Contaminant Assessment and Reduction Project
Water

CARP

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The Hudson River flows from the eastern Adirondacks through power dams, and into the long lower estuary before reaching New York Harbor and the sea. As it moves, it passes through different social and economic settings where it picks up and transports residuals of those settings. By the time it reaches New York Harbor the river is carrying traces from all the places it has passed. This is an attempt to quantify those traces and to gain an understanding of how the deleterious ones might be reduced.

DEVELOPMENT OF CARP

In the spring of 1996, a few New York Sate Department of Environmental Conservation (NYSDEC) staffers took the train down from Albany to the Hudson River Foundation on W 20th St. in Manhattan to sit in on a meeting that Dennis Suszkowski, HRF's science director, had organized. The Hudson River Foundation was created to accept money levied from a court settlement against paper mills and power generators using Hudson River water. HRF distributes the money as grants for research on the Hudson. It also hosts meetings, arranges seminars, and generally serves as a meeting site for academics, consultants, people from the Environmental Protection Agency, the Army Corps of Engineers, the Port Authority of New York/New Jersey, the New York City Department of Environmental Protection, the New Jersey Harbor Discharges Group, citizens groups like the Bay Keeper and Friends of Jamaica Bay, and people from the New Jersey and New York state conservation departments.

HRF had awarded a grant to Robert Thomann and Kevin Farley, both professors at Manhattan College in the Bronx. In the 1970s, Thomann had developed a mathematical model for PCBs in the Hudson. HRF's grant was to update the model and to include more chemicals, particularly dioxins, pesticides, and a class of substances produced by combustion called polynuclear aromatic hydrocarbons, or PAHs for short.

Mathematical modeling is a scientific rather than simply descriptive approach to environmental studies. It begins with a general framework of boxes with lines between them. Each box represents a compartment such as "fish" or "water" or "sediment" and the lines are rates of movement of a substance between the boxes. The model looks at the study area as a grid and calculates the rates of movement of chemicals, water, suspended solids, and so forth, both within and between the grid segments over some length of time. Models organize information and help understand what is important and what isn't. If the modelers really understand the relevant rates and have information about the concentrations of the chemicals in the various compartments and at the systems boundaries, they can predict the consequences of changing inputs or chemical loading. A loading is a rate at which some chemical enters the system. Regulatory programs or changes in the uses of chemical should be capable of reducing these loadings and the model could predict how long it would take before reduced concentrations are seen in fish or the water.

After two meetings at HRF a sampling strategy was sketched out calling for sediment and biota (birds, fish, shellfish, benthos, zooplankton), and water sampling. The water component called for samples from sewage treatment plant discharges, sewage treatment plant sludges, combined sewer overflows, storm sewer overflows, landfill leachates, industrial effluents, and tributaries. Loads (mass per time such as kilograms of a chemical/year) would then be calculated. In order to tie the loads together, the strategy also requested ambient seasonal sampling at 19 sites throughout the area including the Hudson, Passaic, and Hackensack Rivers, the Arthur Kill, Raritan Bay, Upper and Lower Bays, Jamaica Bay, East River, Long Island Sound, and New York Bight.

The logic of this modeling approach is sound but the execution is extremely difficult. Tidal systems like New York Harbor are physically complicated. There was almost no information on chemical concentrations in the water and the extensive data from landfills, sewage treatment plants, and tributaries were usually inadequate or incomplete.

Harbor Estuary Program (HEP)

Much of the focus for the attention on water quality in New York Harbor comes from the 1996 Comprehensive Conservation and Management Plan (CCMP). This document is a product of the Harbor Estuary Program, itself stemming from 1987 amendments to the Clean Water Act. The CCMP is, as implied, comprehensive, and deals with floating debris, pathogenic bacteria, nutrients, habitat, storm discharges, dredging, and toxic chemicals. Toxic impacts are noted in sediments of the harbor and some areas in the Bight and in ambient harbor waters to sensitive organisms in laboratory tests. Reproductive impairments to fish-eating birds have been attributed to DDT. Some birds nesting in the Kills may have suffered from decreased reproductive success and some fish have exhibited fin rot (winter flounder) and liver tumors (tomcod), developmental abnormalities, behavioral impairments, and altered life histories (mummichogs) attributable to chemical pollution.

Body burdens of some chemicals exceed levels believed safe for human consumption. The CCMP identifies 15 chemicals (“chemicals of concern”) as either exceeding enforceable standards (mercury, PCBs, dioxin, PAHs, chlordane), exceeding unenforceable criteria (arsenic, cadmium, DDT and metabolites, dieldrin, heptachlor, heptachlor epoxide, hexachlorobenzene, and gamma-hexachlorocyclohexane (?-HCH), or predicted by modeling to exceed enforceable criteria (copper).

HEP calls for 13 specific actions to reduce continuing inputs of toxic chemicals to the harbor. These are:

1) Reduce municipal discharges of chemicals of concern.
2) Reduce industrial discharges of chemicals of concern.
3) Minimize the discharge of toxic chemicals from CSOs, storm water, and non-point sources.
4) Reduce air emissions of chemicals of concern.
5) Remediate identified solid and hazardous waste sites.
6) Track-down and clean-up of other sources of chemicals of concern.
7) Improve chemical/oil spill response and prevention.
8) Focus pollution prevention activities on chemicals of concern.

9) Identify and remediate selected contaminated sediments.
10) Establish consistent methodology to assess risks and improve communication of fish advisories.
11) Review and develop criteria for copper and other priority chemicals.
12) Assess ambient levels, loadings, and effects of chemicals.
13) Develop mass balances for metals and organic chemicals.

Mud Dump Site/HARS/Dredging

Besides HEP's CCMP, other actions directly related to navigational dredging deal with toxic chemicals. The Port of NY/NJ is the largest on the eastern seaboard. Parts of it are naturally very shallow necessitating navigational dredging. Historically, dredge spoils were deposited in the bay and later just beyond the Rockaway/Sandy Hook line. Ocean dumping of dredge spoil is regulated by the 1972 Marine Protection, Research and Sanctuaries Act (MPRSA). In 1982, USEPA Region 2 designated a Mud Dump Site six miles east of Sandy Hook, NJ and eleven miles south of Rockaway, New York. By 1984, the New York District of the USACOE and USEPA Region 2 published a regional guidance manual to implement the national manual (revised also in 1984) in New York Harbor. The local guidance established three categories of dredge spoil:

Category I which is suitable for unrestricted ocean disposal,
Category II sediments may be ocean disposed if capped with Category I material, and

> Catagory II materials have total DDT (sum of DDT, DDE, and DDD) greater than 40 ppb, cadmium greater than 0.3 ppm, or mercury greater than 0.2 ppm in either clams or worms. PCBs are greater than 100 ppb in clams and, as of September 2000, greater than 113 ppb in worms (formerly 400 ppb in worms). Also, if 2,3,7,8-TCDD is greater than 1 ppt and less than 10 ppt or if total ***TEQ*** (minus 2,3,7,8-TCDD) exceeds 4.5. And finally, Category II is not toxic to clams or worms.

Category III sediments are not suitable for ocean disposal.

> Category III material is toxic to laboratory organisms or has dioxin TEQ exceeding 10 ppt.

Under the original 1984 protocols, 95% of the dredged material was Category I and a little less than 5% was Category II. Thus, more than 99% of the harbor dredge spoil could be ocean dumped at a cost of $5-$10 per cubic yard. However, growing public pressure for a clean environment forced the federal agencies in 1992 to reevaluate the criteria. The revised criteria resulted in 66% of the dredge spoil being classified Category III (not suitable for ocean disposal) and 9% became Category II (suitable only if promptly covered by Category I). This change in categorization greatly increases dredging costs perhaps to the point of threatening the continued economic viability of the port.

Furthermore, continued ocean disposal of Category II material was halted by executive order in 1996 and in 2000 the criteria for categorization were yet again revisited and made more stringent.

New York/New Jersey Harbor is estimated to have 124,000 directly related jobs with a combined payroll of $16.5 billion.

With this economic background, the need to get a better understanding of toxics in the harbor became apparent to the governors of both New York and New Jersey and to the Port Authority of New York/New Jersey. The Port Authority articulated a coherent vision of an alliance between the states, the relevant federal agencies, major dischargers, citizen environmental groups, and the Port Authority. The Port Authority also brought $130 million to the table. The Army Corps of Engineers offered to fund a data management contractor. Thus was born CARP.

Contaminant Assessment and Reduction Project (CARP)

CARP is a cooperative effort of the States of New York and New Jersey, with assistance from EPA and the Army Corps of Engineers, as well as academic and private scientists and engineers, to understand and to reduce contaminants in the harbor (www.carpweb.org).

The principal issues requiring address are:

1) To what extent is chemical contamination of harbor sediments and biota historical versus ongoing?
2) If a significant portion of harbor chemical contamination is ongoing, what can be done to reduce that load?
3) How long will it take before harbor sediments and biota attain certain qualities following cessation or diminution of new inputs?

The target chemicals, to be discussed in greater detail below, are PCBs, dioxins, DDTs and chlordane, mercury, and cadmium. A major impediment to open ocean disposal of dredge material is toxicity. While the above listed chemicals are toxic, they are of interest for their bioaccumulation and carcinogenicity. They are not expected to be at concentrations responsible for the toxicity seen in short exposure laboratory tests. Some existing data points to polynuclear aromatic hydrocarbons (PAHs) as potential short-term toxicants to harbor test organisms.

The 1996 strategy set the sampling sites and chemical list. The other parts of the project were settling the chemical analytical methods, the logistics of getting people and supplies to where they need to go, deciding what to do in the field, and setting up a data management process.

Some of the People Who Made CARP Possible

The NYSDEC workplans were extensively discussed during many meetings held at the Hudson River Foundation in 1997 and 1998. Active participants in the process were Dennis Suszkowski (HRF), Tom Wakeman (Port Authority, NY/NJ), Seth Ausable (the EPA Habror Estuary Plan coordinator), Bruce Brownawell (SUNY Stony Brook), Carleton Hunt (Battelle Ocean Sciences), Richard Bopp (RPI), Dominic DiToro (Hydroqual), John St. John (Hydroqual), Mick DeGraeve (Great Lakes Environmental Center), George Korfiatias (Stevens Institute), Mike Bruno (Stevens Institute), Phil Heckler (NYCDEP), Alan Stubin (NYCDEP), Fred Grassle (Rutgars University), Steve Eisenreich (Rutgars University), Greg Durell (Battelle Ocean Sciences), Eric Evenson (USGS, New Jersey), and Pat Phillips (USGS, New York).

The project leaders from the NYSDEC were Paul Gallay (Special Assistant to the Commissioner) and Jeff Sama (Director, Division of Regulatory Affairs). The supervisor of the NYSDEC sampling operation was Italo Carcich, Chief of the Bureau of Watershed Assessment and Research. Sharon Hotaling helped with the proof-reading.

The labor involved in just accomplishing the water part of the program was substantial. Most of the ambient samples were taken with boats large enough to have internal labs and AC power. Steve Cluett of SUNY Stony Brook helped with the 50 foot *Onrust* based in Port Jefferson on Long Island. Through the assistance of Dore LaPosta and Doug Pabst we were able to get sea time on EPA's *Anderson*. We also spent a considerable amount of time on EPA's smaller 55 foot *Cleanwaters* with the assistance of Randy Braun and Steve Hale. The City of New York generously provided the Marine Science's harbor vessel *Osprey* and field assistance from Jordan Adelson and Mike Cacioppo under the direction of Alan Stubin and Beau Ranheim.

Tributary sampling was performed by Pat Phillips and Gary Wall of the USGS out of Rensselaer, New York.

Wastewater treatment plants in New York City were sampled with the help of Max Obra and his crew at Wards Island. Additional help in ambient and WPCF sampling came from the NYSDEC Region 2 staff, particularly Annetta Vitale, Selvin Southwell, and particularly the Dredge Team members George Hyde and Dare Adelugba. Jimmy Pyn graciously put up with a great many unannounced visits to the Newtown Creek WPCF.

Landfill sampling in New York was done with help from Susan Pepitone of NYCDEP (Pelham Bay), and Ted Nabavi of NYCDOS (Fresh Kills). NYSDEC's Dan Walsh provided much of the basic concepts of landfill sampling. In New Jersey, we were helped by Tom Maturano of the New Jersey Meadowlands Commission.

The design of CSO sampling was worked out by Tom Newman, then of Hydroqual, and accomplished by Iris Martin and Al Torres of Staunton-Chow, a contractor to Hydroqual. SWO sampling was done by a NYCDEP team under the direction of Jerry Volgende and Carol Neptune.

Lily Lee and Ronald Lochan, in addition to Gerry Volgende's staff designed and assisted in the trackdown work in New York City.

The chemists at the labs, particularly Brian Fowler, Coreen Hamilton, Georgina Brooks, Dale Hoover, and Laurie Phillips at Axys Analytical, provided an enormous amount of advice, insight, quantitative data, and encouragement.

Much of the logistics, that is keeping track of supplies and equipment, was handled by Mike Dauphinais here at NYSDEC. NYSDEC rented space at the USACOE facility at Caven Point in Jersey City, NJ to keep sampling equipment for the ambient sampling cruises. In this endeavor we were assisted by Alan Dorfman at the USACOE and by our attorney, Jennifer Hairie.

Larry Bailey and his staff, particularly Gail Dieter and Sue Barbuto, provided a great deal of assistance with lab contracts and in assisting with the interpretation of lab QC procedures.

Particular thanks go to John Donlon at NYSDEC. John built and maintained the TOPS, participated in a great many sampling surveys, assembled equipment and supplies, shipped samples to the labs, entered data, created all the maps, and organized the massive amount of paper and other reporting media returned by the labs.

Over the life of the project people have changed jobs and I'm sure there are many others whose important contributions I've left out. I thank them all.

NEW YORK HARBOR

New York Harbor lies at the bottom of Hudson, Passaic, and Hackensack Rivers. The surrounding counties have a combined population of 13.5 million. New York City and the adjacent communities in New Jersey and New York operate 31 sewage treatment plants having a total design capacity of 2,400 million gallons per day (mgd). These plants generate about 15,000 tons of dry sewage sludge a month. One hundred and 85 square kilometers (20% of the surface area of NYC) is composed of landfill. Almost all of the landfills were built on wetlands adjacent to the estuary. Rainwater percolating through these sites results in 41 mgd of Coca Cola ® colored leachate. New York City's 394 combined sewer outfalls are estimated to discharge
135 mgd of untreated sewage.

Major Tributaries

Yearly average discharges of five major rivers (at head of tide) are:

Tributary Rivers:	cubic feet per second, CFS
Hudson at Waterford above confluence with Mohawk R.	5,300
Mohawk River at Cohoes	3,700
Wallkill at Gardiner, New York	690
Passaic River at Little Falls, NJ	740
Raritan River and Bound Brook, NJ	770

There is an enormous degree of daily and even hourly variability in these river discharges. The estuary responds to freshwater flows, to tides, and to other forces such as wind velocity and barometric pressure.

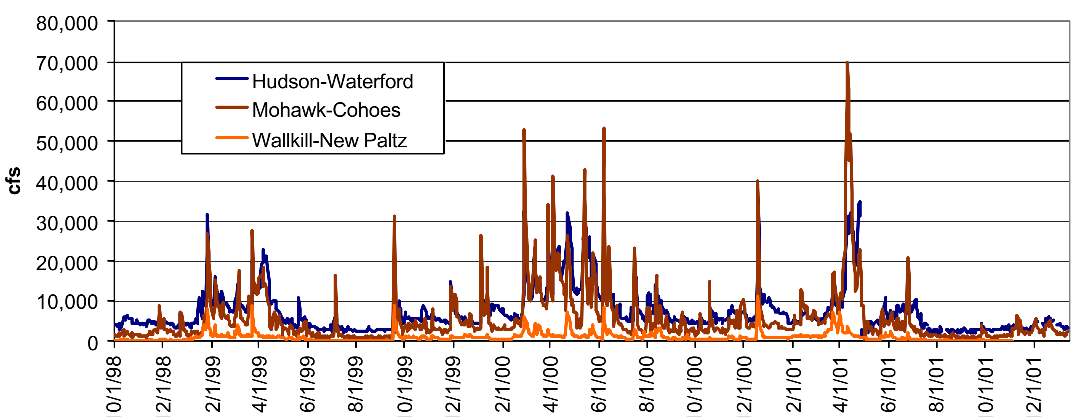

Figure 1. Comparison of discharges of the three largest freshwater sources to the Hudson Estuary over the life of CARP.

One can safely assume that a parcel of water entering the estuary will eventually reach the sea; it's much harder to know when. It is very much more difficult to predict when a particle entering the estuary will reach the sea or the harbor. It may spend a significant amount of time buried in a deposition area and in regions nearer the ocean large amounts of sediments are brought into the harbor from the continental shelf.

USGS researchers working within the CARP studied the loading of particles particularly during high flow events. Generally, about half a river's discharge occurs in about 10% of the year in a small number of events. The loading of solids and more particularly, organic carbon may occur over shorter spans. A separately funded investigation by Gary Wall of the USGS and Rocky Geyer of Woods Hole, instigated by CARP observations, is investigating some of the fine-grain detail of particle movement in the mid-Hudson near Poughkeepsie, New York. This work will yield insights that will assist in predicting the movement of particles through the tidal portion of the Hudson.

Minor Tributaries

The CARP design called for investigating the contributions of some of the minor tributaries. The extent of urbanization in New York City is such that there are few surface streams. CARP selected three; the Bronx River in the Bronx, Saw Mill River in Westchester, and the Gowanus Canal in Brooklyn. The Gowanus Canal and Saw Mill River are obviously affected by street run-off, CSOs, and probably contaminated groundwater. The Bronx River is, particularly as it makes its way through the New York Botanical Garden, surprisingly lovely but still chemically affected by its passage through Westchester County and the Bronx.

While neither the Saw Mill River nor the Bronx River are gauged, discharges may be estimated by assuming proportionality to that of nearby streams that are monitored.

The Gowanus Canal is an odd choice as a tributary. It was at one time a real tidal creek but is no longer. It had been canalized and served as part of the terminus of the Erie Canal. Raw sewage had rendered the Gowanus obnoxious and, in 1911, the City of New York installed a pumping system to flush it out with East River or Upper Bay water. The flushing system was rebuilt in 1999 and uses East River water. The present system has an average pump rate of 200 mgd and a maximum rate of 300 mgd. The pump rate varies with the tidal elevation so as not to mobilize contaminated bottom sediments. In this case, discharge is East River water that may have some entrained bottom sediments.

There is a concern that the flushing activities would mobilize contaminated sediments and we decided to sample the Gowanus as a potential contaminant source via transport of resuspended solids.

Sewage Treatment Plants

There are 14 sewage treatment plants in New York City alone. They are on Staten Island (Port Richmond in the north and Oakwood Beach in the south), two in Manhattan (North River in the northwest and Wards Island in the northeast – actually in the East River), one in the Bronx (Hunts Point), three in Queens (Bowery Bay in Steinway near Rikers Island, Tallman Island in College Point near the Whitestone Bridge, and Jamaica near Kennedy Airport), and six in Brooklyn (Newtown Creek in Greenpoint, Red Hook next to the Brooklyn Navy Yard, Owls Head in Bay Ridge, Coney Island in Sheepshead Bay, 26th Ward in Spring Creek, and Rockaway).

Besides the 14 NYC plants, the CARP also sampled plants in Rensselaer (near Albany), Poughkeepsie, Rockland, and Yonkers. NYSDEC sampled two plants in New Jersey, Passaic Valley Sewerage Commissioners (PVSC) and Edgewater.

Table 1. Harbor area WPCFs.

WPCFs	MGD
Newtown Creek (NC)	286
Passaic Valley (PVSC)	*283*
Wards Island (WI)	258
North River (NR)	161
Hunts Point (HP)	148
Bowery Bay (BB)	126
Owls Head (OH)	124
Coney Island (CI)	115
Yonkers (Westchester Co.) (YO)	92
Jamaica (JA)	81
26th Ward (26)	68
Tallman Island (TI)	55
Red Hook (RH)	41
Port Richmond (PR)	35
Oakwood Beach (OB)	27
Rockaway (RO)	27
Rockland County (RK)	26
Rensselaer (RE)	24
Poughkeepsie (City) (PO)	14
Orangetown SD2,	13
Tri-City	12
Newburgh	9
Haverstraw	8
Kingston	7
Beacon	6
Poughkeepsie (Town)	4
Wallkill (Town)	4
Edgewater	*3*
Ulster (Town)	1.6
Yorktown Heights	1.5

Each of the targeted WPCFs was sampled at least three times with the exception of Red Hook where there were field problems and one sample set was rejected. Some plants

(Newtown Creek, Port Richmond, Hunts Point, and 26th Ward) were sampled more intensively. Two facilities in New Jersey (PVSC and Edgewater) were visited once each as part of an investigation in sampling technique.

Sewage treatment plants generally do four things. They remove stuff that sinks ("grit") and stuff that floats ("scum"). They grow and harvest bacteria that degrade and metabolize dissolved organic material. And they disinfect the final water with chlorine. Solids, called sludge or biosolids, are dewatered, palletized, and used as fertilizer. Not all the WPCFs in New York City have dewatering facilities necessitating the transport of watery sludges by ship to plants with drying capabilities from those without. The eight plants that have dewatering capabilities and their estimated monthly output of sludge are listed below:

Table 2. Biosolids production at NYSDEP WPCFs.

WPCF	Tons/month, dry weight
Wards Island	3000
Hunts Point	2500
26th Ward	1200
Bowery Bay	1000
Oakwood Beach	820
Jamaica	690
Tallman Island	450
Red Hook	230

Municipal treatment plants are not designed to remove toxic chemicals and on occasion, toxic chemicals discharged to sewers may disrupt treatment plants by harming the bacteria and protozoa essential to the process. Therefore, sewage treatment plant operators run programs, called "pretreatment", to regulate what is discharged into sewers by manufacturers or certain commercial establishments. The following table shows the kinds and numbers of facilities in the New York City pretreatment program by wastewater treatment catchment area[1].

[1] Data kindly supplied by Leslie Lipton, NYCDEP, 7/17/2003.

Table 3. Type and number of NYC industries discharging to city WPCFs. The key to the abbreviations is in Table 1.

	Totals	177	110	68	28	26	23	19	13	10	9	8	6	1	1
		NR	NC	BB	OH	WI	HP	JA	26	TI	RH	CI	PR	OB	RK
new source metal finishing	248	141	53	32	6	1	3	4	5	2	1				
radiator shop	31		2	3	4	6	6	4	2	1		2	1		
industrial launderer	26		9	3	2	3	1	3	1		1	1	1	1	
metal finishing/non-cat	24	6	8	4	2	1		2	1						
miscellaneous	23	3	5	4			3	3	1	1	2	1			
paint/ink formulator	21	2	4	2	3	3	3		1		1	2			
metal finishing	17	10	1	1	1	1				1	1		1		
textile dyer	14	2	6	1		1	1			2		1			
soap & other detergents	9		2	1	3	1		1	1						
steam electric generation	9		1	2	1	2					1		1		1
centralized waste treatment	8	1	2	1	1	1				1	1				
electroplating-> 10k gpd	7		1	5						1					
electroplating- < 10k gpd	7		3	1	1		1					1			
organic chemicals/non-cat	7			3	1	1	1			1					
pharmaceutical manfg.	6		1	1		3		1							
metals molding & casting	4		1	1	1						1				
nonferrous metals form & powders.	4	1			1	1		1							
organic chemical/categorical	4		1				2						1		
photoengraver	4	3	1												
steel drum reconditioner	4		4												
fur dresser & dyer	3	1	2												
pesticide chemicals	3			1		1	1								
heat treater	2		1				1								
metals molding & casting/non-cat	2	1							1						
nonferrous metals manfg.	2	2													
NS metal molding & casting	2	1		1											
photofinishing	2	2													
copper forming	1				1										
inorganic chemicals/non-cat	1		1												
instruments & related products	1		1												
new source metal finishing	1	1													
NS metal molding & casting/MF	1			1											
pulp & paper products	1												1		

CSOs and SWOs

Sewage gets to sewage treatment plants by means of sewers. Sewers and sewage treatment plants have designed capacities. Too much water cannot be properly treated and may, if unchecked, harm the process by washing out the bacteria being farmed at the sewage treatment plants. The collection system can divert excess water and the sewage treatment plant operators also watch their intake and can divert excess water. In some cases, at 26th Ward in Brooklyn for example, diverted water is held in vast underground tanks and processed at the treatment plant during dry weather but in most instances, diverted water goes directly into surface water. When the diverted sewage is a mixture of rain water and what is politely called "sanitary" waste, its called combined sewer overflow (CSO); when it's only run off from the streets or roofs, it's called storm water overflow (SWO). In newer areas, cities build separate collection systems for storm water and sanitary water. In a separated system, the discharge of excess water during a storm is less contaminated and the treatment plants are less exposed to excessive flows. Most of New York City has combined sewers but there are some separate sewers in parts of Queens and in southern Staten Island. We thought that the CSOs might turn out to be important sources for loading of chemicals into the harbor.

The capacities, number of CSOs, and estimated average CSO discharges are shown below for 13 New York City WPCFs (Oakwood Beach omitted).

Table 4. NYC CSOs. See Table 1 for the key to the abbreviations.

WPCF	Max Cap. (mgd)	# CSO	Est. Avg. CSO Disch. (mgd)
NC	602	66	14
WI	457	76	11
BB	300	47	13
NR	298	46	5
HP	272	30	15
OH	234	8	9
CI	181	3	10
JA	160	14	31
26	125	4	12
TI	114	16	10
PR	109	33	1.0
RH	92	29	3.7
RO	37	22	0.47

CSOs (combined sewer overflows) should occur only when the amount of water entering a treatment plant exceeds twice its design capacity. When influent flows are greater than design capacity but below twice design capacity, some primary treatment (removal of solids) is possible but higher flow rates may damage the facility. Treatment plant operators throttle down the intakes and the water exits the system through diversions. The system's design permits some overflow to escape under minimal rains so that CSOs actually occur during times when twice design capacity has not been reached. Modeling studies estimate that the city's 394 CSOs release about 140 mgd of untreated wastewater.

During CARP, CSOs were assessed indirectly by taking samples at the influent to wastewater treatment plants during wet weather. Sampling persisted over the time that influent flows exceeded the plant's design capacity. Water at inlets is a mixture of the entire system and it avoids the parochialism of a particular sampling point. Furthermore, access to the wastewater treatment plant is simpler than to actual CSOs. Simpler is not necessarily simple. Wastewater treatment plants recycle water from various operations back into the influent often at a place upstream of the most convenient sampling point.

We do not want to sample these mixed streams. Also, some plants receive water in more than a single trunk. These were sampled separately. The amount of water required (about 100 L) and the length of time over which samples were collected (4 hours) limited the field crew to a single sample per storm event.

Landfills

About 20% of the surface area of New York City is landfill. Much of the 46,000 acres of landfill were created to hold ash generated in heating and cooking. Only a small proportion, some 2000 acres, are modern landfill. These acres are in the Bronx (Pelham Bay, 100 acres), Brooklyn (Pennsylvania Ave., 100 acres; Fountain Ave., 300 acres; Edgemere, 120 acres), and Staten Island (Fresh Kill, 1200 acres, and Brookfield, 180 acres). Assuming a yearly rainfall of 1.1 meters and infiltration rate (proportion of rainfall that becomes part of the groundwater) [2], the estimated leachate production is 2.6 mgd. Furthermore, an appreciable amount, perhaps 1 mgd of this total, is treated, at Fresh Kills Leachate Treatment Plant for the Fresh Kills and at Hunts Point WPCF for Pelham Bay Landfill. Experience at the Fresh Kill Landfill Treatment Plant suggests that this estimate may be high but the discharge may suffice for modeling.[3]

Some of the leachate from the New Jersey Meadowlands Commission sites is treated at the Passaic Valley Sewerage Commissioners (PVSC) WPCF in Newark, NJ but some leachate flows directly into the Passaic River. Assuming a similar size of landfills in New Jersey, a rough estimate of 4.2 mgd of untreated leachate may be entering the harbor area surface waters from both states.

Leachate is colored, high pH, and strong smelling. It is the product of the breakdown of mounded garbage flushed out by ground water or rainwater. Toxic chemicals, particularly metals, occur in leachates. Illegally dumped waste oils and other substances also have gotten into either the wastestream or have been directly placed in landfills.

Leachate was taken from two New York City facilities, Pelham Bay in the Bronx and Fresh Kills in Staten Island. Pelham Bay has a leachate collection system that delivers leachate to the Hunts Point WPCF. Our samples came from holding tanks at Pelham Bay. The Fresh Kills site consists of numbered mounds. Leachate from the mounds is gathered by a system of trenches and pumps. Most of the leachate production comes from mounds 1 and 9. Mounds 6 and 7 are also important producers. As they enter the Fresh Kills treatment plant they are combined into 1/9 and 6/7. There are several sampling points around the mounds, a few of which have been sampled in CARP. These include 1/9 B and 1/9 F. Three mounds, 1A, 1D, and 1E, were sampled in New Jersey at the New Jersey Meadowlands Commission (formerly called the Hackensack Meadowlands Development Commission).

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[2] Walsh, D.C., 1996. Geochemistry of solid waste landfills. Ph.D. Thesis submitted to Rensselaer Polytechic Institute, Troy, NY.

[3] Personal conversation, Philip Gleason, NYS Department of Sanitation, June 1, 2001.

SAMPLING HISTORY AND METHODS

Despite an enormous effort to monitor trace contaminants, Bob Thomann and Kevin Farley had virtually no data for their model. Why? In most places the concentrations of these chemicals are very low relative to the capabilities of conventional analytical methods. They are not, however, low relative to the risk-based water quality standards required for protection of human health. For example, the canonical technique for measuring PCBs (US EPA Method 608 – based on gas chromatography, electron capture detection, and pattern recognition of PCB congeners or domains characteristic of Monsanto's Aroclor mixtures) in wastewater has a method detection limit of 65 parts per trillion (ppt) but a practical detection level, taking variability and interferences into account, of often more than 300 ppt. The old New York ambient water quality standard for PCB (to protect humans eating wildlife) was 1 ppt. A three hundred-fold difference is a little larger than the difference between the speed of the space shuttle (17,500 mph) and New York's highway speed limit (65 mph). This situation is somewhat analogous to equipping speed cops with radar guns incapable to telling whether the space shuttle is moving or staying still. The current New York State (NYS) water quality standard for PCBs is three orders of magnitude lower (0.001 ppt or 1 part per quadrillion).

Persistent bioaccumulative chemicals like PCBs occur in all surface waters and in all wastewaters but the methods most often used are incapable of measuring toxicologically significant concentrations. Even when they are detected, sampling and laboratory errors introduce so much variability that the value of the data to modeling becomes suspect. This problem was compounded by the magnitude of the project. Sampling would be performed by many teams in two states using six different labs for organic chemical analysis and two for metals. The field methods themselves were novel and under development. The laboratory methods were also far from routine.

TOPS

One of the fundamental goals of the CARP is consistent detection of all target chemicals from all media. This has been a new idea. As noted before, the field and lab methods commonly used in regulatory programs are often incapable of detecting PCBs in surface or waste waters and always incapable of measuring dioxins and furans in water. This is caused by insufficient mass of analyte, interferences, and sometimes in the case of PCBs, unexpected patterns of congeners.

Taking these issues in reverse order, the occurrence of non-Aroclor congeners will not be seen by pattern-recognition where Aroclors are expected. The question of interferences becomes large in places where a lot is going on, like New York Harbor. Consider the task of weighing yourself. Step on a bathroom scale in the privacy of your bathroom and the reading you get from the instrument will only reflect your own weight. But if you set the scale up on a crowded sidewalk other people might be stepping on the scale at the same time you are trying to weigh yourself. Much of what the analytical chemist does with the sample is to reduce these interferences and techniques have gotten quite good – but still not perfect. And, investigation into interferences has played an important part in environmental science. It was Søren Jensen's studies of interferences in DDT analysis that initially revealed the wide-spread existence of PCB in 1963. Later researchers saw unexplained chromatographic peaks while looking for PCBs and discovered the flame retardant and insecticide Mirex. Interfering chemicals may be mistaken for the target chemical or they may be recognized and eliminated but in the clean-up process, target analyte is also lost. More commonly, interferences increase the signal noise and consequently result in degradation of the signal.

The bathroom scale analogy is relevant to the question of accuracy. Consistent data produced by a single system are useful for making decisions even if not highly accurate. However, data collected by multiple systems are useful only if they be related back to a standard. The difficulty in doing this increases with the complexity of the data collection system. There are differences in extraction efficiencies between different environmental matrices (sewage versus landfill leachate versus surface water), between sampling systems (TOPS, PISCES, grab samples), between labs, between sets of field personnel, and so on.

The analyte mass issue can also be analogized by trying to weigh something that's very small, say a feather on our bathroom scale. The scale is too insensitive to register such a light object. However, if we collected enough feathers, we would be able to use the scale to measure them. But then, we'd need to be able to put the resulting mass into the correct units. Perhaps we might count the feathers and divide the total mass by the count to get a mean mass per feather. Similarly, in doing trace organics sampling, processing large water volumes can result in significantly lower detection limits – and we have to be able to measure accurately the volumes of water processed.

