Pool	36	134,150	5,000	$400-670
5	Lock 6 Pool (4)	21-24 and (3) 26-27	55,500	2,460	$340-560 (4)

(1) Hot Spots 28 and 35 have been identified as containing significant wetlands and hence have a lower priority for removal.

(2) Hot Spot 40 has been identified as containing a significant wetland and hence has a lower priority for removal.

(3) Hot Spot 25 has been identified as a significant wetland and hence has a lower priority for removal.

(4) Lock 6 Pool is non-navigable and therefore inaccessible to dredging without special provisions incurring considerable expense. Cost per lb PCB removed does not reflect these additional costs.

Note: Prioritization was done using the MPI estimates of contaminated volumes and PCB masses listed in Table 2.

TABLE 4

RESCOPED PROGRAM

Hot Spot Dredging
High Estimate of Unit Cost

Pool	Hot Spots	Contaminated Material	
		vol, cu yd	PCB Mass, lb
Thompson Island	1 thru 20	645,500	105,800
Lock 5[(1)]	29 thru 34	155,350	22,530
		800,850	128,330

Hot Spot Dredging
Low Estimate of Unit Cost

Pool	Hot Spots	Contaminated Material	
		vol, cu yd	PCB Mass, lb
Thompson Island	1 thru 20	645,500	105,800
Lock 5[(1)]	29 thru 34	155,350	22,530
Lock 3[(2)]	37 partial	109,650	9,310
		910,500	137,640

(1) Hot Spots 28 and 35 are identified as containing significant wetlands and hence have a lower priority for removal.

(2) Partial removal will recover approximately 80 percent of in-place PCB in Hot Spot 37.

Note: All values based upon MPI estimates as presented in Draft EIS, N.Y. State Environmental Quality Review, September 1980.

Under the rescoped dredging program between 37 and 40 percent of the 347,200 pounds of PCB in the hot and cold spot in the Upper Hudson river bed will be dredged. Under the original project, 49 percent of the PCB in the river bed was expected to be dredged. The PCB masses used in calculating these percentages are the total masses of PCB associated with the volumes of material expected to be dredged. These percentages therefore do not reflect quantities of PCB missed in the dredging process, lost to the water column or returned to the river in treatment plant effluent. Earlier studies have shown that the losses in these three areas total in the range of 6 to 9 percent. A comparison of the percentage removal of PCB under the original and rescoped project is shown in Table 5.

Estimated costs for the rescoped program are presented in Table 6.

This dredging program is based upon removal of hot spots as complete units with partial removal when estimated project funds will not allow for complete removal of the last hot spot dredged. Those hot spots which contain wetland areas have been avoided.

An alternative removal program would be to make partial removal of a hot spot area on the border of a wetland and leave the wetland area undisturbed. The additional probing and sampling program proposed in 1981 will provide the detailed data necessary for developing such a removal program. Some existing additional data not used in the present analysis will also assist in such an effort.

An alternative program involving partial removal of hot spots containing wetlands may give a slightly higher removal of PCB than the rescoped program described herein. The differences, however, will not significantly change the environmental and cost impacts of alternative removal programs.

TABLE 5

PCB QUANTITIES TO BE CONTAINED UNDER THE ORIGINAL AND RESCOPED PROJECT

Location	Mass of PCB (lb)	Original Project: Mass of PCB to be Removed from Location (lb)	Original Project: % Removal of PCB from Location[1]	Rescoped Project: Mass of PCB to be Removed from Location (lb)	Rescoped Project: % Removal of PCB from Location[1]
Upper Hudson River Bed					
Hot Spots	169,900	169,900	100%	128,330-137,640	76-81%
Cold Areas	177,300	0	0%	0	0%
Subtotal	347,200	169,900	49%	128,330-137,640	37-40%
Remnant Deposits (Banks)	46,770	41,200[2]	88%	0	0
Subtotal	393,970	211,100	54%	128,330-137,640	33-35%
DOT Spoil Areas[3]	71,455-96,980	35,300-35,700[4]	37-49%	35,300-35,700[4]	37-49%
Dumps[6]	736,130-745,000	328,100-337,000[5]	44-45%	0[6]	0%
Totals	1,201,555-1,235,950	574,500-583,800	47-48%	163,630-173,340	

(1) Removal estimates do not account for quantity of PCB missed in the dredging process, to the water column during dredging, or returned to the river in treatment plant effluent.
(2) Remnant deposit areas 3 and 5 - complete removal. Partial removal options not included.
(3) Materials which are not planned for movement under rescoped project, but for which containment site capacity exists.
(4) Three DOT spoil areas - Spoil Area 13, Site 212 and Site 204 Annex.
(5) Three dumps - Old Fort Edward, Fort Miller and Caputo. See (6).
(6) All dumps to be stabilized in place under the DEC - General Electric agreement of Septemter 23, 1980.

TABLE 6

ESTIMATED COSTS FOR RESCOPED PROGRAM
(All costs in Thousand Dollars)

Phase	1981[(3)]	1982[(4)]	1983[(4)]	Total by Phase
Site Construction[(1)] and Acquisition	$3905			$ 3905
Intermediate Cover		$ 100		100
Cover Costs			$1071	1071
Site Modifications After Closure[(2)]			429	429
Remnant Deposit Areas 3 & 5 Top Dressing and Fencing	200			200
Thompson Island Pool Dredging		6534		6534
Lower Pool Hot Spots Dredging			3060	3060
Material Rehandling		221	199	420
Sub-Total	$4105	$6855	$4759	$15,719
Contingencies	371	2057	1428	3856
Engineering Design	978	800	50	1828
Probing and Sampling	500	100		600
Monitoring	600	400	400	1400
Field Engineering & Construction Administration	384	880	1078	2342
Legal & Administrative	290	305	320	915
Totals By Year	$7228	$11,397	$8035	$26,660
Total For Project				$26,660

Notes:
(1) Includes site work costs for all phases, except site modifications after closure and cover costs.
(2) Includes south dike channel, additional swale drops, and razing and regrading the roughing & storage pond, surge pond and the treatment plant basins.
(3) Escalated 13.2 percent from third quarter 1980 to mid-1981.
(4) Escalated 24 percent from 1979 to 1980, and 10 percent/year from 1980.

Containment Site

The original containment area had an approximate capacity of 2,260,000 cu yds. This provided for all 40 hot spots, remnant deposit areas 3 and 5, and the three selected DOT spoil areas. Under the rescoped project, the required containment volume was reduced due to the deletion of remnant deposit relocation and containment and the reduction in hot spot dredging. In addition, the fluff factor[1] applied to the dredged hot spot material in the Thompson Island pool was reduced due to a probing and sampling program done in this pool, autumn, 1980, by Gahagan, Bryant & Associates. For these reasons, the required containment capacity under the rescoped project is approximately 1,100,000 cu yds. This capacity is sufficient to accommodate hot spots 1 thru 20 in the Thompson Island pool, hot spots 29 thru 34 in the Lock 5 pool and hot spot 37 in the Lock 3 pool, all with the required fluff factors.

The actual capacity of the rescoped containment area was determined by reducing the size of the original containment area to a point where further reductions resulted in only minimal savings. The capacity of the rescoped containment area is approximately 1,400,000 cu yds. This additional volume of 300,000 cu yds gives the project the flexibility to accommodate any of the following:

- Containment of DOT Spoil Areas - Spoil Area 13, Site 212 and Site 204 Annex
- Partial Remnant Deposit Removal and Containment - Partial Area 3 and Complete Area 5.
- Complete remnant deposit removal - Areas 3 and 5.
- Containment of any additionally dredged hot spot materials if costs are less than expected or more monies become available.

[1] Fluff factor is defined as the ratio of volume in containment to volume in situ.

- o Provision for the occurrence of unexpectedly high fluff factors.

The funding for any removal and transport of either the DOT spoil areas and the Remnant Deposits is not included under the rescoped project.

On the basis of the rescoped containment areas reduced volume the following modifications were made to the containment site:

- o Reduction of leachate collection system
- o Revised and reduced storm water drainage system
- o Reduction of appurtenances

These reductions in the containment site result in a cost savings of $1,065,000.

The proposed two season dredging plan will still be incorporated in the rescoped project. The contaminated material dredged during the first season will be covered between the two seasons.

The Thompson Island dredged material will be placed in one half of the containment area, and capped with a permanent clay cover.

The final clay cap cover has also been reduced by the rescoped containment area.

Other areas of possible savings which will be investigated in the redesign are:

- o balancing cut and fill operations
- o lowering containment dike heights
- o using filter fabric and additional crushed stone in lieu of paving storm water drainage channels
- o leaving the roughing and storage, surge pond, and treatment pond dikes in place after completion of dredging program

OTHER PROGRAM ELEMENTS

Probing and Sampling Program

Prior to dredging any of the pools below Thompson Island, there will be a comprehensive program of probing for bottom characteristics and sampling for PCB contamination in these down pools. This additional data is essential to more precisely delineate hot spots and will be used to finalize the lower pool dredging strategy.

Sediment samples will also be taken at remnant deposit areas 3 and 5 to verify depth of contamination. In addition, additional sampling will be done in the Hudson River above and adjacent to these deposits to determine their PCB contribution to the water column.

The lower pools dredging program and any actions taken at the remnant deposits will reflect the results of these studies.

Monitoring Program

A brief description of the proposed program for monitoring the effectiveness of the dredging program follows. A more detailed description is under preparation by DEC and will be available by mid-March. The program will include two overlapping categories of monitoring, environmental and operations.

Environmental monitoring will involve atmospheric, aquatic and terrestrial sampling before, during and after the completion of dredging activities. Samples will be taken at least daily during dredging and more intensively during early phases of the project to provide supplemental operations control data. Dredged material will be regularly sampled to assure that the dredging operation is recovering contaminated material.

Environmental monitoring after the completion of dredging will record the more immediate effects of the PCB dredging program on PCB levels in the air and water; and, later, any residues on land, foliage and in animal tissues.

The following studies will be included under the environmental monitoring program:

- o Sediment Transport Monitoring
- o Hudson River Fish Flesh PCB Analysis
- o Sediment PCB Desorption Study
- o Biological (Macroinvertebrate) PCB Uptake Study
- o Foliar Contamination by PCB in Washington County Forage Crops
- o Air-Plant PCB Relationships
- o Agricultural Inplace Studies.
- o Site 10, ground water monitoring.

Operations control includes both monitoring and dredge control. The dredge phase losses, bucket losses, losses to the water column and air, and the loss of PCB in the treatment plant effluent will all be monitored. The purpose of the monitoring is not simply to record the effectiveness of the related processes, but to provide "real time" data that can increase and maintain the best attainable dredging efficiency.

RESCOPED PROGRAM SCHEDULE

In this section the assumed schedule for the rescoped project is presented:

- o Containment Site Construction (Summer 1981)
- o Sampling and Probing Program (Summer 1981) for the Lower Pools
- o Dredging Thompson Island Pool (Summer 1982)
- o Additional Sampling and Probing Program for the Lower Pools, if Required (Summer 1982)
- o Partial Closure of Containment Area (1982)
- o Dredging of some of the Lower Pools (Summer 1983)
- o Final Site closure and Site Modifications after Closure (1983)
- o Monitoring before, during and after all phases.

REFERENCES

1. Phase 1 Engineering Report, Dredging of PCB Contaminated Hot Spots, Upper Hudson River, NY, Malcolm Pirnie, Inc., (December 1978).

2. PCB in Sediments and Water, and Their Transport, New York State Department of Environmental Conservation, (March 1980).

3. Telephone conversation between Dr. E.H. Buckley, Boyce Thompson Institute, and James Catterton, MPI, (January 30, 1981).

4. Comments on PCB Hot Spot Dredging Program, Upper Hudson River, New York, Rescoping Report, USEPA, (February 1981).

APPENDIX C

Review of the Sediment Transport Model

and the PCB Ecosystem Model

Appendix C contains a review by WAPORA, Inc. of the Sediment Transport Model (Lawler, Matusky and Skelly Engineers, 1978; 1979) and the PCB Ecosystem Model (Hydroscience, Inc., 1978; 1979).

Appendix C

1. REVIEW OF LMS SEDIMENT AND TRANSPORT MODEL

A sediment and PCB transport model was developed by Lawler, Matusky & Skelly Engineers to assess the impact of the "No Action" alternative and subsequently to evaluate two "Action" alternative schemes. The results of these modeling studies are presented in two reports by Lawler, Matusky & Skelly Engineers (LMS 1978, 1979).

This review is designed to put the PCB transport in the Hudson River into perspective with the "No Action" alternative. The review is concentrated in two aspects: overall methodology and technical results.

The overall methodology adopted by Lawler, Matusky & Skelly Engineers is not clearly understood. This selection of the HEC-6 model as the basis of the sediment transport model seems adequate but without a thorough discussion of the other models available. A model review and selection process is missing from the report. Further, the linkage of the HEC-6 model and the water quality problem (in this case, PCB transport in the Hudson River) is lacking. This may be due to the lack of discussion of the goals of this modeling study. In addition, how the temporal and spatial scales of the selected model and of the water quality parameters to be addressed match is not presented.

The biggest drawback of the LMS approach of using the HEC-6 model is that the HEC-6 model is designed for alluvial stream beds while the PCBs in the Hudson River are associated with fine organic materials. The sedimentation characteristics between alluvial channels and fine-particle beds are quite different. After all, the PCBs in the hot spots are primarily associated with the fine organic particles (Hetling et al. 1978). It should be pointed out that the LMS sediment and PCB transport model have been calibrated but not verified because of lack of adequate data.

The most difficulty encountered in reviewing the LMS report is Chapter 4, Model Calibration. There are significant amounts of data analysis presented in this chapter such that it is difficult to differentiate which is data analysis and which is model calibration. Further, in most cases, the data are so scattered and not substantial. The comparison of model calculation with observation seems more like a pure model calculation. Usually, at the end of model calibration, a summary of key model parameters is presented. This particular list is missing which makes the review extremely difficult. At best, only the model segmentation list is found in Appendix D without any other parameters (such as hydrographic characteristics, at the least) used in model calibration.

It is understood that the HEC-6 model calibration was based on a relatively short time period of field survey data. In order to conduct long-term projections of PCB movement, a proper transition from short-term computation and long-term projection is required to accommodate such a change in temporal scales. The report stops short of its transition effort at statistical analyses of the Hudson River and tributary flows. The other key features of the sediment and PBC transport such as upstream boundary conditions are not specified. Subsequently, a summary of the model projection scenarios is not presented, although model projection runs were conducted for constant source, diminishing source, and flow control conditions.

Based on the above discussion, the LMS modeling is not considered a state-of-the-art approach. Additional data are required to further refine the calculations. Therefore, the results from the LMS study should not be taken as the definitive predictions of PCB transport in the Hudson River. Instead, the results can be considered as the "best" estimate and trends of PCB loadings from the upper Hudson River to the estuary. Effort should be examined to construct a rational and credible analysis of the transport and ultimate fate of PCBs in the movable bed sediment PCBs, the PCBs in the sediments, and the PCBs in the water column, in order to estimate accurate transport loads in the Hudson River.

Nevertheless, the LMS studies provide as preliminary assessment of average annual PCB loads to the estuary in terms of No-Action, Remnant Deposits Mitigation, and Hot Spot Dredging alternatives. The results of the LMS studies have been modified by WAPORA in order to reflect the effects of volatilization and routine navigational dredging in the upper Hudson River.

2. REVIEW OF HYDROSCIENCE PCB ECOSYSTEM MODEL

Hydroscience (1978, 1979) developed a food web model to simulate PCBs in the Hudson estuary ecosystem. The model was used to estimate the possible effects of remedial acton, to reduce PCB sources in the upper Hudson River, on the Hudson River ecosystem. In addition, the model was used to determine the fate of PCBs in the ecosystem of the Hudson estuary. These tasks were accomplished by analyzing the existing PCB data on the water column, various portions of the food chain and the striped bass, within the modeling framework. Projections of expected reductions were made and compared to the existing action level of 5 ug/g and the proposed action level of 2 ug/g in fish.

