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The 1984 Superfund Decision for the Hudson River

The Case for Reconsideration

August 25, 1989

Important events that have occurred since the Superfund decision for the Hudson River warrant reconsideration of the decision to forestall the cleanup of PCB contaminated river sediment. The results of recent studies have caused an increase in the estimated health risks posed by leaving PCBs in the Hudson. Congress and the public have further clarified their intent to have hazardous waste sites cleaned up. Furthermore, dredging technology has very recently emerged as an environmentally sound and responsible technique for the cleanup of aquatic ecosystems contaminated by PCBs.

The Record of Decision (ROD)(1) regarding the PCB contamination of the Hudson River provides the opportunity for reconsideration of the decision although it does not establish a clear protocol for reopening. The decision, which was issued by the United States Environmental Protection Agency (EPA) on September 25, 1984, found that cost-effective technology was not available to mitigate the damage to public health and the environment by the PCB contamination of the riverbed. The ROD suggested a decreasing public health and environmental threat posed by PCBs in the Hudson but noted that the lack of sufficient information on the fate and transport of PCBs precluded a final determination of no-action. The reliability and effectiveness of dredging were also questioned by the ROD. The decision was based in large part upon the results of the feasibility study conducted by NUS (2) during 1983-1984.

Health Risk

Several developments since 1984 would substantially alter the assessment of health risks posed by the PCB contamination of the Hudson River from the analysis contained in the 1984 feasibility study. Those developments include a new EPA estimate of the carcinogenic risk of PCB exposure, epidemiological evidence of health effects due to consumption of PCB contaminated fish, new EPA guidance on the estimation of exposure to recreational fishermen, and new information on the effectiveness of health advisories to recreational fishermen.

Results of experiments published in 1985 in which PCB-fed rats developed liver cancer led to a reevaluation by EPA of the carcinogenic potency[1] of PCBs (3). The 1984 feasibility study presented levels of PCB in fish and water that would be associated with individual lifetime cancer risks of 1 in 100,000 (10^{-5}). Those levels are presented in Table 1 along with levels that would be currently estimated using the updated EPA carcinogenic potency (q_1^*) for PCB. (The inconsistency between water and fish consumption PCB doses associated with a 10^{-5} risk in the 1984 study is due to a calculation error by NUS. The water concentration used by the feasibility study to compare to river data was ten times the correct concentration.)

The feasibility study acknowleged that consumption of contaminated fish "represent(s) the most serious human health hazard". However, rather than estimating and addressing those risks directly, the then temporary FDA tolerance level of 5 ug/g was used for comparison to fish data in a general discussion of those risks[2]. Table 1 also presents cancer risk estimates associated with two consumption rates for fish at the former FDA tolerance level. Today, unfortunately, 5 ug/g is still a reasonable overall average PCB concentration in Hudson River fish to represent exposure.

The fish consumption rate of 6.5 g/d used in the 1984 study produces a cancer risk estimate of 3.6×10^{-3}. The consumption rate of 30 g/d, recommended by EPA's recently published Exposure Factors Handbook (4) to represent the 50th percentile of consumption by recreational fisherman, produces a risk estimate of 1.6×10^{-2}. This consumption rate is close to the rate of 32 g/d employed by the New York State Department of Health (NYSDOH). These cancer risks are of the magnitude that federal regulatory agencies consistently act to reduce, apparently regardless of the size of the exposed population (5). The fish consumption rates for the 90th percentile of recreational fishermen produce risk estimates approaching 1 in 10 (i.e., 0.075).

Fish consumption has been demonstrated to be a significant mechanism of human exposure to PCBs. Correlations between fish consumption patterns and serum PCB levels have been established for several studied populations (6,7). Developmental toxicity to unborn and newborn from PCB exposure through the placenta and milk has been suggested by independent studies of non-occupationally exposed populations (8,9).