When I started working for DEC in 1979 we sampled for PCBs by collecting water into a quart Mason jar. Since the early 1980s researchers in Canada and the United States have been experimenting with ways to field concentrate larger and larger volumes. Early work on the Niagara River, by Peter Goulden and others at Environment Canada's Canada Centre for Inland Waters in Burlington, Ontario, resulted in a series of devices to mix sample water with the solvent dichloromethane chloride (DCM) and then to remove the DCM for analysis. The result of their work was a complicated piece of glassware called the Large Sample Extractor and, after Peter's unexpected death, renamed the Goulden Large Sample Extractor or GLSE. The GLSE is used by Environment Canada on the Niagara River and elsewhere, and the USEPA has operated it on board their Great Lakes Research Vessel *Lake Guardian*. To use the GLSE water is first clarified by filtration or by centrifugation. Particles collected on the filter or from the centrifuge can be sent to a lab for extraction and analysis. Some of the clarified water is fed into the GLSE where its heated and then stirred up in a mixing vessel with DCM. The rest of the GLSE separates the DCM from the water. The water is wasted and the DCM is recirculated back to the mixing vessel. Since DCM dissolves rather well into warm water, a separate pump makes up for the DCM losses. Dissolved PCBs are captured by the bulk phase DCM so the DCM that is lost through dissolving into the water does not carry with it much of the PCB. The retained DCM then contains the dissolved phase of the PCB.

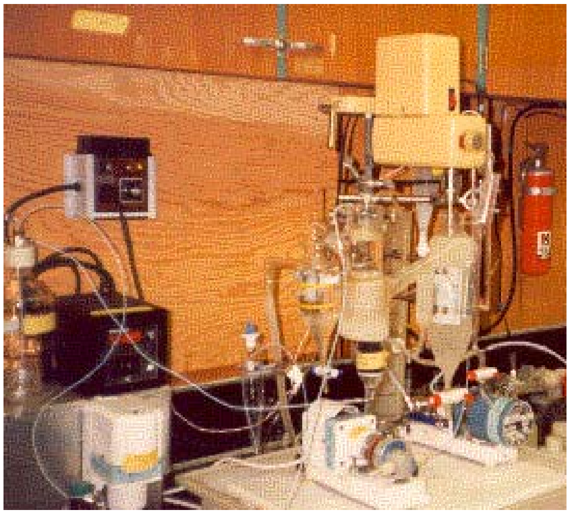

Figure 2. Goulden Large Sample Extractor set up in Environment Canada's monitoring station in Fort, Erie, Ontario.

In 1992 over a 32 hour period, we tested duplicate GLSEs, one set up, with the assistance of Dave DeVault then at EPA, on a bridge over the Oswego River in upstate New York at Minetto and another set up on the *Lake Guardian* moored a few miles away in the City of Oswego. Both processed Oswego River water collected at the same time through the same plumbing.

At the same time we were performing that experiment, Tony Ethier of Seastar, a Canadian oceanographic equipment manufacturer in Sidney, British Columbia, had set up a commercial sampling device called Infiltrex also from the Minetto Bridge. Tony sat in his car reading a book while I was rushing around tending to the GLSE.

The results of the experiment on the Oswego River Bridge showed that minute differences in glassware or operation produced order of magnitude differences between samples processed on the bridge and on the ship. This finding dashed the hope that we could have sufficiently sensitive and comparable field technique deployed in open lake waters from the *Guardian* and also from truck mounted sampling on the tributaries.
A few years later, in 1995, the EPA gave NYSDEC a grant to determine if dioxins, PCBs, and chlorinated pesticides occurred in final effluents from sewage treatment plants discharging to Lake Ontario. EPA suggested that we consider using a device that captures a "cubic meter" of water. This device turned out to be the same one that Tony Either had deployed on the Minetto Bridge.

Infiltrex is a self-contained submersible unit powered by a stack of lantern batteries. It pumps water through a glass fiber filter and then through a Teflon ® column holding a synthetic resin called XAD-2. After a set volume, or time, or if the filter is plugged, Infiltrex shuts off. The filter and the XAD are extracted and the extract may be analyzed. While the GLSE processed 50 to 100 L, Infiltrex dealt with 200 to 300 L of water. EPA was suggesting that we process 1000 L. After speaking with a number of Infiltrex users we decided to build our own version using AC power and many of the pumps left over from the ill-fated GLSE experiment. Infiltrex could be used with either a flat Whatman GFF grade glass fiber filter (0.7 micron nominal porosity) or a 4-inch wound glass cartridge filter (1.0 micron nominal porosity). We selected the cartridge filter as it had a much greater capacity than the flat filter and would make the unit less likely to suffer plugging and then to pre-maturely shut-down. Everything needs a name and one of our engineers, Cynthia Leece, suggested calling it "TOPS" for Trace Organics Platform Sampler.

TOPS was designed with our GLSE experience in mind. It was, unlike GLSE, entirely self-contained so no part of the sample was exposed to the air. There had been problems with GLSE picking up PCBs from the air. TOPS was also intended to be physically rugged in contrast to all the breakable glassware in GLSE. Unlike Infiltrex, TOPS was capable of filtering more water than it passed through the XAD. Most synthetic chemicals of interest are poorly soluble in water and tend to adhere to suspended particles. We had seen in the Niagara many cases where we were detecting substances only from the particulate phase. TOPS was intended to filter very large volumes of water, particularly in low turbidity situations. And finally, TOPS was to be very easy to run in the field. The last wish was achieved initially but has been has steadily receding.

Using TOPS in 1996, we were able to determine the presence of the target analytes in all the treatment plant effluents. In 1997, we used TOPS to investigate dioxin and PCB levels in tributaries to Lake Ontario. In the later summer I brought it to Burlington, Ontario where Melanie Nielson and her staff and colleagues at the Canada Centre for Inland Waters criticized the design. We followed up on the many excellent suggestions and were able to re-engineer a better instrument. An improved TOPS permitted measuring open lake PCBs from the *Lake Guardian* in October of 1997 during a four day cruise.

For that work we had to figure out a way to get water from the lake while the ship was in motion. Ships are dirty and clean sampling requires avoiding smoke and ship-generated effluents. The ship's crew and captain, David Moser, helped rig a 45 pound bomb-shaped device, called "DL-76" (made to be lowered from a bridge into a flowing river to collect a sample of water for measuring suspended sediments) from an A-frame on the starboard rear. On contact with the flowing stream the DL-76 swings around to point into the current. NYSDEC Engineering Technician John Donlon attached a TOPS intake to the top surface of the DL-76. A test run out of the Port of Rochester showed the set up to be stable up to about 5 knots but at higher speeds the tow-fish had a tendency to dolphin, particularly in choppy water.

Figure 3. TOPS on the EPA' s New York Harbor Survey Vessel *Clean Waters*. The "U" shaped device near the top holds a cartridge filter and the two white double-ended cartridges hold XAD. The two small boxes in the upper right side are flow meters.

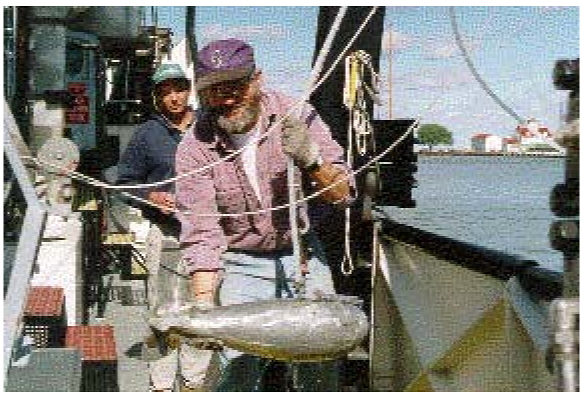

Figure 4. The DL-76 tow fish on board the R/V *Lake Guardian* moored at the mouth of the Genessee River, Rochester, New York.

As CARP was getting going in 1997 and 1998 we were gaining experience in obtaining very large volume samples from ships and at wastewater treatment plants. We knew we could detect all the target analytes. XAD was still new to us and somewhat mysterious. We knew that it was being used in large lake studies in Green Bay, Wisconsin and in the Lake Michigan Mass Balance Study. It had had some 20 years of use in the environmental field and we had seen that it appeared to behave similarly to the GLSE set up on the Niagara River. While initially we didn't have a way to evaluate it, we believed that if we followed the literature and used the same procedure everywhere, we would have a consistent data set.

Over the next few years we followed suggestions from Brian Fowler, at the Axys Group in British Columbia, to add more and more quality control tests. These were:

1) to set XAD columns in series and to analyze each individually as a way to measure break-through,
2) to spot the columns with chemical surrogates to test for wash-out and recovery,
3) to pump water through the XAD at different rates (pump speeds), and finally
4) to meter into the water stream chemical surrogates that would mimic trapping dissolved chemicals by the XAD.

The last, at least for the analytes most similar to the surrogates, is a more realistic test of XAD trapping efficiency, but one not without flaws. Naturally occurring macromolecules like humic and fulvic acids appear to bind synthetic hydrophobic chemicals and reduce their availability for extraction by hexane. Research by Mark Driscoll at the SUNY Environmental and Forestry College in Syracuse, New York, suggests that the length of time needed for PCBs to reach a binding equilibrium with these dissolved materials is days or even weeks. This effect is not being captured in the metered surrogate delivery used with TOPS. Dr. Driscoll had some success with simultaneous hot chromic acid digestion and extraction for PCBs but this harsh treatment would have destroyed some target pesticides.

The specific details of operating the TOPS during CARP are set out in an attached document, <u>TOPS- Standard Operating Procedure</u>. Dr. Gary Wall of the USGS devised some critical modifications for long duration TOPS operation in streams with very high suspended sediment concentrations. These are discussed in an attached paper, <u>Use of a Large Volume Sampler in River Settings</u>.

Many samples were taken during the course of CARP to help evaluate the efficiency of both XAD and the filter. At the outset of CARP a large sediment sample was taken, thoroughly mixed, subdivided, frozen, and periodically sent in for analysis to help understand inter and intralab variability. Results of these studies are reported and discussed in an appended paper (<u>The Performance of An XAD/ One-Micron Cartridge Filter Trace Organic Platform Sampling System (TOPS</u>)**.**

PISCES

In the mid-1980's we were looking for a cheap way to capture PCBs. The only really useable tools then available were to collect natural concentrators like sediments or biota. Those media were spotty and inconsistent. In many instances, a sample collection could be very time consuming. John Hassett at the State University of New York College of Environmental Science and Forestry in Syracuse, New York, had been thinking about passive samplers as surrogates for fish. Passive samplers use a membrane separating water from a solvent. PCBs, as well as pesticides and some PAHs (in theory dioxins and furans too) will migrate through a solvent saturated membrane and become trapped in a non-polar medium. The rate of movement is a function of the analyte/solvent interaction, the porosity of the membrane, and temperature. Dr. Hassett was working on a passive sampler that used hexane as the solvent and one mil polyethylene as the membrane. He called it PISCES for **P**assive **I**n-**S**itu **C**hemical **E**xtraction **S**ampler.

In 1988 we had success in identifying a PCB source to the Black River at Carthage, New York using PISCES and, in 1992, we found a PCB source to the Arthur Kill in New York Harbor with the device. The NYSDEC Fish and Wildlife program uses them as well as the USGS in Massachusetts, the New Jersey Harbor Dischargers Group at Linden Roselle, and a private contractor working on Alaska's North Slope uses PISCES to locate PCBs on the Colville River.

Different teams use slightly different versions of the same idea. Basically, PISCES consists of a container holding about 200 mL of hexane. We use a schedule 80 4-inch brass nipple sealed at the top with a Teflon ® disk and at the bottom with the polyethylene. I place them in rivers, streams, or sewers with the membrane side down and leave them in the water for about two weeks. Derivation of a sampling rate requires knowing the water temperature. By knowing the rate, membrane area, and time of exposure, we can roughly estimate the volume of water sampled through the use of an empirically derived equation that John determined. PISCES are cheap (our model costs about $20 each) enough to permit placement in risky locations where losses are possible and rugged enough to withstand severe buffeting in storm charged sewers or streams.

Figure 5. Preparing PISCES in the field. PISCES are usually deployed in pairs in case one fails. The bottles in the truck hold hexane.

Data Management

The data produced by CARP are voluminous. Battelle Ocean Sciences of Duxbury, MA, maintains an official data base.

SAMPLES
Sampling for organic chemicals was accomplished using TOPS. The sampling routine was similar everywhere but not identical. For sampling the three minor tributaries and the 20 ambient stations, a 100 mesh Nytex plankton net was used to strain out larger zooplankton. In some cases, the plankton net removed a considerable amount of material. This required deploying a submersible pump and use of a stainless steel can as a receptacle for the strained water.

Landfill samples were taken from leachate collection systems. The purpose of the sampling was to obtain a quality estimate for leachate escaping the various treatment systems. Since the escaped leachate was entering the surface waters through diffusion, there was no way to estimate the particle bound phase of the transport. Therefore, only glass fiber filtered water was processed in CARP. There is no reason to collect POC or TSS data from leachate samples.

Two of the three major tributary monitoring stations (Hudson and Mohawk) were essentially identical. Water from a submerged intake ran into a shed holding a TOPS and ISCO samplers for the metals, whole water PAHs, and DOC/POC, and suspended sediment samples. The set up on the Wallkill was a little different. Very high event related suspended sediment concentrations resulted in the rapid plugging of the glass fiber filters. To overcome this problem, Dr. Gary Wall of the US Geological Survey (USGS) devised a settling tank made from a modified stainless steel milk can. The can was on an electronic scale. As the can filled and as it’s weight increased, a datalogger triggered the TOPS to pull partially clarified water from the can. At the end of the event, the heavy material that settled out in the can was scraped out and incorporated with the filter as the particulate sample.

The success of sampling the tributaries can be seen in graphs displaying the hydrograph of the study period and the hydrograph of the period sampled.

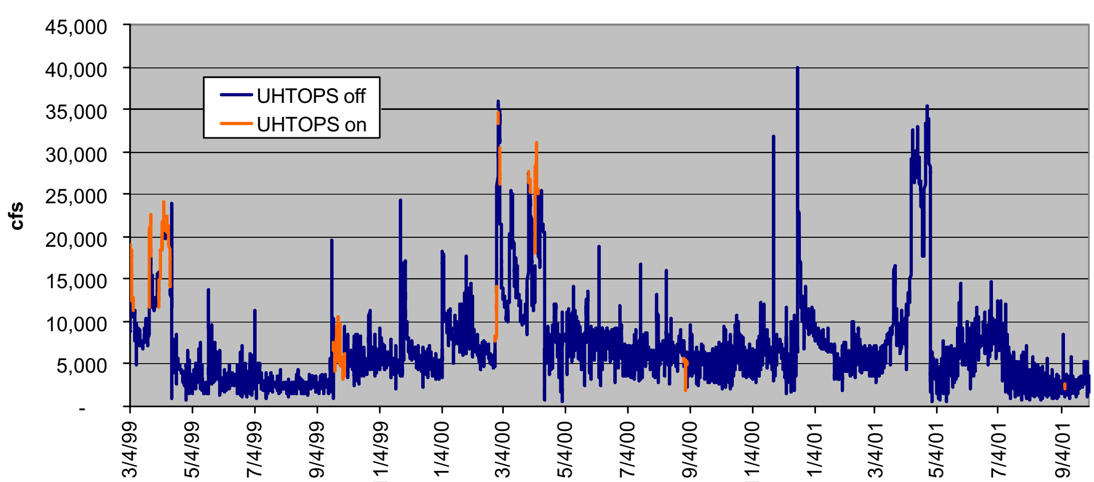

Figure 6. Over the period of study, TOPS was pumping while 7% of the Hudson’s flow was passing.

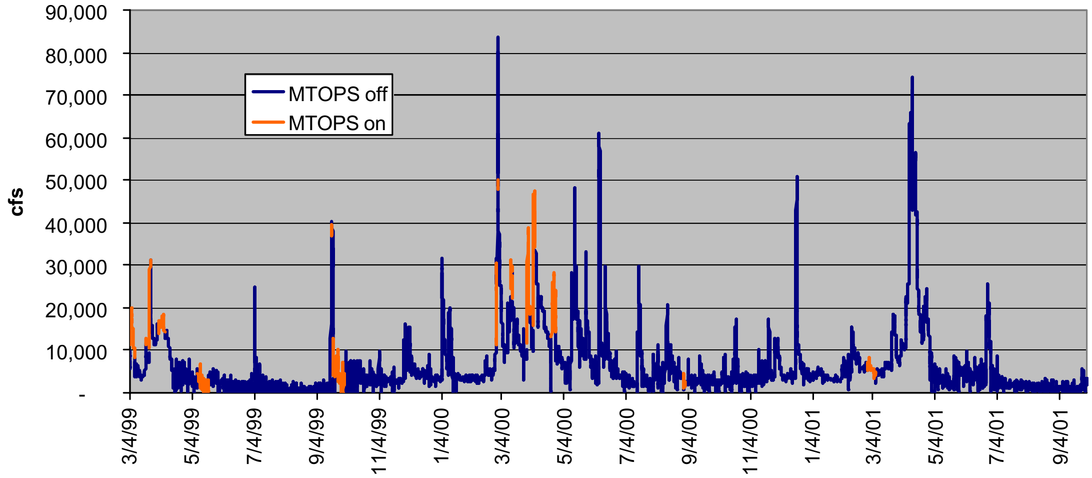

Figure 7. Over the study period, TOPS was pumping while 11% of the Mohawk's flow passed.

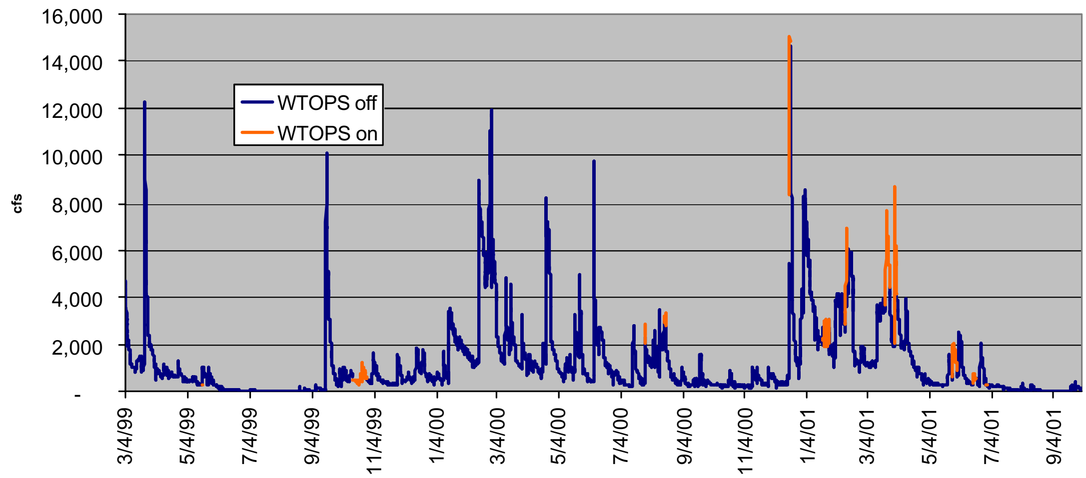

Figure 8. During the period of record, TOPS was pumping while 10% of the Wallkill flow was passing.

Most of the samples taken under CARP were done so through the use of conventionally set up TOPS and allowed the sample volume, the number of liters passed through the filter or the XAD columns, to be adjusted in the field. The average volumes of water (in L) processed using conventional TOPS are shown below:

Table 5. Average volume of water passed through TOPS media, by sample type.

Sample Type	XAD	GLASS FIBER CARTRIDGE
AMB-clean	680	3100
AMB-Hudson	210	890
AMB-Kills	170	760
AMB-Non Kills	190	720
Industrial effluents	190	1000
Landfill leachate	90	
Major Tribs	260	850
Minor Tribs	190	740
WPCF	140	380

Figure 9. TOPS running on the Passaic River. Notice the stainless steel can on the left where large zooplankton are removed by filteration. A syringe pump delivering metered surrogates is seen on the table to the right of the TOPS. The plastic carboys on the deck collected water during timed intervals as an independent check of pumping rates. Note the lack of simplicity.

We had wanted to use metered surrogates at an early date in the project but experienced a variety of problems executing it. The "gas-tight" glass syringes turned out to be temperature sensitive and the fittings leaked. These problems were eventually solved by the decision to move the process into the lab. The lab-based set-up was called "TOPS-Next Generation". Beginning in February of 2001, 35 samples were processed using TOPS-Next Generation. This modification was made to permit much slower XAD processing rates (from about 600 mL/min to about 16 mL/min) and it allowed for much better control of the metered surrogates. The disadvantage of the process was that it limited the total sample size to a little less than 100 L and there were more opportunities for sample contamination.

Cosine Tide

The average duration of sampling in tidal ambient sites (in areas other than Long Island Sound and the New York Bight) was 5.6 hours. This is a portion of a tidal cycle and results may be affected by the direction of the tide. To obtain a quantitative value expressing the tides over the duration of sampling we considered the tide to be a sine wave where each point of the tidal cycle can be mapped as an angle. If we take the cosine of the wave, high tide has a cosine of 1 (cos 0 = 1), low tide has an angle of 180 (cos 180 = -1), and points half way between (90 and 270 degrees) have cosines of 0. The difference between the end of the run and the beginning can have a maximum value of 2 if sampling starts at high tide and ends at low tide; a value of –2 if it starts at low tide and ends at high tide, and 0 if it starts at the mid-ebb and ends at the mid-flood.

High and low tides were obtained from NOAA gauges at the Battery, the Narrows, Kill van Kull, and Kings Point on the eastern end of the East River.

Ambient Sampling Stations

Twenty ambient sampling stations are shown in Figure 10. There were two Long Island Sound sites (LISE and LISJ), and two New York Bight stations.

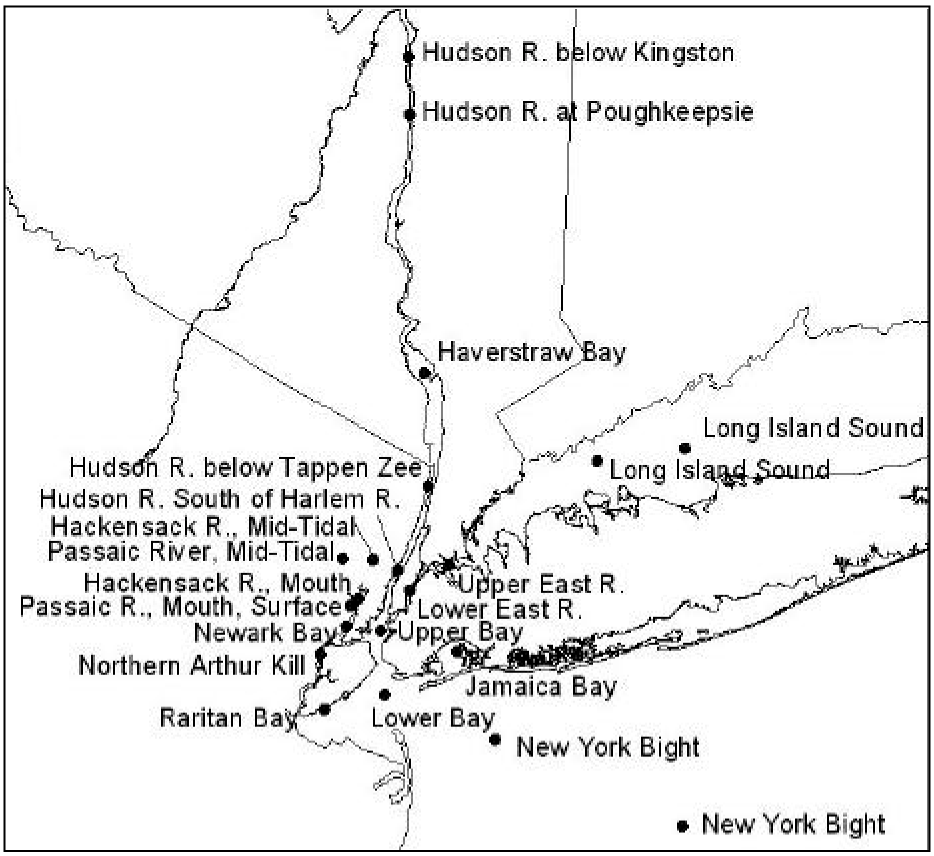

Figure 10. Centroids of ambient sampling stations.

Table 6 shows the ambient samples, the date sampling began, cosine tide, and mean sample values for DOC, POC, and SS. Some of the samples were performed over more than one tidal cycle and hence, no cosine tide value was calculated.

Table. 6. Ambient samples.

Site type and name	Date	Cosine tide	DOC, mg/L	POC, mg/L	SS, mg/L
Ambient-Non_Kills: Lower East R.	9/18/98	-0.41		1.23	5.33
Ambient-Non_Kills: Lower East R.	3/11/99	-1.52	3.79	1.18	19.00
Ambient-Non_Kills: Lower East R.	7/27/99	0.86	2.74	0.67	57.20
Ambient-Non_Kills: Lower East R.	6/2/00	1.78	3.35	0.37	18.60
Ambient-Hudson: Haverstraw Bay	11/24/98	-1.50	4.38	0.20	
Ambient-Hudson: Haverstraw Bay	2/10/99	-1.04	4.86	0.18	19.60
Ambient-Hudson: Haverstraw Bay	7/11/99	1.93	3.63	1.04	316.00
Ambient-Hudson: Haverstraw Bay	4/4/00			0.55	30.60
Ambient-Hudson: Hudson R. South of Harlem R.	12/17/98	0.47		0.33	10.60
Ambient-Hudson: Hudson R. South of Harlem R.	3/16/99	-1.11	4.29	0.97	47.50
Ambient-Hudson: Hudson R. South of Harlem R.	8/12/99	1.92	2.65	0.44	19.70
Ambient-Hudson: Hudson R. South of Harlem R.	12/14/99	1.88	3.88	0.42	11.88
Ambient-Hudson: Hudson R. South of Harlem R.	6/14/00	1.11	6.59	0.33	9.74
Ambient-Hudson: Hudson R. below Kingston	5/25/99	-1.64	3.53	0.27	
Ambient-Hudson: Hudson R. below Kingston	10/8/99		6.05	0.72	25.70
Ambient-Hudson: Hudson R. below Kingston	6/28/00		4.86	0.49	16.50
Ambient-Kills: Hackensack R., Mouth	11/12/98		6.97	0.62	5.90
Ambient-Kills: Hackensack R., Mouth	2/8/99	-1.67	5.81	0.39	3.20
Ambient-Kills: Hackensack R., Mouth	7/7/99	-1.88	5.48	0.46	24.40
Ambient-Kills: Hackensack R., Mouth	4/11/00	-1.98	9.28	2.09	12.70
Ambient-Kills: Hackensack R., Mid-Tidal	3/17/99	0.31	13.94	2.77	43.50
Ambient-Kills: Hackensack R., Mid-Tidal	9/2/99	-1.06	8.36	0.30	35.30
Ambient-Kills: Hackensack R., Mid-Tidal	10/12/99	-0.71	7.46	1.25	37.00
Ambient-Kills: Hackensack R., Mid-Tidal	11/2/99				
Ambient-Kills: Hackensack R., Mid-Tidal	5/10/00	-0.72	9.15	1.56	46.10
Ambient-Hudson: Hudson R. at Poughkeepsie	3/1/99		1.49	3.31	53.5
Ambient-Hudson: Hudson R. at Poughkeepsie	3/28/99		2.21	3.34	61.54
Ambient-Hudson: Hudson R. at Poughkeepsie	4/16/99		2.61	3.1	93.16
Ambient-Hudson: Hudson R. at Poughkeepsie	4/17/99		2.15	3.06	96.32
Ambient-Hudson: Hudson R. at Poughkeepsie	10/23/99		2.23	4.58	90.82
Ambient-Hudson: Hudson R. at Poughkeepsie	3/18/00		4.07	3.59	146.1
Ambient-Hudson: Hudson R. at Poughkeepsie	5/17/00		2.79	4.17	85.71
Ambient-Hudson: Hudson R. at Poughkeepsie	6/15/00		2.28	4.45	94.49
Ambient-Hudson: Hudson R. below Tappen Zee	12/1/98		10.52	0.64	
Ambient-Hudson: Hudson R. below Tappen Zee	2/19/99		4.73	0.61	38.20
Ambient-Hudson: Hudson R. below Tappen Zee	7/10/99	1.03	3.76	0.92	14.40
Ambient-Hudson: Hudson R. below Tappen Zee	4/4/00		10.70	0.58	41.10
Ambient-Non_Kills: Jamaica Bay	10/14/98	-1.98	2.45	0.65	7.50
Ambient-Non_Kills: Jamaica Bay	2/23/99	-1.80	3.71	1.07	19.90
Ambient-Non_Kills: Jamaica Bay	7/9/99	0.21	4.55	1.40	33.50
Ambient-Non_Kills: Jamaica Bay	5/4/00	1.23	5.03	0.96	6.09
Ambient-Non_Kills: Lower Bay	12/3/98	0.04	2.60	0.19	2.80
Ambient-Non_Kills: Lower Bay	3/2/99	1.45	4.26	2.00	22.40
Ambient-Non_Kills: Lower Bay	7/28/99	1.13	2.58	1.04	13.80

Table 6 continued.

Site type and name	Date	Cosine tide	DOC, mg/L	POC, mg/L	SS, mg/L
Ambient-Non_Kills: Lower Bay	6/1/00	0.43	3.54	1.09	
Ambient-clean: Long Island Sound	11/19/98		3.17	0.17	
Ambient-clean: Long Island Sound	3/2/99		2.74	0.13	5.27
Ambient-clean: Long Island Sound	5/27/99		2.46	0.23	
Ambient-clean: Long Island Sound	10/19/99		4.58		4.69
Ambient-Kills: Northern Arthur Kill	11/17/98	1.67	3.75	0.61	
Ambient-Kills: Northern Arthur Kill	2/17/99	1.56	18.18	0.67	4.9
Ambient-Kills: Northern Arthur Kill	7/8/99	-1.29		0.71	21.9
Ambient-Kills: Northern Arthur Kill	4/18/00	0	8.43	0.99	9.95
Ambient-Kills: Newark Bay	11/25/98	-1.07	3.52	0.28	
Ambient-Kills: Newark Bay	1/27/99	-1.94	4.89	0.5	3.8
Ambient-Kills: Newark Bay	8/11/99	1.52	3.36	0.46	44.2
Ambient-Kills: Newark Bay	12/15/99	-1.51	3.82	0.38	6.14
Ambient-Kills: Newark Bay	4/12/00	-1.22	6.04	0.75	11.3
Ambient-clean: New York Bight	12/9/98		1.5	0.11	
Ambient-clean: New York Bight	1/29/99		1.73	0.07	7.8
Ambient-clean: New York Bight	1/30/99		1.76		7.85
Ambient-clean: New York Bight	1/31/99		3.82	0.1	2.87
Ambient-clean: New York Bight	4/27/99			0.09	1.78
Ambient-clean: New York Bight	3/14/00		19.03	0.13	
Ambient-Kills: Passaic R. , Mouth, Bottom	2/5/99	-0.24	7.07	0.26	
Ambient-Kills: Passaic R., Mouth, Bottom	7/21/99	-1.25	4.4	1.64	30.1
Ambient-Kills: Passaic R., Mouth, Bottom	5/2/00	1.45	8.91	0.89	60.7
Ambient-Kills: Passaic R., Mouth, Bottom	6/26/00	-1.61	7.22	1.24	16.2
Ambient-Kills: Passaic R., Mouth, Surface	11/13/98	-1.81	6.07		4.8
Ambient-Kills: Passaic R., Mouth, Surface	2/3/99	1.7	7.61	0.15	5.92
Ambient-Kills: Passaic R., Mouth, Surface	6/17/99	0.07	4.54	0.08	23.9
Ambient-Kills: Passaic R., Mouth, Surface	6/27/00	-1.95	6.8	1.51	15.8
Ambient-Kills: Passaic River, Mid-Tidal	3/16/99	0.07	4.62	0.21	11.4
Ambient-Kills: Passaic River, Mid-Tidal	8/25/99	0.75	6.27	2.93	56.5
Ambient-Kills: Passaic River, Mid-Tidal	5/9/00	-1.78		1.49	10.3
Ambient-Kills: Passaic River, Mid-Tidal	10/18/00	-1.01	6.78	1.49	44.5
Ambient-Non_Kills: Raritan Bay	11/16/98	0.25	2.36	0.22	1.2
Ambient-Non_Kills: Raritan Bay	2/24/99	-1.83	3.15	1.35	10.9
Ambient-Non_Kills: Raritan Bay	7/12/99	1.85	4.04	0.64	10.3
Ambient-Non_Kills: Raritan Bay	5/3/00	1.78	3.56	1.56	10.3
Ambient-Non_Kills: Upper Bay	12/15/98	-1.19	8.87	0.29	3.7
Ambient-Non_Kills: Upper Bay	3/18/99	1.99	3.31	0.73	15.6
Ambient-Non_Kills: Upper Bay	8/11/99	1.1	2.97		13.3
Ambient-Non_Kills: Upper Bay	6/15/00		5.69	0.21	6.62

Table 6 continued.