The analysis framework upon which the food web model was developed is at the state-of-the-art stage. With the full utilization of available data during the study period, the model provides the best estimate and range of charge in PCB levels in the Hudson estuary ecosystem which will result if the PCB water column concentrations are reduced.

The Hydroscience model was developed based on the fundamental mass balance principle in a deterministic fashion. The model has a solid scientific basis as well as sound engineering practicality. Of course, each model has its limitations. The Hydroscience model is no exception. The reports clearly describe the model assumptions and the associated limitations. As a result, it should be noted that the results from this modeling analysis are not meant to recommend any remedial actions. Instead, the modeling report indicates the necessity of a systematic data collection process program to detail the PCB concentrations in the sediments, water column, and biomass of the estuary is needed so that an additional basis will be available for estimates of the fate of PCBs.

Some key conclusions from the modeling analysis help to put the remedial action into perspective in terms of PCB levels in fish. Projections indicate that if a concentration of 0.01 ug/l was obtained in the estuary, as a result of remedial measures, then the striped bass body burden of juvenile and 4-year-old fish would decline to 4-8 ug/g depending on the assumed excretion rate. Older fish under a "worst case" would not decline below 15 ug/g. The response time to reach these levels is estimated to be 2-4 years from the time reduction in water concentration is accomplished. Significant reductions in the PCB levels in the striped bass would accompany the assumed concentration of 0.01 ug/l in the estuary water column. However, the results indicate the virtual impossibility of reducing striped bass body burdens over the near term to the level of 2 ug/g (the proposed action limit) due to the potential for high bioaccumulation in the striped bass and the ubiquitous presence of PBCs. Based upon the above conclusions, it is seen that the benefit of remedial actions (such as dredging) would not be immediately realized in fish.

3. CONCLUSIONS OF THE REVIEWS

Based on the LMS modeling results, dredging is expected to offer reduction of PCB transport into the Hudson estuary. However, the effect of dredging would not be immediately realized in fish in the estuary. In fact, the response time in fish upon extensive reduction of upstream PCB sources may vary from a year to perhaps less than a decade. However, significant evaporative losses, estuary sediment burial, and slow diffusion rates in sediment may shorten this response time. Compared to the No Action alternative which is estimated to take longer than at least a decade to flush out PCBs from fish, dredging offers a substantial reduction of response time, if not immediately.

The conclusions on fish recovery are based on the water column PCB concentrations in the estuary which, in turn, depend on the PCB transport load from the upper Hudson River into the estuary. The conclusions, therefore, hinge on the predictions of PCB transport. It was concluded earlier that the PCB transport model still needs refinement with additional calibration. It is recommended, therefore, that effort should be expended to construct a rational and credible analysis of the transport and ultimate fate of the PCBs in the estuarine water column (dissolved and particulate), the movable bed sediment PCBs, and the PCBs in the sediments, in order to estimate water column response times in the estuary under different control strategies.

Continued work is necessary to further refine the food chain model and striped bass model as the data become available, in order to provide a better understanding of PCB transfer in the ecosystem, and to improve the ability to forecast PCB responses under different environmental controls.

It is recommended that remedial action be taken to remove the PCBs in the upper Hudson River. Until then, flow control should be implemented to mitigate the storm effects which would resuspend the PCBs and further disperse the PCBs into the estuary. In the meantime, field monitoring should continue to expand the data base and to provide understanding of the problem in the Hudson River and estuary.

APPENDIX D

Cost Estimates for In-River Containment of

Hot Spots and Covering of Remnant Deposits

MPI (written communication) March 16, 1981. The cost of rock diking around hotspots 28 and 35; and sheetpiling. Memorandum from J.A. Bedard, Engineer, Malcolm Pirnie, Inc., White Plains, New York to Howard Schwartz, Project manager, WAPORA, Inc., New York, New York.

Mulligan, J.B. (written communication) March 6, 1981. Cost estimates for clay cover at remnant deposit sites 3 and 5. Correspondence from J.B. Mulligan, Engineer, Malcolm Pirnie, Inc., White Plains, New York to R.F. Thomas, Project manager, Malcolm Pirnie, Inc., White Plains, New York.

MPI (written communication) April 22, 1981. Cost comparison for dredging and alternatives to dredging; cost for incineration. Memorandum from J.A. Bedard, Engineer, Malcolm Pirnie, Inc., White Plains, New York to Howard Schwartz, Project manager, WAPORA, Inc., New York, New York.

MALCOLM PIRNIE, INC.
Consulting Environmental Engineers

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To: WAPORA
211 East 43rd St.
New York, NY
10017
Attention: Mr. Howard Schwartz

Date: April 22 1981
Re: Hudson River PCB Reclamation Project Cost Comparison for Dredging and Alternatives to Dredging; cost for Incineration

GENTLEMEN:
We are sending you ☒ Enclosed ☐ Under separate cover via ☒ EXPRESS Mail ☐ Messenger, the following items.

☐ shop drawings ☐ prints ☐ data sheets ☐ ________
☐ specifications ☐ sketches ☐ brochures ☐ ________

Our action relative to items submitted for approval has been noted on the drawings.

COPIES	PREPARED BY	REFERENCE NO	DESCRIPTION
1	MPI		Letter from RF Thomas to JG DeZolt summarizing costs dated 4/17/81. (C-43)
1	MPI		Memo from JAB to WAPORA (3/16/81) on cost of rock diking and sheetpiling (TM-4)
1	MPI		Memo - calculations by TDV 4/13/81 on cost of insitu confinement in Thompson Island Pool
1	MPI		Memo from F Crister to RF Thomas dated 4/22/81 on River Bed Material Incineration Costs

THESE ARE TRANSMITTED AS CHECKED BELOW:

☒ As requested
☐ For your use
☐ For review & comment
☐ For your information
☐ Approved
☐ Approved as Corrected
☐ Revise and Resubmit
☐ Not Approved
☐ Resubmit ____ copies for approval
☐ Submit ____ copies for distribution
☐ Return ____ corrected Prints
☐ ________

Remarks: ________

MONS 010074

Very truly yours
MALCOLM PIRNIE, INC.
by Judith A. Pickard

T-30

Copies to: RF Thomas; JC Schwerz; JG DeZolt

D-1

MALCOLM PIRNIE, INC.

Inter-Office Correspondence

To: R.F. Thomas

Date: 3/6/81

From: J.B. Mulligan JBM

Subject: Cost Estimates for Clay Cover at Remnant Deposit Sites 3 and 5

As requested by Judy Bedard, we have prepared a cost estimate for covering the above referenced remnant deposit sites to reduce PCB volatilization and the percolation of surface water into the sites. The estimate is based upon the following criteria:

- The minimum depth of clay cover practical is 18-inches;
- To prevent the cover from drying out and cracking, a 12-inch thick layer of material suitable for establishing turf will be placed over the clay cover;
- The areas will be seeded to wild grasses;
- The face of the stone fill bank and channel protection can not be effectively sealed as it must drain with changes in river depth;
- Two existing drains under a railraod spur at Area 5 presently discharge onto the site and should be extended across the site to the river using good drain pipe or a paved ditch;
- The access road at Area 3 is still useable without acquiring a new easement.
- Surface waters flowing onto both sites from the highlands away from the river does not have to be intercepted and carried around the sites but can be carried over the sites as sheet flow.

JBM;mhn

CLAY COVER COSTS

AREA 3 (6.8 Acres)

Estimate of Cost For Clay Cover = $251,000 This does not include NYSDEC costs for permits, public hearings, or project administration.

AREA 5 (5 Acres)

Estimate of Cost for Clay Cover = $180,000 This does not include NYSDEC costs for permits, public hearings or project administration.

Costs for covering these areas with organic material and providing a fence around each area ~~has~~ have been calculated under the rescoping project to be $300,000.

All of these are current costs.

MALCOLM PIRNIE, INC.
CONSULTING ENVIRONMENTAL ENGINEERS

April 17, 1981

Mr. James G. DeZolt, Project Manager
Hudson River PCB Reclamation Project
N.Y. State Dept. of Environmental
Conservation
50 Wolf Road
Albany, New York 12233

Dear Mr. DeZolt:

This will summarize cost estimates prepared by Malcolm Pirnie, Inc. for several alternatives considered in the Hudson River, PCB Reclamation Project.

1. Rock Dikes or Sheetpiling (Hot Spot 35)

   a) Hot spot dredging of 27,250 cu. yd. containing 2,090 lb. PCB has a 1980 dollar cost of $440,000 for typical second season dredging. This includes, dredging, transport and return flow treatment.

   b) Several dike (or sheetpiling) configurations were evaluated. Costs (not including annual maintenance, access or engineering and administrative costs) ranged from $370,000 to $510,000 (1980 dollars). Further evaluation will be required to determine the most feasible sections. See attached Bedard memo to WAPORA, 3/16/81 for details.

2. Top dressing and fencing of remnant deposit areas 3 and 5 is estimated at $200,000 plus contingencies, engineering and administrative costs (page 20, Scoping Report, March 1981).

C-43

2 CORPORATE PARK DRIVE • WHITE PLAINS, N.Y. 10602

3. Costs for clay cover and fencing at remnant areas 3 and 5 are given on page 3 of the Response to USEPA Comments transmitted to Mr. Manning by Mr. Thomas's letter of March 26, 1981. The value for clay cover for area 3 given on page 3 should be corrected to $400,000. The cost for clay cover for remnant deposit area 5 is $180,000.

4. A preliminary estimate of cost for a rock blanket to cover in-place hot spots is $160,000/acre of river bed covered. This system is quite preliminary and will require extensive further analysis to prove feasibility. (See attached memo TDV-4/13/81.)

5. The cost of incinerating two million cu. yds. of river bed material using current multiple hearth technology is on the order of $200,000,000.

Very truly yours,

MALCOLM PIRNIE, INC.

Richard F. Thomas, P.E.
Project Manager

RFT:hkh

cc: Robin Rohn

BY LP DATE 3/16/91 | MALCOLM PIRNIE, INC. 2 CORPORATE PARK DRIVE WHITE PLAINS, N.Y. 10602 | SHEET NO. 1 OF 2

CHKD. BY .... DATE .... | JOB NO. 266-22-1100

SUBJECT ....

MEMO

TO: WAPORA

FROM: JA EEGARD (MALCOLM PIRNIE, INC.)

SUBJECT: THE COST OF ROCK DIKING AROUND HOTSPOTS 28 AND 35; AND SHEETPILING

MR. HAROLD SCHWARTZ,

A PRELIMINARY COST ESTIMATE HAS BEEN DONE ON TWO ALTERNATIVES TO HOT SPOT DREDGING:

- THE USE OF A PERMEABLE ROCK DIKE ALONG THE EDGE OF THE HOTSPOT TO PREVENT ICE SCOUR AND TURBULENCE.
- THE USE OF SHEETPILING FOR THE SAME REASONS.

THE PURPOSE OF THE ESTIMATE WAS TO DETERMINE IF EITHER METHOD OF CONTAINMENT WAS SUBSTANTIALLY LESS COSTLY THAN DREDGING THE HOTSPOT. FOR THE PURPOSES OF THIS ESTIMATE HOT SPOT 35 WAS CHOSEN FOR SEVERAL REASONS:

- IT CONTAINS A DESIGNATED WETLAND AND THEREFORE HAS A LOW PRIORITY FOR REMOVAL.
- IT LIES ALONG THE HUDSON RIVER BANK AND THEREFORE REQUIRES DIKING ONLY ALONG ONE SIDE.
- IT LIES COMPLETELY OUT OF THE NAVIGATIONAL CHANNEL.

PRELIMINARY ESTIMATES FOR HOT SPOT 35 YIELD THE FOLLOWING:

METHOD	COST (1980 dollars)
1. DREDGING 27,250 cy includes dredging, transport to site and treatment (2090# PCB)	$327,000 - 545,000

MONS 010079

TM-4

SUBJECT ....

METHOD	COST (1980 dollars)
2. PLACING ROCK DIKING TO CONTAIN ENTIRE HOTSPOT	
a) 5 FT TOP WIDTH OF DIKE PLACED FROM BARGE	$372,000
b) 10 FT TOP WIDTH OF DIKE PLACED FROM BARGE OR SMALL TRUCK	$434,000
c) 16 FT TOP WIDTH OF DIKE PLACED FROM TRUCKS	$509,000
3. SINGLE SHEETPILING NO BRACING	$422,000

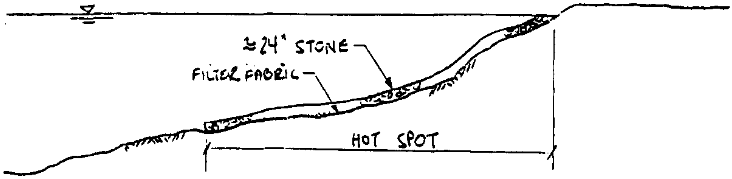
THESE COSTS DO NOT INCLUDE MAINTENANCE, ACCESS OR ENGINEERING COSTS.

SUBJECT IN-SITU CONFINEMENT OF TIP HOT SPOTS.

USING PHASE I REPORT 12/78

PLACEMENT OF FILTER FABRIC AND STONE OVER HOT SPOTS (Thompson Island Pool)

GENERAL



COSTS - STONE

=	$4.00/TON @ 1.5 TONS/Yd^3	=	$6.00/Yd^3	MATERIAL
=	$2.00/TON " "	=	$3.00/Yd^3	TRANSPORT
=		=	$21.00/Yd^3	PLACEMENT (BARGE, DUMP-
		≈	$30.00/Yd^3	

- FABRIC

=	¢ 7½ /FT^2		MATERIAL
=	¢ 90 /FT^2		PLACEMENT
		≈ $1.00/FT^2	

MONS 010081

TOTAL COST

THOMPSON ISLAND POOL HOT SPOTS #1-20 - page II-3

TOTAL AREA = 204,900 + 5,604,800 = 5,809,700 FT²

∴ = $30.00 /yd³ × (2'/27') = $2.22 /FT²

∴ = $2.22 + $1.00 + 15% cont. = $3.70/FT²

TOTAL COST = (5,809,700 FT²)($3.70/FT²) = $21,495,890

= $21,500,000

COST / ACRE = $161,172 = $160,000 /ACRE

MONS 010082

MALCOLM PIRNIE, INC.

Inter-Office Correspondence

To: RFThomas Date: 4/22/81

From: FCristea *F.C.* 266-22-1400

Subject: PCB - Hudson River - Dredged Material Incineration Costs

1. Based on the following data:
   a. Dredged material 30% water & 70% sand/silt by weight
   b. Solids contain 10% volatiles having heating value of 10,000 BTU/LB
   c. Total mass desity of 92.8 lbs/cubic foot
   d. Total volume of dredged material is 2×10^6 cubic yards
   e. Total time for a continuous operation to be five years.

2. Calculations
   a. Total weight of dredged material ....

$$2 \times 10^6 \text{ yds}^3 \times 27 \frac{\text{ft}^3}{\text{yd}^3} \times 92.8 \frac{\text{lbs}}{\text{ft}^3} = 5.01 \times 10^9 \text{ lbs}$$

   b. Total weight of dry material ....

$$2 \times 10^6 \text{ yd}^3 \times 27 \frac{\text{ft}^3}{\text{yd}^3} \times 92.8 \frac{\text{lbs}}{\text{ft}^3} \times .7 = 3.51 \times 10^9 \text{ lbs}$$

   c. Loading rate ....

$$\frac{5.01 \times 10^9 \text{ lbs}}{8760 \frac{\text{hrs}}{\text{yrs}} \times 5 \text{ yrs}} = 114,000 \text{ lbs/hr (Total mass)}$$

$$\frac{3.51 \times 10^9}{43800} = 80,000 \text{ lbs/hr (dry material)}$$

   d. Number of Incinerators required ....

$$114,000 \frac{\text{lbs}}{\text{hrs}} \div 23,000 \frac{\text{lbs}}{\text{hrs}} = 5 \text{ units}$$

   Note: Use five incinerators plus one stand-by unit
   Total = six incinerators

   e. Capital Investment costs for incinerators ....
   at $15,000,000 per unit, installed
   Total investment costs = $90,000,000
   (Includes escalation through 1984)

   f. Fuel required ....