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[1]In the lexicon of risk assessment, the intrinsic threat posed by a carcinogen is termed the carcinogenic potency. In the mechanics of risk assessments for probable human carcinogens, such as PCBs, carcinogenic potency is derived from studies in which laboratory animals exposed to the chemicals developed cancer. When applied to humans, risks are estimated as the product of the carcinogenic potency and exposure rate which is also referred to as the dose rate. In this case, risk is the incremental probability of an individual developing cancer during their lifetime due to longterm exposure to PCB. Exposure may occur through inhalation of contaminated air, consumption of contaminated food and water, and by direct contact with the skin. Estimation of individual doses consequently requires not only estimates of the concentration of chemical in various environmental media but information on the nature of contact such as the volume of water consumed, quantity of food ingested, or volume of air inhaled. Doses are typically expressed in units of daily intake of milligrams of chemical per kilogram of body weight (i.e., mg/kg-d). Carcinogenic potency has reciprocal units. Individual risk, given by the product of longterm dose and carcinogenic potency is hence unitless (e.g. one in a million, one in a thousand, etc.).

[2]The FDA tolerance level of 2 ug/g, set for the regulation of fish sold in interstate commerce, was announced in May, 1984, and became effective in August, 1984, prior to the ROD.

Table 1. PCB Exposure and Lifetime Cancer Risk.

Route	Consumption Rate	PCB Level	Cancer Risk	Comment
		calculated PCB levels associated with a 10^{-5} lifetime risk		
Fish	6.5 g/d	0.0246 ug/g	10^{-5}	NUS (1984)
Water	2 L/d	0.8 ug/L		NUS (1984)
Fish	6.5 g/d	0.014 ug/g		Using current EPA
	30 g/d	0.0030 ug/g		$q_1{*}$= 7.7 $(mg/kg\text{-}d)^{-1}$
Water	2 L/d	0.045 ug/L		
		calculated risk associated with consumption of contaminated fish		
Fish	6.5 g/d	5 ug/g	3.6×10^{-3}	Using current EPA
	30 g/d	5 ug/g	1.6×10^{-2}	$q_1{*}$= 7.7 $(mg/kg\text{-}d)^{-1}$

The ROD noted that "Consumers of fish are warned of exposure by NYSDEC restrictions." It also acknowledged that "the fish consumption limitation suggested by the ban certainly is not a solution to the problem, it does offer some level of protection." The feasibility study suggested that the continuation of fishing restrictions and health advisories could be considered a cost-effective remedy. A subsequent study of New York Harbor recreational fishermen found that 60 percent of those interviewed consumed their catch (10). A slightly higher fraction gave away a portion of their catch which was presumably eaten. The investigators concluded that health advisories were ineffective: "the urban fishermen knew little about the risk and what they believed was often incorrect" (10).

The ROD also made an important, erroneous, and unsubstantiated conclusion that even if PCBs decrease to an acceptable level "fishing bans would continue on the basis of these other types of contamination" including dioxin, dibenzofurans, mercury and chlordane. NYSDOH has issued special health advisories to restrict consumption of fish from a number of New York's waters, including the lower Hudson, based upon levels of contaminants[3]. However, only in the Hudson and waters downstream of the Hudson are fishing bans in effect due to the extraordinary levels of contamination found there. There are two bans in effect: a commercial striped bass fishing ban and a ban on all fishing in 40 miles of the upper Hudson. Both bans were originally set considering PCB levels alone. The

[3] For the lower river, those advisories recommend eating none of the following: largemouth bass, walleye, brown bullhead, white perch, white catfish, carp, goldfish, American eel, striped bass and pumpkinseed. The advisory also recommends eating no more than one meal per month of bluefish, black crappie, rainbow smelt, Atlantic needlefish, northern pike, and tiger mukellunge.

commercial fishing ban is keyed to the FDA tolerance level for PCBs. Levels of other contaminants are below tolerance levels or there are no tolerance levels for those contaminants[4]. It is reasonable to assume that fishing health advisories would be maintained in the lower river if fish PCB levels somehow declined below levels of concern independently of other contaminants. However, in light of the apparent association between PCBs and some of these other contaminants, a decline in PCBs alone would appear unlikely. In either event there would be no basis for maintaining fishing bans due to contaminants other than PCB.

PCB Fate and Transport

The feasibility study and the ROD assumed that natural processes would effect a continued gradual decline. The feasibility study claimed "It is not known whether exposure of more highly contaminated sediments after flood scouring could lead to an increase in fish contamination." At that time, one could have reasonably inferred from well established premises, regarding bioaccumulation and partitioning of organic contaminants, that exposure of more highly contaminated sediment would lead to an increase in fish contamination. Empirical evidence now directly supports such a conclusion. A single runoff event that occurred during the spring of 1983 accounted for a 50 percent increase in annual PCB transport from the upper Hudson River over the prior year. This event, which has an expected frequency of one in ten years, immediately preceded a statistically significant increase in PCB concentrations in key monitored fish species. An overall longterm decline in PCB concentrations is still a reasonable expectation. However, recent data demonstrate a slower rate of longterm recovery than would have been derived from data prior to 1984 and that short-term reversals might also be expected.