Site type and name	Date	Cosine tide	DOC, mg/L	POC, mg/L	SS, mg/L
Ambient-Non_Kills: Upper East R.	36139	-0.97	3.31	0.21	
Ambient-Non_Kills: Upper East R.	36222	-1.05	6.1	0.94	24.9
Ambient-Non_Kills: Upper East R.	36382	0.63	2.58	0.18	2.58
Ambient-Non_Kills: Upper East R.	36592	-0.65	17.31	0.63	9.35

Tributaries

The locations of sampling points on the three major and three minor tributaries are shown on Figure 11. The site on the Mohawk at Cohoes was always in the same position. Changes were made in the TOPS intake locations on the Hudson at Pleasantdale and on the Wallkill at New Paltz. On the minor tributaries, the sampling locations on the Saw Mill River and the Gownus Canal remained constant but two stations were used on the Bronx River.

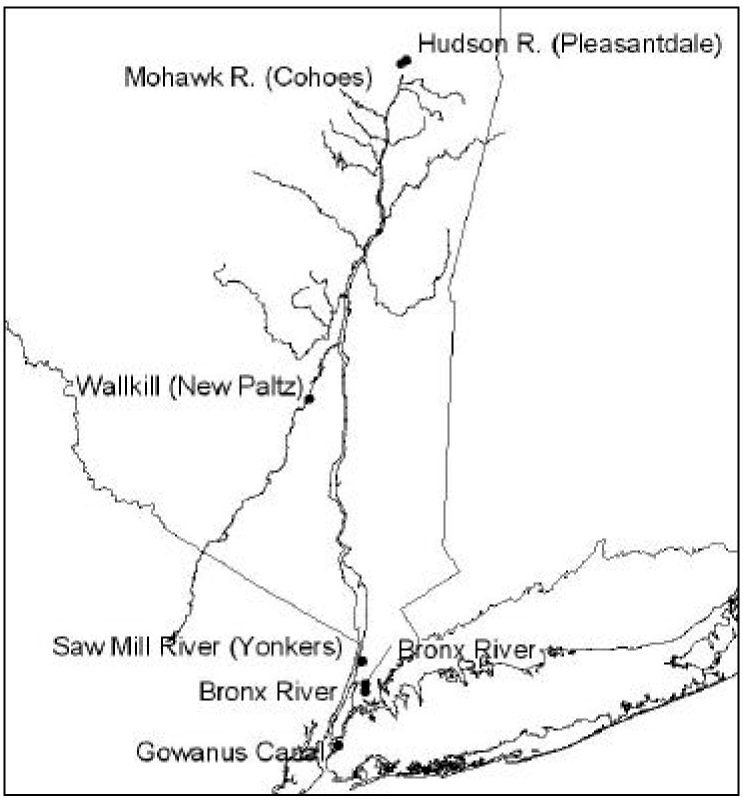

Figure 11. Locations of sampling points on major and minor tributaries.

Table 7 shows the samples taken from tributaries, their dates, discharges (in cubic feet per second), and average concentrations of POC, DOC, and suspended sediment.

Table 7. Major and minor tributary samples.

Sample	CFS	Date_Start	Date_End	POC mg/L	DOC mg/L	SS mg/L
Major tributary: Hudson R. (Pleasantdale)	18650	3/4/99	3/6/99			
Major tributary: Hudson R. (Pleasantdale)	18603	3/22/99	3/23/99	2.07	3.65	95.82
Major tributary: Hudson R. (Pleasantdale)	18887	4/1/99	4/7/99	1.23	3.22	18.04
Major tributary: Hudson R. (Pleasantdale)	18953	4/8/99	4/12/99	0.79	3.45	9.16
Major tributary: Hudson R. (Pleasantdale)	6467	9/20/99	9/30/99	0.47	4.59	10.63
Major tributary: Hudson R. (Pleasantdale)	13136	2/25/00	2/27/00	2.09	4.58	75.33
Major tributary: Hudson R. (Pleasantdale)	33634	2/28/00	2/28/00	5.77	4.05	293.46
Major tributary: Hudson R. (Pleasantdale)	28555	2/29/00	3/1/00	2.97	3.91	85.95
Major tributary: Hudson R. (Pleasantdale)	26562	3/29/00	3/30/00	3.30	3.39	53.61
Major tributary: Hudson R. (Pleasantdale)	27725	4/4/00	4/7/00	2.86	3.94	92.71
Major tributary: Hudson R. (Pleasantdale)	4967	8/29/00	8/31/00	0.29	4.89	2.36
Major tributary: Hudson R. (Pleasantdale)	2040	9/7/01	9/7/01			
Major tributary: Mohawk R. (Cohoes)	17040	3/4/99	3/23/99	1.94	3.64	1.94
Major tributary: Mohawk R. (Cohoes)	16515	4/1/99	4/7/99	1.05	2.97	23.15
Major tributary: Mohawk R. (Cohoes)	2339	5/10/99	5/20/99	0.43	3.67	8.56
Major tributary: Mohawk R. (Cohoes)	37790	9/17/99	9/17/99	5.05	3.92	158.49
Major tributary: Mohawk R. (Cohoes)	18396	2/26/00	2/27/00	2.86	3.52	92.66
Major tributary: Mohawk R. (Cohoes)	48240	2/28/00	2/28/00	10.76	3.84	478.05
Major tributary: Mohawk R. (Cohoes)	23650	3/12/00	3/13/00	2.81	4.27	130.54
Major tributary: Mohawk R. (Cohoes)	25950	3/28/00	3/31/00	3.75	3.80	143.93
Major tributary: Mohawk R. (Cohoes)	38240	4/4/00	4/5/00	4.78	3.92	194.46
Major tributary: Mohawk R. (Cohoes)	19790	4/21/00	4/26/00	1.12	4.13	33.05
Major tributary: Mohawk R. (Cohoes)	2600	8/29/00	8/31/00	0.46	4.54	5.09
Major tributary: Mohawk R. (Cohoes)	6060	2/26/01	3/5/01			
Major tributary: Wallkill (New Paltz)	279	5/17/99	5/18/99	0.70	5.90	10.00
Major tributary: Wallkill (New Paltz)	1350	9/17/99	9/19/99			
Major tributary: Wallkill (New Paltz)	608	10/13/99	10/27/99	0.70	7.40	9.00
Major tributary: Wallkill (New Paltz)	6346	2/15/00	2/16/00			
Major tributary: Wallkill (New Paltz)	2150	2/25/00	2/26/00			
Major tributary: Wallkill (New Paltz)	2551	7/27/00	7/28/00	2.20	6.80	108.00
Major tributary: Wallkill (New Paltz)	3202	8/15/00	8/17/00	7.40	9.30	114.00
Major tributary: Wallkill (New Paltz)	12134	12/17/00	12/18/00	19.70	4.50	580.00
Major tributary: Wallkill (New Paltz)	589	1/19/01	1/23/01	1.33	3.87	3.20
Major tributary: Wallkill (New Paltz)	1463	2/10/01	2/12/01	2.56	4.52	34.42
Major tributary: Wallkill (New Paltz)	6270	3/21/01	3/25/01	5.90	4.90	87.00
Major tributary: Wallkill (New Paltz)	6137	3/30/01	4/2/01	6.40	4.90	101.00
Major tributary: Wallkill (New Paltz)	1474	5/26/01	6/1/01	4.80	8.20	72.00
Major tributary: Wallkill (New Paltz)	589	6/17/01	6/19/01	1.30	5.30	39.00
Major tributary: Wallkill (New Paltz)	344	6/29/01	6/30/01	2.20	9.00	61.00
Minor tributary: Bronx River	16	10/29/98	10/29/98	0.23	7.09	3.60
Minor tributary: Bronx River	221	3/8/99	3/8/99	0.05	7.63	5.62
Minor tributary: Bronx River	6	7/27/99	7/27/99	0.76		4.83
Minor tributary: Bronx River	8	10/26/99	10/26/99	0.34	4.95	3.22
Minor tributary: Gowanus Canal		3/17/99	3/17/99	1.26	3.98	25.60
Minor tributary: Gowanus Canal		8/24/99	8/24/99	0.41		17.60

Table 7 continued.

Sample	CFS	Date_Start	Date_End	POC mg/L	DOC mg/L	SS mg/L
Minor tributary: Gowanus Canal		3/21/00	3/21/00	1.32	6.47	6.07
Minor tributary: Gowanus Canal		9/28/00	9/28/00	0.29	2.97	4.83
Minor tributary: Saw Mill River (Yonkers)	125	11/10/98	11/10/98	0.61	11.28	21.7
Minor tributary: Saw Mill River (Yonkers)	76	3/10/99	3/10/99	0.27	13.25	1.76
Minor tributary: Saw Mill River (Yonkers)	24	5/5/99	5/5/99	1.09	8.68	5
Minor tributary: Saw Mill River (Yonkers)	2	8/20/99	8/20/99	0.53		2.13

Water Pollution Control Facilities (WPCFs).

The locations of the upstate WPCFs sampled by CARP are shown in Figure 12.

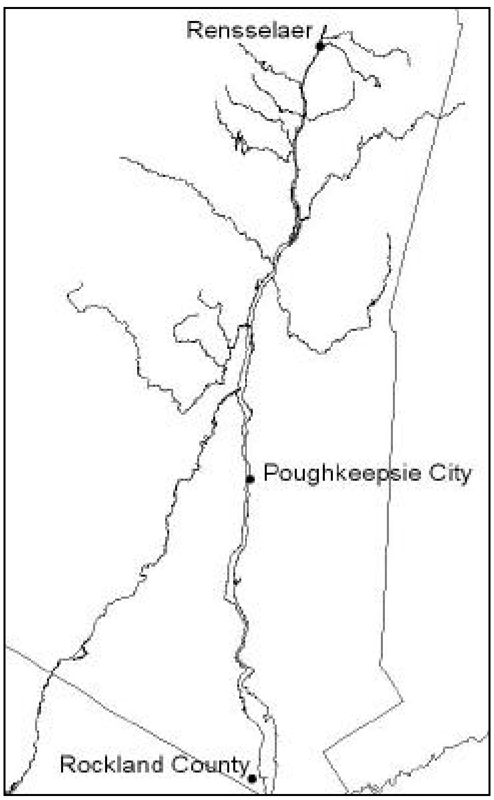

Figure 12. Upstate WPCFs samples by CARP.

Figure 13 shows the locations of New York City area WPCFs. All NYCDEP plants were sampled by CARP.

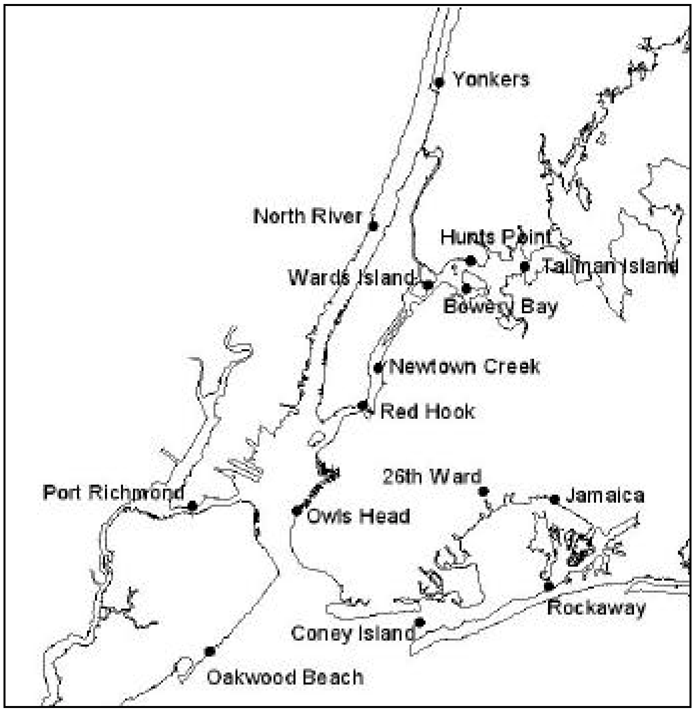

Figure 13. Locations of Yonkers and NYCDEP WPCF discharge points.

Table 8 shows summary sample data from the WPCF (sewage treatment plant) samples. WPCF discharges are conventionally shown in mgd.

Table 8. WPCF samples.

WPCF	Date Start	MGD	POC mg/L	DOC mg/L	SS mg/L
26th Ward	1/27/99	53	2.39	10.41	12.8
26th Ward	5/5/99	60	2.4	8.97	8.38
26th Ward	9/20/00	83	0.61	7.06	4.95
26th Ward	6/11/01	64			
26th Ward	6/18/01	68			
Bowery Bay	11/5/98	101	0.59	9.88	4.35
Bowery Bay	4/21/99	138	5.14	10.8	17
Bowery Bay	9/22/99	103	0	7.44	2.98
Coney Island	3/17/99	105	2.99	8.81	10.3
Coney Island	7/28/99	103	0.76	7.89	2.7
Coney Island	10/4/00	87	0.98	7.7	3.84
Edgewater	5/21/01	3			
Hunts Point	4/18/01	125			
Hunts Point	2/19/99	149	3.41	9.05	5.85
Hunts Point	4/30/99	133	0.35	9.66	48.1
Hunts Point	2/1/01	142	0.68		10.2
Hunts Point	3/19/01	120			
Hunts Point	3/28/01	181			
Hunts Point	4/11/01	146			

Table 8 continued.

WPCF	Date Start	MGD	POC mg/L	DOC mg/L	SS mg/L
Jamaica	2/5/99	84	6.68	10.58	14.5
Jamaica	6/30/99	90	1.62		6.7
Jamaica	2/15/01	88	0.7		11.6
Newtown Creek	4/8/01	248			
Newtown Creek	4/30/01	240			
Newtown Creek	5/21/01	416			
Newtown Creek	3/11/99	257	2.69	20.54	44.4
Newtown Creek	6/22/99	260		28.27	33.5
Newtown Creek	9/28/99	275	10.37	24.57	25.8
Newtown Creek	1/5/00	249	13.1		
Newtown Creek	1/5/00	249	13.1		
Newtown Creek	3/28/01	335			
North River	3/24/99	153	1.56	11.62	4.08
North River	9/1/99	167	1.28	9.91	4.28
North River	1/25/01	152	0.32		7.67
Oakwood Beach	2/11/99	25	0.97	10.99	6.33
Oakwood Beach	8/18/99	25	1.2	9.37	2.28
Oakwood Beach	10/13/99	36		9.27	3.98
Owls Head	9/15/98	113	4.88		26.7
Owls Head	7/7/99	119	1.44		7.01
Owls Head	8/23/00	115	1.88	8.98	6.41
Port Richmond	2/24/99	31	6.52	19.1	15.6
Port Richmond	8/25/99	35	1.38	13.04	2.58
Port Richmond	10/20/99	78	4.13	17.67	10.4
Port Richmond	4/11/01	49			
Port Richmond	4/30/01	29			
Poughkeepsie City	4/1/99	7	5.51	11.17	15.1
Poughkeepsie City	8/19/99	5	38.63	28.97	85.7
Poughkeepsie City	12/5/00	4	3.54		9.44
PVSC	5/22/01	318			
Red Hook	2/3/99	40	2.43	837.12	7.04
Red Hook	4/14/99	30	1.92	12.64	7.71
Rensselaer	1/12/99	16	4.43	25.48	15.6
Rensselaer	3/30/99	23	0.91	19.44	6.63
Rensselaer	8/11/99	14	1.71		6.04
Rockaway	4/1/99	21	0.33	8.17	3.59
Rockaway	8/11/99	22		9.03	18.3
Rockaway	11/3/99	19	0.45	7.28	6.38
Rockland County	4/20/99	20	3.02	16.18	16.6
Rockland County	8/19/99	17	1.37	18.61	2.94
Rockland County	3/8/00	22	8.94	29.21	

Table 8 continued.

WPCF	Date Start	MGD	POC mg/L	DOC mg/L	SS mg/L
Tallman Island	2/12/99	56	2.32		
Tallman Island	7/20/99	59	0.89	8.66	4.1
Tallman Island	9/6/00	41	1.2	8.3	3.73
Wards Island	1/20/99	221	1.57	7.81	4.83
Wards Island	4/28/99	179	0.09	7.33	2.48
Wards Island	8/10/00	220	0.88	5.73	2.51
Yonkers	4/22/99	89	1.73	10.3	6.8
Yonkers	8/18/99	85	1.16	10.62	13.5
Yonkers	3/22/00	95	10.12	19.15	26.4

Industrial Effluents and Landfill Leachates

Figure 14 shows the locations of industrial effluents and leachates sampled by CARP.

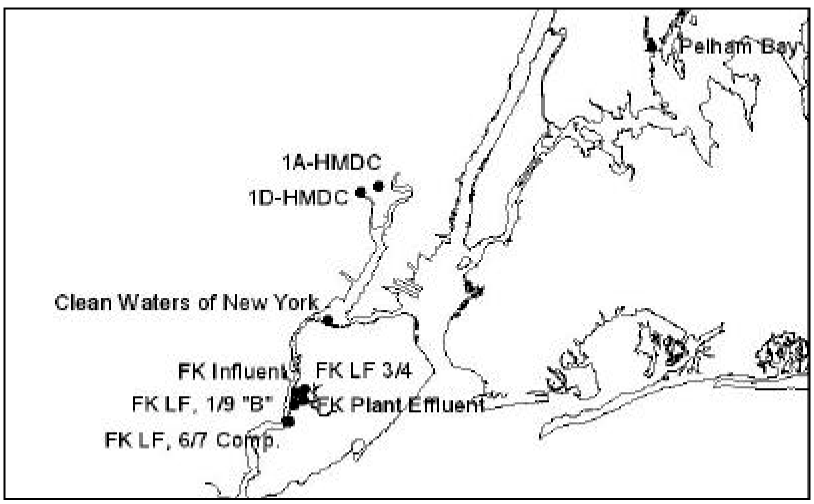

Figure 14. Locations of industrial effluents and landfill leachates sampled by CARP.

Table 9 lists the samples taken for Industrial effluents and Landfill leachates. Names, dates, DOC, POC, and TSS are also given.

Table 9. Industrial effluent and landfill leachate samples.

Sample	Date	DOC mg/L	POC mg/L	SS mg/L
Industrial effluent: Clean Waters of New York	4/29/99	6.02	0.19	
Industrial effluent: Clean Waters of New York	9/20/99	6.79	0.25	24.9
Industrial effluent: FK Plant Effluent	10/25/00	176		4.63
Industrial effluent: FK Plant Effluent	3/20/01			
Industrial effluent: FK Plant Effluent	4/19/01		0.31	30.7
Industrial effluent: FK Plant Effluent	7/25/01		0.45	8.49
Landfill leachate: 1A-HMDC	6/22/00			
Landfill leachate: 1D-HMDC	6/22/00	235		
Landfill leachate: 1D-HMDC	9/14/01			
Landfill leachate: 1E-HMDC	6/22/00	430		
Landfill leachate: 1E-HMDC	9/14/01			
Landfill leachate: FK Influent	4/5/99			
Landfill leachate: FK Influent	6/3/99			
Landfill leachate: FK LF 3/4	5/11/00	120		
Landfill leachate: FK LF, 1/9 "B"	5/11/00	490		
Landfill leachate: FK LF, 1/9 "F"	5/11/00	34.9		
Landfill leachate: FK LF, 1/9 Comp.	5/11/00	365		
Landfill leachate: FK LF, 1/9 Comp.	10/25/00	1680		
Landfill leachate: FK LF, 1/9 Comp.	3/20/01			
Landfill leachate: FK LF, 1/9 Comp.	4/19/01			
Landfill leachate: FK LF, 6/7 Comp.	5/11/00	161		
Landfill leachate: FK LF, 6/7 Comp.	10/25/00	821		
Landfill leachate: FK LF, 6/7 Comp.	7/25/01			
Landfill leachate: FK LF, 6/7 Comp.	8/9/01			26.1
Landfill leachate: Pelham Bay	11/6/98	143	1.42	4.80
Landfill leachate: Pelham Bay	1/29/01			

CSOs and SWOs

Locations of the CSO and SWO samples are indicated on Figure 15.

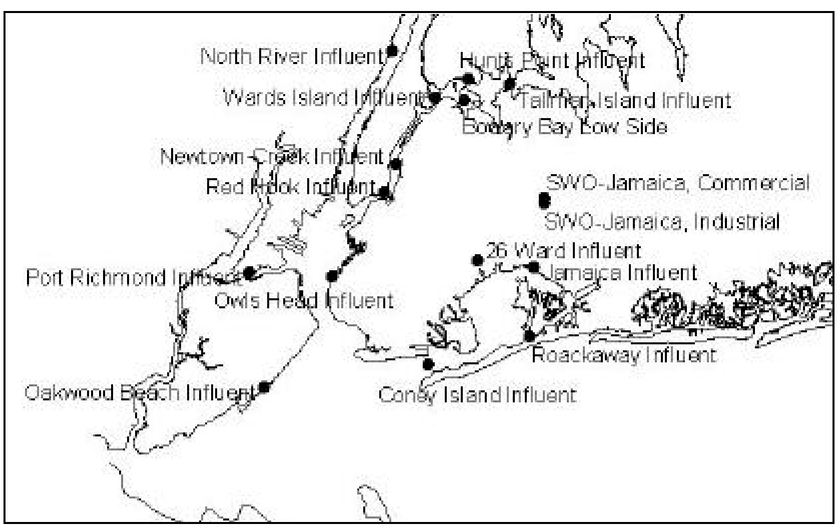

Figure 15. CSO and SWO sampling sites.

Table 10. CSOs and SWOs, names, dates, DOC, POC, and SS.

Short_Name	MGD	Date	DOC mg/L	POC mg/L	SS mg/L
26th Ward, High Side	12	6/2/01			
26th Ward, Low Side	12	5/21/01			
Bowery Bay High Side	13	3/21/01			
Bowery Bay Low Side	13	2/25/01			
Coney Island Influent	10	11/26/00		65.7	180
Hunts Point Influent	15	7/8/01			
Jamaica Influent	31	9/20/01			
Manhattan Grit Chamber	11	9/24/01			92
Manhattan Pump Station	14	2/5/01		0.667	
Newtown Creek Influent	14	1/30/01			
North River Influent	5.0	6/23/01			
Owls Head Influent	9.3	11/9/00			169
Port Richmond Influent	1.0	12/16/00	342		298
Red Hook Influent	3.7	8/27/01			404
SWO-Jamaica, Commercial		6/22/00	260	28	
SWO-Jamaica, Industrial		10/16/00		0.390	158

THE CHEMICALS

The CARP chemicals are polychlorinated biphenyls (PCBs), dioxins/furans, chlorinated pesticides, polynuclear aromatic hydrocarbons (PAHs), and the metals mercury and cadmium. Accessory parameters of particulate organic carbon (POC), dissolved organic carbon (DOC), and suspended sediment (SS) were also measured.

PCBs

PCBs and pesticides samples were usually acquired by TOPS. Extracts came from XAD resin and the glass fiber filters. On some occasions, samples were also taken from whole water grab samples, hexane (PISCES samples), sludges, and, for purposes of quality control, sediments. Details of the sampling procedures are to be found in the TOPS Standard Operating Procedure (SOP).

PCBs were measured by USEPA Method 1668A. The original Method 1668 was developed to measure the "co-planar" or "toxic" PCBs. At the outset of CARP one of the participating labs, Axys Analytical Services, suggested using an advanced version of 1668 called 1668A to measure all 209 PCB congeners. Methods 1668 and 1668A are descendents of 1613 in that they are isotopic dilution HRGC/HRMS methods. The modifications used were (a) using a single GC column (SPB-Octyl) which resulted in not all of the 209 congeners being resolved and (b) a 100 µL final extract volume which resulted in a 5-fold increase in the detection levels for each congener. The SPB-Octyl chromatographic column is short-lived and less familiar to many labs. This method was still experimental and has proved to be difficult for some of the labs to use.

Method 1668A does not resolve each of the 209 PCB congeners. During CARP Axys usually reported 159 domains consisting of from one (126 congeners) to 6 congeners or coelutions. Coeluted congeners are virtually identical. With two exceptions, each of the co-planar PCBs is resolved. The exceptions, IUPACs 156 and 157, have the same WHO98 TEF. Since these are HRMS data, all the coelutions have the same molecular weight. By convention, CARP reports all the coelutions under the name of the congener with the numerically lowest IUPAC designation.

PCBs can be treated as dioxins by summing the products of all congeners and their TEFs or they can summed to obtain a total PCB. The New York State Ambient Water Quality Standard (for protection of humans eating fish) sums all PCBs and is 1 pg/L. NYSDEC WQS do not recognize the co-planar PCBs. PCBs may have from one to 10 chlorine atoms. These result in one to 10 homologues. The relative abundances of the homologues can be useful in determining the source of the PCB.

PCBs were intentionally manufactured in the United States under the "Aroclor" trademark. Table 11 relates percent homologue abundance patterns to four Aroclors[4].

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[4] Shultz, D.E., Petrick, G., and Duniker, J.C. 1989. Complete characterization of polychlorinated biphenyls in commercial Aroclor and Clophen mixtures by multidimensional gas chromatography-electron capture detection. <u>ES&T</u> 23, 852-859.

Table 12, also using data from Shultz et al, shows the percent abundances of congeners unique (some overlap, less than 10%, was permitted) to the lighter Aroclors (1016/1242) and heavier Aroclors (1254/1260). Typical Axys coelutions are indicated.

Table 11. Percent homologue abundances in four Aroclors.

Homologues	1016	1242	1254	1260
1-mono				
2-di	21.47	14.95		
3-tri	49.76	35.33	1.21	0.1
4-tetra	27.83	32.64	16.61	0.99
5-penta	0.99	13.16	50.96	13.51
6-Hexa	0.19	2.39	23.86	46.98
7-Hepta		0.22	4.38	33.83
8-Octa			0.68	7.27
9-Nona				0.67
10-Deca				0.05

Table 12. PCB congeners “uniquely” characteristic of Aroclors 1016/1242 (“Light”) and 1254/1260 (“Heavy”). In percent abundance.

IUPAC	Group	1016	1242	1254	1260	Coelution	IUPAC	Group	1016	1242	1254	1260	Coelution
4	Light	3.89	3.01				131	Heavy			0.16	0.16	
5	Light	0.13	0.06				134	Heavy			0.49	0.62	143
6	Light	1.83	1.38				135	Heavy		0.08	1.62	2.56	151, 154
7	Light	0.6	0.6				136	Heavy		0.07	1.12	2.23	
8	Light	10.8	7.65				137	Heavy			0.25	0.06	
9	Light	0.95	0.54				138	Heavy	0.19	0.54	3.2	6.13	129
10	Light	0.37	0.2				141	Heavy			1.04	2.56	
15	Light	2.9	1.51				143	Heavy					134
16	Light	2.86	2.01				146	Heavy			0.83	1.49	
17	Light	3.84	2.88	0.19			147	Heavy					149
18	Light	9.03	6.28	0.41		30	151	Heavy			1.17	3.67	135
19	Light	0.96	0.53				153	Heavy		0.68	4.26	10.8	168
20	Light	1	0.29			28	154	Heavy					135
21	Light					33	156	Heavy		0.09	1.62	0.88	157
22	Light	4.8	3.41				157	Heavy				0.14	156
24	Light	0.3	0.22				158	Heavy			0.77	1.55	
25	Light	1.19	0.79				160	Heavy				0.05	129
26	Light	1.92	1.33			29	163	Heavy					129
27	Light	0.47	0.28				166	Heavy					128

Table 12 continued.

IUPAC	Group	1016	1242	1254	1260	Coelution	IUPAC	Group	1016	1242	1254	1260	Coelution
28	Light	8.71	6.52	0.25	0.05	20	167	Heavy			0.21	0.26	
29	Light	0.19	0.1			26	170	Heavy		0.11	0.31	3.91	
30	Light					18	171	Heavy		0.05	0.5	2.16	173
32	Light	1.34	0.88				172	Heavy			0.05	0.75	
33	Light	6.25	4.79	0.14		21	173	Heavy			0.09	0.36	171
34	Light	0.12	0.05				174	Heavy			0.34	3.85	
35	Light	0.08	0.11				175	Heavy			0.05	0.23	
37	Light	0.3	0.27				176	Heavy			0.32	0.95	
45	Light	1.66	1.16			51	177	Heavy			0.21	2.21	
46	Light	0.7	0.49				178	Heavy			1.35	1.62	
51	Light	0.36	0.23			45	179	Heavy			0.21	1.79	
59	Light	0.29	0.34			62, 75	180	Heavy		0.06	0.38	7.12	193
62	Light					59	183	Heavy			0.17	1.76	185
69	Light		0.11			49	185	Heavy				1.34	183
75	Light	0.08	0.11			59	187	Heavy			0.32	3.97	
122	Heavy			0.5	0.3		190	Heavy			0.08	0.79	
128	Heavy			2.07	1.06	166	193	Heavy				0.66	180
129	Heavy			0.23	1.11	138, 160, 163	201	Heavy			0.68	0.99	
130	Heavy			0.63	0.08								

Dioxins/Furans

Dioxins and furans were usually quantified only from suspended materials recovered by filters. Some XAD samples were analyzed for the dioxins but the margin between the detection limit and the amount recovered was usually uncomfortably small. There were also some whole water samples analyzed for the dioxins. Towards the end of the project a number of experiments were performed using metered surrogates of dioxins to examine the efficiency of XAD for these chemicals. Details of the sampling procedure for dioxins can be found in the TOPS SOP.

In the lab, the chlorinated dioxins and furans are measured using EPA Method 1613. This isotopic high-resolution gas chromatography/high resolution mass spectrometry procedure is well established and familiar to all the project labs.

Seven chlorinated dioxins and 10 chlorinated furans are considered. Each of these 17 chemicals is regarded as having a similar toxicological mode of action but also to have greatly differing potencies. These potencies are expressed as Toxic Equivalency Factors (TEFs). They also have differing potentials for bioaccumulation that are expressed as Bioaccumulation Equivalency Factors (BEF). The NYS Ambient Water Quality

Standard for the chlorinated dioxins and furans is the sum of the products of the observed concentrations and their TEFs and BEFs. The result is called the dioxin equivalents (TEQ). The NYSDEC Ambient Water Quality Standard (for protection of humans eating fish) for TEF, BEF chlorinated dioxins and furans is 0.6 femtograms/L (parts per quintillion).

Table 13. Dioxin/furan TEFs and BEFs

PARAMETER	WHO94	BEF
2,3,7,8-TCDD	1	1
1,2,3,7,8-PeCDD	0.5	0.9
1,2,3,4,7,8-HxCDD	0.1	0.3
1,2,3,6,7,8-HxCDD	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.05
OCDD	0.001	0.01
2,3,7,8-TCDF	0.1	0.8
1,2,3,7,8-PeCDF	0.05	0.2
2,3,4,7,8-PeCDF	0.5	1.6
1,2,3,4,7,8-HxCDF	0.1	0.08
1,2,3,6,7,8-HxCDF	0.1	0.2
2,3,4,6,7,8-HxCDF	0.1	0.7
1,2,3,7,8,9-HxCDF	0.1	0.6
1,2,3,4,6,7,8-HpCDF	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.4
OCDF	0.001	0.02

Pesticides

Chlorinated pesticides were analyzed using a modification of USEPA Method 1613B. This is also a method high-resolution gas chromatography/high-resolution mass-spectrometry, combined with partial isotope dilution. A DB-5 column was used with a 200 µL final volume. Twenty-seven chlorinated pesticides were determined using 5 C-13 labeled and one deuterium labeled standards.

Table 14. CARP pesticides.

PARAMETER	WQS (ug/L)
2,4'-DDD	NA
2,4'-DDE	NA
2,4'-DDT	NA
4,4'-DDD	0.00008
4,4'-DDE	0.000007
4,4'-DDT	0.00001
Aldrin	0.001
HCH, alpha	0.002
HCH, beta	0.007
HCH, gamma	0.008
Chlordane,alpha (cis)	1
Chlordane,gamma (trans)	1
Chlordane,oxy-	NA
Heptachlor	0.0002
Hexachlorobenzene	0.00003
Mirex	0.000001
Nonachlor, cis-	NA
Nonachlor, trans-	NA
Dieldrin	6E-07
Endosulfan sulfate	NA
Endosulfan, alpha	0.001
Endosulfan, beta	0.001
Endrin	0.002
Endrin aldehyde	NA
Endrin ketone	NA
Heptachlor epoxide	0.0003
Methoxychlor	0.03

PAHs

PAHs were determined using high resolution gas chromatography with Selected Ion Monitoring low resolution mass spectrometry. A DB-5 column was used with a final volume of 500 µL.

The XAD resins used in TOPS release some of the PAHs targeted in the CARP. Therefore, dissolved phase PAHs were taken from the effluent of the TOPS cartridge filters. PAHs attached to particles were measured from glass fiber cartridge extracts.

The list of PAHs CARP uses includes a few where there are one or two methyl substitutions. These are called “C1” or “C2” as in “C1-Naphthalene”. PAHs can be summed but they may also be summed as a molar concentration. In this approach the individual chemical concentrations are divided by their molar weight and then added together.

Table 15. CARP PAHs.