   Fuel required for combustion at 1800°F = 898 GPM

   Fuel required for combustion at 2200°F = 1533 GPH

   Total fuel required ....

MONS 010083

At $1800^{\circ}F = 898 \frac{gal}{hrs} \times 8760 \frac{hr}{yr} \times 5 \text{ yrs} = 39 \times 10^6$ gallons

At $2200^{\circ}F = 1533 \times 8760 \times 5 = 67 \times 10^6$ gallons

Projected average cost of fuel oil during 5 year period = $1.75/gal

$$39 \times 10^6 \times \frac{\$1.75}{gal} = \$68,250,000$$

$$67 \times 10^6 \times \frac{\$1.75}{gal} = \$117,250,000$$

3. The installation of heat recovery boilers or combustion air preheaters will reduce the amount of fuel oil required significantly.

   A computer analysis was made, using a preheater to raise combustion air to $800^{\circ}F$, that calculated a fuel oil consumption of 214 gallons/hr

$$214 \frac{gal}{hr} \times 8760 \frac{hr}{yr} \times 5 \text{ yrs} = 9.37 \times 10^6 \text{ gallons}$$

$$9.37 \times 10^6 \times \frac{\$1.75}{gal} = \$16,397,500$$ (fuel savings over 5 year)

   Estimated additional capital investment costs for preheaters is $15,000,000 installed and adjusted for escalation through 1984.

4. Summary (without air preheaters) ....

	Combustion Temperature 1800°F	2200°F
Fuel required (gal)	39×10^6	67×10^6
Fuel costs $1.75/gal	$68,250,000	$117,250,000
Capital Costs:		
Incinerators	$90,000,000	$ 90,000,000
Material Handling Equip. costs	$ 9,000,000	$ 9,000,000
Estimated Labor Costs	$ 5,000,000	$ 5,000,000
	$172,250,000	$221,250,000

FC/rf

cc: RFBonner
SCSchwarz
JJTansey

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APPENDIX E

Water Quality Data

Table E-1

Classifications and Standards for Fresh Surface Waters

			DISSOLVED OXYGEN STANDARDS					COLIFORM STANDARD[1]						RADIOACTIVITY STANDARDS		
			Trout Waters			Non Trout Waters										
Classification	Best Usage	Conditions of Best Usage	Trout Waters Spawning	Min. Daily Average	Min.	Min. Daily Average	Min.	Monthly Median Value	20% of Sample	Monthly Geometric Mean	ph	Total Dissolved Solids	Phenolic Compounds	Gross Beta	Radium 226	Strontium 90
Class AA	Water supply for drinking or food processing	Waters will meet Health Department standards	7 mg/l	6 mg/l	5 mg/l	5 mg/l	4 mg/l	Less than 50/100ml Coliforms	Less than 240/100ml Coliforms	——	6.5-8.5	As low as practicable. Less than 500 mg/l	Less than 0.001 mg/l (phenol)	Less than 1000pc/l (in absence of Sr90 and alpha emitters)	Less than 3pc/l	Less than 10pc/l
Class A	Water supply for drinking or food processing	Waters will meet Health Department standards for drinking water with approved treatment	7 mg/l	6 mg/l	5 mg/l	5 mg/l	4 mg/l	Less than 5000/100ml coliforms	Less than 20,000/100ml coliforms	Less than 200/100ml fecal coliforms	6.5-8.5	As low as practicable. Less than 500 mg/l	Less than 0.005 mg/l (phenol)	Less than 1000pc/l (in absence of Sr90 and alpha emitters)	Less than 3pc/l	Less than 10pc/l
Class B	Contact recreation and other uses except water supply and food processing	——	7 mg/l	6 mg/l	5 mg/l	5 mg/l	4 mg/l	Less than[2] 2,400/100 ml coliforms	Less than[2] 5,000/100 ml coliforms	Less than[2] 200/100ml fecal coliforms	6.5-8.5	None detrimental to aquatic life. Waters currently less than 500mg/l shall remain below this limit.	——	——	——	——
Class C	Fishing and other uses except water supply, food processing and contact recreation	——	7 mg/l	6 mg/l	5 mg/l	5 mg/l	4 mg/l	——	——	Less than[2] 10,000/100ml coliforms and 2,000/100ml fecal coliforms	6.5-8.5	None detrimental to aquatic life. Waters currently less than 500mg/l shall remain below this limit.	——	——	——	——
Class D	Secondary contact recreation. Waters are not suitable for propagation of fish	Waters must be suitable for fish survival	——	——	——	——	3 mg/l	——	——	——	6.0-9.5	——	——	——	——	——
Class N	Enjoyment of water in its natural condition for whatever compatible purposes	No waste discharges whatsoever permitted without approved filtration through 200' of unconsolidated earth	Natural	Natural	Natural	Natural	Natural	Natural	Natural	Natural	Natural	Natural	——	Natural	Natural	Natural

NOTES:

1) A minimum of five examinations are required.

2) Intended to be met during all periods of disinfection.

3) Additional standards applicable to the above classifications: Turbidity-no increase that will cause a substantial visible contrast to natural conditions; Color-None from man-made sources that will be detrimental to the specified best usage of waters; Suspended, colloidal or other solids-None from any waste discharge which will cause deposition [illegible] to the best usage of waters; Oil and floating substances-No residue attributable to a waste discharge nor visible oil film nor globules of grease [illegible]; toxic wastes and deleterious substances-None that will be injurious to fish life or which will adversely affect the flavor, color or odor thereof, or impair the waters for the specified best usage of waters; Thermal discharges-No discharge which will be injurious to fish life or to make the waters unsafe or unsuitable for any classified use.

4) With reference to certain toxic substances affecting fish life, the establishment of any single numerical standard for waters of New York State would be too restrictive. There are many waters, which because of poor buffering capacity and composition will require special study to determine safe concentrations of toxic substances. However, most of the non-trout waters near industrial areas in this state will have an alkalinity of 80 milligrams per liter or above. Without considering increased or decreased toxicity from possible combinations, the following may be considered as safe stream concentrations for certain substances to comply with the above standard for this type of water. Waters of lower alkalinity must be specifically considered since the toxic effect of most pollutants will be greatly increased. Ammonia or Ammonium Compounds-Not greater than 2.0 milligrams per liter expressed as NH_3 at pH of 8.0 or above; Cyanide-Not greater than 0.1 milligrams per liter expressed as CN; Ferro or Ferricyanide-Not greater than 0.4 milligrams per liter expressed as $Fe(CN)_6$; Copper-Not greater than 0.2 milligrams per liter expressed as Cu; Zinc-Not greater than 0.3 milligrams per liter expressed as Zn; Cadmium-Not greater than 0.3 milligrams per liter expressed as Cd.

Source: MPI (1978a)

Table E-2

Water Quality Constituents, Upper Hudson River

Constituents (mg/l)	Fort Edward (M.P. 192.2) Max.	Min.	Mean	Thomson (M.P. 181.4) Max.	Min.	Mean	Schuylerville Max.	Min.	Mean	Stillwater (M.P. 165.7) Max.	Min.	Mean	Waterford (M.P. 156.0) Max.	Min.	Mean	NYS Standards(4) (Class A through D)	USEPA Recommended Criteria for Aquatic Life(5)
Dissolved Oxygen[1]	14.4	7.6	10.8	14.6	10.0	13.0				13.6	6.4	10.2	16.4	7.1	10.6	5.0 mg/l (3.0 for D)	5.0 mg/l
C.O.D.[1]	25.0	4.0	15.0	19.0	14.0	16.3				22.0	5.0	13.2	24.0	12.0	17.5		
Total Suspended Solids[1]	8	1	4	13	2	7.5				29	2	7	78	1	13	Cannot be deleterious to best use	10% reduction of norm. comp. pt.
Phosphates (as P)[1]	.22	.01	.13	.09	.06	.07				.22	.02	.07	.14	.01	.07		0.1 mg/l total P
Nitrates (as N)[1]	.70	.16	.36	.44	.32	.36				.64	.10	.39	1.10	.18	.51		90 mg/l for warmwater fish
Heavy Metals (µg/l)[2]																	
Arsenic	2.0	0.0	0.5	10.0	0.0	2.4				10.0	0.0	3.7	1.0	0.0	0.4		-
Copper	20.0	0.0	8.5	20.0	0.0	8.0				20.0	0.0	6.3	40.0	0.0	12.1	200 µg/l*	**
Mercury	2.0	<0.5	<0.7	7.0	<0.5	<1.0				3.0	<0.5	<0.75	0.0	0.4	<0.5		.05 µg/l
Lead	10.0	0.0	8.0	15.0	2.0	6.4				62.0	3.0	16.6	300.0	4.0	66.0		**
Cadmium	(1 reading)		1.0										10.0	0.0	1.6	300 µg/l*	0.4 µg/l for sens. orgs. in soft water
Chromium (tot.)	(1 reading)		0.0										20.0	0.0	1.6		100 µg/l
Cyanide	(1 reading)		10.0													100 µg/l*	5.0 µg/l
Zinc	(1 reading)		60.0										100.0	10.0	33.6	300 µg/l*	**
PCB[3] (µg/l)							2.2	0.0	0.5	2.4	0.0	0.6	1.4	0.0	0.3	Not impair fish, or best use	.001 µg/l

* For waters with greater than 60 mg/l alkalinity. In less buffered water such as the Hudson River, these limits would be lowered.

** Criterion expressed as a percent of the 96-hour LC50 (that concentration lethal to 50 percent of individuals, using a sensitive resident species).

Notes:

1. NYSDEC Water Quality Surveillance, Water Quality Statistical Summary Report 10-1-75 to 9-30-76. (Thomson results from NYSDEC Water Quality Surveillance, Raw Data Listing 10/74 to 4/75).
2. USGS Water Resources Division, Albany, NY, 1971 to 1976. Water Quality Data, Hudson River System.
3. USGS Water Resources Division, Albany, NY. Water Quality Data Water Year October 1976 to September 1977.
4. State of New York, Official Compilation Codes, Rules and Regulations, Article 2, Part 701, "Classifications and Standards of Purity."
5. USEPA, 1976. Quality Criteria for Water (pre-publication copy).

Source: MPI, 1978a

Table E-3

PERFORMANCE OF REMOVAL SYSTEMS, PCB MISSED OR LOST FOR COMPLETE HOT SPOT DREDGING PROGRAM

HYDRAULIC DREDGING OF THOMPSON ISLAND POOL HOT SPOTS CLAMSHELL DREDGING OF LOWER POOL HOT SPOTS

	Hydraulic Dredging (Thompson Island Pool) PCB Mass (lbs)	Clamshell Dredging and Hydraulic Pumpout (Lower Pools) PCB Mass (lbs): w/Recycle of Return Flow	Clamshell Dredging and Hydraulic Pumpout (Lower Pools) PCB Mass (lbs): w/o Recycle of Return Flow	Total: PCB Mass (lbs)	Total: Percent
Total PCB in Hot Spots	105,800	64,100	64,100	169,900	100
PCB Missed by Dredge					
2% with Hydraulic Dredging	2,100	-	-	5,300	3.1
5% with Clamshell Dredging	-	3,200	3,200		
PCB Lost In Dredging Process[1]					
Water Column Losses					
20% of Hydraulic Dredging Plume	420	-	-	940	0.6
20% of Clamshell Dredging Plume	-	520	520		
Resettled Losses					
80% of Hydraulic Dredging Plume	1,680	-	-	3,760	2.2
80% of Clamshell Dredging Plume	-	2,080	2,080		
PCB Lost in Return Flow Water at 10 ug/1[2]	160	20	150	180-310	0.1-0.2
Total PCB Lost to Water Column[3]	580	540	670	1120-1250	0.7
Total Hot Spot PCB Missed and Lost	4,360	5,820	5,950	10,180-10,310	6-6.1

(1) Hydraulic dredging results in 2% of the dredged PCB entrained in dredge plume; clamshell, 4%.
(2) Water treatment plant flows estimated to be 12 mgd and 1.6 mgd for these calculations.
(3) Includes losses to water column during dredging process, and losses to water column from return water flow.

Source:

TABLE E-4

SUMMARY, BED MATERIAL HEAVY METAL CONCENTRATIONS

LOCATION	Concentration in μg/g								
	As	Cd	Cr	Cu	Pb	Hg	Ni	Ag	Zn
Fort Edward[1]-East Channel (RM 194.2-194.3)	ND	0.78	9.1	21.2	18.2	0.17	7.4	NM	50.6
		1.0	12.9	18.9	26.7	0.11	8.7		53.2
		0.95	7.7	16.1	19.2	0.10	10.2		52.8
West Channel	ND	0.46	8.4	19.0	18.5	0.06	6.9	NM	43.3
(RM 194.3-194.4)		0.76	23.7	29.9	77.5	0.10	9.9		57.8
Buoy 214 (RM 192.4)[2]	2.1	1.1	255	35	150	NM	16.5	NM	150
Thompson Island Pool[2] (RM 188.4)	1.9	27	450	53	375	NM	24	NM	245
Moses Kill (RM 189.1)[3]									
50 Barrel Sample	4	16	560	100	440	0.1	40	26	360
40 Barrel Sample	4	35	825	150	840	1	41	125	680
Northumberland (RM 183.5)[2]	1.2	4.4	42	3.2	180	NM	NM	NM	180
Buoy 212 (RM 192.3)[4]	NM	6.0	27	25	77	NM	NM	NM	88
Representative Bed Material Concentrations, Thompson Island Pool [5]	3	30	500	100	500	0.5	30	80	500

ND = None Detected, NM = Not Measured

[1] Malcolm Pirnie, Inc., Environmental Assessment-Maintenance Dredging Champlain Canal, Fort Edward Terminal Channel, p. III-21, (1977)

[2] Tofflemire, T.J., DEC, Preliminary Report on Sediment Characteristics and Water Column Interactions Relative to Dredging the Upper Hudson River, (1976)

[3] General Electric Corp., Corporate Research and Development, Laboratory Data Sheet (September 9, 1977).

[4] Tofflemire, T.J., DEC, "Buoy 212 Dredging-Update and Conclusions," Memorandum to Mr. Mt. Pleasant, (January 1977)

[5] Based on a subjective analysis of the existing data for Thompson Island Pool as presented above

Table E-5

PROJECTED INCREASES IN AMBIENT HEAVY METAL CONCENTRATIONS FROM DREDGEHEAD LOSSES ONLY; HYDRAULIC VS. CLAMSHELL DREDGES

All values µg/l except concentration in bed materials, mg/g

Element	Hydraulic Dredge: Representative Concentration in Bed Materials[1]	Hydraulic Dredge: Estimated Initial Increase Above Ambient[2]	Hydraulic Dredge: Settling Factor[3]	Hydraulic Dredge: Estimated Final Increase Above Ambient	Clamshell Dredge: Estimated Initial Increase Above Ambient[2]	Clamshell Dredge: Settling Factor[3]	Clamshell Dredge: Estimated Final Increase Above Ambient	Ambient background levels-range and average[4]	Estimated Cumulative Ambient Range: Hydr.	Estimated Cumulative Ambient Range: Clmsl.	NYSDEC Certification Standards
Arsenic	3	0.1	0.5	0.1	0.2	0.5	0.1	0.0 - 1.0 (0.4)	0.1- 1.1	0.1- 1.1	50
Cadmium	30	0.8	0.5	0.4	1.0	0.5	0.5	0.0 - 10.0 (1.6)	0.4- 10.4	0.5- 10.5	10
Chromium	500	11.4	0.5	5.7	17.2	0.5	8.6	0.0 - 20.0 (8.6)	5.7- 25.7	8.6- 28.6	50
Copper	100	2.2	0.5	1.1	3.4	0.5	1.7	0.0 - 40.0 (12.1)	1.1- 41.1	1.7- 41.7	200
Lead	500	11.4	0.5	5.7	17.2	0.5	8.6	4.0 - 300.0 (66.8)	9.7- 305.7	12.6- 308.6	30
Mercury	0.5	0.0	0.5	0.0	0.0	0.5	0.0	0.4 - 0.8 (0.5)	0.4- 0.8	0.4- 0.8	2
Nickel	30	0.8	0.5	0.4	1.0	0.5	0.5	Not measured	-	-	2500
Silver	80	1.8	0.5	0.9	2.8	0.5	1.4	Not measured	-	-	-
Zinc	500	11.4	0.5	5.7	17.2	0.5	8.6	10.0 - 100.0 (33.6)	15.7- 105.7	18.6- 108.6	300

1. Based on a range of bed material values sampled by NYSDEC, General Electric Co., and Malcolm Pirnie, Inc. (see Table IV-1).
2. Based on in-situ metal levels presented above, 2 and 4 percent loss rates for the hydraulic and clamshell dredges, respectively, and complete dilution of the plume at 3000 cfs.
3. Derived from 2 jar tests performed on Northumberland bed materials without flocculation or filtration of supernatant (Tofflemire, T.J., DEC, Preliminary Report on Sediment Characteristics and Water Column Interactions Relative to Dredging the Upper Hudson River for PCB Removal, 1976.) See Appendix F.
4. Measured at Waterford. USGS Water Resources Division, Albany, N.Y. Water Quality Data, Hudson River.