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[4]Levels of chlorinated dioxins, dibenzofurans and biphenyls in fish are highly correlated. There is no clearly evident distinction in the real risks posed by each class of these contaminants to Hudson River fish consumers. For example, although the EPA estimated carcinogenic potency of 2,3,7,8-TCDD is 20,000 times that of PCBs, the levels of PCBs are generally more than 150,000 times the level of 2,3,7,8-TCDD in Hudson River fish. In the lower Hudson there is evidence of chlorinated dioxin and dibenzofurans sources other than the upper Hudson River sediment. Sediment data for the upper Hudson suggest that dioxins, dibenzofurans and certain heavy metals share coincident contamination histories and were codeposited in sediment. Areas and sediment strata with the highest PCB concentrations also have the highest concentrations of other chlorinated organics and metal contaminants. Dibenzofuran levels in sediment are consistent with their presence as trace contaminants of the PCB mixtures used by the GE capacitor factories. It appears that sediments are the major reservoir and resupplier of these contaminants as well PCBs to the fish. Physical and chemical processes that would ultimately reduce PCB levels in fish would also reduce the levels of these other contaminants in fish. Biodegradation and biotransformation processes might effect a disproportional reduction of contaminants in the fishery in the future. Compound selectivity, the hallmark of biodegradation processes, could result in a greater reduction in the availability of certain PCB compounds than other PCB compounds, dioxins and dibenzofurans. Biotransformations of metal contaminants in upper Hudson River sediments have not been well studied although there is evidence of some activity and resistance in the microbiological community.

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Results of the 1984 sediment survey (11) dispelled the simplistic notion that clean sediment is capping contaminated sediment. There are no uncontaminated surficial sediments in the Hudson River downstream of Hudson Falls. The longterm process of recovery is more realistically described as one in which relatively clean sediment derived from upstream areas is contaminated by adsorption of dissolved PCB and mixing with contaminated bed sediment. This addition of sediment and its mixing with contaminated sediment would effect a steady continuous decline in the release of PCB from the riverbed if not for the dynamics of river flow. Empirical evidence of the ability of high river flow to expose more highly contaminated sediment was noted earlier. The modeling analysis of erodibility of Thompson Island Pool sediments conducted as part of the 1984 sediment survey produced an estimate that 2300 kg of PCB would be eroded from this pool alone during a 100-year flood. Such transport would be comparable to the observations of annual transport from the entire upper Hudson during the mid- to late-1970's.

The release of PCB from the bed of the Hudson River sustains the contamination of the fishery to levels higher than those found in any ecosystem of nearly comparable scale in the United States. Table 2 presents PCB levels in the fillets of Hudson River fish. The data presented in Table 2 were selected from a presentation of results of fish monitoring during 1982-1986 (12) because of their recreational and commercial relevance.

Table 2. Mean PCB concentrations in Hudson River fish fillets (ug/g).

Location/Species	1982	1983	1984	1985	1986
Fort Edward					
largemouth bass	--	--	19(30)*	20(20)	10(18)
brown bullhead	--	--	--	--	38(20)
Stillwater					
largemouth bass	3.6(20)	6.8(20)	6.4(22)	9.3(21)	6.0(21)
brown bullhead	9.8(20)	17(20)	11(20)	15(19)	12(23)
Albany					
striped bass	--	--	8.7(6)	19(20)	16(36)
Catskill					
largemouth bass	--	8.2(20)	6.7(20)	6.7(20)	11(20)
striped bass	--	8.3(20)	7.2(18)	7.6(26)	9.6(20)
Tappan Zee					
striped bass	3.6(50)	6.0(50)	3.6(34)	3.8(65)	3.1(60)

* number of fish analyzed presented in parentheses

These data represent only a portion of the entire fisheries contamination monitoring effort for the Hudson. Figures 1a and 1b reflect trends in fish PCB contamination. Figure 1b presents the PCB concentration per unit of fat in largemouth bass. For monitoring trends in resident fish these units are better than wet weight PCB concentrations because of the apparent control body-fat content exerts on overall PCB concentration and the substantial year-to-year variations in body fat. The variations in fat content, which can be attributed only generally to ecological factors such as feeding dynamics and disease, can obscure overall trends in the