PARAMETER	WQS (ug/L)	Molecular Wt.
1-Methylnaphthalene	NA	142.2
2-Methylnaphthalene	NA	142.2
Acenaphthene	6.6	154.2
Acenaphthylene	NA	152.2
Anthracene	NA	178.2
Benz[a]anthracene	NA	228.29
Benzo[a]pyrene	0.0006	252.3
Benzo[b/j/k]fluoranthenes	NA	252.3
Benzo[b]fluoranthene	NA	252.3
Benzo[e]pyrene	NA	228.3
Benzo[ghi]perylene	NA	228.3
Benzo[k]fluoranthene	NA	252.3
Biphenyl	NA	154.2
C1 Naphthalenes	NA	142.2
C1 Phenanthrenes/Anthracenes	NA	192.26
C2 Naphthalenes	NA	156.23
C3 Naphthalenes	NA	170.26
Chrysene	NA	228.3
Dibenz[a,h]anthracene	NA	278.4
Fluoranthene	NA	202.3
Fluorene	2.5	166.2
Indeno[1,2,3-cd]pyrene	NA	276.3
Naphthalene	16	128.2
Perylene	NA	252.32
Phenanthrene	1.5	178.2
Pyrene	NA	202

Metals

Field contamination has posed a substantial problem in sampling trace levels of metals, particularly mercury. Overcoming this problem requires a great deal of vigilance and the procedure has been formalized into an act of ritual cleanliness called “Clean Hands/Dirty Hands”. It’s also called USEPA Method 1669. Early in the life of the project we brought Michelle Gauthier from Frontier Geosciences in Seattle, WA to help us with the sampling technique. We took her out on the East River and to the Newtown Creek WPCF to see two typical and different sampling environments.

Details of the procedure to avoid contaminating the sample in the field are given in the TOPS SOP. Essentially, one person handles the placement of water into the bottles and a second helper opens Ziploc bags holding the sampling equipment while a third takes field notes. Filtration for dissolved metals is performed in the field.

During trackdown, metals were collected by duct taping a clean sample bottle to a weighted line, submersing the bottle, capping it immediately on recovery, and re-double bagging it.

All metals sample processing took place using ultra-clean handling techniques in a class 100 clean area known to be low in atmospheric mercury. Reagents, gases, and reagent water were all reagent or ultra-pure grade and previously analyzed for trace metals to ensure very low blanks.

Water samples were prepared according to Frontier Geosciences SOP #FGS-032. Metals (Ag, Cd, and Pb) preserved to pH 1.8 with HNO_3 are extracted with Co-APDC, and the precipitate is collected by filtration. The precipitate is then dissolved in concentrated HNO_3 , then diluted in 5% HNO_3 to 10 mL. This method allows for the removal of the analytes of interest from the sample matrix, and makes possible up to 20-fold concentration of the sample.

Silver, cadmium, and lead were determined using inductively coupled-mass spectrometry (ICP-MS, US EPA Method 1640, modified) with a Perkin-Elmer Elan 6000. All results are reported instrument and preparation blank corrected.

Mercury analyses were performed using cold vapor atomic fluorescence spectrometry (CV-AFS). Total mercury standards are prepared by direct dilution of NIST-certified NBS-3133 mercury standard solution and results are independently verified by analysis of NIST 1641d. For the digestion/oxidation of water samples, BrCl was added to an aliquot of the sample at a level of 1-5 mL/ 100 mL of sample depending on apparent level of organics and turbidity of the samples. Sample oxidation took place on the same day of sample receipt. Samples were allowed to digest overnight at room temperature. Digests were analyzed for total Hg by CV-AFS. Aliquots of each digest were reduced in pre-purged reagent water to Hg° with $SnCl_2$ and then the Hg° purged onto gold traps as a preconcentration step. The Hg contained ion the gold traps was then analyzed by thermal desorption into an atomic fluorescence detector using the dual amalgamation technique.

For methyl mercury analysis water samples were distilled to liberated MeHg (US EPA Draft Method 1630). For water samples, 45 mL of 0.4% (v/v) HCl acidified sample was distilled using 50 mL Teflon distillation tubes. To each sample, 0.2 mL of 1% APDC solution was added prior to distillation, to enhance reproducibility and recovery. The distillate was received into a tube containing 5.0 mL of DDW to start, and distilled to 40.0 mL. Thus 35 mL out of 45 mL of sample was distilled over for analysis. The historic mean MeHg distillation recovery is 90.6 %. All net MeHg results are corrected for this efficiency factor.

Distilled samples were analyzed using aqueous phase ethylation, purging onto a Carbotrap, isothermal GC separation, and CV-AFS detection. Prior to ethylation, the distillate was diluted to 55 mL with DIW, and the pH brought to 4.9 with acetate buffer. Samples were ethylated by the addition of sodium tetraethyl borate, and then the volatile ethyl analogs purged with N_2 onto Carbotrap.After a trap drying step, the mercury ethyl analogs were thermally desorbed into a 1 m isothermal GC column (15% OV-3 on Chromosorb WAW-DMSC) held at 100°C for separation. The column resolves elemental Hg, dimethyl Hg, methyl ethyl Hg, and diethyl Hg. Only methyl ethyl Hg, the MgHg analog, is quantified. The organo-Hg compounds are pyrolytically decomposed to Hg° prior to entering the CV-AFS detector.

Water quality standards for the metals appear in Table 16.

Table 16. Water Quality Standards for metals.

	ng/L	Water Class	Type	form
Cadmium	7,700	SA, SB, SC, I	A(C)	
Lead	8,000	SA, SB, SC, I	A(C)	
Mercury	0.7	SA, SB, SC, I, SD	H(FC)	dissolved
Silver	100	A, A-S, AA, AA-S, B, C	A(C)	ionic

SS/DOC/POC

Suspended solids (SS) measures the total amount of particulate material suspended in the water column. At the beginning of the project we collected bottles of water that would be passed through pre-weighed filter paper, dried, and re-weighed. Some of the sites had very low suspended solids concentrations resulting in non-detections. We changed the procedure and brought pre-weighed filters and filtration equipment into the field where sufficient water was passed through the filters to obtain noticeable plugging. Particulate Organic Carbon (POC) sampling was similar. For POC, we tried to collect and filter water continuously over the span of time that TOPS was operated. Both SS and POC samples were kept frozen before being sent for analysis. The POC filters were also cored. David Hirschberg, the POC/DOC expert at SUNY Stony Brook, asked us to send him 10 mm disks. Initially, we sent him one 10 mm disk for each sample but later we sent three. This was due to apparent inhomogeneity of deposition on the filters. Dissolved organic carbon (DOC) was field filtered and acidified. Details of all three procedures appear in the TOPS SOP.

POC was measured on a Carlo Erba EA1108 CNS Analyzer. DOC was quantitated on Shimadzu TOC-5000, a high temperature oxidation type instrument. POC accuracy was assessed through use of a variety of internal and NIST standard reference materials. DOC analyses are intercalibrated through the use of internationally distributed intercalibration materials supplied by Dr. Jon Sharp at the University of Delaware and supported by the National Science Foundation.

Determination of suspended sediments, POC, and DOC at the USGS stations was more complicated. Large numbers of samples were taken across a changing hydrograph. These observations were combined to yield loads. We took the loads and back-calculated concentrations. The methods for combining the observations are described in Potterfield

(1972) - Techniques of Water Resources Investigations (TWRI) of the United States Geological Survey, Book 3, Chapter C3 - Computation of Fluvial-Sediment Discharge. The TWRIs are a series of "How To" publications the USGS puts out on a wide variety of things done on a regular basis. All survey offices computing suspended sediment loads use the same method - how they perform the computation (by hand, spreadsheet, USGS daily loads software, etc.) may vary based on the available data set.

Steps for calculating suspended sediment loads:

1 - Compile the discharge data
   1a) review and correct daily values
   1b) determine which 15 minute and hourly raw values are good/bad (USGS doesn't correct raw 15 min data, only the daily data).

2 - Compile the concentration data
   2a) review QC samples
   2b) track down missing data and any discrepancies.

3 - Determine a "box coefficient"
   3a) plot equal width vs. point samples
   3b) determine if coefficient is flow or seasonally dependent - other factors are possible.

4 - Apply the coefficient to the data.

5 - Generate a plot of concentration vs. discharge (and/or other parameters) for possible use in estimating periods with no record.

6 - Plot the adjusted data on a trace of stage and/or discharge.

7 - Generate a continuous concentration curve - this involves some art and a feel for how the constituent behaves at the site, it's basically an educated guess as to what the concentration was between samples. Obviously, the quality of the curve is highly dependant on the sample frequency - during TOPS event we were collecting a lot of samples, so the quality of the concentration curve is pretty good during these periods.

8 - Determine if the day should be "subdivided" - i.e. if the concentration curve and or the discharge changes dramatically over the course of the day ("dramatically" is more clearly defined in Potterfield (1972),
   8a) subdivision involves segmenting the day into smaller, more uniform parts, computing the load for those periods, and summing the periods for the day,
   8b) if required, the day was broken down into hour segments and the"mid-interval" method described by Potterfield (1972) was used.

9 - If the day doesn't need to be subdivided, determine the average concentration for the day from the continuous concentration curve.

For POC and DOC many of the same steps used in the sediment computation apply - here are some of the highlights:

POC

1 - Apply sediment box coefficient to POC data.

2 - For all 3 sites, reasonable relations exist between POC and suspended sediment these

are used to help estimate POC concentrations during periods with no data.

3 - Plot adjusted POC, model POC, and anything else that might help determine the continuous concentration curve on a trace of discharge and or stage.

4 - Computations are identical to sediment - including subdividing days.

DOC

1 - The variability of DOC between samples is generally small, so linear interpolation between samples (computation of a noon value) was used to estimate many of the daily values.

2 - Plot DOC, model DOC (interpolated values), and anything else that might help determine the continuous concentration curve on a trace of discharge and or stage; 2a - if the model wasn't responding to the discharge (for example – samples bracketing a discharge event) the concentration curve was adjusted by hand based on knowledge of how the constituent behaves at the site.

3 - Subdivision was rarely necessary because of the low variability in DOC concentrations, otherwise the computations were identical to POC and sediment.

QUALITY CONTROL

Data generated by the CARP are initially loaded into a data management system operated by Battelle Ocean Sciences of Duxbury, MA under the direction of Tom Gulbransen. Battelle screens incoming data for conformity to the rules of the Electronic Data Deliverable and admits those that are properly formatted. A second step of validation is being performed by Booze Allan Hamilton, a contractor to the Hudson River Foundation. The validation will consist of passing all data through a screen to determine compliance with certain QC parameters. At this time, none of the data have been “validated”. “Validated” data will supplant unvalidated data. NYSDEC does not normally used third part validation for its regulatory or enforcement work.

The amount of data collected by CARP is enormous; the water portion alone has produced a quarter of a million records. Many interested users will want to ask questions of the data that we have not anticipated. Others may want to have a simpler contact with the project and will be satisfied to have us paint a broad picture of the findings. The first group of users will go to our website (www.carpweb.org). This site includes maps, a variety of data screens, and a metadata document that explains the structure of the database.

Quality Control – Field QC

Previous experience has indicated that there may be significant lab to lab differences in measurement of trace organic chemicals. In CARP, three organics laboratories produced data for the NYSDEC water program. In order to determine the degree of inter-laboratory variability, a 5-gallon sediment sample was taken from the Arthur Kill near the northern side of Pralls Island at the beginning of the project. This material was thoroughly homogenized and divided into vials that were kept frozen. From time to time, these vials were sent in to the labs and analyzed for the suite of CARP substances. Ultimately, Axys (AAS) received 26, Severn Trent (QTS) saw 10, and Wright State University (WSU) got 4. Each lab should have been receiving essentially the same material and should have been producing the same results. The actual results (average/standard deviation) are indicated below graphically (Figures 16-21).

Table 17. Interlab variability, Pralls Island sediments.

	AAS	QTS	WSU
Dieldrin, ug/kg	5/1.3	2.3/1.1	10/4.4
Dioxin/Furans, ug/kg TEQ	0.18/0.076	0.05/0.014	0.14/0.12
PAH, umoles/kg	91/28	24/2.8	55/48
PCB, ug/kg	1700/380	880/94	1100/160
Total Chlordane, ug/kg	31/9	10/4.4	50/46
Total DDT, ug/kg	980/400	840/1200	1000/340

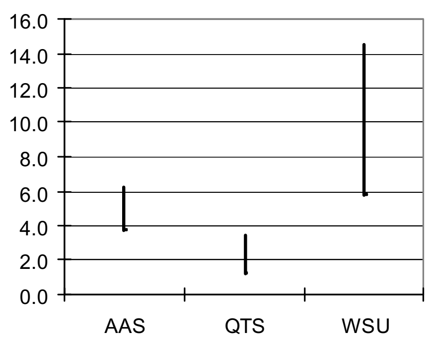


Figure 16. Field QC comparisons, Dieldrin in ug/kg. Mean +/- one standard deviation.

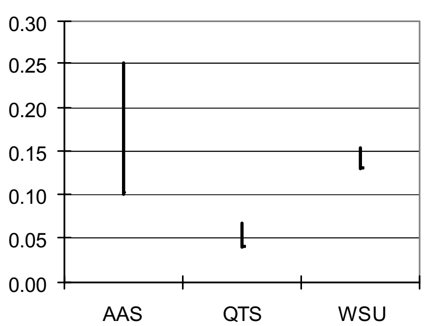


Figure 17. Field QC comparisons, TEQ dioxin/furan in ng/kg, mean +/- one standard deviation.

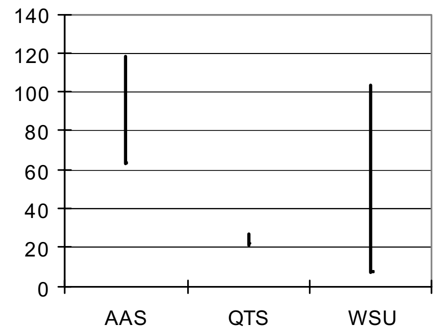


Figure 18. Field QC comparisons, PAHs in umoles/kg. Mean +/- one standard deviation.

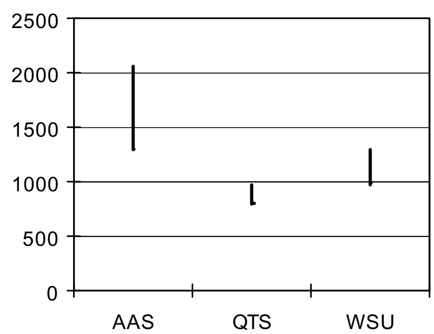


Figure 19. Field QC comparisons, PCBs in ug/kg. Mean +/- one standard deviation.

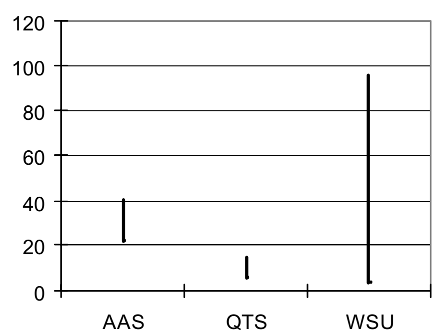


Figure 20. Field QC comparisons. Total chlordane in ug/kg. Mean +/- one standard deviation.

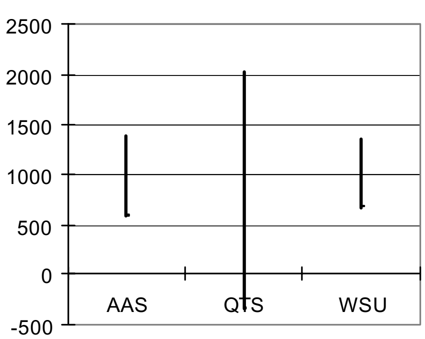


Figure 21. Field QC comparisons. Total DDT in ug/kg. Mean +/- one standard deviation.

Quality Control – Field Blanks and Equipment Blanks

A variety of experiments were performed to assess inadvertent contamination of the samples. The experiments fall into two broad groups, Field Blanks (FB) and Equipment Blanks (EB). FB are samples of media, glass fiber filters or XAD columns that are brought into the field unused, and returned to the lab. EB are samples of filters, XAD, or water that had been run through TOPS after routine cleaning.

The results of the blank experiments should be compared with the samples on the basis of total mass of recovered analyte rather than concentration.

1) unfired filter
2) processed after lower East River cruise
3) 96 L of Colonie, New York tap water transported to a sampling site on Staten Island and back to Colonie, New York and then processed via TOPS-Next Generation.

The significance of the field and equipment blank values is in how they measure against actual sample observations. The relevant units from the blanks are mass, not concentration. Therefore, the comparison with the sample observations must be the mass of analyte recovered from the medium.

Table 18 summarizes the results of field and equipment blanks.Table 18. Field and equipment blanks.

Samp ID	Field Code	Lab ID	Medium	dieldrin ng	diox-F pg TEQ	PAH nmoles	PCB ng	T Chlor. ng	TDDT ng
1SPL00015	FB	AAS	filt. Water			0.1			
1SPL00521	FB	AAS	glass fiber cart.	<0.32	1.57	1.4	1.3	0.2	0.24
1SPL00588	FB	AAS	reagent water			0.24			
1SPL00595	FB	AAS	glass fiber cart.	<0.37	2.1	0.75	2.6	<3.8	<11
1SPL00596	FB	AAS	XAD	<0.59	1.6		25	<4.5	<14
1SPL00944	FB	AAS	XAD	<0.82		0.12	3.7	<3.4	<3.6
1SPL01625 [1]	FB	AAS	glass fiber cart.	0.13	11	72	74	0.91	0.27
1SPL01780	FB	AAS	XAD	<0.22			1.4	<0.41	0.48
1SPL01781	FB	AAS	glass fiber cart.	<0.096	8	1	1.5	<0.35	<1.7
1SPL01814	FB	AAS	glass fiber cart.	<0.077	7	0.67	8.3	<0.26	<1.2
1SPL01815	FB	AAS	XAD	<0.15			1.6	0.38	3.4
1SPL01858	FB	AAS	XAD	<0.083			0.83	0.33	<6.1
1SPL01859	FB	AAS	glass fiber cart.	<0.16	0.24		0.31	<0.76	<4.8
1SPL01896	EB	AAS	filt. water (AE,GF/F)		0.3		0.17		
1SPL01897	EB	AAS	filt. AE+GF/F				0.58		
1SPL02123	FB	WSU	XAD	<4.6			6.4	<12	<6.2
1SPL02124	FB	WSU	glass fiber cart.	<2.7	7.1	3.6	15	<11	280
1SPL02145 [2]	FB	WSU	glass fiber cart.	<3.1		2.6	15	<16	15
1SPL02159 [2]	FB	WSU	XAD	<3.1			11	<8.3	<5.4

Table 18 continued.

Samp_ID	Field Code	Lab_ID	Medium	Dieldrin ng	Diox-F pg TEQ	PAH nmoles	PCB ng	T Chlor. ng	TDDT ng
1SPL02182	EB	WSU	filt. water (AE,GF/F)			0.48			
1SPL02183	EB	WSU	filt. water (AE,GF/F)			0.34			
1SPL02193	EB	WSU	filt. water (AE,GF/F)			0.42			
1SPL02194	EB	WSU	filt. water (AE,GF/F)			0.47			
1SPL02210	EB	WSU	XAD	<1.6			13	<10	<5.1
1SPL02212	EB	WSU	glass fiber cart.	<5.3	28	5.9	11	<21	<6.1
1SPL02285	EB	WSU	filt. water (AE,GF/F)			0.87			
1SPL02294	EB	WSU	filt. water (AE,GF/F)			1.3			
1SPL02295	EB	WSU	filt. water (AE,GF/F)			1.3			
1SPL02309	EB	WSU	glass fiber cart.	<3.5	0.26	5.7	13	<15	<7.8
1SPL02310	EB	WSU	XAD	<2.5			9.1	<17	<6.8
1SPL02317	EB	WSU	filt. water (AE,GF/F)			0.26			
1SPL02318	EB	WSU	filt. water (AE,GF/F)			0.19			
1SPL02373	EB	AAS	filt. water, Post XAD	<0.0045	1.5	1.2	11	<0.031	<180
1SPL02374	EB	AAS	XAD	0.036			4.8	0.062	<1.5
1SPL02375	EB	AAS	glass fiber cart.	0.046	1.7	0.79	1.4	<0.37	<2.2
1SPL02577	FB	AAS	glass fiber cart.	<0.030	2.9	1.4	0.78	<0.41	<3.1
1SPL02578	FB	AAS	XAD	<0.019			0.8		
1SPL02621	FB	AAS	XAD	<0.0041			1.6	<1.1	<2.7
1SPL02622	FB	AAS	glass fiber cart.	<0.057	4	1.3	0.8	<0.34	<2.6
1SPL02820 [3]	EB	AAS	XAD	<0.056			5.6		
1SPL02821 [3]	EB	AAS	XAD	2.6			68		
1SPL02873 [3]	EB	AAS	glass fiber cart.	<0.086			0.67		
1SPL02953	EB	AAS	reagent water		12		1.2		
1SPL03012	EB	AAS	XAD	<0.32	5.6		48	<2.3	<7.9
1SPL03013	EB	AAS	glass fiber cart.	<0.19	7.3	6.7	1.4	<2.1	<8.1

PCB Blanks

In the case of PCBs, the highest blank value for XAD was 68 ng. The lowest sample mass from either a primary XAD column (first in the series) or a combined XAD (both columns extracted and analyzed together) was 80 ng and the 1th percentile (99 percent of observations were greater) was 100 ng. That 68 ng blank was from a sample of 96 L of tap water that had been put in large glass carboys, driven to Staten Island and back, and then processed in the lab. Had it been treated as a sample, the resultant concentration would have been 0.7 ng/L. The blank XAD with the next lowest PCB mass came from a column with visible discoloration and had last been used to process landfill leachate. The homologue distribution of that blank does not look like a commercial PCB.

The highest levels of PCB found in a filter cartridge (74 ng) occurred from one that had not been fired in a furnace for 4 hours at 450?C. All glass fiber filter media used in the project for samples had been fired. The next highest blank filter PCB value was 15 ng. This value does begin to impinge on the data.

Dioxin/Furan Blanks

Dioxins/furans were measured mostly from glass fiber cartridges. The maximum blank was 28 pg TEQ and the next highest value (11 pg TEQ) was from the unfired filter. The average glass fiber filter blank was 6.2 pg TEQ. These blanks impinge on sample data; the 25th percentile for glass fiber cartridges was 23 pg TEQ and the 10th percentile was 10 pg TEQ.

Data from 99 dioxin/furan analyses on XADs (first or combined) had a median value of 3.4 pg. The blanks had a mean of 3.6 pg TEQ.

PAH Blanks

The average blank for PAHs from cartridges expressed as summation of moles, (ignoring the unfiltered cartridge with its 72 nmoles) was 2.7 nmoles. This is compared against the 5th percentile value for samples of 6.9 nmoles. The maximum cartridge blank contamination level was 6.7 nmoles.

The average blank value for water analyzed for PAHs was 0.63 nmoles. The 30th percentile value for the filtered water samples was 0.6 nmoles. Dissolved PAHs had no field concentration due to the potential of contamination by XAD resin.

Total DDT Blanks

Total DDT (2,4'-DDT, DDD, and DDE and 4,4'-DDT, DDD, and DDE) samples were much like the PCBs where they were measured from cartridges and XAD. Ten cartridge blanks had total DDT masses below the detection limit (max detection limit was 8.1 ng). Four samples had quantifiable TDDTs and ranged from 280 to 0.24 ng. The 1th percentile TDDT mass in the samples was 3.6 ng. There is no ready explanation for the very high blank (280 ng); the next highest, 15 ng, was from the unbaked filter. It is possible that the large value was a decimal error but there were values for five of the six analytes.

The 5th percentile of the first and combined XAD columns for TDDT was 2.8 ng. Ten XAD blanks were non-detect and two were quantitated values of 3.4 and 0.48 ng.

Dieldrin Blanks

Dieldrin was non-detect on 13 blank cartridges and detected twice at 0.046 and 0.13 ng. The 1th percentile for dieldrin on samples was 0.37 ng.

Blanks for dieldrin were non-detect from 13 XADs and quantitated on two at 0.036 and 2.6 ng. Of the first and combined sample XAD columns, the 5th percentile was 4.6 ng.

Total Chlordane Blanks

Total chlordane (alpha-, trans, and oxy-chlordane) had non-detect blanks on 12 cartridges and detected values in two of 0.2 and 0.91 ng. The 5th percentile for total chlordane on cartridges was 2.3 ng.

Nine XAD blanks had no measurable chlordane. Three had values ranging from 0.38 to 0.062 ng. The 1th percentile for total chlordane in first or combined sample XADs was 0.77 ng.

SAMPLE RESULTS

Sample results are shown below for PCBs, dioxins/furans, pesticides, PAHs, metals, and the accessory parameters SS/DOC/POC.

PCBs

PCBs are treated here as the summation of homologues. Data were evaluated against laboratory blanks and sample specific detection limits. Data collected by TOPS were also adjusted by factors derived from research more completely discussed in the paper, XAD in the Real World.

PCB Data Quality

PCB homologue data were evaluated against two tests;

> Is the sum of the analyte masses in a sample 5 times greater than the sum of the analyte masses in its associated SDG method blank?
>
> Is the sum of the analyte masses in a sample exceeded by the 10 times the sum of the sample specific detection limits from that sample?

Table 19 shows the success of the sampling program in obtaining adequate PCB samples. Attaining adequate data is a function of the amount of chemical present, the size of the sample, the laboratory detection level, and the lab's cleanliness. Samples from Severn-Trent have not been formally accepted into the database and lack method blanks. These SDGs with missing blanks are designated "M MB". Samples where the analyte was not detected are "ND". Samples with high detection limit and high method blank are "Hi DL" and Hi MB". Samples meeting the criteria are "USE DL" and "USE MB".

Table 19. Number of analyzed PCB homologs meeting certain data quality criteria.

	ND	Hi DL, Hi Bk	Hi DL, M MB	Hi DL, USE MB	USE DL, Hi Bk	USE DL, M MB	USE DL, MB
1-mono	36	42	27	121	61	12	472
2-di	42	26	25	183	5	23	468
3-tri	9	34	19	80	24	29	576
4-tetra	0	25	8	117	23	43	555
5-penta	7	47	32	116	27	15	527
6-Hexa	6	73	38	118	19	9	508
7-Hepta	22	68	34	176	10	7	454
8-Octa	90	87	19	174	11	6	384
9-Nona	220	23	17	181	4	7	319
10-Deca	178	67	12	98	50	6	360

The overall success rate of analyses is shown in Table 20. Inadequate detection limits resulted in non-detections or in observed masses insufficiently separated from SPDLs in 35% of the homologues. Only 5% of homologues were problematic due to method blanks being either high or missing. The major data quality problem was insufficient sample size relative to the detection limits available in HRGC/HRMS.

Table 21 gives the average volumes (in liters) of water passed through the glass fiber filter and the XAD columns by sample type. As apparent, a significant effort was made to avoid under sampling. The actual amount of water processed for PCBs was less than indicated. Extracts were split into 4 (XAD) or 5 (cartridge filter samples); one for reserve in case of accident, one for dioxins/furans, one for pesticides, one for PAHs (cartridge filters only) and one for PCBs.

Table 20. Percent of high quality PCB homologues.

1-mono	61%
2-di	61%
3-tri	75%
4-tetra	72%
5-penta	68%
6-Hexa	66%
7-Hepta	59%
8-Octa	50%
9-Nona	41%
10-Deca	47%

Table 21. Volumes of water (L) processed

sample_type	cartridge filter	XAD
Ambient, clean	3000	710
Ambient, Hudson R.	680	200
Ambient, Kills	750	170
Ambient, Non Kills	720	180
CSO/SWO	91	82
Industrial effluent	470	100
Landfill leachate		70
Major tributary	770	210
Minor tributary	740	180
WPCF	330	120

While these statistics show a large number of homologues failing to meet the criteria for being good data, a comparison between PCB concentrations from sample sites (Table 22) using all data versus “high quality” data reveals little difference in most cases.

PCB Results

Table 22 shows average PCB concentrations (ng/L) by sites where homologues are screened for inclusion by method blank and detection limit exceedences (censored data) and where all data were used. In subsequent analyses, all the data were used. The highest concentrations for each set of observations are highlighted.

The three highest concentrations of PCB were seen from a leachate sample (1E-HMDC), final effluent from the Passaic Valley Sewerage Commissioners (PVSC) in Newark, NJ, and a wet weather raw sewage influent used to simulate CSO samples (26th Ward, High Side). The PVSC sample was dominated by a single homologue; actually, a single congener. The 26th Ward, High Side shows Aroclor 1260. 1E-HMDC shows evidence of multiple Aroclors (Figure 21).

Table 22. Average PCB concentrations at each site without and with quality censoring (ng/L).

Sample	raw	censored	Censored/raw
Ambient-clean: Long Island Sound	0.47	0.285	61%
Ambient-clean: New York Bight	0.0732	0.0286	39%
Ambient-Hudson: Haverstraw Bay	25.8	25	97%
Ambient-Hudson: Hudson R. at Poughkeepsie	92.4	91	98%
Ambient-Hudson: Hudson R. below Kingston	19.6	19.4	99%
Ambient-Hudson: Hudson R. below Tappen Zee	31.8	31.1	98%
Ambient-Hudson: Hudson R. South of Harlem R.	14.5	14	97%
Ambient-Kills: Hackensack R., Mid-Tidal	28.3	27.5	97%
Ambient-Kills: Hackensack R., Mouth	13.3	12.3	93%
Ambient-Kills: Newark Bay	9.54	8.86	93%
Ambient-Kills: Northern Arthur Kill	15.9	14.9	94%
Ambient-Kills: Passaic R., Mouth, Bottom	22.4	21.9	98%
Ambient-Kills: Passaic R., Mouth, Surface	33.7	33.2	98%
Ambient-Kills: Passaic River, Mid-Tidal	38.5	37.7	98%
Ambient-Non_Kills: Jamaica Bay	1.45	0.601	41%
Ambient-Non_Kills: Lower Bay	3.69	2.77	75%
Ambient-Non_Kills: Lower East R.	11.6	10.3	89%
Ambient-Non_Kills: Raritan Bay	3.82	3.04	79%
Ambient-Non_Kills: Upper Bay	8.02	7.95	99%
Ambient-Non_Kills: Upper East R.	4.35	4.09	94%
CSO: 26th Ward, High Side	3500	3500	100%
CSO: 26th Ward, Low Side	851	851	100%
CSO: Bowery Bay High Side	297	297	100%
CSO: Bowery Bay Low Side	10.2	10.2	100%
CSO: Coney Island Influent	43.7	43.7	100%
CSO: Hunts Point Influent	57.7	57.7	100%
CSO: Jamaica Influent	65	65	100%
CSO: Manhattan Grit Chamber	130	130	100%
CSO: Manhattan Pump Station	153	153	100%
CSO: Newtown Creek Influent	261	261	100%
CSO: North River Influent	351	351	100%
CSO: Owls Head Influent	65.8	65.8	100%
CSO: Port Richmond Influent	561	561	100%
CSO: Red Hook Influent	1310	1310	100%
CSO: SWO-Jamaica, Commercial	47.6	47.6	100%
CSO: SWO-Jamaica, Industrial	69.8	69.8	100%

Table 22 (continued).

Sample	raw	censored	censored/raw
Industrial effluent: Clean Waters of New York	0.046	0	0%
Industrial effluent: Fresh Kills Landfill Plant Effluent	16.6	16.5	100%
Landfill leachate: 1A-HMDC	946	946	100%
Landfill leachate: 1D-HMDC	91.2	91.2	100%
Landfill leachate: 1E-HMDC	1490	1490	100%
Landfill leachate: Fresh Kills LF 3/4	97.3	97.3	100%
Landfill leachate: Fresh Kills LF, 6/7 Composite	275	275	100%
Landfill leachate: Fresh Kills LF, 1/9 "B"	186	186	100%
Landfill leachate: Fresh Kills LF, 1/9 "F"	87	87	100%
Landfill leachate: Fresh Kills LF, 1/9 Composite	545	545	100%
Landfill leachate: Pelham Bay Landfill Holding Tank	9.03	11.9	132%
Major_tributary: Hudson R. (Pleasantdale)	30.4	26.8	88%
Major_tributary: Mohawk R. (Cohoes)	8.42	3.96	47%
Major_tributary: Wallkill (New Paltz)	1.82	1.31	72%
Minor_tributary: Bronx River	4.52	4.35	96%
Minor_tributary: Gowanus Canal	7.94	6.38	80%
Minor_tributary: Saw Mill River (Yonkers)	4.73	4.5	95%
Trackdown: Mill Creek at Arthur Kill Rd	2.97	2.97	100%
WPCF: 26th Ward	40.7	40.6	100%
WPCF: Bowery Bay	5.74	5.22	91%
WPCF: Coney Island	2.25	1.93	86%
WPCF: Edgewater	6.51	6.51	100%
WPCF: Hunts Point	4.4	4.33	98%
WPCF: Jamaica	5.5	5.13	93%
WPCF: Newtown Creek	12.6	12.2	97%
WPCF: North River	3.77	3.43	91%
WPCF: Oakwood Beach	9.22	8.96	97%
WPCF: Owls Head	3.41	3.11	91%
WPCF: Port Richmond	137	137	100%
WPCF: Poughkeepsie, City	15.3	15.3	100%
WPCF: PVSC	334	334	100%
WPCF: Red Hook	3.71	3.36	90%
WPCF: Rensselaer	5.93	5.68	96%
WPCF: Rockaway	4.44	4.1	92%
WPCF: Rockland County	4.42	4.36	99%
WPCF: Tallman Island	5.33	5.02	94%
WPCF: Wards Island	2.39	2.23	93%
WPCF: Yonkers	8.24	4.61	56%

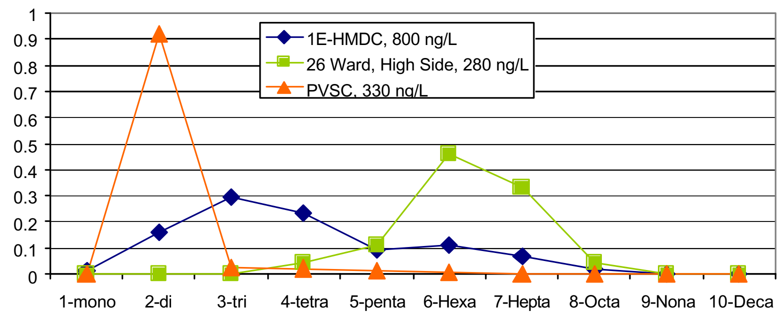


Figure 22. Relative abundances of PCB homologues from the three samples with the highest PCB concentrations.