Table E-6

CHANGES IN AMBIENT WATER QUALITY AS A RESULT OF COMBINED ESTIMATES OF RETURN FLOW LOSSES AND DREDGEHEAD LOSSES (ALL UNITS μg/l)

	Hydraulic Dredge				Clamshell Dredge					
Measurement	Concentration in return flow[1]	Estimated increase above ambient from return flow[4]	Estimated increase above ambient from dredgehead	Total increase	Concentration in return flow[1]	Estimated increase above ambient from return flow[4]	Estimated increase above ambient from dredgehead	Total increase	Background Range, Waterford	Ambient NYSDEC Certification Standards[1]
PCB	100	2.0 (0.1)	0.2	2.2 (0.3)	100	0.1 (0.0)	0.4	0.5 (0.4)	0.0- 1.4[2]	0.5
Arsenic	500	10	0.1	9.9	500	0.5	0.1	0.6	0.0- 1.0[3]	50
Cadmium	100	2.0	0.4	2.4	100	0.1	0.5	0.6	0.0- 10.0[3]	10
Chromium	500	10	5.7	15.4	500	0.5	8.6	9.1	0.0- 20.0[3]	50
Copper	2,000	40	1.1	40.3	2,000	2	1.7	3.8	0.0- 40.0[3]	200
Lead	300	6	5.7	11.5	300	0.3	8.6	8.9	4.0-300.0[3]	30
Mercury	20	0.4	0.0	0.4	20	0.02	0.0	0.02	0.4- 0.8[3]	2
Nickel	25,000	500	0.4	490	25,000	25	0.5	26.3	Not measured	25,000
Zinc	3,000	60	5.7	64.4	3,000	3	8.6	11.7	10.0-100.0[3]	300

References:

1. Based on NYSDEC certification of NYSDOT 10 year maintenance dredging program for Champlain Barge Canal and Hudson River.
2. USGS, Water Resources Division. Hudson River at Waterford, N.Y. Route 4 Bridge. Water Year October 1976 to September 1977.
3. USGS, Water Resources Division. Water Quality Surveillance Network, Trace Metal Analysis. Station 11-003 at Waterford. April 1975 to July 1976.
4. Without carbon adsorption treatment of return flow. Carbon adsorption estimates for PCB in parenthesis.

TABLE E-7

NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS

Subpart B-Maximum Contaminant Levels

Section 141.11 Maximum contaminant levels for inorganic Chemicals.

(a) The maximum contaminant level for nitrate is applicable to both community water systems and non-community water systems. The levels for the other inorganix chemicals apply only to community water systems. Compliance with maximum contaminant levels for inorganic chemicals is calculated pursuant to {141.23.

(b) The following are the maximum contaminant levels for inorganic chemicals other than fluoride:

Contaminant	Level, milligrams per liter
Arsenic	0.05
Barium	1
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.
Selenium	0.01
Silver	0.05

(c) When the annual average of the maximum daily air temperatures for the location in which the community water system is situated is the following, the maximum contaminant levels for fluoride are:

Temperature Degrees Fahrenheit	Degrees Celsius	Level, milligrams per liter
53.7 and below	12.0 and below	2.4
53.8 to 58.3	12.1 to 14.6	2.2
58.4 to 63.8	14.7 to 17.6	2.0
63.9 to 70.6	17.7 to 21.4	1.8
70.7 to 79.2	21.5 to 26.2	1.6
79.3 to 90.5	26.3 to 32.5	1.4

Section 141.12 Maximum contaminant levels for organic chemicals.

The following are the maximum contaminant levels for organix chemicals. They apply only to community water systems. Compliance with maximum contaminant levels for organix chemicals is calculated pursuant to { 141.24.

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Table E-7 (Continued)

		Level, milligrams per liter
(a)	Chlorinated hydrocarbons:	
	Endrin (1, 2, 3, 4, 10, 10-hexachloro-6,7-epoxy-1,4, 4a 5,6,7,8, 8a-octahydro-1, 4-endo, endo-5, 8-dimethano naphthalene).	0.0002
	Lindane (1, 2, 3, 4, 5, 6-hexachlorcyclohexane, gamma isomer).	0.004
	Methoxychlor (1, 1, 1-Trichloroethane). 2, 2-bis (p-methoxyphenyl).	0.1
	Toxaphene ($C_{10}H_{10}Sl_8$-Technical chlorinated camphene, 67-69 percent chlorine).	0.005
(b)	Chlorophenoxy:	
	2, 4 - D, (2, 4-Dichlorophenoxyacetic acid).	0.1
	2, 4, 5-TP Silvex (2, 4, 5-Trichlorophenoxypropionic acid).	0.01

Source: U.S. EPA, 1976

TABLE E-8

NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS

§143.3 Secondary Maximum Contaminant Levels.

The Secondary Maximum Contaminant Levels for public water systems are as follows:

Contaminant	Level
Chloride........................	250 mg/l
Color...........................	15 Color Units
Copper..........................	1 mg/l
Corrosivity.....................	Non-Corrosive
Foaming Agents..................	0.5 mg/l
Iron............................	0.3 mg/l
Manganese.......................	0.05 mg/l
Odor............................	3 Threshold Odor Number
pH..............................	6.5-8.5
Sulfate.........................	250 mg/l
Total Dissolved Solids (TDS)....	500 mg/l

These levels repreeent reasonable goals for drinking water quality. The States may establish higher or lower levels which may be appropriate dependent upon local conditions such as unavailability of alternate source water or other compelling factors, provided that public health and welfare are not adversely affected.

MONS 010094

Source: U.S. EPA, 1979

APPENDIX F

The Hudson River Fish Fauna

Smith, C. Lavett. 1977. The Hudson River fish fauna. In: McKeon, Warren H. and Gerald J. Lauer (eds.) Hudson River ecology. Proceedings of a symposium. Hudson River Environmental Society Paper No. 32. 12 pp.

THE HUDSON RIVER FISH FAUNA

C. Lavett Smith
The American Museum of Natural History, New York

Because of its morphometry and geographical location, the Hudson River drainage is inhabited by extraordinarily rich fish fauna. About 120 fish species have been recorded in the literature as occurring in the Hudson River system and recent collecting has pushed the total to more than 130. In spite of the changes brought about by human uses and abuses of the river, there are more different kinds of fishes in the Hudson now than there were when Henry Hudson arrived in 1609. There have been a number of successful introductions, but there are no convincingly documented examples of any species becoming extinct, although some have not been reported for a long time and the ranges of others have been severely restricted.

INTRODUCTION

Like other large rivers, the Hudson has been badly neglected and our knowledge of its fishes is far from complete. Large rivers are singularly difficult to sample because depth and current prohibit some types of gear and rough bottom restricts the use of others. Furthermore, there has been a lack of interest in the fishing resources of the Hudson for political and economic reasons so that little effort has been directed to the scientific study of its fishes.

The Hudson River fish fauna is a young one. The entire drainage was covered by glaciers during the Wisconsin glacial interval, hence the fauna can be no older than 10,000 years. It has, however, been pointed out that sections of what is now the Hudson Canyon would have been uncovered by Pleistocene sea-level lowering and may have served as a refugium from which some fishes could have repopulated the present-day basin as soon as the glacial front began to retreat (Cole, 1967). Glacial drainage patterns also provided access to the Hudson basin from the Gulf of Mexico drainage and this, more than any other single factor, accounts for the richness of the Hudson River fish fauna.

HUDSON RIVER GEOGRAPHY AND FISH HABITATS

The upper Hudson, from its source streams in the Adirondacks to about the Glen, is a fast-flowing cool, oligotrophic stream. The granitic rocks are poor in calcium and relatively insoluable so that minerals are limited. This region lies within the boundaries of the Adirondack Park and is well forested so that runoff is naturally controlled.

Between the Glen and Troy, the River flows more slowly and the underlying rocks provide more nutrients. Between Warrensburg and Troy, a series of natural waterfalls has been augmented and harnessed for hydro and hydroelectric power, which has created a series of slow water environments. Major tributaries, including the Schroon, the Sacandaga, the Batten Kill, the Hoosic and the Mohawk, provide still more diverse fish habitat. Here too, the Hudson is joined by two major canals, the Champlain-Hudson Canal (opened in 1819) that connects with the St. Lawrence River and the New York Barge Canal, the present-day version of the Erie Canal which first connected the Hudson with the upper Great Lakes in 1825 (Hubbs and Lagler, 1947:6).

From the Troy lock to the Verrazano Narrows, the Hudson River is a long, narrow tidal estuary. Except for the Cornwall to Verplanck section where it passes through the Hudson Highlands, it proceeds southwards in almost a straight line. All of the estuary is tidal, but the salt wedge extends upstream only to the vicinity of Newburgh, its exact limit varying according to the amount of freshwater coming downstream.

In spite of its straightness and austere appearance on the charts, the lower Hudson presents a wide spectrum of fish habitats. Islands, tributary streams, shallow flats deep channels and bays that have been partially walled-off by railroad beds provide rich and varied cover for fishes and their food organisms. Much of the shoreline is protected by stone rip-rap that provides excellent she ter for small fishes.

Although it would appear that the Hudson River is divided into well-defined fish habitats, the fishes themselves do not recognize such sharp distinctions. While it is generally true that the small creeks of the Adirondacks are dominated by brook trout and blacknose dace, and the lowe Hudson contains such marine species as anchovies and bluefish, there are no really pronounced faunal breaks. Many species have a wide range in the River - the yellow perch white suckers and golden shiners, for example, are taken in small Adirondack streams and also in the main River at Haverstraw. Most species have preferred habitats in whicl they reach their greatest abundance and marginal habitats where they exist as minor components of the community. Thus, a complete study of their distribution must also include information on relative and absolute abundance. Unfortunately, it is frequently the unusual or stray indiviual that finds its way into museum collections, and for this reason a plot of recorded occurrences often does not give a true picture of the species range.

FISH DISTRIBUTION PATTERNS

MARINE AND EURYHALINE FISHES

Numerous marine fishes enter the lower Hudson and travel upstream varying distances depending on their ability to tolerate freshwater. Some are present throughout much of the year; others come in only at certain seasons. Still others are strays or wanderers and are recorded only sporadically. In theory, almost any species from the North Atlantic, or even the West Indies, might at sometime enter the lower reaches of the Hudson, and new records will appear as long as we continue to study the River.

A. Marine and Euryhaline Species Commonly Taken in the Hudson

The jack crevalle, Caranx hippos, is an example of a marine fish that is frequently taken in the River during later summer and early fall. Like the bluefish (Pomatomus saltatrix), the weakfish (Cynoscion regalis) and the silver perch (Bairdiella chrysura), it appears to enter the River in numbers only when young. Most of the jack crevalle are less than 6" long and presumably are less than one year old.

Other marine and brackish water fishes common in the lower Hudson are:

Brevoortia tyrannus	Atlantic menhaden
Anchoa mitchilli	Bay anchovy
Strongylura marina	Atlantic needlefish
Fundulus heteroclitus	Mummichog
Menidia menidia	Atlantic silverside
Menidia beryllina	Tidewater silverside
Syngnathus fuscus	Northern pipefish
Apeltes quadracus	Fourspine stickleback
Morone americana	White perch
Pomatomus saltatrix	Bluefish
Lutjanus griseus	Gray snapper
Leiostomus xanthurus	Spot
Mugil cephalus	Striped mullet
Paralichthys dentatus	Summer flounder (fluke)
Pseudopleuronectes americanus	Winter flounder
Trinectes maculatus	Hogchoker

Of these, Apeltes quadracus, Morone americanus and Trinectes maculatus are able to tolerate freshwater for extended periods and range well upstream. Lutjanus griseus is a West Indian species, once recorded from near Tarrytown (Boyle, 1968:33).

B. In contrast to these regular inhabitants, some other marine species are rare or sporadic in the lower Hudson and have only been taken on one or a few occasions:

Carcharhinus obscurus	Dusky shark
Raja laevis	Barndoor skate
Gadus morhua	Atlantic cod
Merluccius bilinearis	Silver hake
Fundulus majalis	Striped killifish
Membras martinica	Rough silverside
Hippocampus erectus	Lined seahorse
Pungitius pungitius	Ninespine stickleback
Gasterosteus aculeatus	Threespine stickleback
Myoxocephalus octo-decemspinosus	Longhorn sculpin
Rachycentron canadum	Cobia
Lutjanus griseus	Gray snapper
Micropogon undulatus	Atlantic croaker
Peprilus triancanthus	Butterfish

C. Some of the best known Hudson River fishes are diadromous forms that spend part of their life cycle in freshwater and part in salt. The American eel, *Anguilla rostrata*, is a catadromous species that must return to the sea to spawn. Juvenile and adult eels are extremely abundant in the lower Hudson and even up into the Mohawk River, where there was formerly a considerable fishery for eels.

Three herrings, the American shad (*Alosa sapidissima*), the blueback (*Alosa aestivalis*) and the alewife (*Alosa pseudoharengus*), are well known for their spring spawning runs, as is the striped bass (*Morone saxatilis*). During the late fall and winter months, the tomcod (*Microgadus tomcod*) moves into the River to spawn.

Other anadromous fishes are:

Petromyzon marinus	Sea lamprey
Acipenser brevirostrum	Shortnose sturgeon
Acipenser oxyrhynchus	Atlantic sturgeon
Osmerus mordax	Rainbow smelt

Although there are a few early records of Atlantic salmon, *Salmo salar*, entering the River, it is doubtful that the Hudson was ever a salmon stream (Boyle, 1969:39-41).

FRESHWATER FISHES

The freshwater fishes of the Hudson River pose some interesting distribution problems. Introductions - both deliberate and accidental - occurred early in our history, in many cases long before there was any attempt to determine the original ranges of the species in question.

A. Lake-Dwelling Species

The lake trout (Salvelinus namaycush Walbaum), the round whitefish (Prosopium cylindraceum Pallas), and the lake whitefish (Coregonus artedii Lesueur) are apparently native species, having invaded the region through glacial outlets and lakes at the end of the Pleistocene. Their habitat requirements restrict them to lakes rather than streams.

B. Wide-Ranging Stream and River Species

The following list includes species that are generally distributed on the Atlantic coast and occur in stream drainages on each side of the Hudson. Their presence is, therefore, expected and, in general, they offer no clues as to the corridor by which they invaded the Hudson River drainage.