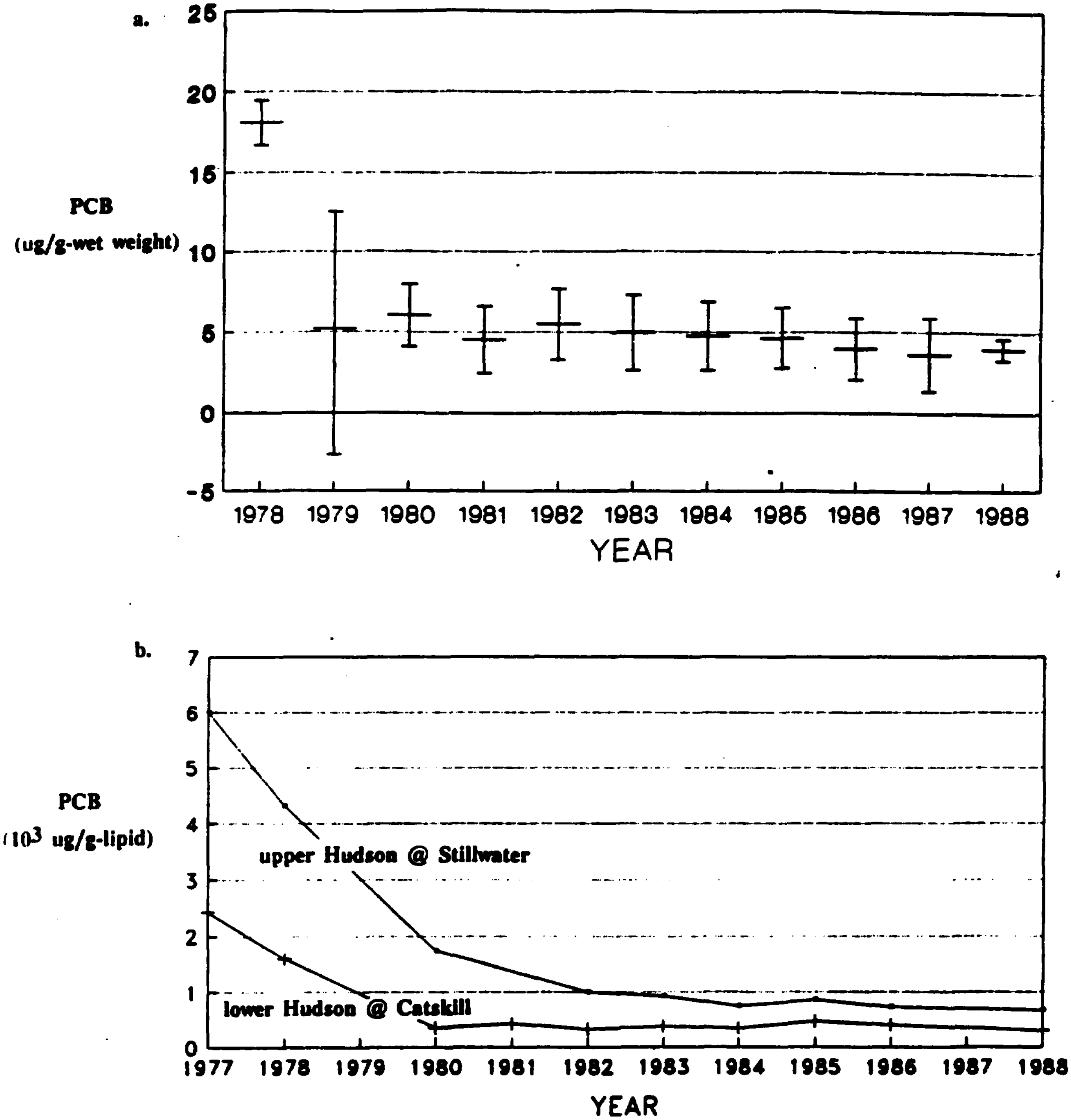

Figure 1. Mean PCB concentrations in striped bass collected throughout the lower Hudson (a) and largemouth bass (b).