Samples from tributaries, CSOs, and WPCFs have associated discharges that can be multiplied with concentration to obtain loads. Table 23 shows the average loads (g/hour) from the CSOs, tributaries, and WPCFs. The loads shown here are averages of the observed events and are not attempts to compute yearly loads encompassing unsampled times. The tributary loads are biased in that the samples were generally taken during hydrological events. Samples from wastewater treatment plants and minor tributaries were taken during different seasons but were not specifically intended to reflect wet or dry days. Samples called "CSO" were wet weather influents to treatment plants.

Table 23 shows four dominant PCB sources, the Hudson and Mohawk Rivers, the PVSC wastewater treatment plant, and 26th Ward CSOs. PVSC, the Newark, NJ treatment plant, was sampled once as part of a bi-state inter-comparison program. That program also involved DEC sampling at Edgewater, NJ.

The upper Hudson PCB source is well known to be from General Electric's manufacturing of capacitors at Hudson Falls and Fort Edward. PCBs in the capacitor facility varied over the years but the largest type was Aroclor 1242. This is apparent in the homologue fingerprints from the top four loading events (Figure 23)

Table 23. Average loads (g/hr) from tributaries and point sources.

Name	PCB load in g/hr
CSO-26th Ward	4.3
CSO-Red Hook Influent	0.76
CSO-Newtown Creek Influent	0.45
CSO-Bowery Bay	0.42
CSO-Jamaica Influent	0.32
CSO-North River Influent	0.28
CSO-Wards Island	0.22
CSO-Hunts Point Influent	0.14
CSO-Owls Head Influent	0.097
CSO-Port Richmond Influent	0.092
CSO-Coney Island Influent	0.069
INDEF-Fresh Kills Landfill Plant Effluent	0.0017
Major_TRIB-Hudson R. (Pleasantdale)	63
Major_TRIB-Mohawk R. (Cohoes)	33
Major_TRIB-Wallkill (New Paltz)	1.0
Minor_TRIB-Bronx River	0.033
Minor_TRIB-Saw Mill River (Yonkers)	0.02
WPCF-PVSC	17
WPCF-Port Richmond	0.96
WPCF-Newtown Creek	0.53
WPCF-26th Ward	0.5
WPCF-Yonkers	0.12
WPCF-Bowery Bay	0.11
WPCF-Hunts Point	0.1
WPCF-North River	0.093
WPCF-Wards Island	0.08
WPCF-Jamaica	0.075
WPCF-Owls Head	0.062
WPCF-Tallman Island	0.044
WPCF-Oakwood Beach	0.042
WPCF-Coney Island	0.035
WPCF-Red Hook	0.022
WPCF-Rensselaer	0.016
WPCF-Rockaway	0.015
WPCF-Rockland County	0.014
WPCF-Poughkeepsie	0.011
WPCF-Edgewater	0.0029

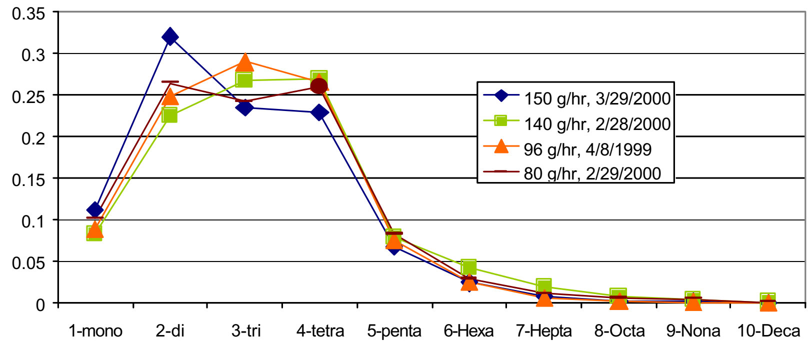


Figure 23. Relative abundances of PCB homologues from the top four loading events at Pleasantdale in the upper Hudson River.

These samples were deliberately biased toward large hydrological events to capture suspended sediments. Some researchers believe that a significant amount of PCB loading in the Hudson comes from biological effects that are at greatest intensity in the late spring or early summer. We do not have samples from that period and may have underestimated the load.

The apparent significance of the Mohawk River was investigated. Much of the weight of the average came from a single event, on February 2, 2000 where 260 g/hr were noted. The homologue pattern was indicative of Aroclor 1254. Pentachlorobiphenyl congners are abundant in most Mohawk samples and were the most abundant group in seven out of 11 samples. February 28, 2000 was the day with the greatest concentration (54 ng/L) and the day of the greatest discharge of those sampled (48,000 CFS).

The fourth largest load was the 26th Ward CSO. This is due to Aroclor 1260 found in the sewers. High concentrations of Aroclor 1260 were seen in two separate wet weather influents as well as in PISCES and grab samples taken from the service area. Specific sources have not been discovered in this formerly industrial area.

The Wallkill, the third major tributary, had relatively low PCB concentrations (1.9 ng/L) but a high volume of discharge.

The third and sixth largest sources are the PVSC and Port Richmond wastewater treatment plants. In the cases of both treatment plants (90% at PVSC and 93% at Port Richmond), the overwhelmingly dominant PCB congener is the inadvertently produced 3,3'-dichlorobiphenyl (IUPAC 11). This congener is not routinely measured because it is not associated with commercial PCBs and it is not thought to be particularly toxic. Figure 24 shows the average relative abundances of IUPAC 11 in ambient sites. While IUPAC 11 is the single most abundant congener in New York Harbor ambient waters, it does not strongly bioaccumulate.

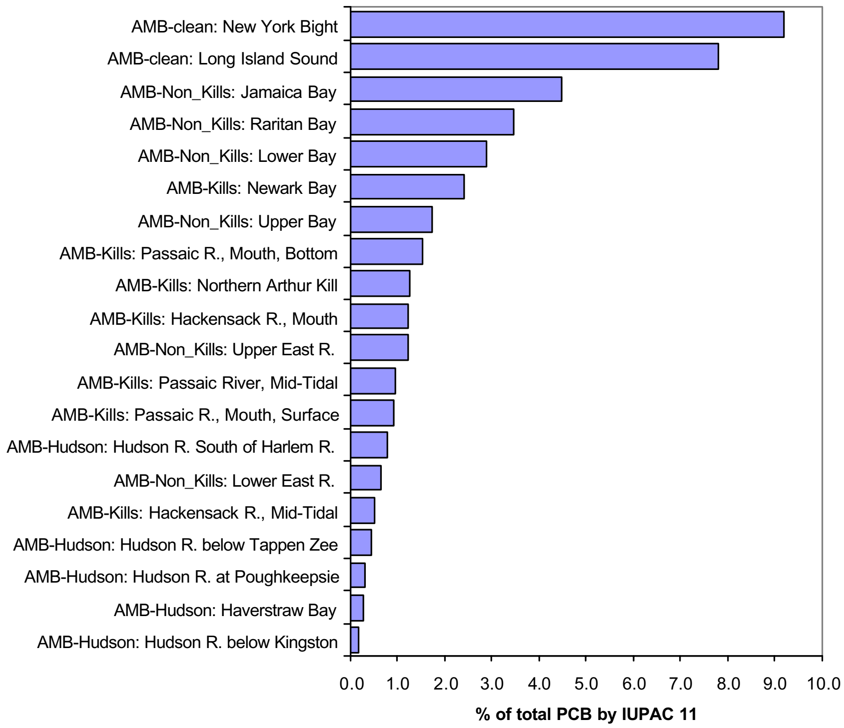


Figure 24. Percent relative abundances of IUPAC 11 in ambient water column sites. Area averages.

IUPAC 11 is produced in a small number of pigment factories in New York and New Jersey. The NYS facility has ceased using the IUPAC 11 precursor (3,3'-dichlorobenzidine) but inadvertently produced PCBs (principally IUPACs 11, 35, 77, and 126) continue to be emitted from the site. Discharge of inadvertently produced PCBs is covered by TSCA and the discharge from the facility falls far below the TSCA level. Elimination of these sources would be the easiest way to reduce total PCBs in New York Harbor water. But such a measure would have very little impact on PCBs in sediments or biota. An appended paper, Identification of a novel PCB source through analysis of 209 PCB congeners by US EPA Modified Method 1668, discussed the subject further.

1E-HMDC, a leachate sample from the New Jersey Meadowlands Commission, breaks out of mound 1E, flows through an area of fill and marsh, and enters the lower Passaic River. The total amount of flow is probably very small and its contribution to loading is probably insignificant. Most of the leachate from the HMDC is captured by PVSC and treated before being discharged into the Upper Bay.

Detailed discussions of PCB concentrations, homologue abundances, and, where appropriate, loads, appear below. The note "DU" indicates that a duplicate sample was taken. Duplicates and samples (SA) drew water from the same point over the same time.

Ambient Concentrations

Ambient samples were taken from 20 sites which, with two exceptions, were taken from slowly cruising boats. The samples were composited over as much of the area as was practical to go. Two sites, in mid-tidal Passaic and Hackensack Rivers, were taken from a bridge or from a dock. A 20th sample, Poughkeepsie, was also taken from a fixed location, the City of Poughkeepsie water treatment plant. This site was sampled primarily during periods of high flow. The other samples were taken to represent each of the four seasons. They were not specifically taken during high or low flow times.

Table 24. PCB concentrations and relative homologue abundances from samples composited between Kingston and Poughkeepsie.

sample ng/L	5/25/1999 - DU 23	5/25/1999 - SA 22	6/28/2000 - SA 16	10/7/1999 - SA 13
1-mono	1.0%	1.0%	1.8%	0.88%
2-di	17%	17%	20%	15%
3-tri	40%	38%	32%	38%
4-tetra	28%	28%	31%	31%
5-penta	9.7%	10%	10%	9.5%
6-Hexa	3.3%	4.2%	3.3%	3.6%
7-Hepta	0.730%	1.1%	1.1%	1.1%
8-Octa	0.22%	0.35%	0.38%	0.32%
9-Nona	0.082%	0.13%	0.13%	0.13%
10-Deca	0.028%	0.053%	0.088%	0.068%

USGS used TOPS to sample at Poughkeepsie in the Poughkeepsie water intake and found the highest average concentration, 92 ng/L. Most samples were taken during times of high flow at Waterford, New York. Table 25 shows for each of the Poughkeepsie samples the total PCB concentration and the percent abundance of each of the homologues. These concentrations are much greater than those found at Pleasantdale.

Table 25. PCB concentrations and relative homologue abundances from Poughkeepsie water intake samples.

sample ng/L	4/17/99 300	4/18/99 140	4/16/99 120	5/17/00 69	3/28/99 59	3/1/99 41	6/15/00 40	10/23/99 40	3/18/00 25
1-mono	2.2%	1.9%	2.1%	2.6%	2.4%	2.1%	3.8%	2.3%	3.2%
2-di	16%	16%	16%	23%	17%	18%	17%	21%	19%
3-tri	35%	35%	36%	26%	36%	36%	30%	35%	34%
4-tetra	28%	29%	29%	32%	28%	27%	28%	28%	24%
5-penta	10%	11%	10%	8.8%	10%	10%	9.0%	8.5%	11%
6-Hexa	5.2%	4.3%	4.9%	5.7%	4.8%	4.3%	11%	3.6%	5.2%
7-Hepta	1.6%	2.1%	1.5%	1.3%	1.5%	1.3%	1.2%	1.2%	1.9%
8-Octa	0.61%	0.87%	0.65%	0.32%	0.59%	0.58%	0.28%	0.36%	0.64%
9-Nona	0.22%	0.22%	0.20%	0.16%	0.23%	0.19%	0.12%	0.10%	0.30%
10-Deca	0.093%	0.076%	0.089%	0.053%	0.10%	0.092%	0.045%	0.059%	0.12%

Table 26. PCB concentrations and relative homologue abundances on samples collected from continuous tows between the Tappen Zee Bridge and Bear Mountain Bridge.

Sample ng/L	7/11/1999 34	2/10/1999 31	11/24/1998 19	4/4/2000 12
1-mono	0.61%	4.6%	0.75%	1.4%
2-di	10%	24%	11%	16%
3-tri	32%	31%	36%	34%
4-tetra	37%	26%	32%	28%
5-penta	13%	8.8%	13%	12%
6-Hexa	5.0%	4.1%	5.3%	6.5%
7-Hepta	1.5%	1.3%	2.1%	1.4%
8-Octa	0.56%	0.45%	0.68%	0.33%
9-Nona	0.19%	0.15%	0.22%	0.13%
10-Deca	0.12%	0.074%	0.12%	0.063%

Table 27. PCB concentrations and relative homologue abundances from the Hudson River between Tappen Zee Bridge and the Harlem River.

sample ng/L	2/19/99 65	4/4/00 23	12/1/98 18	7/10/99 16
1-mono	2.0%	0.96%	0.81%	0.59%
2-di	17%	15%	11%	9.0%
3-tri	35%	34%	33%	29%
4-tetra	27%	29%	28%	34%
5-penta	9.9%	12%	14%	17%
6-Hexa	5.6%	6.2%	7.1%	7.3%
7-Hepta	2.0%	1.6%	3.2%	2.5%
8-Octa	0.94%	0.41%	1.2%	1.0%
9-Nona	0.30%	0.19%	0.51%	0.31%
10-Deca	0.14%	0.09%	0.28%	0.20%

The trend toward lower concentrations but heavier congeners continues in the set of samples taken in cruises off Manhattan between the Battery and the Harlem River. Tides may play a role in congener abundances. Table 28 shows the cosine tides. See Table 6 for the cosine tides associated with all the ambient samples.

Table 28. Hudson River between the Harlem River and the Battery. Cosine tide is positive during ebb tide and negative during flood tide.

sample	3/16/99	12/17/98	6/14/00	10/5/01	8/12/99	12/14/99	8/12/99	12/14/99
field QC	SA	SA	SA	SA	SA	DU	DU	SA
cosine tide	-1.1	0.47	1.1	1.4	1.9	1.9	1.9	1.9
ng/L	31	19	14	12	12	8.3	7.5	5.5
1-mono	0.89%	0.75%	0.93%	0.66%	0.67%	0.70%	0.85%	0.67%
2-di	12%	12%	12%	10%	8.8%	11%	10%	12%
3-tri	33%	31%	31%	30%	30%	31%	29%	30%
4-tetra	30%	31%	33%	32%	34%	33%	28%	33%
5-penta	13%	12%	13%	14%	15%	14%	16%	15%
6-Hexa	6.8%	8.2%	7.0%	8.5%	7.8%	7.0%	9.5%	6.7%
7-Hepta	2.6%	3.3%	1.8%	3.2%	3.0%	2.5%	4.2%	2.2%
8-Octa	1.1%	1.5%	0.66%	1.0%	0.92%	1.0%	1.4%	0.77%
9-Nona	0.35%	0.48%	0.29%	0.41%	0.37%	0.29%	0.56%	0.26%
10-Deca	0.18%	0.32%	0.17%	0.22%	0.25%	0.17%	0.38%	0.13%

Table 29. PCB concentrations and relative homologue abundances for samples taken on cruises around the Upper Bay.

sample	3/18/1999 - SA	6/15/2000 - SA	8/11/1999 - SA	8/11/1999 - DU	12/15/1998 - SA
ng/L	12	7.9	7.8	7.2	5.4
1-mono	0.80%	0.79%	0.60%	0.77%	0.64%
2-di	12%	11%	8.7%	9.6%	10%
3-tri	29%	27%	28%	29%	31%
4-tetra	28%	30%	30%	30%	29%
5-penta	16%	14%	17%	16%	15%
6-Hexa	8.3%	14%	9.4%	8.8%	8.3%
7-Hepta	3.6%	2.4%	3.4%	3.2%	3.4%
8-Octa	1.5%	0.75%	1.1%	0.98%	1.1%
9-Nona	0.51%	0.24%	0.37%	0.34%	0.43%
10-Deca	0.29%	0.14%	0.36%	0.22%	0.27%

Table 30 shows concentrations and relative homologue abundances from samples taken on cruises between the Verrazano Narrows, the Sandy Hook-Rockaway line, and a line drawn south from Great Bay on Staten Island.

Table 30. PCB concentrations and homologue abundances in the Lower Bay.

sample ng/L	3/2/1999 - SA 3.3	6/1/2000 - DU 3.3	12/3/1998 – SA 3.1	6/1/2000 - SA 2.7	7/28/1999 - SA 1.8
1-mono	0.65%	0.71%	0.50%	1.0%	0.54%
2-di	13%	9.2%	10%	10%	12%
3-tri	27%	21%	28%	21%	28%
4-tetra	29%	34%	31%	33%	28%
5-penta	15%	18%	18%	18%	20%
6-Hexa	9.4%	10%	7.5%	10%	8.23%
7-Hepta	3.6%	4.4%	3.2%	4.0%	2.7%
8-Octa	1.3%	1.0%	1.1%	1.0%	0.79%
9-Nona	0.36%	0.44%	0.44%	0.40%	0.22%
10-Deca	0.21%	0.42%	0.25%	0.30%	0.15%

Samples from the New York Bight were taken beyond the Sandy Hook – Rockaway line (Table 31). The sample taken on April 26, 1999 had a significant contribution from IUPAC 11 (20%) but usually Bight samples had heavier congeners than harbor samples.

Table 31. PCB concentrations and homologue abundances in New York Bight.

sample field QC ng/L	12/9/98 SA 0.27	2/1/99 SA 0.15	3/13/00 SA 0.11	4/26/99 SA 0.084	1/30/99 SA 0.077	1/29/99 DU 0.07	2/1/99 DU 0.068	1/30/99 DU 0.06	1/29/99 SA 0.059
1-mono	0.54%	3.1%	5.6%	6.7%	5.0%	8.6%	6.8%	7.0%	7.1%
2-di	5.2%	12%	14%	28%	12%	16%	13%	12%	16%
3-tri	28%	16%	17%	19%	18%	21%	22%	21%	20%
4-tetra	34%	26%	20%	22%	19%	22%	20%	21%	24%
5-penta	17%	24%	25%	15%	31%	17%	22%	25%	19%
6-Hexa	12%	15%	15%	7.1%	11%	12%	12%	12%	11%
7-Hepta	3.4%	3.1%	3.2%	1.3%	2.4%	2.7%	3.0%	1.7%	2.7%
8-Octa	0.51%	0.63%	0.29%	0.43%	0.34%	0.33%	0.16%	0.05%	0.45%
9-Nona	0.043%	0.068%	0.084%	0.12%	0.054%		0.16%		0.10%
10-Deca	0.03%	0.13%	0.28%	0.08%	0.11%	0.16%	0.35%	0.11%	0.34%

Table 32. PCB samples and relative homologue abundances in Long Island Sound.

sample ng/L	5/27/99 - SA 0.6	11/18/98 - SA 0.55	10/19/99 - SA 0.49	5/27/99 - DU 0.48	3/2/99 - SA 0.4
1-mono	1.8%	0.44%	0.71%	2.3%	3.3%
2-di	15%	5.9%	19%	13%	8.1%
3-tri	19%	17%	11%	15%	13%
4-tetra	26%	26%	27%	22%	20%
5-penta	18%	26%	19%	21%	21%
6-Hexa	13%	15%	14%	17%	20%
7-Hepta	4.7%	6.0%	5.4%	7.0%	8.9%
8-Octa	1.6%	2.4%	1.8%	2.5%	3.6%
9-Nona	0.48%	0.68%	0.58%	0.67%	0.89%
10-Deca	0.23%	0.46%	0.39%	0.45%	0.59%

Table 33 shows sample results from cruises on the East River between Hell Gate and the Throgs Neck Bridge. Concentrations in the upper East River are much higher than those in central Long Island Sound and the congeners are lighter.

Table 33. Upper East River PCB concentrations and homologue abundances.

Sample ng/L	12/10/98 5.8	3/7/00 4.2	3/3/99 4.1	8/10/99 3.9
1-mono	0.46%	1.8%	0.88%	0.49%
2-di	7.8%	8.6%	13%	6.8%
3-tri	27%	19%	29%	25%
4-tetra	28%	30%	26%	29%
5-penta	19%	18%	14%	19%
6-Hexa	10%	14%	11%	12%
7-Hepta	4.8%	6.6%	3.9%	4.6%
8-Octa	1.5%	0.72%	1.6%	1.3%
9-Nona	0.63%	0.35%	0.52%	0.55%
10-Deca	0.43%	0.48%	0.23%	0.39%

Table 34. Lower East River samples taken on cruises between Hell Gate and the Brooklyn Bridge, PCB concentrations and homologue abundances.

Sample ng/L	6/2/2000 - DU 13	9/18/1998 - SA 12	6/2/2000 - SA 9.3	3/11/1999 - SA 8	7/27/1999 - SA 7
1-mono	0.77%	0.64%	0.75%	0.80%	0.50%
2-di	7.7%	7.2%	7.5%	12%	7.1%
3-tri	19%	23%	21%	31%	25%
4-tetra	33%	34%	32%	29%	29%
5-penta	18%	17%	16%	13%	22%
6-Hexa	14%	12%	16%	9.2%	10%
7-Hepta	5.2%	4.3%	4.5%	3.4%	3.9%
8-Octa	1.0%	1.0%	0.83%	1.2%	1.5%
9-Nona	0.60%	0.44%	0.64%	0.37%	0.42%
10-Deca	0.48%	0.31%	0.54%	0.24%	0.32%

Table 35. Jamaica Bay PCB concentrations and relative homologue abundances.

sample ng/L	2/23/99 2.3	7/9/99 1.7	5/4/00 1.4	10/14/98 0.74
1-mono	0.68%	1.3%	0.46%	0.61%
2-di	12%	13%	14%	6.9%
3-tri	26%	22%	25%	20%
4-tetra	25%	28%	29%	25%
5-penta	18%	20%	18%	22%
6-Hexa	12%	11%	12%	15%
7-Hepta	5.2%	3.5%	1.8%	6.9%
8-Octa	1.0%	1.1%		2.0%
9-Nona	0.48%	0.26%		0.68%
10-Deca	0.00%	0.21%		0.39%

Samples were taken at three sites in the Passaic River, cruises near the mouth at the surface; cruises near the mouth and 1 meter above the bottom, and from a bridge at Nutley, NJ.

Table 36. Passaic River, mouth surface PCB concentrations and homologue abundances.

Sample ng/L	6/17/99 87	6/27/00 21	2/3/99 14	11/13/98 11
1-mono	0.28%	0.23%	0.38%	0.21%
2-di	4.8%	4.6%	7.8%	5.0%
3-tri	19%	21%	24%	28%
4-tetra	29%	35%	27%	40%
5-penta	21%	18%	16%	14%
6-Hexa	15%	13%	14%	8.0%
7-Hepta	7.0%	6.4%	7.7%	3.2%
8-Octa	2.7%	1.8%	2.5%	0.68%
9-Nona	0.69%	0.37%	0.52%	0.19%
10-Deca	0.40%	0.27%	0.28%	0.10%

Table 37. Passaic River, mouth bottom PCB concentrations and homologue abundances.

sample ng/L	5/2/00 31	7/21/99 24	6/26/00 20	2/5/99 14
1-mono	0.23%	0.21%	0.30%	0.40%
2-di	5.5%	4.3%	4.3%	12%
3-tri	20%	21%	18%	26%
4-tetra	32%	35%	34%	29%
5-penta	17%	22%	20%	14%
6-Hexa	14%	11%	12%	11%
7-Hepta	7.7%	4.4%	7.6%	5.1%
8-Octa	2.1%	1.4%	2.4%	1.8%
9-Nona	0.63%	0.27%	0.55%	0.44%
10-Deca	0.26%	0.17%	0.31%	0.25%

Table 38. Passaic River, mid-tidal PCB concentrations and homologue abundances.

Sample ng/L	10/18/00 71	8/25/99 64	5/9/00 12	3/16/99 7.1
1-mono	0.17%	0.25%	0.65%	1.5%
2-di	3.1%	4.2%	6.5%	8.9%
3-tri	15%	21%	20%	17%
4-tetra	30%	32%	35%	28%
5-penta	22%	21%	16%	20%
6-Hexa	16%	13%	15%	14%
7-Hepta	9.7%	6.1%	5.0%	7.2%
8-Octa	3.0%	1.9%	0.98%	2.4%
9-Nona	0.65%	0.44%	0.26%	0.52%
10-Deca	0.36%	0.24%	0.17%	0.23%

The Hackensack River was sampled from cruises at its mouth onto Newark Bay (Hackensack, mouth) and from a dock at the foot of Plank Road (Hackensack mid-tidal).

Table 39. Hackensack River mouth, PCB concentrations and homologue abundances.

sample ng/L	11/12/98 11	2/8/99 8.1	7/7/99 25	4/11/00 6.8
1-mono	0.17%	0.35%	1.2%	0.33%
2-di	3.5%	10%	8.0%	9.3%
3-tri	24%	27%	20%	30%
4-tetra	44%	33%	35%	42%
5-penta	16%	14%	19%	13%
6-Hexa	8.4%	8.7%	10%	4.4%
7-Hepta	3.1%	4.0%	4.2%	1.3%
8-Octa	0.63%	1.4%	1.6%	0.05%
9-Nona	0.19%	0.31%	0.38%	0.00%
10-Deca	0.12%	0.17%	0.23%	0.00%

Table 40. Hackensack, mid-tidal PCB concentrations and homologue abundances.

sample ng/L	3/17/99 14	9/2/99 27	10/12/99 29	5/10/00 41
1-mono	0.45%	0.19%	0.16%	0.13%
2-di	5.1%	3.8%	3.5%	3.8%
3-tri	24%	27%	20%	20%
4-tetra	41%	42%	41%	43%
5-penta	18%	18%	20%	17%
6-Hexa	7.0%	5.8%	8.6%	12%
7-Hepta	2.9%	2.3%	4.0%	3.4%
8-Octa	0.95%	0.57%	1.4%	0.80%
9-Nona	0.23%	0.15%	0.38%	0.19%
10-Deca	0.13%	0.09%	0.23%	0.11%

Table 41. Newark Bay from Shooter's Island to the NJ Turnpike. PCB concentrations and homologue abundances.

sample ng/L	8/11/99 - SA 14	11/25/98 - SA 10	1/27/99 - SA 9.2	12/15/99 - SA 8.2	12/15/99 - DU 6.8	4/12/00 - SA 4.9
1-mono	0.29%	0.35%	0.43%	0.30%	0.32%	0.58%
2-di	5.8%	8.3%	11%	8.2%	8.7%	9.3%
3-tri	25%	27%	27%	24%	25%	34%
4-tetra	35%	30%	29%	34%	35%	30%
5-penta	20%	18%	15%	18%	16%	16%
6-Hexa	9.4%	9.2%	11%	9.7%	9.0%	7.3%
7-Hepta	3.7%	4.9%	4.3%	3.8%	3.9%	2.4%
8-Octa	1.1%	1.5%	1.6%	1.4%	1.4%	0.32%
9-Nona	0.32%	0.49%	0.41%	0.26%	0.36%	0.12%
10-Deca	0.24%	0.30%	0.24%	0.16%	0.20%	

Table 42. Arthur Kill from the Goethals Bridge to the northern mouth of Fresh Kills, PCB concentrations and homologue abundances.

sample ng/L	11/17/1998 25	2/17/1999 18	7/8/1999 13	4/18/2000 7
1-mono	0.34%	0.50%	0.27%	0.18%
2-di	5.3%	3.6%	7.1%	7.2%
3-tri	20%	16%	18%	22%
4-tetra	36%	23%	26%	33%
5-penta	19%	19%	17%	16%
6-Hexa	11%	19%	17%	13%
7-Hepta	5.2%	15%	10%	7.2%
8-Octa	1.8%	3.9%	3.2%	1.3%
9-Nona	0.41%	0.55%	0.48%	0.29%
10-Deca	0.34%	0.30%	0.28%	0.16%

Table 43. Raritan Bay west of a line dropped from Great Kills south, PCB concentrations and homologue abundances.

sample ng/L	7/12/1999 6.4	2/24/1999 4.2	5/3/2000 3.8	11/16/1998 2.4
1-mono	0.36%	0.28%	0.25%	0.31%
2-di	6.7%	13%	8.6%	7.2%
3-tri	25%	19%	26%	27%
4-tetra	40%	27%	35%	31%
5-penta	17%	19%	16%	16%
6-Hexa	6.9%	13%	11%	10%
7-Hepta	2.2%	5.9%	2.6%	5.1%
8-Octa	0.56%	1.6%	0.46%	1.5%
9-Nona	0.17%	0.39%	0.24%	0.45%
10-Deca	0.12%	0.22%	0.00%	0.28%

Tributaries

Two kinds of tributary samples were taken, major tributaries (Hudson and Pleasantdale, Mohawk at Cohoes, and Wallkill at New Paltz) and minor tributaries (Bronx River at Botanical Garden and below the Bronz Zoo, Saw Mill River in Yonkers, and the Gowanus Canal from the Carroll Street Bridge). The major tributaries were sampled by the USGS to capture high flow events and a few base flows. The minor tributaries were sampled seasonally. Discharges are shown as cubic feet per second (CFS).

Table 44. Hudson River at Pleasantdale PCB concentrations and homologue abundances.

sample	3/29/00	4/8/99	2/28/00	4/1/99	9/7/01	2/29/00	3/22/99	9/20/99	3/4/99	8/29/00	2/25/00	4/4/00
CFS	26,600	19,000	33,600	21,100		28,600	19,100	6,470	17,000	4,970	13,100	29,300
ng/L	56	50	41	38	32	28	25	20	20	18	14	11
1-mono	11%	8.8%	8.4%	7.6%	5.0%	10%	7.8%	8.6%	7.9%	8.0%	17%	11%
2-di	32%	25%	22%	23%	36%	26%	22%	38%	23%	38%	39%	31%
3-tri	23%	29%	27%	28%	31%	24%	25%	16%	27%	26%	22%	21%
4-tetra	23%	26%	27%	28%	20%	26%	27%	26%	23%	22%	15%	27%
5-penta	6.9%	7.6%	7.9%	9.2%	5.4%	8.3%	12%	6.8%	11%	4.3%	4.1%	6.8%
6-Hexa	2.5%	2.5%	4.3%	3.2%	1.6%	2.9%	4.8%	2.6%	5.1%	1.3%	2.3%	2.5%
7-Hepta	0.74%	0.64%	2.0%	0.82%	0.39%	1.0%	1.2%	1.1%	1.4%	0.19%	0.93%	0.77%
8-Octa	0.24%	0.21%	0.84%	0.45%	0.12%	0.66%	0.59%	0.19%	0.71%	0.06%	0.28%	0.24%
9-Nona	0.19%	0.08%	0.46%	0.22%	0.05%	0.49%	0.26%	0.02%	0.28%	0.06%	0.12%	0.14%
10-Deca	0.04%	0.02%	0.14%	0.04%	0.01%	0.11%	0.09%	0.01%	0.12%	0.01%	0.04%	0.04%

Table 45. Mohawk River at Cohoes PCB concentrations and homologue abundances.

Sample	2/28/00	4/4/00	3/4/99	4/1/99	9/17/99	2/26/00	3/12/00	3/28/00
CFS	48,000	38,200	17,000	17,500	21,500	18,400	23,700	31,500
ng/L	54	9.9	6.7	6.1	5.1	2.2	2	1.7
1-mono	0.25%	7.50%	0.19%	1.20%	0.10%	0.00%	1.30%	0.42%
2-di	2.30%	20%	2.50%	13%	1.60%	2.10%	4.50%	3.40%
3-tri	15%	28%	9.90%	23%	12%	15%	21%	15%
4-tetra	24%	27%	19%	27%	23%	27%	21%	24%
5-penta	31%	10%	38%	20%	29%	28%	24%	29%
6-Hexa	19%	4.90%	21%	11%	22%	18%	17%	19%
7-Hepta	6.30%	1.60%	6.70%	3.00%	8.80%	7.30%	7.00%	6.50%
8-Octa	1.30%	0.54%	2.00%	0.70%	2.20%	2.10%	2.50%	1.50%
9-Nona	0.28%	0.29%	0.35%	0.14%	0.50%	0.35%	1.20%	0.76%
10-Deca	0.25%	0.07%	0.21%	0.08%	0.00%	0.33%	0.30%	0.48%

Table 46. Wallkill at New Paltz PCB concentrations and homologues.