Lampetra lamottei	American brook lamprey
Dorosoma cepedianum	Gizzard shad
Salvelinus fontinalis	Brook trout
Esox niger	Chain pickerel
Esox americanus americanus	Redfin pickerel
Erimyzon oblongus	Creek chubsucker
Catostomus commersoni	White sucker
Hypentelium nigricans	Northern hog sucker
Notemigonus crysoleucas	Golden shiner
Exoglossum maxillingua	Cutlips minnow
Semotilus corporalis	Fallfish
Semotilus margarita	Pearl dace
Semotilus atromaculatus	Creekchub
Rhinichthys cataractae	Longnose dace
Rhinichthys atratulus	Blacknose dace
Phoxinus eos	Northern redbelly dace
Pimephales notatus	Bluntnose minnow
Notropis hudsonius	Spottail shiner

Notropis cornutas	Common shiner
Notropis bifrenatus	Bridle shiner
Hybognathus nuchalis regius	Silvery minnow
Ictalurus nebulosus	Brown bullhead
Ictalurus natalis	Yellow bullhead
Percopsis omiscomaycus	Trout-perch
Fundulus diaphanus	Banded killifish
Culaea inconstans	Brook stickleback
Enneacanthus obesus	Banded sunfish
Lepomis auritus	Redbreast sunfish
Lepomis gibbosus	Pumpkinseed
Perca flavescens	Yellow perch
Stizostedion vitreum vitreum	Walleye
Percina caprodes	Logperch
Etheostoma olmstedi	Tessellated darter
Cottus cognatus	Shiny sculpin

The gizzard shad, Dorosoma cepedianum, is of particular interest because it has only recently been taken in the River (Dew, in press). Whether it arrived via the Champlain-Hudson Canal, the barge canal or along the coast is not obvious.

C. Northern Species Reaching Their Southern Limits In Or Near the Hudson

Some of these species occur only in headwater tributaries and were presumably able to become established through glacial outlets as the ice receded. Probably they are habitat (temperature?) limited. The range of Hybognathus hankinsoni Hubbs, for example, extends from the Missouri drainage of Colorado, Wyoming and Montana across Nebraska and The Dakotas, Wisconsin, Iowa, Northern Illinois, Michigan and Southern Ontario to the Adirondack region of New York (Bailey, 1954). Others have even broader ranges. The longnose sucker, Catostomus catostomus Forster, occurs in eastern Siberia as well as most of Canada and the Northern United States.

Esox lucius	Northern pike
Catostomus catostomus	Longnose sucker
Moxostoma macrolepidotum	Shorthead redhorse
Couesius plumbeus	Lake chub
Phoxinus neogaeus	Finescale dace
Pimephales promelas	Fathead minnow

Hybognathus hankinsoni	Brassy minnow
Notropis heterolepis	Blacknose shiner
Notropis heterodon	Blackchin shiner

D. Species That Reach Their Northeastern Limit in the Hudson

There are species of the Atlantic coastal plain that have not extended their range north or east of the Hudson Valley. Possibly they are temperature limited, but other explanations cannot be ruled out at this time.

Umbra pygmaea	Eastern mudminnow
Notropis chalybaeus	Ironcolor shiner
Ictalurus catus	White catfish
Noturus insignis	Margined madtom
Noturus gyrinus	Tadpole madtom
Acantharchus pomotis	Mud sunfish
Enneacanthus gloriosus	Bluespotted sunfish

E. Two other species, the rosyface shiner (Notropis rubellus) and the spotfin shiner (Notropis spilopterus) have wide ranges in the Mississippi and Great Lakes drainage and on the Atlantic coast when N. spilopterus occurs in the Susquehanna, Delaware and Hudson basins, and N. rubellus is found south to the James River. They have not, however, extended their ranges to the east.

F. Introduced Species

Species that are not native to Northeastern North America are clearly introduced, but there are some species that occur in nearby drainages and may or may not have been introduced. I believe that the following species were intentionally introduced into the Hudson River system.

Salmo salar	Atlantic salmon
Salmo trutta	Brown trout
Salmo gairdneri	Rainbow trout
Carassius auratus	Goldfish
Cyprinus carpio	Carp
Micropterus dolomieui	Smallmouth bass
Micropterus salmoides	Largemouth bass
Pomoxis annularis	White crappie
Pomoxis nigromaculatus	Black crappie

Ambloplites rupestris	Rock bass
Lepomis macrochirus	Bluegill

The restricted occurrence of the green sunfish, Lepomis cyanellus, in the New Croton Reservoir, and the warmouth, Lepomis gulosus, in the Sawkill near Anandale, strongly suggests that they were accidentally introduced (Greeley, 1937:102-103).

Finally, there are several species whose presence in the Hudson drainage may have resulted from their moving through canals. Most canals, however, follow ancient stream connections and glacial outlets, and for this reason we cannot always be certain that the species was absent before the canal was built. Thus, Gibbs (1963:525) interpreted the presence of Notropis analostanus in the Mohawk-Hudson as "evidence in favor of a formerly wider distribution in New York, for the species probably entered that river system when it was the outlet for the waters of glacial Lake Lundy or Lake Iroquois." In contrast, Snelson (1968:796) states, "There are two alternate explanations for the widespread occurrence of Notropis atherinoides in the Mohawk-Hudson system. Transfer could have been via the Mohawk outlet which shunted water from glacial Lake Vanuxem down the Mohawk-Hudson Valley. . . . Just as likely, however, is the hypothesis that Notropis atherinoides more recently entered the Hudson drainage via the Erie Barge Canal system which was opened as a continuous waterway connecting the Finger Lakes - Lake Ontario drainage with the Mohawk-Hudson drainage in 1825."

Western species that probably gained access through the Erie Canal are:

Umbra limi	Central mudminnow
Notropis atherinoides	Emerald shiner
Clinostomus elongatus	Redside dace
Labidesthes sicculus	Brook silverside
Etheostoma blennioides	Greenside darter

Species that could have entered through the Erie Canal or through the Champlain-Hudson Canal, since they occur in the St. Laurence River.

Noturus flavus	Stonecat
Morone chrysops	White bass
Etheostoma flabellare	Fantail darter

The hornyhead chub, *Nocomis biguttatus*, reaches its eastern limit in the Mohawk system, where Hubbs and Lagler (1947) considered it to be native.

Three species are known only from western tributaries of the lower Hudson with a few records from the River itself. They are *Notropis amoenus*, *Notropis analostanus* and *Percina peltata*. These may have entered the Hudson drainage by stream capture where the Wallkill reversed its flow from the Delaware drainage to the Hudson drainage. One must also consider the possibility that they gained access through the Delaware-Hudson Canal.

SUMMARY

In addition to its well-known commercial and sport fishes, the Hudson River basin contains a wide variety of smaller fishes that serve to indicate the dispersal routes through which the fishes repopulated the River after the retreat of the last Wisconsin glacier.

More than 100 species live in the Mohawk-Hudson system and twenty-two additional species have been reported so infrequently that they can be considered visitors, although our present knowledge is quite sketchy and this juugement may be modified in the near future.

The origin and distribution of Hudson-Mohawk fishes can be summarized as follows:

	# Species
MARINE AND BRACKISH WATER SPECIES	
A. Common (Residents at least part of the year)	20
B. Rare (Transients)	22
C. Diadromous	10
FRESHWATER SPECIES	
A. Lake-Dwelling Species	4
B. Wide-Ranging Species	34
C. Northern Species	9
D. Atlantic Drainage (reaching northern limit in the Hudson)	7
E. Western (Mississippi Drainage)	2
F. Introduced Species	
1. deliberately introduced	11
2. accidentally introduced	2
3. canal introduction	

a.	Erie Canal	5
b.	Champlain-Hudson or Erie	3
c.	Erie Canal or native	1
d.	Wallkill or Delaware-Hudson Canal	3
		133

While introductions have increased the faunal list, other human influences (such as impoundments and eutrophication due to domestic sewage and other fertilizers) have tended to favor the most tolerant species at the expense of others. The concept of diversity should include equitable distribution of numbers. Although there are more kinds of fish in the River today, the overwhelming preponderance of a few species (carp, white perch, striped bass, sunfish) means that the fishes are actually less diverse than they were in primeval times. Lower diversity is generally a sign of a deteriorating environment, at least in terms of aesthetics.

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TABLE I: Taxonomic Distribution of the Hudson River Fish Fauna (includes some unpublished records)

Family	Number of Species
Petromyzontidae	2
Carcharinidae	1
Rajidae	1
Acipenseridae	2
Anguillidae	1
Clupeidae	5
Engraulidae	1
Salmonidae	8
Osmeridae	1
Esocidae	3
Umbridae	2
Catostomidae	5
Cyprinidae	28
Ictaluridae	6
Percopsidae	1
Gadidae	4
Ophidiidae	1
Belonidae	1
Cyprinodontidae	3
Atherinidae	4
Syngnathidae	2
Gasterosteidae	4
Percichthyidae	3
Lutjanidae	1
Centrarchidae	13
Percidae	7
Pomatomidae	1
Rachycentridae	1
Carangidae	3
Sciaenidae	4
Labridae	1
Mugilidae	1
Stromatidae	1
Cottidae	2
Bothidae	3
Pleuronectidae	1
Soleidae	1
Tetraodontidae	1

APPENDIX G

Hudson River Fish PCB Analysis

1979 and 1980 Samples

New York State Department of Environmental Conservation, unpublished data, Hudson River PCB analysis - 1979 and 1980 samples. Albany, New York.

HUDSON RIVER PCB ANALYSES - 1980 SAMPLES

LOCATION	SPECIES	NUMBER ANALYZED	NO. OF ANALYSES	AVERAGE LENGTH (mm)	LENGTH RANGE (mm)	AVERAGE WEIGHT (g)	WEIGHT RANGE (g)	AVERAGE LIPID (%)	LIPID RANGE (%)	AVERAGE PCB (ppm)	PCB RANGE (ppm)
Catskill	Redbreast Sunfish 7/30/80	20	20	179	160-194	135	100-200	1.7	<0.1-12.0	2.64	<0.30- 25.11
	American shad (4/29)	30	30	516	459-565	1652	1100-2120	11.3	5.4-17.4	1.79	< 0.52-4.04
	Roe	7	3	527	506-545	1769	1550-1920	1.4	1.3-1.6	< 0.42	< 0.34-<0.44
	American shad (5/15)	1	1	443	--	790	--	3.9	--	0.96	--
	Largemouth bass (5/23)	20	20	321	260-410	632	230-1365	0.4	0.1-2.6	<1.08	< 0.30-3.10
	Yellow perch (5/23)	10	10	229	169-325	164	70-395	0.2	0.1-0.5	< 0.98	< 0.30-4.82
	Chain pickerel(5/23)	2	2	386	345-428	382	230-535	0.2	0.1-0.2	< 0.98	< 0.43-1.53
	Walleye (5/23)	1	1	514	--	1710	--	1.7	--	5.61	--
Poughkeepsie	American shad (5/9)	29	29	519	463-559	1762	1160-2360	12.1	3.3-19.2	1.42	0.63-3.87
	Roe	7	3	517	449-547	1786	1560-1970	0.9	0.8-1.0	< 0.32	< 0.32-<0.35
Newburgh	Pumpkinseed (Age 1+) 9/6/80	75	25	--	--	27	--	4.9	3.2-6.2	4.63	2.20- 7.23
Peekskill	American shad (5/7)	31	31	529	476-582	1916	1500-2490	12.3	5.1-16.8	1.27	< 0.54-3.49
	Roe	7	3	529	501-561	1937	1700-2490	2.1	1.2-2.4	< 0.30	< 0.30-<0.30
Indian Point	American eel (10/28)	6	6	357	306-452	110	70-180	4.8	0.9-11.3	9.07	2.14-23.05
Tappan Zee ge	American shad (5/8)	30	30	516	445-580	1806	1450-2480	12.7	7.0-18.6	1.55	< 0.52-3.94
	Roe	7	3	525	490-546	1984	1690-2300	0.9	0.7-1.9	< 0.30	< 0.30-<0.30

HUDSON RIVER PCB ANALYSES - 1980 SAMPLES

LOCATION	SPECIES	NUMBER ANALYZED	NO. OF ANALYSES	AVERAGE LENGTH (mm)	LENGTH RANGE (mm)	AVERAGE WEIGHT (g)	WEIGHT RANGE (g)	AVERAGE LIPID (%)	LIPID RANGE (%)	AVERAGE PCB (ppm)	PCB RANGE (ppm)
above Feeder Dam	Pumpkinseed (Age 1+) 9/9/80	72	24	--	--	18	--	3.9	3.3-4.6	<0.60	<0.46- <0.87
Stillwater	Brown Bullhead 6/23/80	30	30	265	240-299	235	155-355	0.9	0.3-2.5	12.34	3.50- 30.11
	Yellow Perch 6/23/80	7	7	213	187-261	134	90-220	0.1	<0.1-0.1	<0.84	<0.33- 2.15
	Largemouth Bass 6/23/80	26	26	267	126-396	400	35-990	0.5	0.1-2.6	10.16	1.67- 66.78
	Pumpkinseed (Age 1+) 9/10/80	75	25	--	--	19	--	3.2	1.9-4.5	20.12	14.80- 29.48
	Goldfish 6/23/80	30	30	247	220-289	306	170-485	6.7	0.6-18.7	72.62	11.47-267.61
Albany/Troy	Brown Bullhead 7/29/80	21	21	233	178-335	226	110-600	1.4	0.1-5.6	2.09	< 0.30- 3.96
	Pumpkinseed (Age 1+) 9/2/80	75	25	--	--	26	--	3.9	2.9-5.4	16.74	12.66- 22.59
	American shad (5/28)	4	4	518	450-572	1528	790-2390	6.2	2.8-11.7	1.72	< 0.85-3.99
	Roe (5/28)	1	1	572	--	2390	--	1.0	--	< 0.31	--
	Blueback herring (5/28)	40	1	276	230-312	194	120-280	5.6	--	1.81	--
	White perch (5/28)	30	30	182	161-236	110	70-235	5.2	1.6-13.2	16.71	2.60-46.17
	Walleye (5/28)	4	4	474	355-605	1326	410-2640	1.2	0.5-2.2	6.22	2.30-10.13
	Northern pike (5/28)	2	2	616	535-696	1630	1030-2230	0.3	0.1-0.6	2.28	1.08-3.47

HUDSON RIVER PCB ANALYSES - 1980 SAMPLES

LOCATION	SPECIES	NUMBER ANALYZED	NO. OF ANALYSES	AVERAGE LENGTH (mm)	LENGTH RANGE (mm)	AVERAGE WEIGHT (g)	WEIGHT RANGE (g)	AVERAGE LIPID (%)	LIPID RANGE (%)	AVERAGE PCB (ppm)	PCB RANGE (ppm)
Poughkeepsie	Striped bass 5/9/80	27	27	561	510-761	2070	1500-4605	9.2	0.5-18.9	1.99	<0.30-11.69
Peekskill	Striped bass 5/7/80	27	27	644	488-903	3443	1430-9430	5.9	1.5- 8.9	9.05	2.47-47.01
Croton Pt. (Verplanck)	Striped bass 4/14/80 (confiscated)	23	23	520	448-721	1643	990-4890	5.4	0.8-12.0	11.68	2.33-52.12
Tappan Zee Bridge	Striped bass										
	4/14/80	30	30	468	342-578	1242	480-2200	3.2	0.4- 7.3	5.59	<0.90-14.28
	5/8/80	30	30	515	426-682	1553	780-3140	3.1	0.4- 9.8	6.37	<0.99-41.60
George Washington Bridge	Striped bass										
	4/30/80	30	30	515	415-655	1563	720-3370	3.0	0.1- 8.9	5.00	<0.41-19.79
	5/13/80	30	30	558	403-758	2032	620-5660	3.8	0.8-14.4	4.44	1.82-12.59

HUDSON RIVER PCB ANALYSES - 1980 SAMPLES

LOCATION	SPECIES	NUMBER ANALYZED	NO. OF ANALYSES	AVERAGE LENGTH (mm)	LENGTH RANGE (mm)	AVERAGE WEIGHT (g)	WEIGHT RANGE (g)	AVERAGE LIPID (%)	LIPID RANGE (%)	AVERAGE PCB (ppm)	PCB RANGE (ppm)
eorge Washington Bridge	American eel(7/24)	5	5	476	409-587	244	140-440	11.9	2.7-16.7	8.15	2.43-12.74
ier 40(Manhattan)	American eel (7/24)	19	19	486	396-600	247	120-450	9.2	1.5-16.6	5.89	<1.68-10.26
errazano Bridge	American eel (6/18)	16	16	374	199-543	138	20-350	5.5	1.7-16.7	6.76	<1.33-52.95
ast R. Queensboro Bridge)	American eel (6/18)	29	29	421	236-620	195	40-590	10.5	1.1-25.4	7.13	1.34-43.41

Part I

HUDSON RIVER PCB ANALYSIS - 1979 COLLECTIONS

(unless otherwise noted analyses were of individuals on a standard fillet basis)