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bioavailability of PCBs in this ecosystem. These data provide no basis for optimism regarding a natural solution to the problem in the near future. The extraordinarily high levels of PCB found in fish from the upper Hudson have probable ecological impacts in addition to the potential human health impacts attributabe to their consumption. A recently published controlled study (13) has associated the high prevalence of liver pathologies in fish from the Fort Edward area with exposure to organic contaminants.

Remedial Technology

The 1984 Decision was clearly influenced by reservations regarding the effectiveness of dredging:

"The most feasible and reliable alternatives assessed by EPA (limited and full scale hot spot dredging) would be likely to decrease the level of risk somewhat. However, ..., the actual reliability and effectiveness of current dredging technologies in this particular situation is subject to considerable uncertainty. For this reason the no-action alternative is recommended at this time. This decision may be reassessed in the future if, during the interim evaluation period, the reliability and applicability of in-situ or other treatment methods is demonstrated, or if techniques for dredging of contaminated sediment from an environment such as this one are further developed" (8). The ROD noted that it was "difficult" to conclude that dredging technology can be considered feasible. The two important and related aspects of the technology considered uncertain were the efficiency of contaminant recovery and the amount of contaminant resuspension and "short-term damage" caused by dredging.

Recent EPA decisions to remove PCB-contaminated sediment from Waukegan Harbor and the Accushnet Estuary recognized the significant health threat of leaving PCBs in place and the recent findings regarding the reliability and safety of dredging. EPA and the US Army Corps of Engineers conducted pilot-scale dredging of contaminated sediment in the Accushnet Estuary which convinced them that properly operated conventional cutterhead dredges could operate to remove a contaminated sediment layer and "to minimize resuspension with no plume of resuspended material moving away from the dredging area and with no elevated levels of contaminants detected outside the immediate area of dredging and disposal operations" (14). EPA analyses indicate that transport of PCB throughout the system could be permanently reduced by the dredging of the hot spot.

Doubts raised by the feasibility study about the persistence of PCB hot spots were dispelled by additional survey work. Sediment samples during 1983 produced PCB concentrations that were occasionally at odds with those expected by the previous definition of PCB hot spots. A subsequent intensive sampling program demonstrated that although the distribution of sediment contaminants is generally quite variable that continous areas of highly contaminated sediment persist and those areas generally correspond to the previously defined hot spots (11). This program also established a system for prioritizing areas for removal based not only upon PCB concentration but erodibility.

Project Scope Justification

A comprehensive remedial approach that consolidates the disposal of contaminated riverbed sediments and contaminated sediment removed from the

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river as part of maintenance activities can be justified on the basis of health risk reduction and natural resources management policies for environmental protection and restoration. The full extent of the PCB contamination problem in the upper Hudson River Basin involves more than several million pounds of PCB scattered among municipal landfills, dumpsites, dredged material disposal sites, river sediments and river-bank deposits (Figure 2). The remaining scope of remediation consists of the remnant deposist areas, riverbed hotspots from Fort Edward to Schuylerville and NYS Department of Transportation sediment disposal sites.

The contaminated upper Hudson is a series of pools formed by low-level dams as part of the Champlain Canal system. This 40-mile reach contains approximately 150,000 lbs of PCB in riverbed sediment and another 46,000 lbs of PCB in riverbank sediments known as the remnant deposits. These highly contaminated sediments effectively rose on the banks of the river following the removal of a dam at Fort Edward in 1973. The next downstream impoundment, the five-mile long Thompson Island Pool, contains approximately 51,000 lbs of PCB or one third of the mass of PCB in the bed of the upper Hudson.

For the remnant deposits, federal Superfund proposes the placement of a soil cover and armoring of the banks against erosion as interim measures. In addition to the remnant deposits and river sediments, approximately 1,085,000 cubic yards of dredged sediment containing an estimated 175,000 lbs of PCB are located at seven sites in the Fort Edward area. These sites largely contain sediment that was released following the removal of the Fort Edward dam. Only the New Moreau Sediment Disposal Facility, which was constructed and operated during 1977 - 1978, was designed specifically to accommodate PCB-contaminated materials. This clay-lined and clay-capped facility contains approximately 194,000 cubic yards of river and remnant-deposit sediment laden with 32,000 lbs of PCB.

As indicated previously, the health risks associated with Hudson River fish consumption are substantial. The release of PCB from the river bed and banks sustains this contamination. The unconfined sediment disposal sites appear to pose some risk to the local population through the release of PCBs to air and groundwater. Additional work is required to better assess the risks posed by these sites.