Sample	3/21/01	3/30/01	9/17/99	5/26/01	2/15/00	6/29/01	6/17/01	10/13/99
CFS	1,030	6,140	6,350	6,270	589	1,470	589	608
ng/L	4.4	3.6	3	1.6	1.2	0.53	0.47	0.26
1-mono	0.16%	0.18%	0.00%	0.21%	0.00%	0.42%	0.51%	0.47%
2-di	2.60%	2.30%	0.00%	4.70%	0.00%	6.00%	7.00%	4.00%
3-tri	7.60%	7.60%	7.60%	11%	11%	10%	11%	11%
4-tetra	17%	16%	18%	17%	16%	18%	18%	18%
5-penta	31%	32%	29%	27%	31%	29%	29%	29%
6-Hexa	22%	24%	24%	22%	31%	22%	22%	21%
7-Hepta	9.90%	11%	13%	9.40%	8.80%	8.50%	6.80%	10%
8-Octa	3.10%	3.30%	7.30%	3.00%	1.30%	2.90%	2.30%	3.00%
9-Nona	1.30%	0.96%	1.40%	1.20%	0.00%	1.00%	0.87%	0.90%
10-Deca	4.20%	3.00%	0.00%	3.80%	0.78%	1.90%	1.70%	1.80%

Table 47. Bronx River PCB concentrations and homologue abundances.

sample	3/8/99	7/27/99	10/29/98	10/26/99
ng/L	5.3	5.2	4.7	2.9
1-mono	0.13%	0.16%	0.17%	0.36%
2-di	1.7%	1.6%	1.6%	2.9%
3-tri	5.0%	4.9%	3.9%	7.6%
4-tetra	11%	14%	14%	18%
5-penta	17%	21%	16%	19%
6-Hexa	35%	31%	35%	27%
7-Hepta	23%	22%	24%	19%
8-Octa	6.7%	5.2%	4.4%	5.1%
9-Nona	0.66%	0.53%	0.44%	0.52%
10-Deca	0.20%	0.17%	0.11%	0.16%

Table 48. Saw Mill River (at Yonkers) PCB concentrations and homologue abundances.

sample	11/10/1998	3/10/1999	5/5/1999	8/20/1999
ng/L	3.2	1.9	11	4.3
1-mono	0.25%	0.40%	1.00%	0.34%
2-di	3.8%	5.3%	5.8%	7.2%
3-tri	13%	17%	19%	32%
4-tetra	23%	24%	28%	24%
5-penta	29%	24%	27%	21%
6-Hexa	21%	19%	14%	11%
7-Hepta	8.5%	7.0%	3.6%	3.5%
8-Octa	1.9%	2.5%	0.92%	1.2%
9-Nona	0.40%	0.46%	0.16%	0.18%
10-Deca	0.13%	0.17%	0.07%	0.07%

Table 49 shows PCB concentrations and homologue abundances from the Gowanus Canal at the Carroll Street Bridge.

Table 49. Gowanus Canal PCB concentrations and homologue abundances.

Sample ng/L	3/17/1999 11	8/24/1999 5.6	3/21/2000 3.2	9/28/2000 4.5
1-mono	0.96%	0.66%	2.0%	1.0%
2-di	12%	8.2%	1.4%	11%
3-tri	29%	25%	23%	27%
4-tetra	29%	30%	21%	27%
5-penta	15%	18%	26%	16%
6-Hexa	9.1%	12%	18%	11%
7-Hepta	3.5%	4.3%	7.7%	4.9%
8-Octa	1.2%	1.3%	1.1%	1.8%
9-Nona	0.32%	0.46%	0.20%	0.71%
10-Deca	0.16%	0.31%	0.10%	0.47%

Wastewater Pollution Control Facilities

Wastewater treatment plants were usually sampled three times. Only two results are reported from Red Hook due to sampling errors and four plants (Newtown Creek, 26th Ward, Hunts Point, and Port Richmond) were visited more often. Discharges are given in million gallons per day (MGD).

Table 50. 26th Ward PCB concentrations and homologue abundances.

sample MGD ng/L	1/27/99 53 6.9	5/5/99 60 3.3	9/20/00 64 127	6/11/01 83 26
1-mono	0.27%	1.2%	0.02%	0.26%
2-di	5.1%	5.8%	0.26%	1.5%
3-tri	16%	16%	0.49%	2.1%
4-tetra	23%	20%	1.2%	5.9%
5-penta	28%	31%	15%	16%
6-Hexa	18%	18%	48%	46%
7-Hepta	7.1%	5.7%	30%	25%
8-Octa	2.0%	1.8%	4.4%	3.1%
9-Nona	0.42%	0.32%	0.20%	
10-Deca	0.27%	0.14%	0.01%	

Table 51. Bowery Bay PCB concentrations and homologue abundances.

sample	11/5/98	4/21/99	9/22/99
MGD	101	138	103
ng/L	4.7	7.3	5.3
1-mono	0.47%	0.25%	0.30%
2-di	5.2%	4.8%	14%
3-tri	17%	13%	18%
4-tetra	34%	25%	22%
5-penta	22%	26%	20%
6-Hexa	15%	21%	15%
7-Hepta	5.7%	7.6%	8.2%
8-Octa	0.66%	1.9%	1.5%
9-Nona	0.082%	0.28%	0.17%
10-Deca	0.023%	0.081%	0.057%

Table 52. Coney Island WPCF PCB concentrations and homologue abundances.

Sample	10/4/00	3/17/99	7/28/99
MGD	87	105	103
ng/L	1.4	3.0	2.4
1-mono	1.5%	0.30%	0.76%
2-di	14%	8.8%	9.4%
3-tri	18%	16%	21%
4-tetra	19%	20%	24%
5-penta	26%	29%	26%
6-Hexa	15%	18%	13%
7-Hepta	5.9%	6.8%	5.0%
8-Octa	0.75%	1.84%	0.53%
9-Nona	0.17%	0.36%	0.066%
10-Deca	0.08%	0.09%	0.05%

Table 53. Hunts Point WPCF PCB concentrations and homologue abundances.

Sample	2/1/01	2/19/99	3/19/01	3/28/01	4/11/01	4/18/01	4/30/99
MGD	142	149	120	181	146	125	133
ng/L	4.0	14	0.4	3.2	2.2	3.3	6.3
1-mono	3.9%	11%	4.9%	3.2%	3.3%	5.5%	3.2%
2-di	8.9%	21%	20%	13%	17%	36%	15%
3-tri	17%	24%	31%	18%	22%	23%	22%
4-tetra	19%	19%	19%	21%	24%	15%	26%
5-penta	24%	14%	15%	24%	20%	12%	18%
6-Hexa	17%	7.6%	7.6%	16%	9.7%	5.8%	11%
7-Hepta	7.7%	2.9%	2.4%	3.9%	2.6%	1.4%	3.7%
8-Octa	2.2%	0.68%	0.52%	1.03%	0.57%	0.29%	0.98%
9-Nona	0.58%	0.18%					0.19%
10-Deca	0.19%	0.05%					0.075%

Table 54. Jamaica WPCF PCB concentrations and homologue abundances.

Sample	2/5/99	6/30/99	2/15/01
MGD	88	84	90
ng/L	7.6	7.5	4.2
1-mono	0.16%	0.55%	0.80%
2-di	3.8%	6.6%	5.6%
3-tri	11%	18%	11%
4-tetra	21%	28%	18%
5-penta	36%	26%	34%
6-Hexa	20%	15%	21%
7-Hepta	5.6%	4.9%	6.6%
8-Octa	1.4%	0.89%	1.7%
9-Nona	0.28%	0.14%	0.39%
10-Deca	0.21%	0.07%	0.15%

Table 55. Newtown Creek WPCF PCB concentrations and homologue abundances.

sample	1/5/00	1/5/00	3/11/99	3/11/99	6/22/99	6/22/99	9/28/99	9/28/99
field QC	DU	SA	DU	SA	DU	SA	DU	SA
MGD	249	249	249	249	249	249	249	249
ng/L	25	11	6.7	3.4	21	12	7.5	10
1-mono	2.0%	4.1%	0.37%	11%	5.1%	8.8%	8.4%	5.0%
2-di	5.6%	5.6%	3.1%	14%	8.6%	11%	9.6%	7.2%
3-tri	12%	12%	9.7%	21%	15%	16%	17.15%	15%
4-tetra	21%	20%	18%	22%	24%	21%	21%	23%
5-penta	27%	25%	33%	21%	26%	25%	24%	27%
6-Hexa	20%	21%	22%	9.0%	14%	13%	14%	16%
7-Hepta	8.4%	8.9%	9.4%	2.0%	5.4%	4.7%	5.0%	5.7%
8-Octa	3.0%	2.8%	3.5%		1.2%	1.3%	0.88%	1.0%
9-Nona	0.39%	0.40%	0.58%		0.20%	0.25%	0.15%	0.16%
10-Deca	0.083%	0.086%	0.14%		0.047%	0.054%	0.047%	0.044%

Table 56. North River WPCF, PCB concentrations and homologue abundances.

sample	3/24/99	9/1/99	1/25/01
MGD	153	167	152
ng/L	4.7	4.4	2.4
1-mono	0.47%	0.99%	0.47%
2-di	6.8%	7.6%	16%
3-tri	19%	18%	24%
4-tetra	27%	22%	20%
5-penta	24%	28%	22%
6-Hexa	15%	17%	12%
7-Hepta	5.7%	5.5%	3.9%
8-Octa	1.4%	0.77%	0.77%
9-Nona	0.30%	0.13%	0.15%
10-Deca	0.053%	0.032%	0.032%

Oakwood Beach WPCF receives sludge from Port Richmond WPCF. The Port Richmond WPCF receives waste from a pigment manufacturer that inadvertently generates certain PCB congeners, particularly 3,3'-dichlorobiphenyl. This congener accounts for the high proportion of dichlorobiphenyl seen at Port Richmond and Oakwood Beach WPCFs.

Table 57. Oakwood Beach WPCF, PCB concentrations and homologue abundances.

sample	2/11/99	8/18/99	10/13/99
MGD	25	25	36
ng/L	5.5	13	9.6
1-mono	0.36%	0.88%	0.33%
2-di	57%	87%	80%
3-tri	12%	3.2%	5.5%
4-tetra	13%	3.6%	5.0%
5-penta	9.2%	3.4%	4.8%
6-Hexa	6.1%	1.5%	2.8%
7-Hepta	1.8%	0.44%	0.91%
8-Octa	0.45%	0.074%	0.28%
9-Nona	0.11%	0.014%	0.055%
10-Deca	0.020%	0.007%	0.020%

Table 58. Owls Head WPCF PCB concentrations and homologue abundances.

sample	9/15/98	7/7/99	8/23/00
MGD	113	119	115
ng/L	2.9	3.4	3.9
1-mono	0.75%	0.65%	0.77%
2-di	7.4%	6.9%	8.5%
3-tri	16%	23%	18%
4-tetra	18%	24%	24%
5-penta	30%	25%	28%
6-Hexa	19%	14%	15%
7-Hepta	7.1%	5.1%	4.6%
8-Octa	1.2%	0.60%	0.56%
9-Nona	0.25%	0.098%	0.14%
10-Deca	0.098%	0.053%	0.055%

Table 59. Port Richmond WPCF PCB concentration and homologue abundances.

sample	2/24/99	8/25/99	10/20/99	4/11/01	4/30/01
MGD	31	35	78	49	29
ng/L	29	213	143	160	103
1-mono	0.50%	0.049%	0.40%	0.072%	0.14%
2-di	65%	97%	92%	98%	97%
3-tri	7.5%	1.1%	2.5%	0.57%	1.2%
4-tetra	6.3%	0.78%	2.3%	0.38%	0.64%
5-penta	5.3%	0.57%	1.4%	0.35%	0.52%
6-Hexa	7.9%	0.24%	0.87%	0.22%	0.35%
7-Hepta	5.8%	0.070%	0.33%	0.075%	0.098%
8-Octa	1.7%	0.012%	0.091%	0.015%	0.023%
9-Nona	0.16%	0.003%	0.017%		
10-Deca	0.026%	0.0006%	0.0092%		

Table 60. Poughkeepsie WPCF PCB concentrations and homologue abundances.

sample	12/5/00 - SA	4/1/99 – SA	8/19/99 - DU	8/19/99 - SA
MGD	4.3	7.2	4.5	4.5
ng/L	6.4	5.9	27	22
1-mono	1.3%	5.8%	8.9%	8.2%
2-di	11%	8.2%	3.5%	3.8%
3-tri	11%	9.2%	12%	13%
4-tetra	15%	14%	16%	17%
5-penta	32%	28%	29%	28%
6-Hexa	22%	21%	20%	20%
7-Hepta	6.0%	12%	9.4%	9.0%
8-Octa	1.5%	1.4%	1.3%	1.2%
9-Nona	0.39%	0.17%	0.15%	0.15%
10-Deca	0.12%	0.061%	0.041%	0.042%

Table 61. Red Hook (Brooklyn) WPCF PCB concentrations and homologue abundances.

sample	2/3/99	4/14/99
MGD	39.73	30.2
ng/L	5.4	2.1
1-mono	0.47%	0.82%
2-di	4.9%	8.9%
3-tri	16%	22%
4-tetra	26%	31%
5-penta	21%	21%
6-Hexa	19%	12%
7-Hepta	8.9%	4.1%
8-Octa	2.8%	0.73%
9-Nona	0.54%	0.09%
10-Deca	0.12%	0.03%

Table 62. Renesselaer WPCF PCB concentrations and homologue abundances.

Sample	1/12/99	3/30/99	8/11/99
MGD	16	23	14
ng/L	9.3	3.0	5.5
1-mono	1.5%	1.8%	1.8%
2-di	33%	41%	25%
3-tri	10%	12%	20%
4-tetra	13%	14%	19%
5-penta	21%	17%	20%
6-Hexa	15%	9.3%	9.5%
7-Hepta	4.7%	2.9%	2.8%
8-Octa	1.8%	0.89%	1.2%
9-Nona	0.62%	0.29%	0.88%
10-Deca	0.16%	0.08%	0.26%

Table 63. Rockaway WPCF PCB concentrations and homologue abundances.

Sample	4/1/99	8/11/99	11/3/99
MGD	21	22	19
ng/L	3.7	7.1	2.4
1-mono	0.50%	0.34%	0.90%
2-di	4.6%	3.9%	7.6%
3-tri	14%	15%	26%
4-tetra	27%	22%	23%
5-penta	25%	33%	21%
6-Hexa	16%	18%	13%
7-Hepta	11%	6.2%	5.4%
8-Octa	1.7%	1.6%	1.7%
9-Nona	0.38%	0.25%	0.23%
10-Deca	0.10%	0.12%	0.07%

Table 64. Rockland County WPCF PCB concentrations and homologue abundances.

sample	3/8/00	4/20/99	8/19/99
MGD	22	20	17
ng/L	4.6	4.3	5.1
1-mono	1.5%	8.6%	1.7%
2-di	4.4%	22%	8.1%
3-tri	9.1%	16%	20%
4-tetra	20%	21%	22%
5-penta	28%	22%	32%
6-Hexa	28%	8.4%	12%
7-Hepta	7.7%	2.2%	2.8%
8-Octa	0.81%	0.31%	0.32%
9-Nona	0.13%	0.04%	0.10%
10-Deca	0.10%	0.02%	0.03%

Table 65. Tallman Island WPCF PCB concentrations and homologue abundances.

Sample	2/12/99	7/20/99	9/6/00
MGD	56	59	41
ng/L	5.9	5.1	4.9
1-mono	0.29%	0.43%	0.47%
2-di	6.7%	9.4%	6.0%
3-tri	9.2%	25%	14%
4-tetra	15%	25%	22%
5-penta	23%	20%	29%
6-Hexa	28%	13%	20%
7-Hepta	14%	6.7%	7.6%
8-Octa	3.3%	0.76%	1.7%
9-Nona	0.32%	0.086%	0.28%
10-Deca	0.08%	0.021%	0.055%

Table 66. Wards Island WPCF PCB concentrations and homologue abundances.

Sample	1/20/99 - SA	4/28/99 - SA	8/10/00 - DU	8/10/00 - SA
MGD	221	179	220	220
ng/L	3.2	1.8	2.6	2.2
1-mono	0.94%	0.49%	1.5%	1.7%
2-di	8.1%	4.3%	7.0%	7.2%
3-tri	17%	15%	13%	14%
4-tetra	22%	23%	23%	22%
5-penta	25%	29%	30%	27%
6-Hexa	17%	19%	17%	19%
7-Hepta	7.0%	7.5%	6.0%	7.3%
8-Octa	1.8%	1.2%	1.5%	1.4%
9-Nona	0.61%	0.25%	0.35%	0.36%
10-Deca	0.17%	0.12%	0.10%	0.10%

Table 67. Yonkers WPCF PCB concentrations and homologue abundances.

Sample	4/22/99	8/18/99	3/22/00
MGD	89	85	95
ng/L	2.0	2.5	8.6
1-mono	0.28%	0.85%	0.55%
2-di	4.6%	7.2%	2.3%
3-tri	16%	25%	12%
4-tetra	24%	24%	19%
5-penta	32%	27%	23%
6-Hexa	17%	12%	28%
7-Hepta	4.0%	4.0%	12.6%
8-Octa	1.1%	0.34%	1.9%
9-Nona	0.25%	0.075%	0.28%
10-Deca	0.066%	0.020%	0.18%

NYSDEC sampled NJ treatment plants at Edgewater and PVSC. Samples (34 L at Edgewater and 47L at PVSC) were composited over 24 hours beginning on May 21, 2001. They were brought back to the NYSDEC lab and processed identically to the ways of the routine NYSDEC samples. 3,3'-DiCB accounts for almost all of the PCB at PVSC.

Table 68. Edgewater and PVSC PCB concentrations and homologue abundances.

Name Ng/L	Edgewater 6.5	PVSC 330
1-mono	0.72%	0.03%
2-di	5.6%	92%
3-tri	8.1%	2.8%
4-tetra	13%	2.3%
5-penta	19%	1.5%
6-Hexa	29%	0.95%
7-Hepta	20%	0.53%
8-Octa	4.2%	0.14%
9-Nona	0.44%	0.03%
10-Deca	0.11%	0.01%

CSO/SWO

Sixteen samples were taken to represent combined sewer overflows (CSOs) and storm water overflows (SWOs). The CSO samples were wet weather influents to treatment plants. Sampling details are shown elsewhere. SWO samples were taken in two locations in the Jamaica section of Queens. One represents a commercial district and the other represents an industrial area. Table 69 lists the names of the sites and the abbreviations used in Table 70. The order in the list is the same as in the numerical table, in order of ascending concentration. Discharges (MGD) shown on Table 70 are modeled daily total releases from all the individual CSOs in the WPCF's drainage. Three facilities (26th Ward, Bowery Bay, and Newtown Creek) were sampled at two influent points. The two Newtown Creek points are "Manhattan Pump Station" and "Newtown Creek". In these cases, the same MGD value is used for both. Readers may wish to average the concentrations in calculating a load. Manhattan Grit Chamber was used to evaluate raw influent entering the Wards Island facility. Similar values are not available for the two SWOs.

The predominance of dichlorobiphenyls at Port Richmond is due to the inadvertently synthesized PCB congener 3,3'DiCB. The predominance of hexachlorobiphenyls at both 26th Ward samples reflects the Aroclor 1260 previously noted there. It is interesting that high concentrations of Aroclor 1260 occur in both influents reflecting the widespread contamination of this formerly industrial area.

Table 69. Names and abbreviations used in Table 70.

name	abbreviation
26th Ward, High Side	26 High Inf
Red Hook Influent	RH Inf
26th Ward, Low Side	26, Low Inf
Port Richmond Influent	PR Inf
North River Influent	NR Inf
Bowery Bay High Side	BB, High Inf
Newtown Creek Influent	NC Inf
Manhattan Pump Station	Man. PS
Manhattan Grit Chamber	Man. Grit Chamber
Bowery Bay Low Side	BB, Low Inf
SWO-Jamaica, Industrial	SWO-Jam Ind.
Owls Head Influent	OH Inf
Jamaica Influent	JA Inf
Hunts Point Influent	HP Inf
SWO-Jamaica, Commercial	SWO-Jam Com.
Coney Island Influent	CI Inf

Table 70. CSO/SWO PCB concentrations and homologue abundances.

Sample	26 High Inf	RH Inf	26, Low Inf	PR Inf	NR Inf	BB, High Inf	NC Inf	Man. PS
MGD	12	3.7	12	1.0	5.0	13	14	14
ng/L	3500	1300	850	560	350	300	260	150
1-mono	0.004%	0.077%	0.040%	0.73%	0.40%	0.090%	0.81%	0.33%
2-di	0.07%	2.1%	0.50%	87%	1.5%	1.2%	4.2%	2.0%
3-tri	0.38%	19%	1.7%	3.1%	4.0%	4.1%	12%	5.1%
4-tetra	3.4%	37%	3.6%	3.59%	11%	9.2%	19%	9.5%
5-penta	9.7%	17%	9.4%	2.65%	32%	20%	26%	26%
6-Hexa	42%	13%	43%	2.06%	32%	34%	22%	27%
7-Hepta	36%	8.5%	34%	0.89%	13%	23%	12%	20%
8-Octa	8.0%	2.6%	6.7%	0.24%	4.0%	6.8%	3.6%	7.4%
9-Nona	0.38%	0.34%	0.34%	0.065%	1.2%	0.84%	0.68%	1.7%
10-Deca	0.010%	0.064%	0.031%	0.021%	0.18%	0.14%	0.18%	0.18%

Table 70 continued.

Sample	Man. Grit Chamber	BB, Low Inf	SWO-Jam Ind	OH Inf	JA Inf	HP Inf	SWO-Jam Com	CI Inf
MGD	11	13	NA	9.3	31	15	NA	10.0
ng/L	130	110	70	66	65	58	48	44
1-mono	0.16%	0.35%	0.24%	0.30%	0.63%	0.39%	0.48%	0.80%
2-di	1.1%	4.5%	4.1%	3.1%	3.7%	3.8%	3.2%	3.8%
3-tri	3.2%	8.4%	13%	7.8%	9.1%	11%	5.2%	7.7%
4-tetra	13%	17%	22%	16%	17%	17%	12%	15%
5-penta	40%	31%	24%	29%	32%	23%	28%	32%
6-Hexa	29%	25%	22%	26%	24%	27%	29%	26%
7-Hepta	8.5%	9.8%	10%	13%	9.3%	12%	16%	10%
8-Octa	3.5%	3.6%	2.9%	3.1%	2.8%	4.1%	5.3%	3.1%
9-Nona	2.0%	0.84%	0.83%	1.1%	0.88%	1.1%	1.05%	0.94%
10-Deca	0.30%	0.26%	0.29%	0.64%	0.48%	0.38%	0.25%	0.61%

Wastewater Treatment Plant Sludges

Table 71 shows the site names and the abbreviations used in Table 72. All the sludge samples, except the one from Newtown Creek (NC) were composited from daily collections made during February 2001. Port Richmond and Oakwood Beach (PR and OB) have a predominance of 3,3'-DiCB. So, too, does Wards Island South (WI, South).

Table 71. Names used in Table 72.

26th Ward WPCF, Sludge	26W
Bowery Bay WPCF, Sludge	BB
Coney Island WPCF, Sludge	CI
Hunts Point WPCF #10 Sludge	HP#10
Hunts Point WPCF #9 Sludge	HP#9
Jamaica WPCF Sludge	JA
Oakwood Beach WPCF, Sludge	OB
Port Richmond WPCF, Sludge	PR
Red Hook WPCF, Sludge	RH
Tallman Island WPCF, Sludge	TI
Wards Island WPCF, North, Sludge	WI, North
Wards Island WPCF, South, Sludge	WI, South

Table 72. PCB concentrations and homologue abundances in WPCF sludges. Note that the units are mg/kg (ppm).

Name mg/kg	PR 12	26W 2.6	WI, South 2.0	OB 1.6	JA 1.4	RH 0.82	CI 0.69	HP#10 0.61
1-mono	0.27%	0.039%	0.37%	0.23%	0.12%	0.085%	0.14%	0.73%
2-di	94%	0.53%	44%	85%	1.8%	2.5%	1.8%	5.4%
3-tri	2.5%	2.0%	7.3%	2.6%	6.3%	16%	5.2%	10%
4-tetra	1.4%	4.1%	9.9%	3.5%	14%	25%	9.2%	17%
5-penta	0.97%	12%	16%	4.1%	30%	21%	19%	26%
6-Hexa	0.87%	43%	15%	3.1%	29%	21%	36%	26%
7-Hepta	0.35%	31%	5.4%	1.3%	15%	9.7%	23%	11%
8-Octa	0.090%	6.7%	1.6%	0.40%	3.2%	3.1%	4.7%	3.0%
9-Nona	0.024%	0.43%	0.54%	0.11%	0.48%	0.91%	0.68%	0.95%
10-Deca	0.010%	0.051%	0.21%	0.04%	0.18%	0.22%	0.18%	0.30%

Table 72 continued.

Sample mg/kg	BB 0.60	HP#9 0.59	TI 0.41	WI, North 0.40
1-mono	0.15%	1.2%	0.22%	0.19%
2-di	2.4%	4.9%	2.4%	7.2%
3-tri	7.0%	12%	8.2%	9.5%
4-tetra	17%	19%	17%	17%
5-penta	27%	25%	26%	27%
6-Hexa	26%	24%	25%	24%
7-Hepta	15%	9.2%	16%	9.2%
8-Octa	4.0%	2.8%	4.5%	3.5%
9-Nona	0.77%	0.89%	0.69%	1.7%
10-Deca	0.39%	0.30%	0.15%	0.41%

Landfill Leachates

Landfill leachates were only sampled in the dissolved (filtered) phase. There are methods for estimating the amount of liquid leachate that leaves a landfill, but we lack a way to estimate transport of particles from within to outside a mound. Three landfills were sampled; Pelham Bay (PB) in the Bronx, Fresh Kills (FK) on Staten Island, and the New Jersey Meadowlands Commission (formerly Hackensack Meadowlands Development Commission, HMDC). Pelham Bay leachate is collected into holding tanks and then trucked to the Hunts Point WPCF for treatment. Most of the Fresh Kills leachate is collected and treated by a specially built treatment plant on site. Effluent from this plant was also sampled (Table 74). Some of the leachate from the HMDC is treated at Passaic Valley Sewerage Commissioners (PVSC). Pelham Bay holding tanks were sampled twice. The two other much larger operations were sampled at different points and at different times.

Table 73. Leachates, PCBs and relative homologue abundances.

name sample ng/L	1E-HMDC 6/22/00 2200	1A-HMDC 6/22/00 950	FK 1/9 Comp. 10/25/00 950	1E-HMDC 800	FK 1/9 Comp. 9/14/01	FK 1/9 Comp. 3/20/01 4/19/01
1-mono	4.6%	8.2%	3.2%	1.5%	3.6%	0.88%
2-di	14%	32%	14%	16%	14%	15%
3-tri	32%	39%	29%	30%	32%	36%
4-tetra	19%	14%	27%	23%	31%	34%
5-penta	10%	3.9%	14%	9.5%	12%	12%
6-hexa	9.6%	1.9%	8.1%	11%	6.0%	1.4%
7-hepta	6.1%	0.83%	3.0%	6.8%	1.6%	0.37%
8-octa	2.5%	0.34%	1.16%	1.9%	0.40%	0.08%
9-nona	0.86%	0.050%	0.36%			
10-deca	0.16%	0.014%	0.24%			

Table 73 continued.

Name Sample ng/L	FK 6/7 Comp. 10/25/00 430	FK 6/7 Comp. 8/9/01 310	FK 6/7 Comp. 7/25/01 260	FK 1/9 Comp. 5/11/00 240	FK LF 1/9 "B" 5/11/00 190	1D-HMDC 9/14/01 110
1-mono	28%	18%	20%	2.3%	3.3%	0.32%
2-di	48%	31%	40%	9.7%	12%	2.0%
3-tri	17%	27%	26%	23%	31%	6.64%
4-tetra	4.8%	17%	9.3%	34%	33%	18%
5-penta	1.0%	4.6%	2.3%	16%	11%	23%
6-hexa	0.61%	1.9%	1.6%	9.1%	6.1%	28%
7-hepta	0.31%	0.75%	0.79%	4.4%	2.4%	16.63%
8-octa	0.12%	0.25%	0.35%	0.73%	0.34%	5.0%
9-nona				0.22%	0.12%	
10-deca				0.38%	0.35%	

Table 73 continued.

Name Sample ng/L	FK 6/7 Comp. 5/11/00 100	FK 3/4 5/11/00 97	FK 1/9 "F" 5/11/00 87	1D-HMDC 6/22/00 73	Pelham Bay 11/6/98 22	Pelham Bay-DU 1/29/01 3.7	Pelham Bay 1/29/01 1.8
1-mono	0.16%	5.8%	6.1%	0.42%	15%	6.7%	0.34%
2-di	48%	34%	26%	3.6%	16%	27%	4.64%
3-tri	24%	21%	20%	18%	31%	23%	11%
4-tetra	17%	20%	27%	24%	23%	16%	28%
5-penta	5.6%	9.1%	11%	24%	9.0%	11%	24%
6-hexa	3.2%	5.0%	5.2%	17%	4.4%	9.57%	20%
7-hepta	1.8%	2.8%	3.3%	8.4%	1.0%	4.9%	8.7%
8-octa	0.46%	0.45%	0.68%	3.6%	0.16%	2.3%	2.1%
9-nona	0.10%	0.24%	0.15%	0.95%			0.45%
10-deca	0.18%	0.95%	0.24%	0.46%			0.46%

Industrial Effluents

Few New York City industrial concerns discharge directly to surface waters. Two facilities were sampled, Clean Waters of New York (an industrial waste processor) and New York City Department of Sanitation's Fresh Kills Treatment Plant (FK, Eff). This state of the art facility treats only leachates from mounds 1,6,7, and 9.

Table 74. PCB concentrations and homologue abundances from two "industrial" dischargers.

name sample MGD ng/L	Clean Waters 4/29/99 0.022	Clean Waters 9/20/99 0.007	FK, Eff 10/25/00 0.26 11	FK, Eff 3/20/01 0.56 30	FK, Eff 4/19/01 0.67 19	FK, Eff 7/25/01 11
1-mono	5.2%	2.8%	0.89%	0.09%	0.25%	0.48%
2-di	6.1%		9.4%	3.4%	12%	12%
3-tri	17%	17%	18%	7.3%	19%	21%
4-tetra	18%	22%	27%	26%	29%	29%
5-penta	18%	35%	20%	28%	19%	18%
6-Hexa	18%	15%	14%	20%	13%	12%
7-Hepta	11%	6.8%	6.6%	10%	5.3%	5.0%
8-Octa	4.4%	1.1%	2.6%	3.0%	2.0%	1.9%
9-Nona	1.2%		0.66%	0.80%	0.21%	0.12%
10-Deca	1.1%		0.53%	0.70%	0.16%	0.08%

Trackdown

A small level of effort was taken toward identifying PCB sources using PISCES. As noted above, Aroclor 1260 was seen entering and leaving 26th Ward. Table 75 shows the results. Samples at both Van Siclen Ave. and Hendrix St. showed unusually high concentrations of a heavy PCB mixture. These samples were from two separate mains indicating widespread PCB contamination. The same effect was also noted in the raw wet weather influent samples.

Table 75. PISCES results for PCBs in 26th Ward, 6/7/01 – 6/22/01.

	Van Siclen Ave. 1800 ng/L	Hendrix St. 210 ng/L	Flatlands St. 17 ng/L
1-mono	0.04%	0.24%	2.3%
2-di	0.14%	0.76%	9.4%
3-tri	0.38%	1.6%	14%
4-tetra	1.4%	4.5%	17%
5-penta	9.4%	11%	22%
6-Hexa	44%	42%	19%
7-Hepta	37%	32%	10%
8-Octa	7.3%	7.1%	3.9%
9-Nona	0.35%	0.38%	0.78%
10-Deca	0.01%	0.01%	0.19%

Two different PISCES surveys were carried out in the Newtown Creek service area on 1/18-1/29/01 and later on 6/7-6/22/01 (Figure 25). Here too, two separate mains (Greenpoint and Manhattan, south) indicate relatively high PCB concentrations (Table 76).

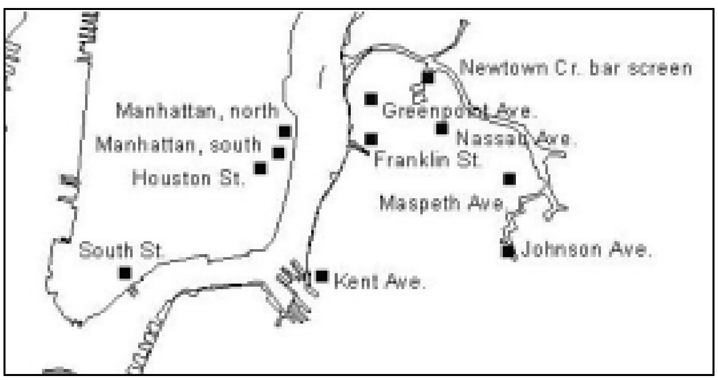


Figure 25. PISCES sampling points in the Newtown Creek area.

76. PISCES results for PCBs from the Newtown Creek area.

	Greenpoint Ave. 1/18-1/29/01 120 ng/L	Manhattan, south 1/18-1/29/01 100 ng/L	Newtown Cr. bar screen 1/18-1/29/01 63 ng/L	Houston St. 6/7-6/22/01 49 ng/L	Maspeth Ave. 1/18-1/29/01 41 ng/L
1-mono	14%	7.6%	4.8%	4.4%	1.9%
2-di	12%	9.9%	9.82%	7.1%	7.6%
3-tri	17%	17%	18%	15%	16%
4-tetra	19%	18%	20%	17%	19%
5-penta	18%	20%	19%	21%	24%
6-Hexa	12%	16%	16%	21%	19%
7-Hepta	4.7%	9.1%	8.6%	10%	9.9%
8-Octa	1.2%	2.6%	2.5%	3.1%	2.7%
9-Nona	0.20%	0.58%	0.41%	0.73%	0.51%
10-Deca	0.05%	0.16%	0.12%	0.18%	0.11%

Table 76 continued.