LOCATION	SPECIES	NO. OF FISH	AVERAGE LENGTH (mm)	LENGTH RANGE (mm)	AVERAGE WEIGHT (g)	WEIGHT RANGE (g)	AVERAGE LIPID (%)	LIPID RANGE (%)	AVERAGE PCB (ppm)	PCB RANGE (ppm)
Above Feeder Dam (Glens Falls)	Pumpkinseed	68 (17)*	96	76-113	--	--	3.2	2.2- 4.0	< 0.44	< 0.33-<0.67
	Brown bullhead	20	308	277-339	441	295-600	0.4	0.1- 1.7	< 0.36	< 0.30- 1.14
Stillwater	Pumpkinseed	64 (16)*	97	78-121	--	-------	1.9	1.4- 2.4	19.91	15.63-25.43
	Brown bullhead	30	251	178-315	225	50-370	0.8	0.1- 7.5	8.97	< 0.83-59.79
Waterford	Largemouth bass	30	317	250-405	494	200-960	0.4	0.1- 1.4	4.60	< 0.55-18.35
Mohawk R. 1/2 mi. from Hudson R. below Lock 7	Smallmouth bass	4	373	349-394	900	667-1036	2.4	2.1- 3.0	4.68	3.34- 7.46
	Blueback herring	30	276	256-307	180	113-255	4.1	0.6- 7.8	2.33	<0.80- 4.91
Albany/Troy	Pumpkinseed	88 (22)*	112	86-135	--	--	1.8	0.7- 2.8	5.89	2.46- 8.39
	Brown bullhead	22	292	193-338	384	85-653	2.2	0.05-10.6	< 6.74	0.30-44.60
	Alewife	18	273	245-315	223	165-379	8.3	3.0- 13.6	4.79	2.48- 7.91
Catskill	Alewife	13	273	250-290	237	180-345	7.0	2.4- 15.1	2.28	0.83- 4.14
Kingston	Pumpkinseed	23 (23)*	111	96-130	--	--	4.3	2.4- 6.0	5.56	2.41- 7.99
Cruger Island	Carp	13	621	464-813	3417	1644-6804	10.7	4.4- 18.0	42.63	11.95-127.10
Esopus Creek	Alewife	18	290	270-310	281	200-330	5.8	2.1- 14.9	2.64	<0.96- 6.99
Rondout Creek (near mouth)	Rainbow smelt	25	134	110-170	8	4-20	2.3	0.9- 6.0	4.03	1.37- 9.89
	Carp	5	566	356-705	3136	2551-4252	9.6	7.6- 14.0	14.73	3.93-29.63
	Alewife	24	287	255-315	268	175-370	8.2	3.8- 12.8	2.55	<0.54- 5.65
Poughkeepsie	Atlantic tomcod	13	164	137-222	34	15-100	0.6	0.3- 0.8	<0.67	<0.35- 1.14

*Number in parenthesis reflects number of composite analyses on a whole body basis of yearling fish.

MDNS 010113

HUDSON RIVER PCB ANALYSIS - 1979 COLLECTIONS

LOCATION	SPECIES	NO. OF FISH	AVERAGE LENGTH (mm)	LENGTH RANGE (mm)	AVERAGE WEIGHT (g)	WEIGHT RANGE (g)	AVERAGE LIPID (%)	LIPID RANGE (%)	AVERAGE PCB (ppm)	PCB RANGE (ppm)
Newburgh	Pumpkinseed	100 (25)*	119	93-134	—	—	4.0	2.1- 4.8	2.99	1.85- 4.18
	Rainbow smelt	16	139	120-180	9	5-20	2.3	0.5- 4.3	4.51	1.57- 9.47
	Alewife	20	283	245-315	262	160-380	8.1	2.6-13.3	2.71	< 0.96- 5.56
Cornwall-on-Hudson	White Catfish	2	374	355-392	610	454-765	3.5	2.1- 5.0	12.12	5.32- 18.91
Foundry Cove	Blue claw crab									
	Hepatopancreas	5	—	—	—	—	5.3	3.4- 7.6	9.64	5.00- 20.21
	Muscle	5	—	—	—	—	0.2	0.1- 0.3	< 0.34	< 0.30- < 0.45
Peekskill	Bluefish	16	177	121-203	74	57-113	1.5	0.4- 3.3	3.15	< 0.65- 6.61
Tomkins Cove	Carp	8	632	392-753	3863	822-4536	8.6	3.0-14.0	56.49	< 0.73- 119.0
Haverstraw Bay	Blue claw crab									
	Hepatopancreas	7	—	—	—	—	3.2	1.7- 4.6	4.62	2.70- 8.51
	Muscle	7	—	—	—	—	0.4	0.2- 0.7	< 0.69	< 0.30- < 2.19
	Atlantic tomcod	15	152	118-183	25	10-60	0.9	0.2- 7.8	< 0.37	< 0.30- < 0.57
Tappan Zee Bridge	Blue claw crab									
	Intact-no shell	5	—	—	—	—	2.7	1.6- 4.5	2.95	< 1.73- 5.55
	Hepatopancreas	5	—	—	—	—	4.2	0.9- 7.7	6.75	< 0.89- 16.92
	Muscle	5	—	—	—	—	0.2	0.2- 0.5	< 0.40	< 0.30- < 0.71
Tappan Zee Bridge	Striped bass									
	3/29/79	14	456	424-495	1070	880-1249	5.5	2.7- 9.2	5.27	2.11- 10.71
	11/20/79	15	366	305-566	601	341-2043	4.7	2.3- 9.8	8.53	< 0.59- 27.11
	American shad	15	511	485-561	1728	1195-2540	17.7	9.5-23.3	1.37	0.57- 2.51

*Number in parenthesis reflects number of composite analyses on a whole body basis of yearling fish.

PCB ANALYSIS OF AMERICAN EEL FROM HUDSON RIVER TRIBUTARIES - 1979 COLLECTIONS

LOCATION	SPECIES	NO. OF FISH	AVERAGE LENGTH (mm)	LENGTH RANGE (mm)	AVERAGE WEIGHT (g)	WEIGHT RANGE (g)	AVERAGE LIPID (%)	LIPID RANGE (%)	AVERAGE PCB (ppm)	PCB RANGE (ppm)
Catskill Creek (So. Cairo)	American eel	20	491	404-790	263	114-1092	10.3	2.1-20.0	<0.47	<0.30- <0.73
Normanskill Creek (Rt. 146 & 443)	" "	22	495	307-843	298	43-1121	3.8	0.2- 9.66	<0.75	<0.30- 2.13
Moodna Creek (Vails Gate)	" "	21	374	216-469	113	<40-198	6.9	1.2-16.6	<1.15	<0.40- 2.38
Sawkill Creek (Annandale-on-Hudson)	" "	20	467	248-635	226	10-531	7.3	0.4-26.9	2.55	<0.69- 6.75
Sawmill River (Yonkers)	" "	20	434	267-546	170	28-304	12.6	0.6-22.2	3.69	<0.68- 6.68

APPENDIX H

Air Quality Data

TABLE H-1

Glens Falls Annual Wind Frequency Distributions
(in percents)

	Wind Velocity Mph					
Direction	1-3	4-7	8-12	13-18	19+	Total
N	5.72	3.01	0.67	0.00	0.00	9.40
NNE	3.63	2.14	0.85	0.20	0.00	6.82
NE	2.19	1.94	1.21	0.11	0.00	5.45
ENE	1.32	0.64	0.22	0.02	0.00	2.32
E	0.32	0.33	0.02	0.00	0.00	1.25
ESE	0.68	0.42	0.00	0.00	0.00	1.10
SE	1.64	0.98	0.17	0.09	0.00	2.88
SSE	2.76	2.71	0.85	0.02	0.00	6.45
S	4.50	8.43	3.98	0.43	0.11	17.34
SSW	2.71	5.21	0.73	0.05	0.00	8.70
SW	1.40	1.61	0.40	0.09	0.00	3.50
WSW	1.27	1.55	1.41	0.17	0.00	4.40
W	1.47	1.43	1.24	0.16	0.00	4.30
WNW	1.89	0.99	0.98	0.22	0.00	4.08
NW	3.26	1.27	0.45	0.00	0.00	4.98
NNW	5.53	1.92	0.45	0.08	0.00	7.98
Total	40.87	34.70	13.63	1.64	0.11	90.95

Note:1. Calm = 9.05%.

Source: NYSDEC, 1979.

Table H-2

Rensselaer Annual Wind Frequency Distributions

(in percents)

	Wind Velocity - MPH					
Direction	1-3	4-7	8-12	13-18	19+	Total
N	1.59	1.50	0.42	0.13	0.00	3.64
NNE	1.62	1.99	0.57	0.20	0.04	4.42
NE	0.98	0.96	0.20	0.10	0.03	2.27
ENE	0.88	0.27	0.08	0.06	0.00	1.29
E $	1.89	0.47	0.14	0.06	0.00	2.56
ESE	2.20	2.83	2.04	0.19	0.04	7.30
SE	2.18	1.82	1.44	0.22	0.00	5.66
SSE	2.43	1.46	0.99	0.51	0.09	5.48
S	5.24	4.22	3.94	2.06	0.10	15.56
SSW	3.78	2.60	0.97	0.24	0.00	7.59
SW	2.15	1.30	0.38	0.09	0.01	3.93
WSW	1.25	1.18	1.44	0.71	0.10	4.68
W	1.80	1.95	0.94	0.33	0.03	5.05
WNW	1.40	2.08	1.68	0.90	0.24	6.30
NW	1.59	3.77	4.31	4.05	1.46	15.18
NNW	1.15	2.37	2.01	1.13	0.10	6.76
Total	32.13	30.77	21.55	10.98	2.24	97.67

Note: 1. Calm = 2.33%.

Source: NYSDEC, 1979.

APPENDIX I

Recommended Guideline for PCB Levels in Air:

New York State Department of Health

Kim, Nancy K. (written communication). March 25, 1981. Letter from Nancy K. Kim, Director, Bureau of Toxic Substances Management, State of New York Department of Health, Albany, New York to Donald Corliss, New York State Department of Environmental Conservation, Region 5, Raybrook, New York.

Hawley, John. (written communication). March 16, 1981. Letter from John Hawley, Chief, Bureau of Toxic Substances Management, State of New York Department of Health, Albany, New York to Italo Carcich, Bureau of Water Research, New York Department of Environmental Conservation, Albany, New York.

STATE OF NEW YORK
DEPARTMENT OF HEALTH OFFICE OF PUBLIC HEALTH
TOWER BUILDING • THE GOVERNOR NELSON A. ROCKEFELLER EMPIRE STATE PLAZA • ALBANY, N.Y. 12237

DAVID AXELROD, M.D.
Commissioner

GLENN E. HAUGHIE, M.D.
Director

DIVISION OF ENVIRONMENTAL HEALTH
LEO J. HETLING, P.E., PH.D.
Director

March 25, 1981

Mr. Donald Corliss
DEC - Region 5
Route 86
Raybrook, New York 12977

Re: Application - Hudson River PCB Reclamation Project

Dear Mr. Corliss:

The attached letters of March 13th and March 16th from John Hawley of my staff to Italo Carcich constitute the Department of Health's response to your February 10th request for comments on the above application. This includes comments on the draft environmental impact statement dated September 1980. I would like to amend one statement in the March 16th letter.

The PCB reclamation program activites should be designed and carried out in such a way as to insure that the 24 hour average (not 8 hour average) PCB concentrations in the ambient air at occupied residences and other sensitive receptors affected by the activities do not exceed one microgram per cubic meter (1 ug/m^3).

Sincerely,

Nancy K. Kim

Nancy K. Kim, Ph.D.
Director
Bureau of Toxic Substances Management

NKK/pab

Attachments

cc: Mr. Italo Carcich
Steve Arella - EPA
Dr. Hetling
Mr. Smith

Distribution: Mr. Decker - Northern Area (Albany Office)
Mr. Reilley - Southern Area (White Plains Office)
Mr. Buff - New York City Area
Mr. Baldwin - Oneonta District Office
Mr. Fear - Glens Falls District Office
Mr. Cunnan - Amsterdam District Office

STATE OF NEW YORK
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Commissioner

GLENN E. HAUGHIE, M.D.
Director

DIVISION OF ENVIRONMENTAL HEALTH
LEO J. HETLING, P.E., PH.D.
Director

March 16, 1981

Mr. Italo Carcich
Bureau of Water Research
DEC
50 Wolf Road
Albany, New York 12233

Dear Italo:

I would like to add to the comments in my letter of March 13th, on the important topic of acceptable exposure to PCB in ambient air.

PCB reclamation program activities should be designed and carried out in such a way as to insure that eight hour average PCB concentrations in the ambient air at occupied residences and other sensitive receptors affected by the activities do not exceed one microgram per cubic meter (1 ug/m^3).

An essential consideration in arriving at this guideline was the limited duration of the reclamation project. Individuals will be exposed to these elevated concentrations for only three or four months in two successive summers.

If you have any further questions, I will be glad to assist in any way I can.

Sincerely,

John Hawley
Bureau of Toxic Substances Management

JH/pb

cc: Don Corliss - DEC
Steve Arella - EPA

APPENDIX J

Estimate of Maximum Probable PCB Flux to the Atmosphere from the Hudson River Sediment Disposal Basin

DiToro, Dominic M. and Donald J. O'Connor, April 14, 1981.
Estimate of maximum probable PCB flux to the atmosphere
from the Hudson River sediment disposal basin.
Unpublished report, HydroQual, Inc.,
Mahwah, New Jersey.

I. SUMMARY AND CONCLUSIONS

An analysis of the maximum probable PCB flux to the atmosphere from the proposed Hudson River Sediment Disposal Basin has been made. In order that an air quality standard of 1 ug/m^3 not be exceeded, the air quality model calculations done by Malcolm Pirnie Engineers indicate that under critical conditions the emission flux should not exceed 780 $ug/m^2/hr$. Similar model calculations by WAPORA indicate a maximum flux rate of 500 $ug/m^2/hr$. This report addresses the probable highest emission flux to be encountered during the dredging operation.

The volatilization mass transfer coefficient is estimated to be in the range of K_L = 0.28 - 0.44 m/day (0.012 - 0.018 m/hr) during critical conditions. The higher value is adopted for this analysis.

An analysis of the behavior of the sedimentation basin indicates that the maximum dissolved PCB concentration to be encountered is the concentration which is in equilibrium with the influent sediment mixture. This is the case regardless of the details of the sediment mixture properties, such as particle size distribution, settling velocities for particle size classes, etc. For the critical flux rate and volatilization mass transfer coefficients given above, the critical dissolved PCB concentrations are C_{di} = 43 ug/l (MPI) or 28 ug/l (WAPORA). If the critical dissolved concentration is exceeded during dredging operations, and the critical meteorology occurs as well, then it is computed that the air quality standard at the nearest receptor of interest could be violated.

The maximum probable dissolved PCB concentration has been estimated by relating, the sediment PCB concentration and the desorption partition coefficient to the percent volatile solids in the sediment. Over the range of volatile solids percentages present in Hudson River sediment to be dredged, the upper limit of the observed sediment PCB concentration has been established. The variation of desorption partition coefficient as a function of volatile solids percentage is less certain. The sparse data available indicates that it is consistently higher than that which would exceed the critical dissolved concentration of 40 ug/l but the data are not definitive. In addition the observed dissolved PCB concentration from elutriate tests and extrapolated settling tests exceeded 10 ug/l in two of the nine cases for which data are available, but did not exceed 40 ug/l in any of the cases.

It is concluded that:

- The critical dissolved concentration in the basin of 28 to 43 ug/l will rarely be exceeded during dredging. However if it is exceeded volatilization can be controlled by adding additional adsorbent to the dredged material, reducing the equilibrium dissolved PCB concentration and, therefore, maintain the basin concentration below the critical value. Before these operational controls are required, additional desorption tests should be made to determine the likelihood of exceeding the critical dissolved concentration.

- The description partition coefficient data is sparse, and although it indicates that the critical concentration will not be exceeded, the quantity of data available cannot rule out the possibility.