The full volume of contaminated sediment currently in the river, on the river banks, and in unconfined disposal sites targetted for remediation is 3.1 million cubic yards. Costs associated with removal, transport, and longterm encapsulation of this material is currently estimated to be $275 million. Technologies capable of decontaminating this material would cost considerably more to implement. The evaluation of such technologies and their eventual application to some or all of this material should also be considered within the scope of the remedial effort.

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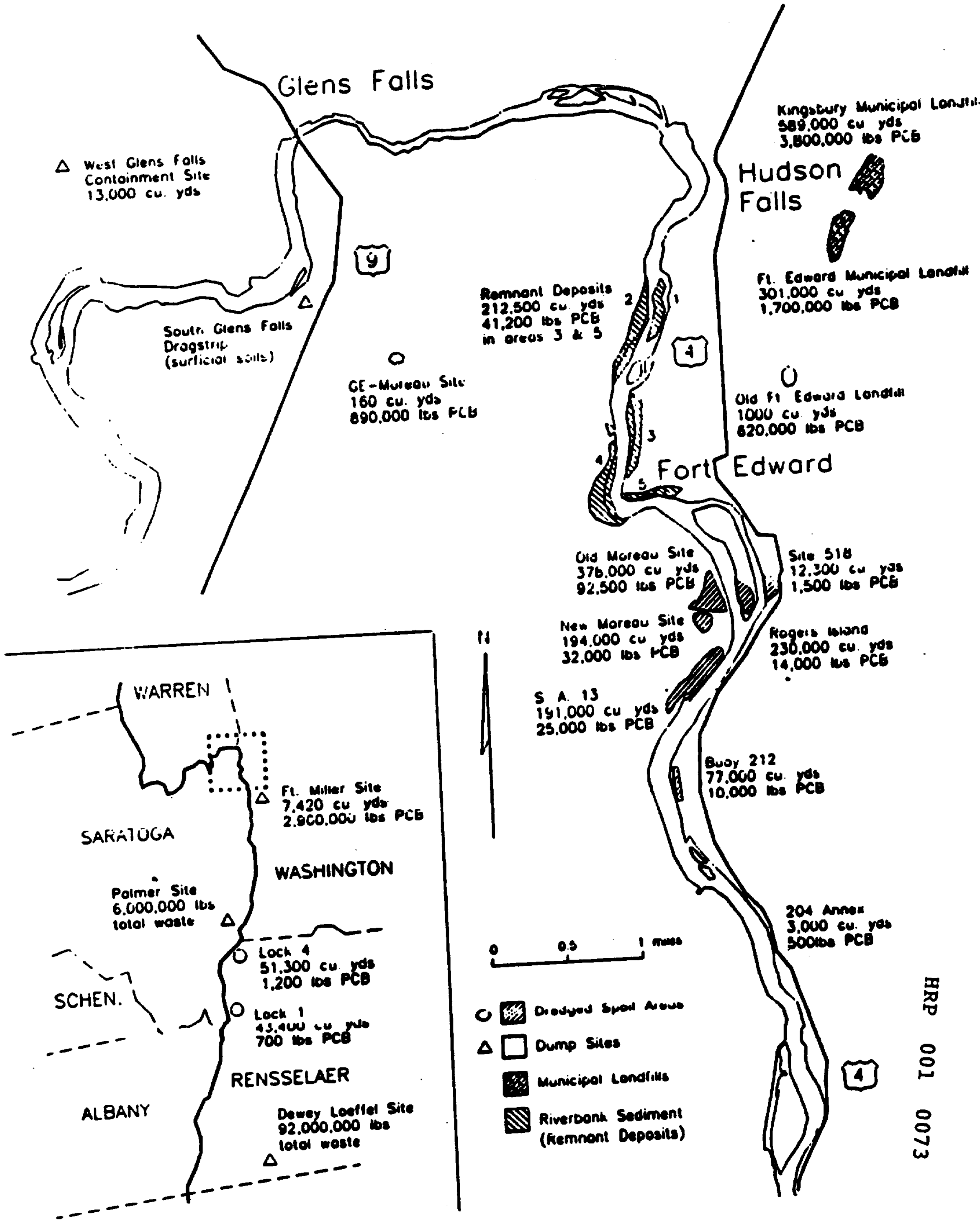
Figure 2 PCB–Contaminated Sites in the Upper Hudson Watershed



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