	Manhattan, north 1/18-1/29/01 40 ng/L	Franklin St. 6/7-6/22/01 37 ng/L	South St. 6/7-6/22/01 36 ng/L	Kent Ave. 6/7-6/22/01 26 ng/L	Nassau Ave. 1/18-1/29/01 18 ng/L	Johnson Ave. 1/18-1/29/01 17 ng/L
1-mono	2.4%	1.9%	5.0%	4.2%	5.7%	2.6%
2-di	8.8%	6.5%	7.1%	10%	14%	9.3%
3-tri	15%	14%	14%	16%	23%	13%
4-tetra	18%	26%	17%	18%	18%	18%
5-penta	24%	21%	21%	24%	17%	28%
6-Hexa	19%	17%	19%	18%	13%	19%
7-Hepta	9.0%	9.2%	12%	7.6%	6.1%	6.1%
8-Octa	2.7%	3.0%	4.4%	2.2%	1.9%	2.2%
9-Nona	0.65%	0.37%	0.98%	0.49%	0.43%	0.80%
10-Deca	0.11%	0.08%	0.10%	0.15%	0.11%	0.18%

A PISCES survey was carried out in Staten Island to positively identify the suspected source of the 3,3'-dichlorobiphenyl. Sample locations are shown in Figure 26 and results appear on Table 77. Sampling dates were July 27 to August 2, 2000. Total concentrations derived from PISCES are only moderately quantitative. Nevertheless, the concentrations from the pigment manufacturer outfall and the Port Richmond WPCF influent are extraordinary. The unusual composition of the pigment outfall material is emphasized in Table 78 which shows the three most important congeners from these two sites. The apparent loss of 3,3',4,4'-tetrachlorobiphenyl (IUPAC 77) between pigment manufacturer and Port Richmond is unexplained. Samplers at the pigment manufacturer and the WPCF were both in place for seven days.

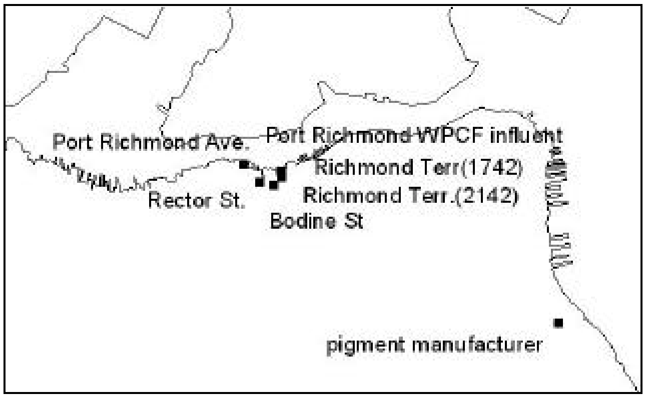


Figure 26. PISCES sampling locations on Staten Island.

Table 77. PCB trackdown (7/27/00 to 8/2/00) on Staten Island.

	pigment outfall 5900 ng/L	PR WPCF inf 520 ng/L	2142 Rich. T. 18 ng/L	Bodine St. 12 ng/L	Rector St. 12 ng/L	Pt Rich. Ave. 2.7 ng/L	1742 Rich. T. 1.3 ng/L
1-mono	0.06%	0.17%	2.2%	5.7%	3.4%	2.5%	3.0%
2-di	61%	95%	14%	13%	9.7%	15%	19%
3-tri	6.6%	1.67%	32%	14%	11%	21%	16%
4-tetra	32%	1.66%	26%	21%	19%	20%	17%
5-penta	0.10%	0.80%	13%	29%	30%	19%	25%
6-Hexa	0.018%	0.41%	7.2%	12%	20%	15%	15%
7-Hepta	0.0033%	0.12%	3.3%	3.8%	5.0%	4.7%	2.8%
8-Octa	0.0007%	0.027%	0.83%	1.1%	1.2%	1.4%	0.74%
9-Nona	0.0004%	0.006%	0.16%	0.18%	0.25%	0.45%	0.19%
10-Deca	0.0025%	0.0014%	0.035%	0.040%	0.067%	0.10%	0.066%

Table 78. Top congeners at PR WPCF influent and pigment outfall, PISCES

IUPAC		PR Influent	Pigment Outfall
	Percent of total PCB	95%	99%
11	3,3'-dichlorobiphenyl	490	3600
77	3,3',4,4'-tetrachlorobiphenyl	2.5	1900
35	3,3',4-trichlorobiphenyl	2.3	380

Congener Analysis

The preceding tables of homologue abundances show a trend toward heavier PCB mixtures in the harbor but the trends are difficult to visualize. Figure 27 uses percent abundances of congeners "unique" to Aroclors 1016/1242 and 1254/1260 (see Table 12) to highlight the patterns. "Unique" appears in quotation marks because a small degree of over-lap is permitted. Overall, the two sets of "unique" congeners account for an average of about 50% of the total mass of PCBs in all the samples. Thirty-four congeners were used to describe 1016/1242 and 41 congeners describe 1254/1260.

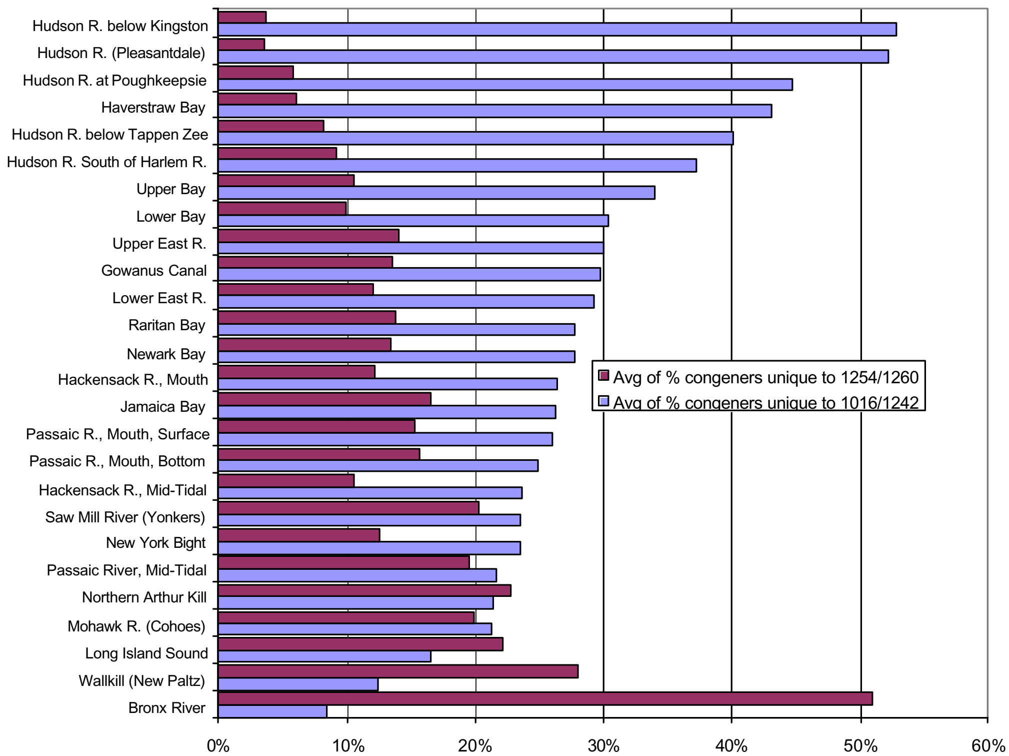


Figure 27. Average percent abundances of congeners "unique" to Aroclors 1016/1242 and 1254/1260 in ambient and tributary sites.

The change in apparent Aroclor composition requires sources of 1254/1260. Both the Bronx River and the Wallkill are such sources. The change in ambient patterns from upstream Hudson toward the harbor is unlikely to be due entirely to volatilization of lighter congeners. The heavy congeners seen to be having increasing abundance in down stream sites are not expected to occur in the lighter Aroclors from the upper Hudson.

Figure 28 shows that CSO/SWO discharges have significantly heavier Aroclors than the ambient samples. WPCFs (Figure 29) show a distribution of Aroclors heavier than those from ambient samples but lighter (a greater proportion of congeners "unique" to 1016/1242) than CSO/SWOs. Figure 30 shows the distributions of light and heavy congeners in biosolids. The very limited samples from landfills also fail to find a metropolitan source for the 1254/1260 congeners (Figure 31). Leachate samples excluded the particulate phase biasing the congener distribution.

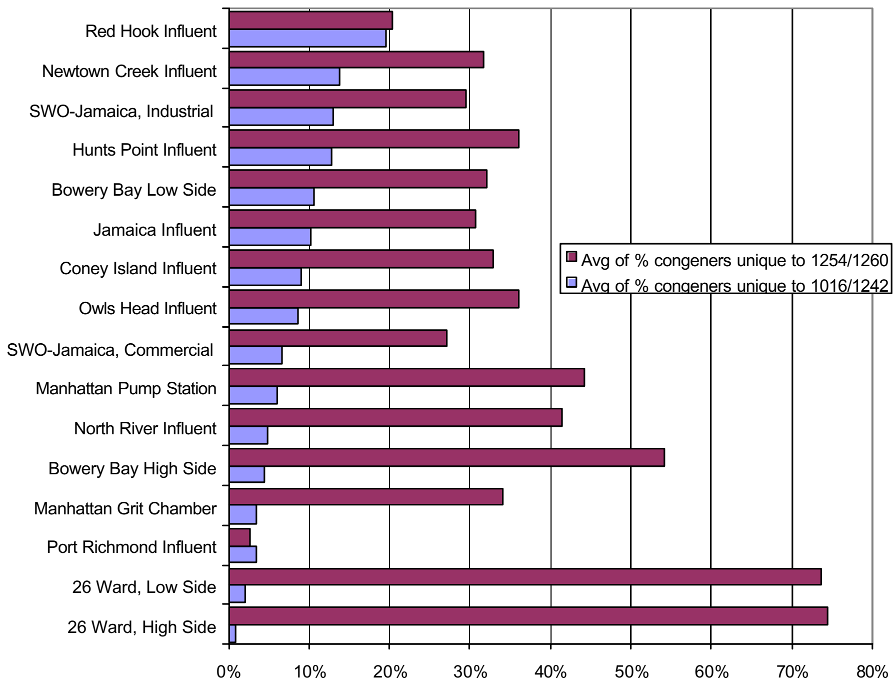


Figure 28. Average percent abundances of congeners “unique” to Aroclors 1016/1242 and 1254/1260 in CSO and SWO sites.

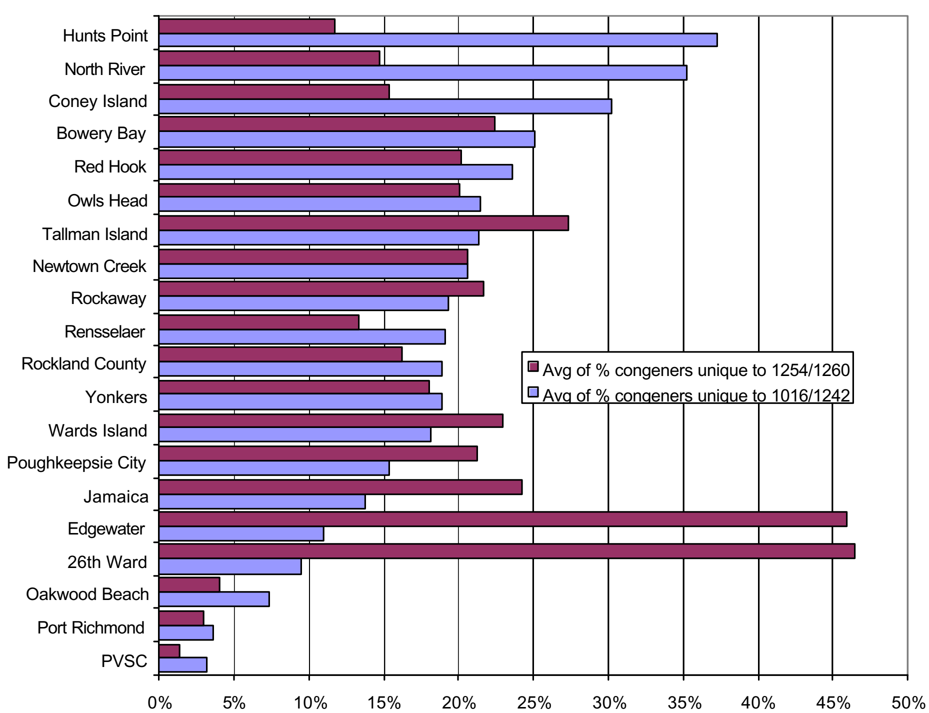


Figure 29. Average percent abundances of congeners “unique” to Aroclors 1016/1242 and 1254/1260 in WPCF sites.

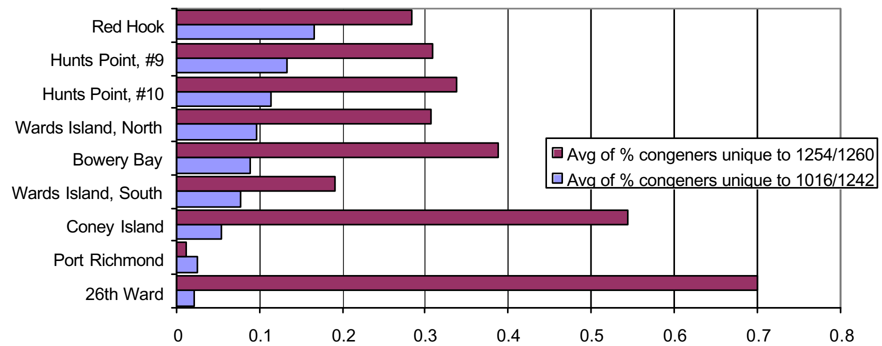


Figure 30. Average percent abundances of congeners "unique" to Aroclors 1016/1242 and 1254/1260 in sewage treatment plant biosolids.

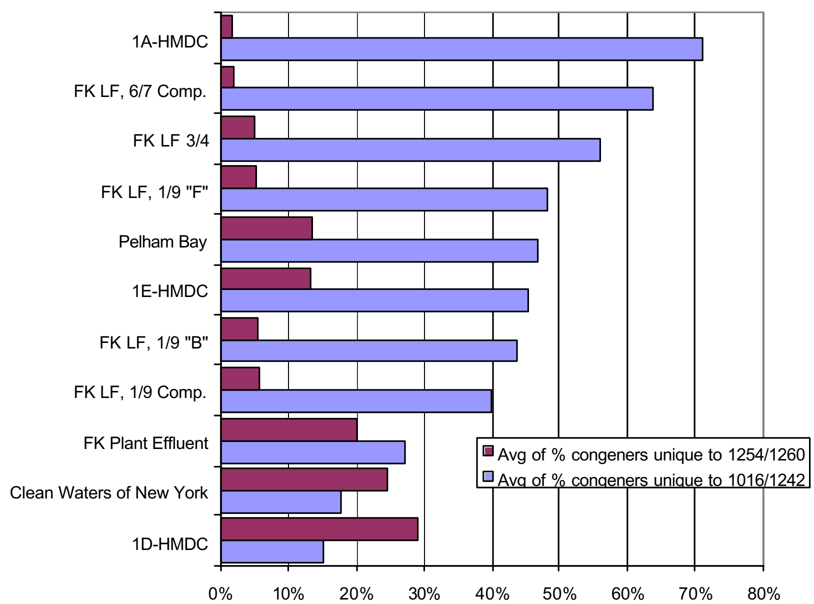


Figure 31. Average percent abundances of congeners "unique" to Aroclors 1016/1242 and 1254/1260 in landfill leachate and landfill treated leachate effluent sites.

PCDD/PCDFs

This section deals with 2,3,7,8-substituted chlorinated dibenzodioxins and dibenzofurans. A separate discussion (Dioxins and Related Compounds: Are Regulators Measuring the Right Chemicals?) discusses with broader issues of dioxin-like properties in other chemicals including the co-planar PCBs.

Dioxins/furans are treated collectively using Toxic Equivalency Factors (TEFs). Two sets of TEFs are used. NYSDEC uses WHO94 values in its Water Quality Standards. WHO98 reflects more recent science. We will use WHO98 values in calculating Toxic Equivalents (TEQs).

Table 79. Dioxin/furan names, ordering, and two TEFs.

PARAM	Order	WHO94	WHO98	BEF
2,3,7,8-TCDD	1	1	1	1
1,2,3,7,8-PeCDD	2	0.5	1	0.9
1,2,3,4,7,8-HxCDD	3	0.1	0.1	0.3
1,2,3,6,7,8-HxCDD	4	0.1	0.1	0.1
1,2,3,7,8,9-HxCDD	5	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDD	6	0.01	0.01	0.05
OCDD	7	0.001	0.0001	0.01
2,3,7,8-TCDF	8	0.1	0.1	0.8
1,2,3,7,8-PeCDF	9	0.05	0.05	0.2
2,3,4,7,8-PeCDF	10	0.5	0.5	1.6
1,2,3,4,7,8-HxCDF	11	0.1	0.1	0.08
1,2,3,6,7,8-HxCDF	12	0.1	0.1	0.2
2,3,4,6,7,8-HxCDF	13	0.1	0.1	0.7
1,2,3,7,8,9-HxCDF	14	0.1	0.1	0.6
1,2,3,4,6,7,8-HpCDF	15	0.01	0.01	0.01
1,2,3,4,7,8,9-HpCDF	16	0.01	0.01	0.4
OCDF	17	0.001	0.0001	0.02

Data Quality

Calculation of TEQs require sufficient data. Since the TEF weighting factors span many orders of magnitude, it is essential that the congeners with high TEFs be detected. TEQs calculated when high TEF substances are not detected are underestimations. The rule used here was that the difference between TEQs using non-detections set to zero or to half the detection level must be less than 10%. Application of this rule ensures that sufficient analyte masses were collected and obviates issues with analyses being near the detection level or samples with lab blank interferences.

Table 80 shows the level of success in quantitating dioxin/furan congeners. The Order on Table 80 is described in Table 79.

Table 80. Success in quantitating dioxin/furan congeners.

	Amb-clean		Amb-Hud.		Amb-Kills		Amb-Non_Kills		CSO		Ind. eff.		Trib.		WPCF	
Order	Det.	ND	Det.	ND	Det.	ND	Det.	ND	Det.	ND	Det.	ND	Det.	ND	Det.	ND
1	9	5	16	8	22		16	8	8		4	1	17	30	26	44
2	12	2	20	4	19	3	20	4	8		3	2	22	25	63	7
3	11	3	21	3	19	3	20	4	8		2	3	23	24	59	11
4	13	1	23	1	20	2	21	3	8		5		27	20	68	2
5	12	2	23	1	19	3	22	2	8		5		28	19	67	3
6	14		24		22		23	1	8		5		44	3	69	1
7	14		24		22		24		8		5		47	0	70	
8	12	2	23	1	22		23	1	8		3	2	33	14	63	3
9	11	3	20	4	19	3	21	3	8		4	1	23	24	52	18
10	14		20	4	19	3	20	4	8		5		24	23	60	10
11	13	1	20	4	21	1	21	3	8		5		27	20	65	5
12	12	2	21	3	20	2	21	3	8		4	1	27	20	63	7
13	12	2	18	6	19	3	21	3	8		4	1	27	20	62	8
14	9	5	6	18	7	15	8	16	6	2	3	2	9	38	20	50
15	14		24		22		22	2	8		5		42	5	67	3
16	9	5	20	4	19	3	18	6	8		4	1	24	23	56	14
17	13	1	24		22		22	2	8		5		42	5	69	1
Total	204	34	347	61	333	41	343	65	134	2	71	14	486	313	999	187

Some congeners are more readily found than others. Table 81 illustrates the success of detection by congener.

Table 81. Success in detecting congeners.

PARAM	Order	Detection success rate
2,3,7,8-TCDD	1	56%
1,2,3,7,8-PeCDD	2	78%
1,2,3,4,7,8-HxCDD	3	76%
1,2,3,6,7,8-HxCDD	4	86%
1,2,3,7,8,9-HxCDD	5	86%
1,2,3,4,6,7,8-HpCDD	6	98%
OCDD	7	100%
2,3,7,8-TCDF	8	89%
1,2,3,7,8-PeCDF	9	74%
2,3,4,7,8-PeCDF	10	79%
1,2,3,4,7,8-HxCDF	11	84%
1,2,3,6,7,8-HxCDF	12	82%
2,3,4,6,7,8-HxCDF	13	80%
1,2,3,7,8,9-HxCDF	14	64%
1,2,3,4,6,7,8-HpCDF	15	95%
1,2,3,4,7,8,9-HpCDF	16	73%
OCDF	17	96%

Samples from some harbor areas were richer in detections than others (Table 82). This reflects concentration, sampling diligence (liters of water filtered in the field), and, in the case of the tributary samples, competence of the labs. Many of the major tributary samples were analyzed by labs that gave high detection limits and, therefore, are more likely to fail to detect the analytes.

Table 82. Detection success by harbor area.

area	detection success rate
Amb-clean	86%
Amb-Hud.	85%
Amb-Kills	89%
Amb-Non_Kills	84%
CSO	99%
Ind. Effluent	84%
Tributaries	61%
WPCF	84%

Sample Data

Table 83 shows average TEQs by site in two ways. The first (WHO98) uses the WHO98 TEF. The second (NYS WQS) uses WHO94 and the bioaccumulation factors as specified by the NYS Water Quality Standard for dioxin for protection of humans eating fish. The water quality standard for this purpose is 0.0006 pg/L and is exceeded by every sample. Table 83 also shows average instantaneous sample loads from those sites having defined discharges. The loads are in milligrams of WHO98 TEQ/hr by site. The major tributaries are seen dominating the loading. However, the Passaic and Hackensack Rivers may be putting large amounts of TEQ into the harbor as well. DEC sampling of those rivers were in portions greatly influenced by tides.

Table 83. Average TEQs (pg/L), using WHO98 and the NYS WQS (WHO94 plus BAF), and average instantaneous TEQ (WHO98) loads (mg/hr).

Sample	WHO98	NYS WQS	mg/hr
Ambient-clean: Long Island Sound	0.039	0.026	NC
Ambient-clean: New York Bight	0.0069	0.0065	NC
Ambient-Hudson: Haverstraw Bay	0.43	0.3	NC
Ambient-Hudson: Hudson R. at Poughkeepsie	1.9	0.91	NC
Ambient-Hudson: Hudson R. below Kingston	0.14	0.081	NC
Ambient-Hudson: Hudson R. below Tappen Zee	0.76	0.55	NC
Ambient-Hudson: Hudson R. South of Harlem R.	0.48	0.35	NC
Ambient-Kills: Hackensack R., Mid-Tidal	2.3	1.8	NC
Ambient-Kills: Hackensack R., Mouth	2.1	1.7	NC
Ambient-Kills: Newark Bay	1.3	1.1	NC
Ambient-Kills: Northern Arthur Kill	1.6	1.4	NC

Table 83 continued.

sample	WHO98	NYS WQS	mg/hr
Ambient-Kills: Passaic R., Mouth, Bottom	3.5	3.1	NC
Ambient-Kills: Passaic R., Mouth, Surface	11	10	NC
Ambient-Kills: Passaic River, Mid-Tidal	11	10	NC
Ambient-Non_Kills: Jamaica Bay	0.17	0.081	NC
Ambient-Non_Kills: Lower Bay	0.11	0.087	NC
Ambient-Non_Kills: Lower East R.	0.31	0.21	NC
Ambient-Non_Kills: Raritan Bay	0.17	0.12	NC
Ambient-Non_Kills: Upper Bay	0.29	0.23	NC
Ambient-Non_Kills: Upper East R.	0.15	0.1	NC
CSO: 26th Ward, High Side	19	4.2	38
CSO: 26th Ward, Low Side	6.5	2.7	13
CSO: Bowery Bay High Side	17	6.3	36
CSO: Hunts Point Influent	7.5	2.1	18
CSO: Jamaica Influent	9.2	2.5	45
CSO: Manhattan Grit Chamber	3	1.7	4.9
CSO: North River Influent	8.6	4.2	6.8
CSO: Red Hook Influent	17	6.5	9.8
Industrial effluent: Clean Waters of New York	0.02	0.013	NC
Industrial effluent: FK Plant Effluent	0.6	0.19	0.053
Major tributary: Hudson R. (Pleasantdale)	0.22	0.092	430
Major tributary: Mohawk R. (Cohoes)	0.24	0.12	420
Major tributary: Wallkill (New Paltz)	0.43	0.17	200
Minor tributary: Bronx River	0.29	0.11	2.5
Minor tributary: Gowanus Canal	0.25	0.17	NC
Minor tributary: Saw Mill River (Yonkers)	0.23	0.089	1.2
TRK: Mill Creek at Arthur Kill Rd	11	7.7	NC
WPCF: 26th Ward	0.31	0.1	3
WPCF: Bowery Bay	0.14	0.067	2.8
WPCF: Coney Island	0.081	0.025	1.3
WPCF: Hunts Point	0.94	0.29	25
WPCF: Newtown Creek	0.38	0.14	22
WPCF: Oakwood Beach	0.17	0.069	0.82
WPCF: Owls Head	0.13	0.058	2.4
WPCF: Port Richmond	0.28	0.087	3.5
WPCF: Red Hook	0.096	0.043	0.56
WPCF: Rensselaer	0.33	0.1	0.89
WPCF: Rockaway	0.24	0.11	0.84
WPCF: Tallman Island	0.12	0.041	1.1
WPCF: Wards Island	0.066	0.033	2.3

Relative abundances of the 17 dioxin congeners (in WHO98 TEQ units) are shown in the following 42 figures. Only samples where there was a small difference (less than 10%) between assigning values of zero or half the detection limit are shown. Non-detected congeners were, in the figures, assigned a value of zero. In each figure, the horizontal axis lists the dioxin and furan congeners (see Tables 76 or 78) and the vertical axis is the relative abundance of the congeners to total TEQ (WHO98). The legend gives site abbreviations, date, and total TEQ.

Ambient-Clean

Figures 32 and 33 show congener distributions from the two background stations, Long Island Sound and the New York Bight.

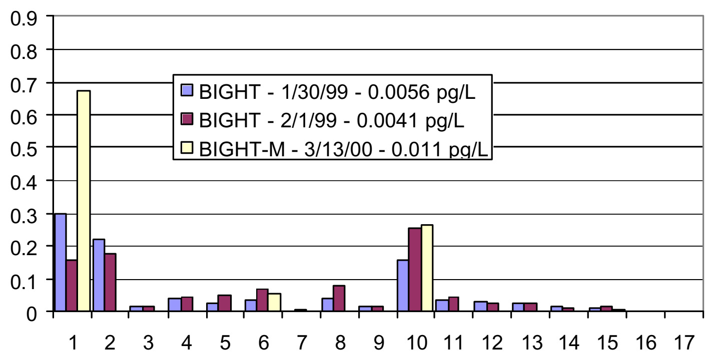


Figure 32. Three New York Bight samples show low total concentrations and dominance by 2,3,7,8-TCDD and 2,3,4,7-PeCDF.

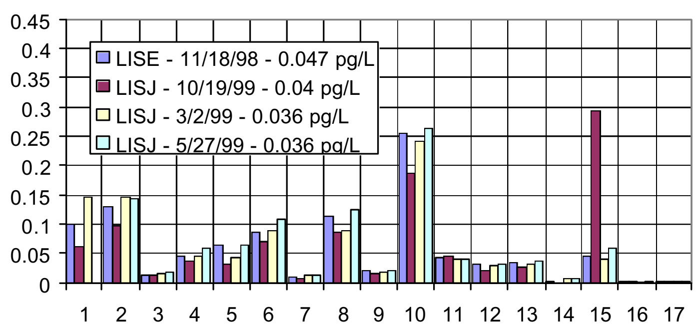


Figure 33. Long Island Sound off Eaton's Point (LISE), and Port Jefferson (LISJ). Cong. 10 is usually dominant. LIS samples have significantly more TEQ than Bight samples and a different distribution of congeners. In no other sample is cong. 15 so important.

Hudson River

Figures 34 to 44 follow the Hudson from the head of tide at Pleasantdale to the Lower Bay.

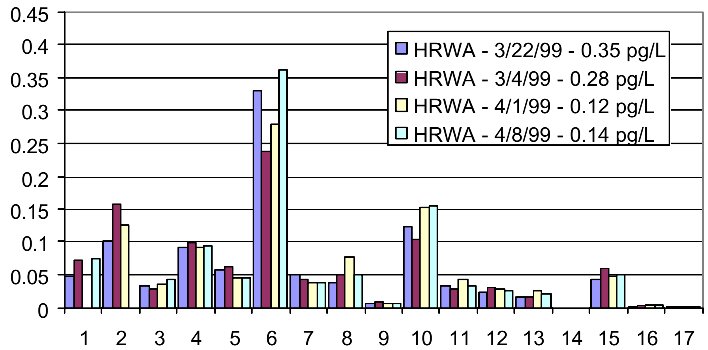


Figure 34. Hudson River at Pleasantdale samples have a fingerprint dominated by congener 6. 2,3,7,8-TCDD is a relatively minor source of TEQ.

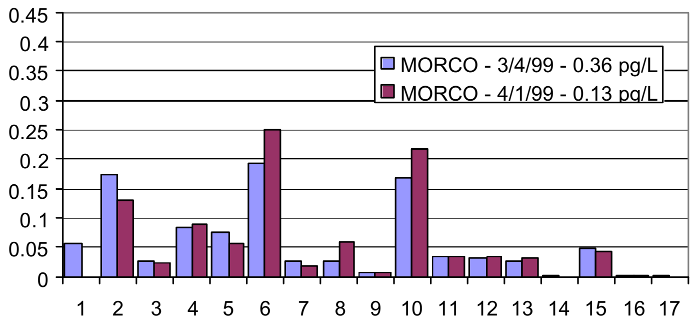


Figure 35. Mohawk River at Cohoes has concentrations similar to those in the upper Hudson. Congener 6 may be less important here.

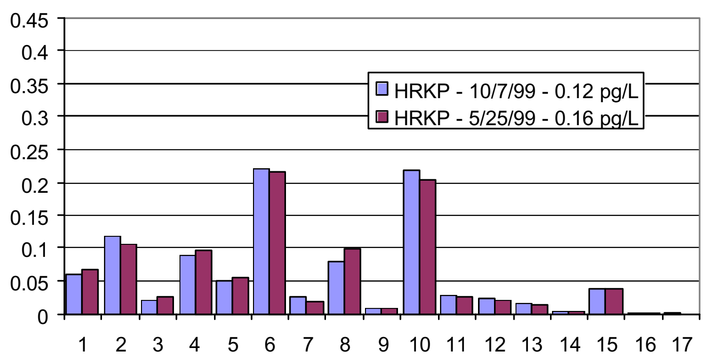


Figure 36. Ambient Hudson River samples collected between Kingston and Poughkeepsie are very similar to the Mohawk patterns. Congener 2 is less abundant at this site.

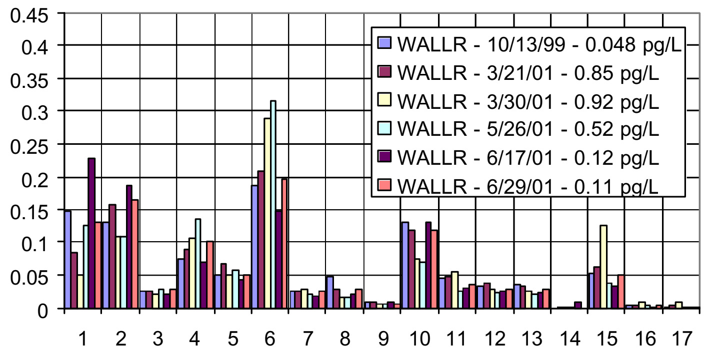


Figure 37. Wallkill at New Paltz shows an increased contribution by 1,2,3,7,8-PeCDD. This congener (#2) may be associated with municipal wastewater. Some total concentrations are higher than those from most ambient samples.

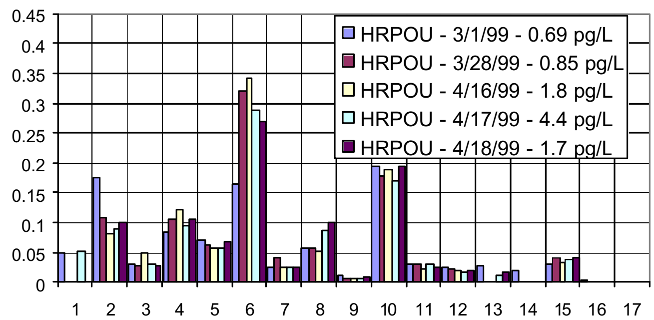


Figure 38. Hudson River at Poughkeepsie shows a typical upper Hudson River pattern (congeners 6 and 10) but some high concentrations.