- The project may proceed, based on the analysis presented below. However, it is strongly recommended that additional desorption data be obtained and a more definitive analysis be made.

II. METHODOLOGY

The methodology employed in making the estimates of the PCB flux to the atmosphere is based upon a mass balance of total PCB within the basin volume. Since the principle sink of PCB is via sedimentation of the particulate fraction, an analysis of the sediment solids themselves is required. Let m_i (mg/l) be the concentration of sediment solids entering the basin at a flow rate, Q (cfs), the basin volume is V, the average depth is H, and the settling velocity of the solids is V_s. It is assumed in this analysis that only one size class of solids is present. Subsequently the analysis is extended to multiple size classes.

The mass balance equation for solids states that:

$$V \frac{dm}{dt} = Qm_i - Qm - v_s Am \qquad (1)$$

where A is the bottom interface area and m is the average solids concentration within the water column volume.

This mass balance equation applies to a completely mixed volume. Spatial variation of solids concentration is addressed subsequently. At steady state, the solids concentration is given by:

$$m = \frac{m_i}{1 + K_s t_o} \qquad (2)$$

where $K_s = v_s/H$, is the apparent first order removal rate (day^{-1}) and t_o = V/Q is the hydraulic detention time (day) of the basin.

The mass balance of PCB is complicated by the existence of two forms of the chemical: the dissolved concentration, C_d, and the particulate concentration, C_p, where these concentrations are expressed as micrograms of PCB per liter of solution volume. Three mechanisms are considered in this analysis: (1) adsorption and desorption; (2) sedimentation of the particulate form; and (3) volatilization of the dissolved form. The latter is the source of concern in this analysis.

1. Adsorption and Desorption

The principal source of dissolved PCB in the storage basin is from the desorption of adsorbed PCB. Let R_d be the rate of PCB desorption (ug/l/day) and let R_a be the rate of PCB adsorption. The mass balance equations for dissolved and particulate PCB are:

$$V \frac{dc_d}{dt} = QC_{di} - QC_d + VR_d + VR_a - K_L AC_d$$

$$(3)$$

$$V \frac{dc_p}{dt} = QC_{pi} - QC_p + VR_d + VR_a - V_s AC_p$$

where K_L is the surface mass transfer coefficient for PCB (m/day). The key to the analysis is to consider the total PCB concentration.

$$C_T = C_d + C_p \tag{4}$$

Adding the mass balance equations yields:

$$V \frac{dC_T}{dt} = QC_{Ti} - QC_T - K_L AC_d - v_s AC_p \tag{5}$$

where the adsorption and desorption kinetic rates cancel.

Since the maximum concentrations are of concern, a steady state analysis is appropriate. Consider an equilibrium between adsorption and desorption.

Define the particulate PCB concentrations per unit solids concentration, r (ug PCB/g solids):

$$r = Cp/m \tag{6}$$

It has been found that a linear isotherm is appropriate to describe the relationship between particulate and dissolved PCB (see Figure 1, Horzempa and DiToro, 1981).

$$r = \pi C_d \tag{7}$$

where   is the partition coefficient (l/g). In fact different partition coefficients are found for adsorption and desorption with the latter being larger. Since the concern is with desorption, it is assumed that equation (7) applies for desorption. Consider the total concentration, c_T, and express it in terms of C_d and r. That is equation (4) becomes:

$$C_T = C_d + mr \tag{8}$$

and using the isotherm equation (7) yields:

$$C_T = C_d (1 + m\pi) \tag{9}$$

so that the ratio of dissolved to total PCB, f_d, is:

$$f_d = \frac{C_d}{C_T} = \frac{1}{1 + m\pi} \qquad (10)$$

Similarly the ratio of particulate to total PCB is:

$$f_p = 1 - f_d = \frac{C_p}{C_T} = \frac{m\pi}{1 + m\pi} \qquad (11)$$

Since these fractions express the relationships between the dissolved and particulate concentrations and the total concentration, they may be used in the total PCB mass balance equation (5) to yield:

$$V \frac{dC_T}{dt} = QC_{Ti} - QC_T - K_L A f_d C_T - v_s A f_p C_T$$

and at steady state:

$$CT = \frac{CT_i}{1 + t_o\ (f_p K_s + f_d K_L/H)} \qquad (12)$$

This equation gives the total PCB concentration in the basin, C_T, in terms of the influent total concentration, C_{Ti}, the hydraulic detention time, t_o, and the removal rates due to sedimentation, K_s, and volatilization, K_L/H, suitably proportioned by the fraction of total PCB that is particulate, f_p, and dissolved, f_d.

The dissolved concentration in the basin, C_d, is then:

$$C_d = f_d C_T \qquad (13)$$

and the flux of PCB to the atmosphere, J, is:

$$J = K_L C_d \qquad (14)$$

Hence the analysis requires an evaluation of equations (12), (13), and (14) with appropriate values for the coefficients.

III. SOLUTION

The key to a straightforward analysis of the basin concentration of PCB is to use the solids mass balance equation solution, equation (2), to evaluate the settling removal rate coefficient, K_s. From equation (2) it is clear that:

$$K_s t_o = \frac{m_i}{m} - 1 \tag{15}$$

Consider the denominator of equation (12):

$$1 + t_o K_s f_p + t_o f_d K_L/H \tag{16}$$

$$= 1 + f_p\left(\frac{m_i}{m} - 1\right) + t_o f_d K_L/H \tag{17}$$

$$= 1 + \frac{m\pi}{1 + m\pi}\left(\frac{m_i}{m} - 1\right) + \left(\frac{1}{1 + m\pi}\right)\frac{K_L}{H}\, t_o \tag{18}$$

$$= \frac{1 + m\pi + m\pi\left(\frac{m_i - m}{m}\right) + t_o K_L/H}{1 + m\pi} \tag{19}$$

$$= \frac{1 + m\pi + m_i\pi - m\pi + t_o K_L/H}{1 + m\pi} \tag{20}$$

$$= \frac{1 + m_i\pi + t_o K_L/H}{1 + m\pi} \tag{21}$$

The algebraic steps are: substitute for $K_s t_o$, equation (17); substitute for f_p and f_d, equation (18), cross multiply by $1 + m$, equation (19), and simplify, equation (20) and (21). The result is:

$$C_T = \frac{(1 + m\pi)\, C_{Ti}}{1 + M_i + t_o K_L/H} \tag{22}$$

Finally, the dissolved basin concentration, C_d is:

$$C_d = \frac{C_T}{1 + m\pi} = \frac{C_{Ti}}{1 + m_i\pi + t_o K_L/H} \tag{23}$$

A further simplification is possible. Note that the dissolved concentration in the influent is:

$$C_{di} = \frac{C_{Ti}}{1 + m_i\pi} \tag{24}$$

and the influent dissolved fraction, f_{di}, is:

$$f_{di} = \frac{1}{1 + m_i\pi} \tag{25}$$

which is eq (10) evaluated at the influent solids concentration, m_i. These expressions can be used to express the dissolved basin concentration, C_d, in terms of the dissolved influent concentrations, C_{di}. The result is:

$$C_d = \frac{C_{di}}{1 + t_o f_{di} K_L/H} \tag{26}$$

The remarkable simplification yields the following conclusion: the dissolved basin concentration, C_d, is the dissolved influent concentration, C_{di}, reduced by the loss due to volatilization only. The dissolved basin concentration does not increase due to desorption but rather decreases due to volatilization.

IV. EXPLANATION AND INTERPRETATIONS

This result is somewhat surprising and requires an explanation. Consider the case for which evaporation is an insignificant loss relative to the basin mass balance of total PCB. (It may still be important from an air quality point of view.) Then $t_o f_{di} K_L/H << 1$ and $C_d = C_{di}$. That is, at steady state, the dissolved basin concentration is the same as the influent dissolved concentra tion. Imagine the following situation: the basin contains initially only water and no suspended solids. Set the initial condition of the water at the influent concentration. This does not affect the final basin concentration since the initial condition washes out eventually and the steady state concentration is independent of the initial condition. Now begin the influent so that the particles begin to enter the basin. Since the dissolved basin concentration is at the influent dissolved concentration the particles see the same concentration and do not desorb any chemical. This assumes that the influent is at desorption equilibrium. This is addressed subseqently. Now the particles settle out. Consider a single particle settling from the water column to the sediment. The removal of this particle does not effect the dissolved concentration. Since the other particles are unaware of its removal, they do not further desorb. Hence the basin dissolved concentration remains at the influent dissolved concentration.

It is clear from this explanation why the basin dissolved concentration is independent of particle size effects and varying settling velocities. It does not matter what size particles settle first since they are in equilibrium with the dissolved influent concentration. It also does not matter what the state of contamination of the individual particles is, since they are all in equilibrium with the influent dissolved concentration and their selective removal by settling does not change the dissolved basin concentration, so long as it is at the influent dissolved concentration. Hence the basin achieves the dissolved concentration that is in equilibrium with the influent sediment mixture regardless of selective removal via sedimentation. The appendix demonstrates this result for particle specific settling velocities and partition coefficients. Hence the conclusion is that the basin dissolved concentration will achieve, as a maximum concentration, the dissolved concentration which is in equilibrium with the influent sediment mixture. The key to the analysis is, therefore, to make an estimate of the dissolved concentration which is in equilibrium with the various sediment mixtures likely to be present in the influent. In addition it is necessary to estimate the volatilization mass transfer coefficient, K_L, and to review the air quality impact calculations. These latter two tasks are presented in the next sections.

V. VOLATILIZATION RATE OF PCB

The rate at which PCB volatilizes from a basin is given by the product of the mass transfer coefficients, K_L (m/day), and the dissolved PCB concentration, C_d. The following analysis follows O'Connor, 1980, 1981. The two film theory of air-water mass transfer gives the overall transfer coefficient in terms of the liquid phase transfer coefficient, K_l, and the gas phase transfer coefficient, K_g (O'Connor, 1980):

$$\frac{1}{K_L} = \frac{1}{K_l} = + \frac{1}{HK_g} \qquad (27)$$

where H is the Henry's constant of PCB. The importance of gas phase resistance depends upon the magnitude of the gas phase mass transfer coefficient, K_g, and the Henry's constant:

There is considerable uncertainty in the Henry's constant, which in dimensionless units is:

$$H = 16 \frac{P}{C_s} \frac{MW}{T} \qquad (28)$$

where P is the vapor pressure (mm Hg), C_s is the aqueous solubility (mg/l), MW is the molecular weight and T is temperature (°K). Table 1 (Tofflemire and Shen) given below, lists the results:

TABLE 1

PCB 1242

Solubility (ug/l)	Vapor Pressure (mm Hg)	Henry's Constant (20°C)
240	4.1×10^{-4}	0.024
80	9.0×10^{-4}	0.16
340	3.0×10^{-4}	0.013

At the critical windspeed of $W = 1$ m/sec, the gas transfer coefficient for water evaporation is $K_g = 200$ m/day. For PCB a correction is needed for the decreased diffusivity of the larger molecule using the ratios of the molecular weights to the 1/2 power yields. $K_g = 53$ m/day for PCB 1242. The factor HK_g, therefore, is in the range of $HK_g = 0.69 - 8.5$ m/day.

For the liquid phase transfer coefficient, K_l) two regions of the basin are considered: the region near the basin influent where water velocities are high, and the remaining region where wind velocities determine K_l. The size of these regions are chosen to be 100 m x 100 m to be consistent with the air quality analysis.

For the influent region, it is estimated that over the 10^4 m^2 region the average water velocity is 0.5 ft/sec (R. Thomas, Malcolm Pirnie, 1981 personal communication).

The liquid film mass transfer coefficient is given by:

$$K_l = \left(\frac{D_L U}{H}\right)^{1/2} \tag{29}$$

where D_L is the molecular diffusivity of PCB, V is the velocity and H is the depth. A correlation to molecular weight (MW) is available to estimate the diffusivity of PCB:

$$D_L = 2.2 \times 10^{-4} (MW)^{-2/3} \qquad (cm^2/sec)$$

$$= 5.43 \times 10^{-6} \ cm^2/sec \tag{30}$$

For a basin depth of $H = 10$ ft in this region the resulting transfer coefficient is:

$$K_l = 0.45 \text{ m/day} \tag{31}$$

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For the other regions the water velocity is negligible and the wind velocity controls. The liquid phase controlled transfer coefficient is given by:

$$K_1 = \frac{C_D^{1/2}}{\lambda_2} \left(\frac{D_L}{v_L}\right)^{2/3} \left(\frac{p_a}{p_w}\right)^{1/2} W \qquad (32)$$

where C_D is the drag coefficient, V_L is the kinematic viscosity of water, W is the wind velocity, p_a/p_w is the ratio of air to water density and λ_2 is related to the viscous sublayer fetch, and height of the waves. For low wind speeds, C_d = 0.0016, $_2$ = 6. The kinematic viscosity is $_L$ = 0.01 cm^2/sec, P_a/P_w = 0.0012 so that:

$$K_1 = 0.46 \text{ m/day} \qquad (33)$$

at a wind velocity of W = 1 m/sec. Since both these transfer coefficients are essentially the same, a transfer coefficient of K_1 = 0.46 m/day is used for this analysis independent of location.

The overall transfer coefficient, including both gas and liquid phase resistances is:

$$K_L = 0.28 \text{ to } 0.44 \text{ m/day} \qquad (34)$$

depending upon which gas phase transfer coefficient is used. In order to be conservative, the upper value of K_L = 0.44 m/day is adopted.

VI. FLUX RATE OF PCB AND AIR QUALITY IMPACT

The flux rate of PCB is given by:

$$J = K_L \, C_{di} \text{ (ug/m2/hr)}$$

$$= 0.44 \text{ m/day} \cdot C_{di} \text{ (ug/l)} \cdot \frac{10^3 \text{ l}}{m^3} \times \frac{1 \text{ day}}{24 \text{ hr}}$$

$$= 18.3 \, C_{di} \text{ (ug/}m^2\text{/hr)} \qquad (35)$$

for C_{di} in ug/l.

The air quality impact at the nearest receptor can be calculated from the analysis made by WAPORA. For the five cells (100 x 100 m) in an axis with the nearest receptor the air concentrations resulting from an emission rate of $J = 10^3$ ug/m^2/hr are given in Table 2.

TABLE 2

Cell No.	Receptor Concentration (ug/m^3)
17	0.336
16	0.312
15	0.198
14	0.252
13	0.168
Total	1.27

An independent air quality assessment was made by Malcolm Pirnie Engineers. For an emission rate of 158 ug/m^2/hr they compute a receptor air concentration of 0.2 ug/m^3. For $J = 10^3$ ug/m^2/hr their result would be $C_{air} = 1.26$ ug/m^3 which is in close agreement with the WAPORA results. Therefore the nearest receptor air quality concentration, C_{air}, is given by:

$$C_{air} = \frac{1.27\ (ug/m^3)}{103\ (ug/m^3/hr)} \times 18.3\ C_{di} \qquad (36)$$

$$= 0.0232\ C_{di}$$

For an air quality standard of $C_{air} = 1$ ug/m^3 the dissolved influent concentration C_{di} must not exceed:

$$C_{di}\ max = 43\ ug/l \qquad (37)$$

Hence the air quality standard at the closest receptor of interest is not exceeded if the equilibrium dissolved influent concentration does not exceed C_{di} 40 mg/l. The factors that control the concentration are discussed in the next section.

VII. PROBABLE MAXIMUM DISSOLVED PCB CONCENTRATION IN THE BASIN INFLUENT

It has been shown previously that the dissolved concentration in the basin reaches the influent equilibrium dissolved concentration at steady state. The volatilization and air quality analysis indicate that dissolved concentrations in excess of 40 ug/l violate the standard for critical conditions. The problem is to estimate the highest probable dissolved influent concentration to be encountered in the dredging program. This analysis is complicated by the variability of the sediment properties and degree of contamination.

The approach taken in the analysis presented below is to index the sediment by the percent volatile solids it contains. The relationship between sediment PCB concentration and percent volatile solids is shown in Figure 2. The upper line on the figure represents the assumed upper bound of sediment PCB concentration to be encountered during the dredging operations.

In order to estimate the equilibrium dissolved concentration as a function of percent volatile solids, the desorption partition coefficient is required.

Some data are available which can be used to estimate the equilibrium dissolved concentrations to be expected. Elutriate experiments have been conducted on various Hudson River sediment samples (Tofflemire, 1981). A four part water to one part sediment mixture is equilibrated for one hour. Desorption experiments conducted at Manhattan College using Saginaw Bay sediments indicated that equilibrium is achieved in less than 15 minutes so that it is reasonable to assume that the elutriate tests are at equilibrium. The results are shown in Table 3 (Tofflemire, 1981). The unfiltered samples are included for completeness but are ignored in this analysis since it is not possible to estimate the dissolved concentration in the supernatant without an actual solids separation.

TABLE 3

Elutriate Test Data

Location	% Silt	% Volatile Solids	Sediment PCB ug/g	Dissolved PCB (ug/l)	Partition Coefficient (1/g)
1. E. Channel Ft.	-	(30% wood)	25.6	19.3	1.3
2. "	< 5	-	20.0	1.5	13.0
3. Buoy 212-214	5.4	6	35	6.6	5.3
4. Lock 1	12	5-24	13	0.3	43.0
5. Albany Port	0.5	2.44	0.08	0.06	2.5
6. Germantown	< 4	1.35	0.08	0.04	2.0
7. Albany Turning Basin	75	6.84	3.5	0.09	39
Unfiltered Samples				**Supernatant PCB (ug/l)**	
Rt. 4 Bridge	2	6	20-30	9.9	2.5
Bouy 202	1.5	-	57.1	61.6	0.93
Bouy 214	< 11	2	45.6	49	0.93
Mosseskill	65	~ 20	191	1	190
"	20-60	-	30-50	20	2
Buoy 210	17	-	149	196	0.76
Thompson Isl	20-60	-	246	138	1.8
"	44	7	293	78	3.8

The resulting partition coefficients versus percent volatile solids are shown in Figure 3. Saginaw Bay data are included to provide some additional information (Horzempa and DiToro, 1981). The line on the figure represents the partition coefficient which, together with the assumed upper bound of sediment PCB (Figure 2) achieves an equilibrium dissolved concentration of C_{di} = 40 ug/l. Although the data are quite sparse, the observed partition coefficients are all in excess of the critical values represented by the line in Figure 2. However at the low volatile solids percentages (1 to 3% volatile solids) the observed partition coefficients are close to critical. It is clear that more data are required for a definitive analysis.

Figure 4 presents the observed dissolved PCB concentration from the elutriate tests (the circles) versus percent volatile solids. Extrapolated dissolved concentrations from settling tests (the squares) are also presented. Note that two samples exceed 10 ug/l of dissolved PCB. This is uncomfortably close to the critical concentration of 40 ug/l.

The conclusion from this analysis is that although it appears probable that the critical concentration of 40 ug/l will not be exceeded with any regularity it is possible that occassional higher concentrations may occur. Therefore mitigating measures should be investigated. In addition more systematic elutriate test data, consistent with this analysis should be collected in order to reinforce the conclusions drawn.

VIII. CONTROL MEASURES

The analysis presented in this report suggests that the controlling variable is the equilibrium dissolved concentration in the influent. Any method which reduces this concentration would reduce the air quality impact proportionally. The most direct method would be to introduce an additional adsorbent (e.g. fine clay or activated carbon) into the dredged sediment. This would increase the partition coefficient of the mixture of sediment and adsorbent and therefore reduce the resulting dissolved concentration. The details of the required quantities of adsorbent and the optimal location for its introduction can be addressed subsequently if the additional elutriate tests indicate that low partition coefficients and highly contaminated sediments occur simultaneously to any significant degree.

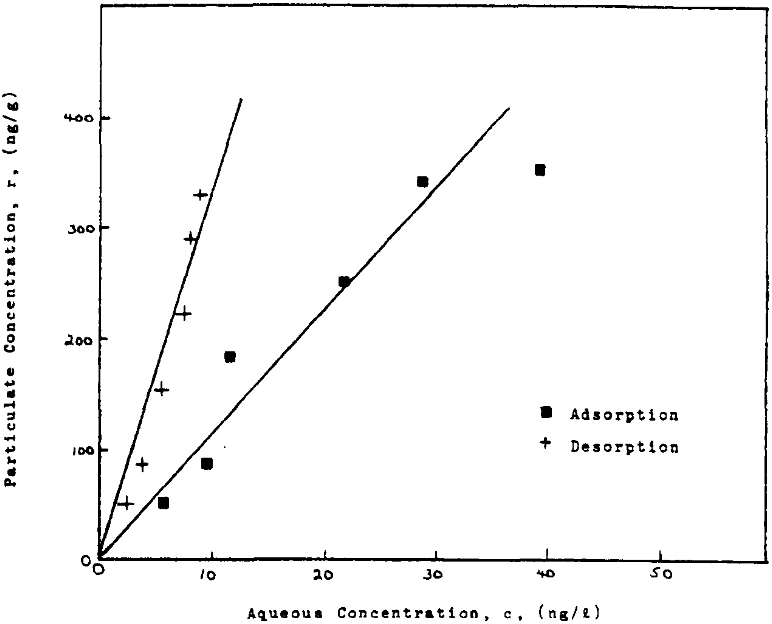

Particulate Concentration, r, (ng/g)
400
300
200
100
0
0
10
20
30
40
50
Aqueous Concentration, c, (ng/ℓ)
Adsorption
Desorption

Figure 1

Fig. 2 SEDIMENT PCB CONCENTRATION VERSUS PERCENT VOLATILE SOLIDS

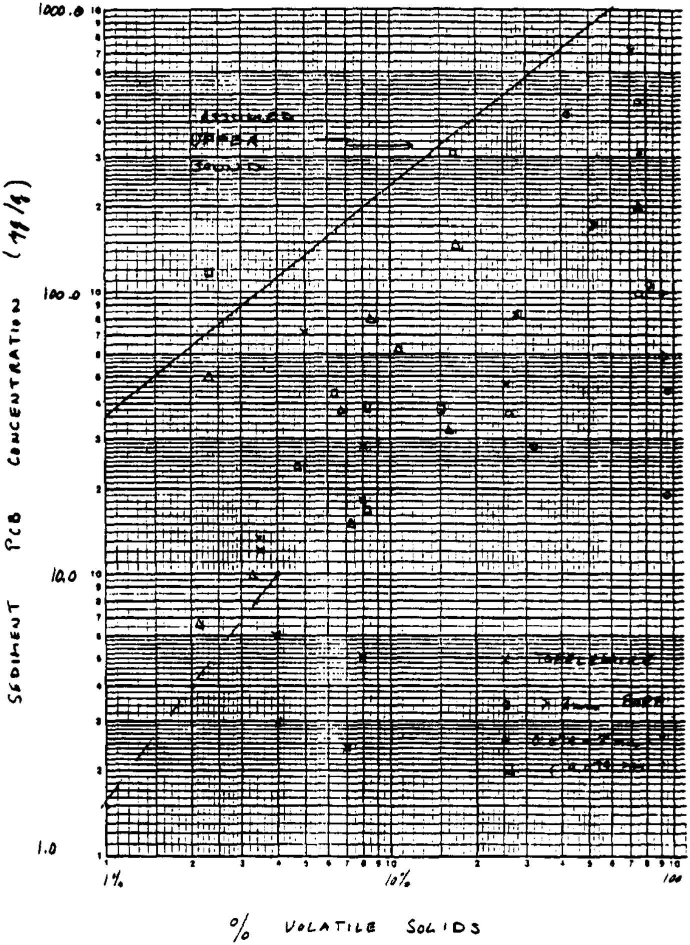
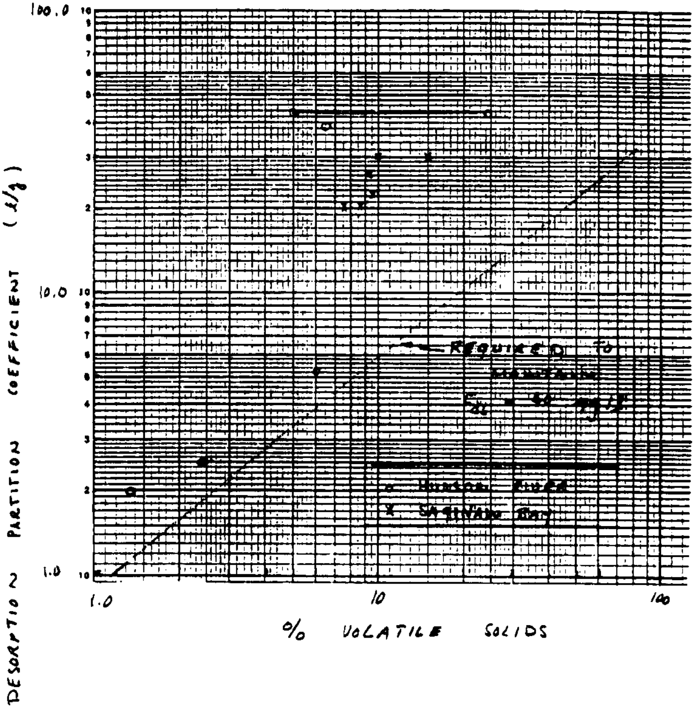


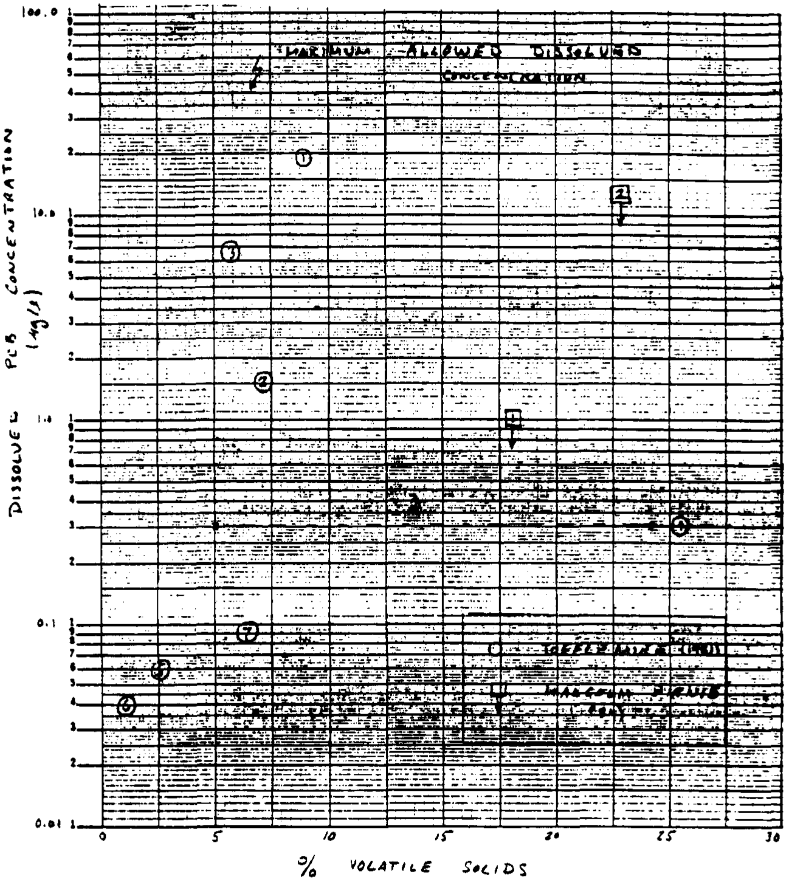
Fig 3 DESORPTION PARTITION COEFFICIENT VERSUS PERCENT VOLATILE SOLIDS



MONS 010140

Fig. 4 ELUTRIATE TEST DATA

DISSOLVED PCB CONCENTRATION VERSUS PERCENT VOLATILE SOLIDS.



MONS 010141

Appendix J.1

Analysis for Particle Specific Settling Velocities and Partition Coefficient.

I. Equations and Solutions.

For an influent sediment mixture of k=1,2,...,N classes of distinct particles let m_{ik} be the influent solids concentration, m_k be the basin concentration, and $K_{sk} = V_{sk}/H$ be the apparent removal rate of particles of class k. Then at steady state:

$$m_k = \frac{m_{ik}}{1+K_{sk}t_o} \qquad (A1)$$

The mass balance equation for total PCB is:

$$V\frac{dC_T}{dt} = Q\,C_{Ti} - Q\,C_T - K_L A\,C_d - \sum_{k=1}^{N} K_{sk}\,A\,C_{pk}$$

Where C_{pk} is the particulate concentration of PCB on the k^{th} particle class. For each particle class, let

$$r_k = \pi_k\,C_d \qquad (A2)$$

Where π_k is the partition coefficient for the k^{th} class. Then:

$$C_T = C_d + \sum_{k=1}^{N} m_k\,r_k \qquad (A3)$$

or:

$$C_T = C_d + C_d\sum_{k=1}^{N} m_k\,\pi_k \qquad (A4)$$

$$= C_d\left(1 + \sum_{k=1}^{N} m_k\,\pi_k\right) \qquad (A5)$$

so that:

$$f_d = \frac{C_d}{C_t} = \frac{1}{1+\sum_k m_k\pi_k} \qquad (A6)$$

The particulate fractions for each of the k classes is:

$$f_{pk} = \frac{C_{pk}}{C_T} = \frac{m_k r_k}{C_T} = \frac{m_k \pi_k}{C_T} C_d$$

$$= \frac{m_k \pi_k}{1 + \sum_n m_n \pi_n} \qquad \text{(A7)}$$

Where the denominator summing index is changed to n for clarity. Hence the total PCB concentration mass balance equation is:

$$V \frac{d\,C_T}{dt} = Q\,C_{Ti} - Q\,C_T - K_L\,A\,C_d - \sum_{k=1}^{N} K_{sk}\,A\,C_{pk} \qquad \text{(A8)}$$

$$= Q\,C_{Ti} - Q\,C_T - K_L\,A\,f_d\,C_T - A\,C_T \sum_{k=1}^{N} K_{sk}\,f_{pk}$$

and the steady-state solution is:

$$C_T = \frac{C_{Ti}}{1 + t_o\,(f_d\,K_L/H + \sum_k f_{pk}\,K_{sk})} \qquad \text{(A9)}$$

The denominator can be simplified as:

$$1 + t_o\,(f_d\,K_L/H) + t_o \sum_k f_{pk}\,K_{sk} \qquad \text{(A10)}$$

$$= 1 + \sum_k \frac{m_k \pi_k}{1 + \sum_n m_n \pi_n} \left(\frac{m_{ik} - m_k}{m_k} \right) + \frac{t_o k_d}{H} \cdot \frac{1}{1 + \sum_n m_n \pi_n} \qquad \text{(A11)}$$

$$= \frac{1 + \sum_n m_n \pi_n + \sum_k m_{ik} \pi_k - \sum_k m_k \pi_k + t_o K_d/H}{1 + \sum_n m_n \pi_n} \qquad \text{(A12)}$$

$$= \frac{1 + \sum_k m_{ik}\pi_k + t_o K_d/H}{1 + \sum_n m_n \pi_n} \quad \text{(A13)}$$

so that the steady state solution is:

$$C_T = \frac{C_{Ti}\,(1+\sum_n m_n \pi_n)}{1 + \sum_k m_{ik}\pi k + t_o K_d/H} \quad \text{(A14)}$$

The dissolved basin concentration is:

$$C_d = f_d\, C_T = \frac{C_T}{1 + \sum_n m_n \pi_n} \quad \text{(A15)}$$

$$= \frac{C_{Ti}}{1 + \sum_k m_{ik}\pi_k + t_o K_L/H}$$

which can be expressed as:

$$C_d = \frac{C_{di}}{1 + t_o f_d K_L/H} \quad \text{(A16)}$$

where:

$$C_{di} = \frac{C_{ti}}{1 + \sum_k m_{ik}\pi_k} \cdot f_d C_{Ti} \quad \text{(A17)}$$

is the dissolved influent concentration. Thus the dissolved basin concentration is the dissolved influent concentration, reduced by the loss via volatization, and independent of the specific settling velocities, particulate concentrations, and partition coefficients of the classes of particles in the influent.

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