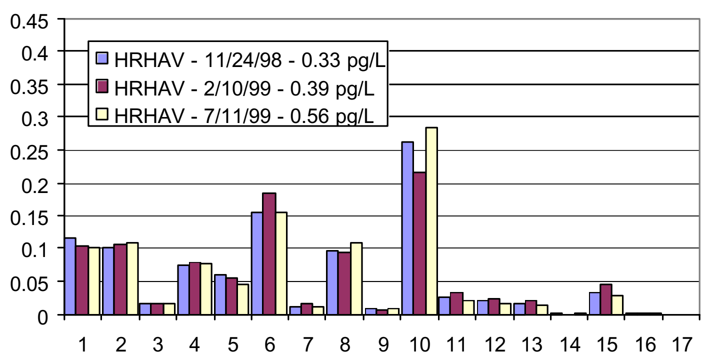


Figure 39. Hudson River, Haverstraw Bay, has a pattern dominated by 2,3,4,7,8-PeCDF. There may be a source of this congener in the Hudson. 2,3,7,8-TCDD begins to increase.

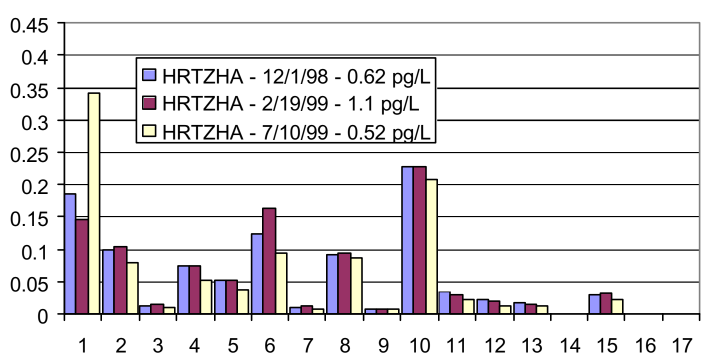


Figure 40. Hudson River, Tappen Zee Bridge to Harlem River, shows more clearly the impact of 2.3.7.8-TCDD.

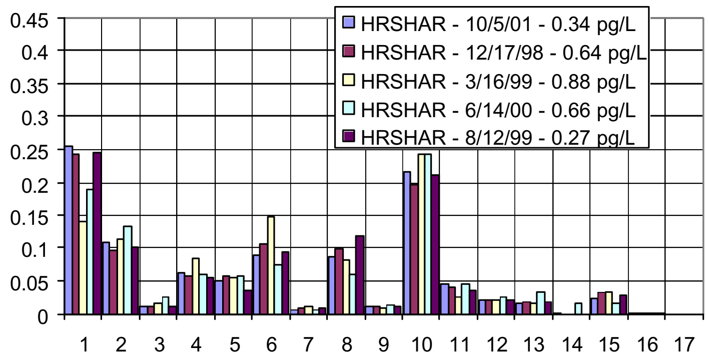


Figure 41. Hudson River, Harlem River to Battery, shows much more contribution by 2,3,4,7-TCDD.

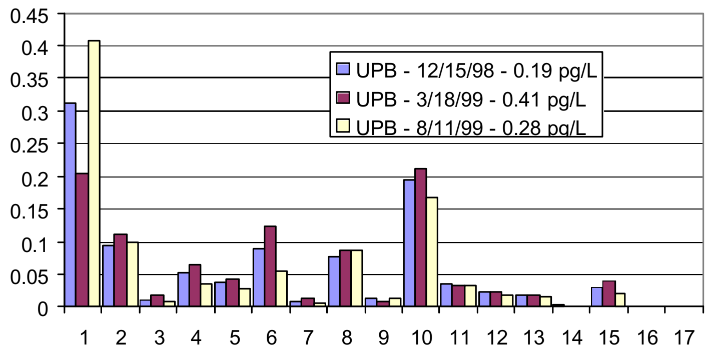


Figure 42. Upper Bay samples begin to be dominated by 2,3,7,8-TCDD.

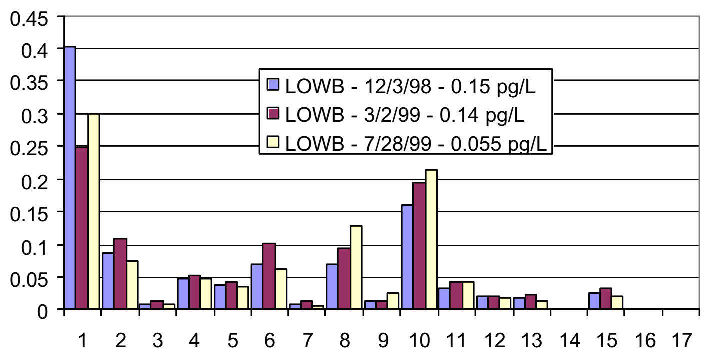


Figure 43. Lower Bay samples have the same congener pattern as the Upper Bay but lower concentrations due to dilution.

Ambient-Kills

Figures 44 to 53 follow the western side of the harbor up from Raritan Bay to the mid-tidal Passaic River.

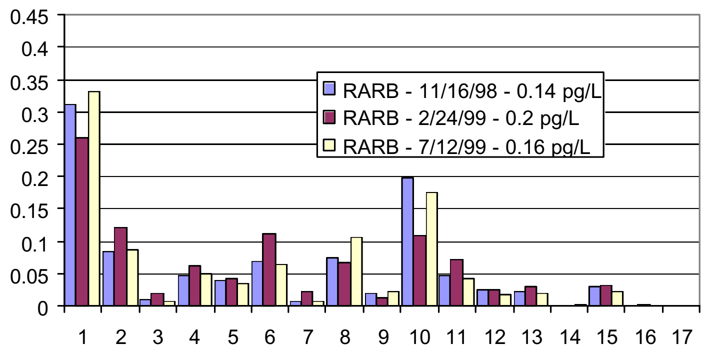


Figure 44. Raritan Bay samples again have a similar pattern but concentrations are higher.

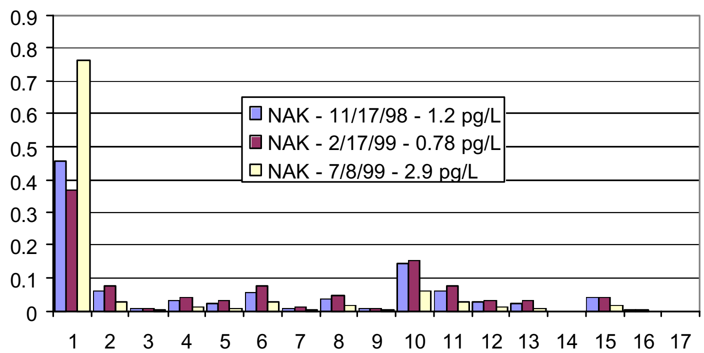


Figure 45. Northern Arthur Kill. All the Ambient-Kills samples are strongly dominated by contributions from 2,3,7,8-TCDD. The TEQ fingerprint in the Arthur Kill is affected by tides.

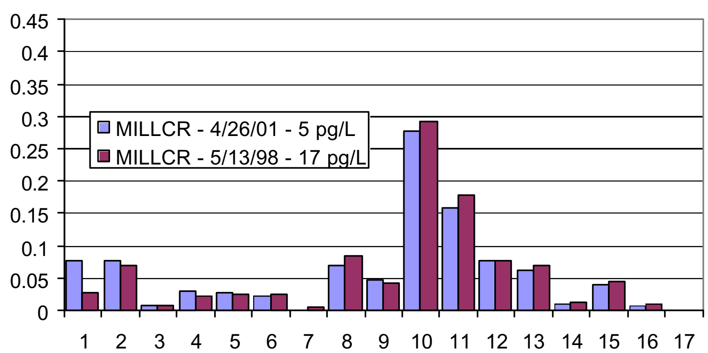


Figure 46. Mill Creek flows into the Arthur Kill and received wastewaters from a facility that incinerated obsolete electronics. TEQ concentrations are high but reflect the capture of bottom sediment. Unlike the Arthur Kill, patterns are dominated by congeners 10 and 11.

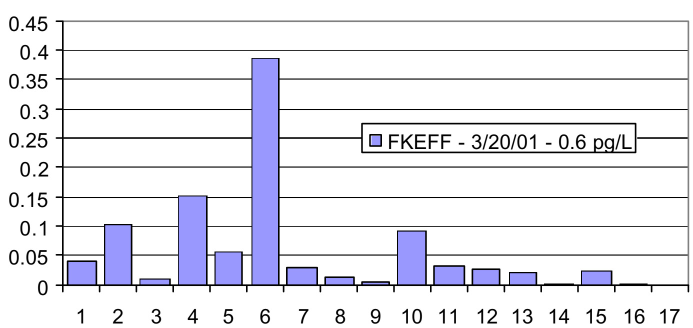


Figure 47. Leachate from the Fresh Kills Landfill is treated and discharged to the Arthur Kill. The pattern is dominated by congener 6.

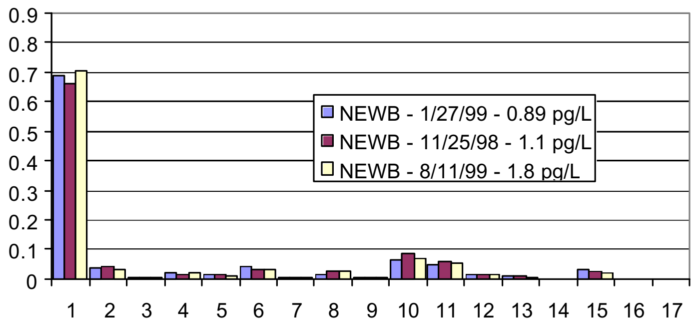


Figure 48. Newark Bay is consistently dominated by 2,3,7,8-TCDD.

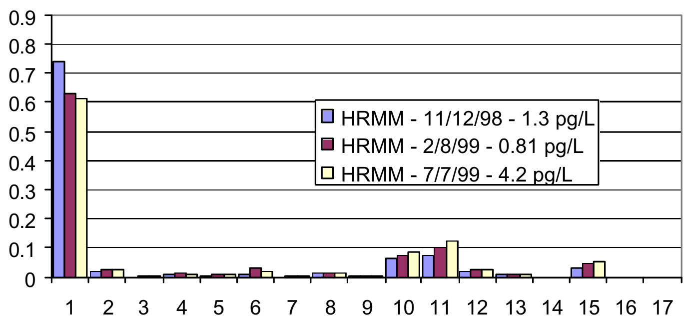


Figure 49. Hackensack River, mouth.

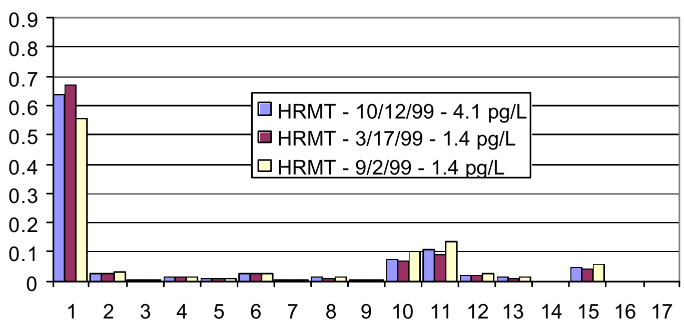


Figure 50. Hackensack River, mid tidal. The relative contribution of 2,3,7,8-TCDD is less here than at the mouth and less than in Newark Bay.

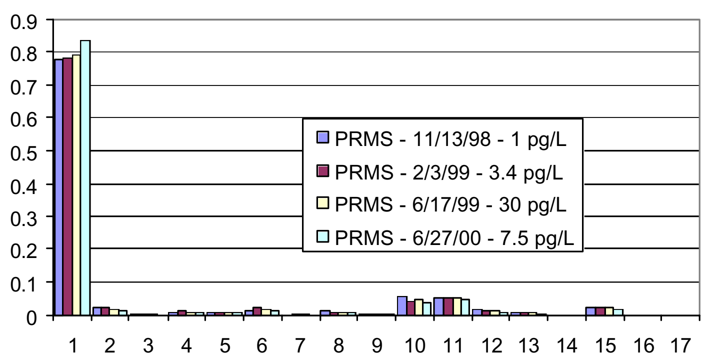


Figure 51. Passaic River, mouth, surface. The Passaic River appears to be the source of 2,3,7,8-TCDD.

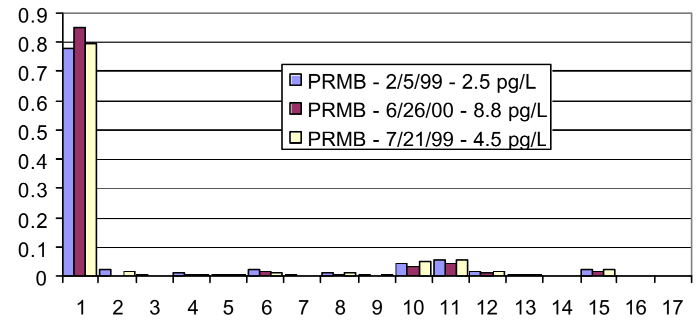


Figure 52. Passaic River, mouth, bottom meter.

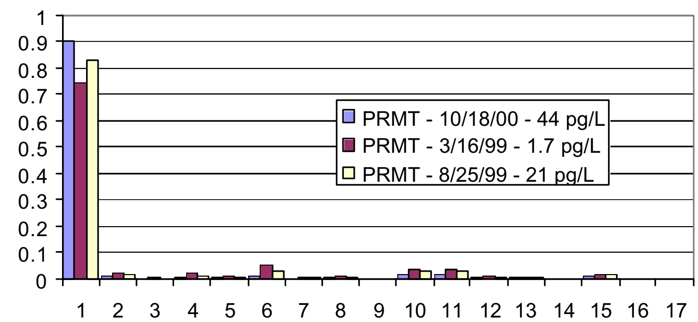


Figure 53. Passaic River, mid-tidal. 2,3,7,8-TCDD abundances and total TEQs are affected by tides. The high proportions of 2,3,7,8-TCDD and high concentrations occur on the flood tide.

Ambient- East River and the Minor Tributaries

Figures 54 to 58 show congener patterns in the East River and at Gowanus Canal, Saw Mill River, and Bronx River.

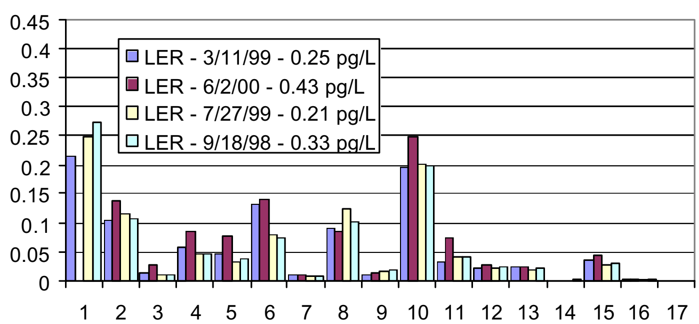


Figure 54. Lower East River. Patterns are similar to those in the Hudson south of Harlem River. 2,3,7,8-TCDD is less important here than in the Upper Bay.

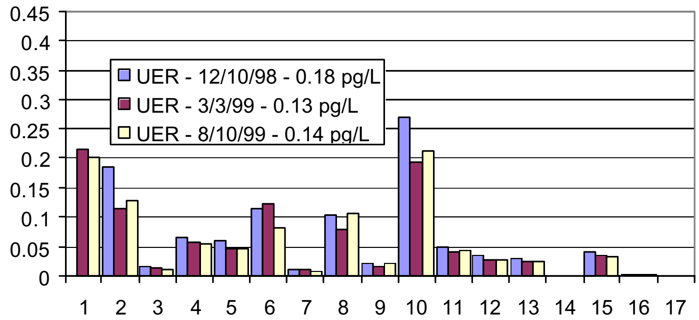


Figure 55. Upper East River. Total TEQ concentrations are lower than in the lower East River and cong. 10 is getting more important relative to 2,3,7,8-TCDD. Cong 2 seems to be associated with WPCFs.

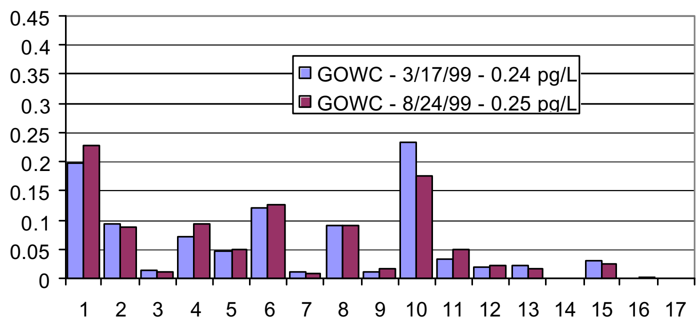


Figure 56. Gowanus Canal.

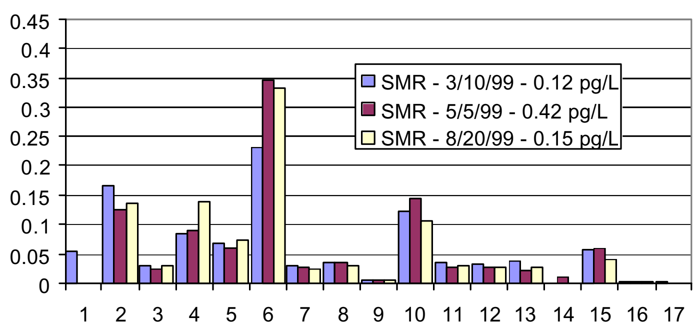


Figure 57. Saw Mill River. Both Saw Mill and the Bronx River, medium sized urban streams, have similar patterns with congeners 6, 10, and 2 dominant.

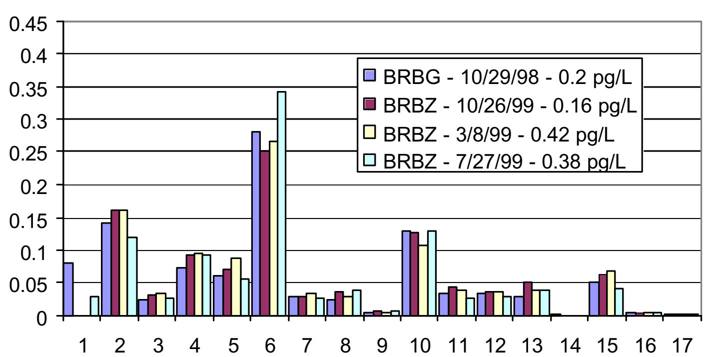


Figure 58. Bronx River at Botanical Garden (BRBG) and below the Bronx Zoo (BRBZ).

CSOs (Wet Weather Influents to Wastewater Treatment Plants)

Figures 59 and 60 show congener patterns from CSOs.

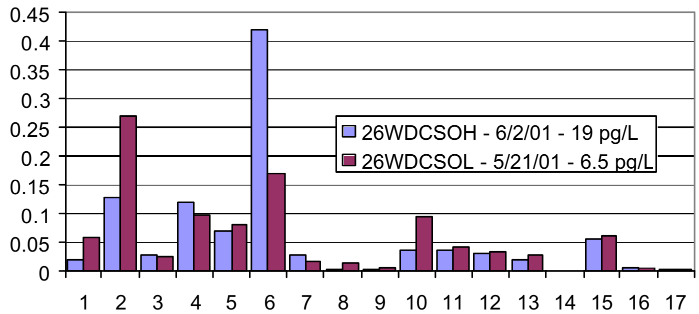


Figure 59. 26th Ward wet weather influents (CSO surrogates) are dominated by congeners 6 and 2.

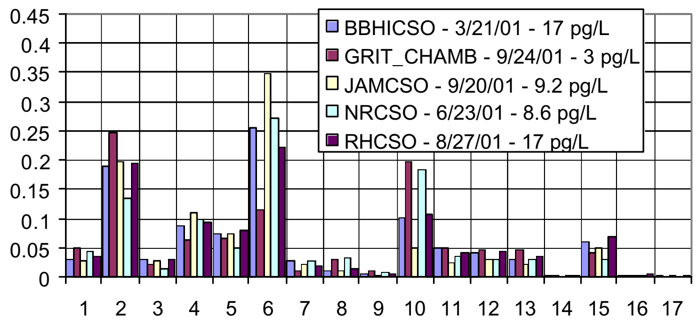


Figure 60. Wet weather influents at Bowery Bay (BB), Wards Island (Grit Chamber), Jamaica (JAM), North River (NR), and Red Hook (RH) show dominance by cong. 6, 2, and 10.

WPCF Final Effluents

Figures 61 to 69 show congener patterns from final treated effluents at wastewater treatment plants.

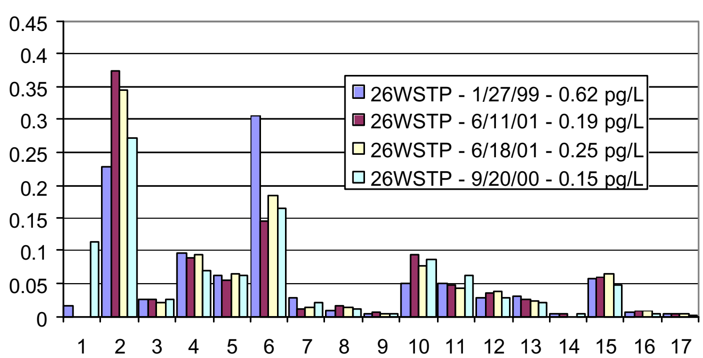


Figure 61. 26th Ward WPCF final treated effluents are dominated by congeners 2 and 6.

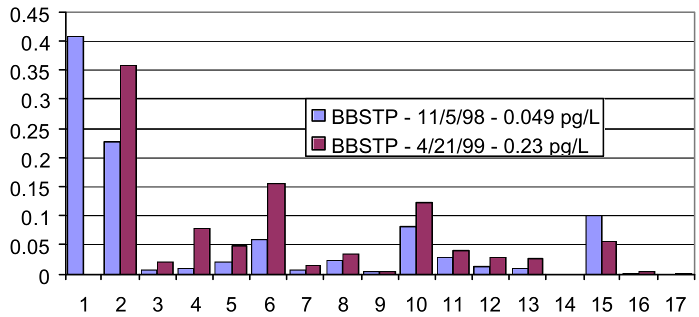


Figure 62. Bowery Bay WPCF effluent had a significant contribution from 2,3,7,8-TCDD but the total TEQ, 0.49 pg/L, was very low.

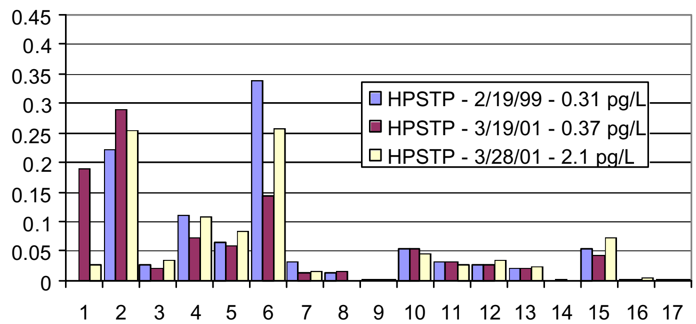


Figure 63. Hunts Point WPCF effluent also had a significant amount of 2,3,7,8-TCDD on one out of three samples.

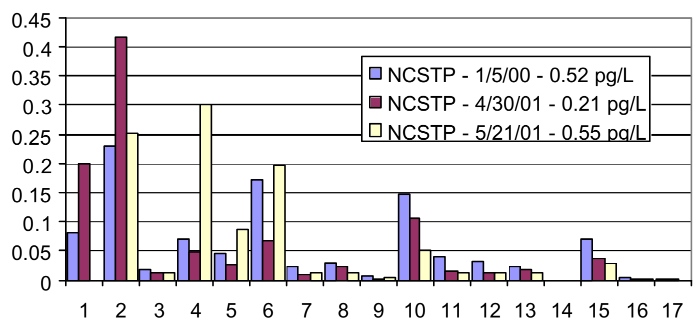


Figure 64. Newtown Creek WPCF effluent showed an unusual contribution from congener 4.

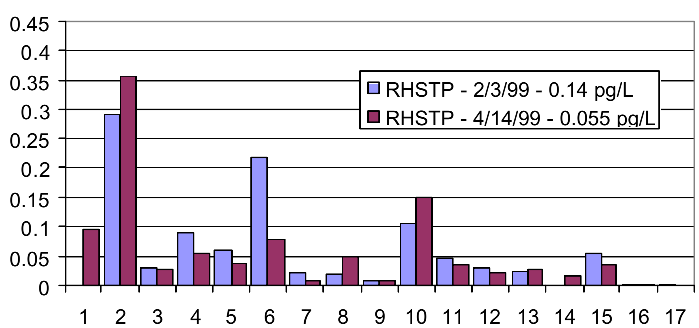


Figure 65. Red Hook WPCF effluent was, as usual, dominated by congener 2.

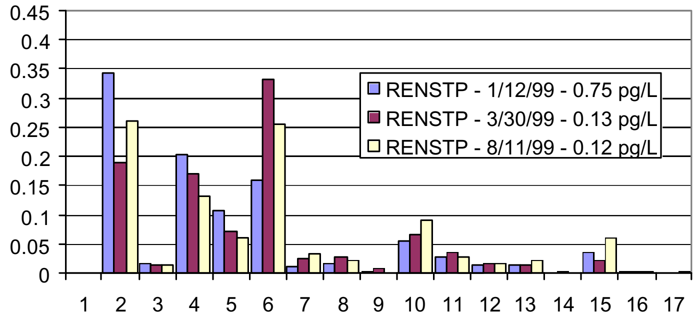


Figure 66. Rensselaer WPCF effluent is dominated by congeners 2, 6, and 4.

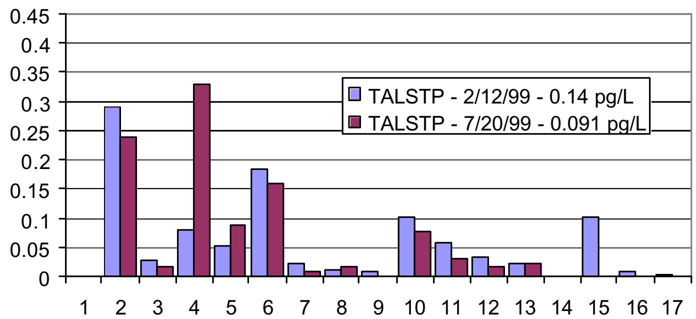


Figure 67. Tallman Island WPCF effluent is dominated by congeners 2, 4, and 6.

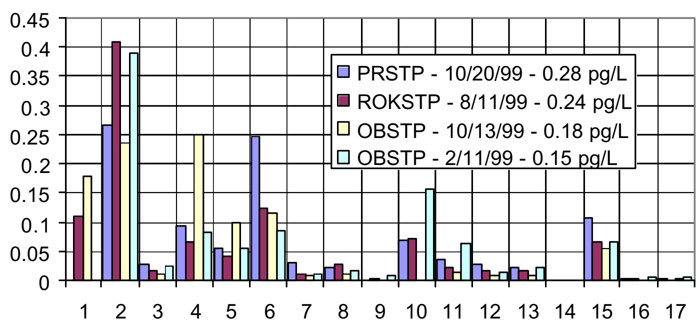


Figure 68. Samples of effluent from three facilities, Port Richmond (PR), Rockland County (ROK), and Oakwood Beach (OB) show typical abundances of congeners 2, 4, and 6.

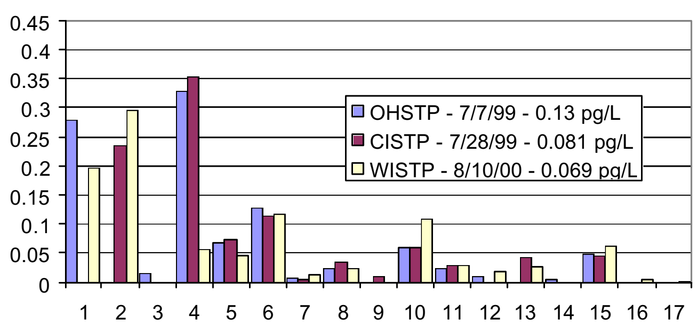


Figure 69. Samples of effluent from three facilities, Owls Head (OH), Coney Island (CI), and Wards Island (WI), have lower total TEQ concentrations. OH and WI show considerable 2,3,7,8-TCDD contributions.

Sludges and Biosolids

Figures 70 to 73 show congener patterns from wastewater treatment plant sludges and biosolids.

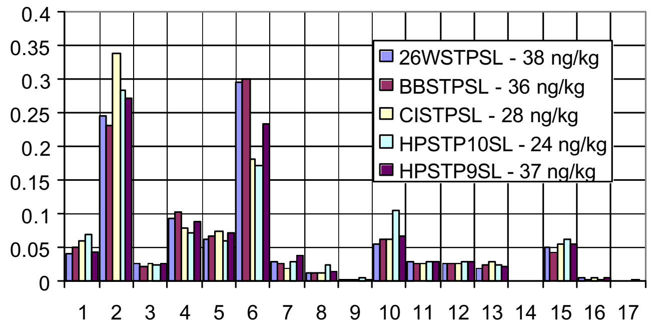


Figure 70. De-watered sludge samples (biosolids) composited daily during February, 2001 from 26th Ward (26W), Bowery Bay (BB), and two places at Hunts Point (HP), show dominance by congeners 2 and 6.

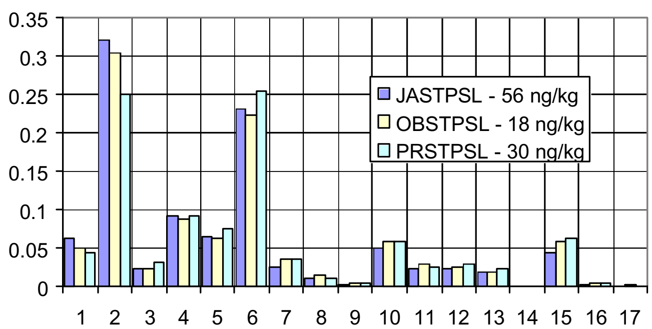


Figure 71. Biosolids samples from Jamaica (JA), Oakwood Beach (OB), and Port Richmond (PR) again show dominance by congeners 2 and 6.

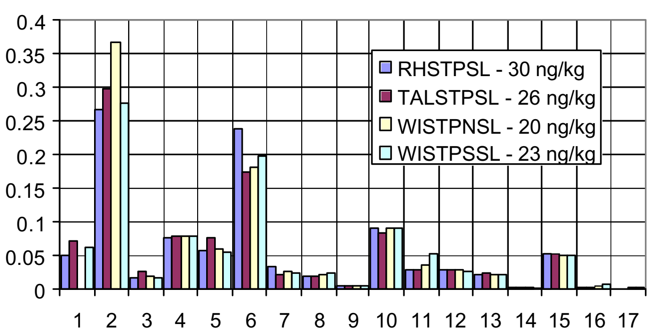


Figure 72. Biosolids samples from Red Hook (RH), Tallman Island (TAL), and two sites at Wards Island (WI), still show dominance by congeners 2 and 6.

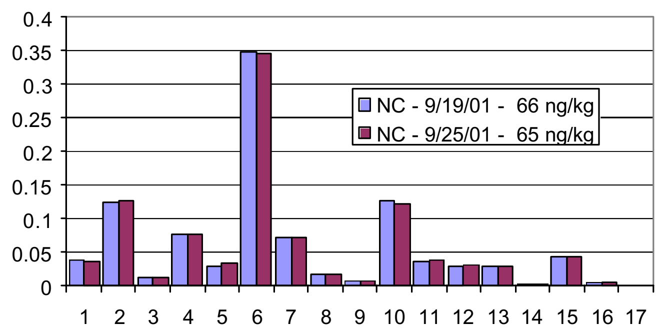


Figure 73. Sludge samples (not dewatered) were taken from the Newtown Creek (NC) facility as part of the investigation of the World Trade Center disaster. NC receives wastes from southern Manhattan. Patterns and total TEQ from the two dates were almost identical but different from the other sludges in the greater proportion of congener 6.

Dioxin congener patterns show considerable variation at various places in the system. Ambient samples from the Kills (the western harbor) all have most of the TEQ contributed by 2,3,7,8-TCDD. This effect spills into the Upper and Lower Bay and may also be seen up the Hudson and East River. However, the major sources of TEQ, the tributaries and urban waters from CSOs or treatment plants, usually have other congeners that are larger contributors.

Congeners 6 and 10 (1,2,3,4,6,7,8-HpCDD and 2,3,4,7,8-PeCDF) appear important in the Hudson at the head of tide down to the Harbor. There may be sources of congener 10 in the lower Hudson. Congeners 2 (1,2,3,7,8-PeCDD), 4 (1,2,3,6,7,8-HxCDD), and 6 may be diagnostic of urban wastewater. They are usually dominant in raw and final wastewater. De-watered sludges have fairly uniform patterns with congener 2 (29% of total TEQ on average), and congener 6 (22% of total TEQ) accounting for much of the total. Ambient waters or rivers receiving considerable treated wastewater also have high percentage contributions from these congeners. We do not know their sources. Some wastewater samples contain 2,3,7,8-TCDD but again, the sources are unknown.

Pesticides

Pesticides were analyzed with TOPS from sites throughout the harbor. Table 84 lists the analytes, the most stringent NYSDEC ambient water quality standards, number of analyses conducted by the CARP water program, and homologues under which one or more individual analytes may be grouped.

Table 84. CARP pesticides, functional groups (homologues), NYSDEC water quality standards, and number of analyses.

Analyte	Homologues	WQS, ug/L	Number of Analyses
2,4'-DDD	TDDT		601
2,4'-DDE	TDDT		597
2,4'-DDT	TDDT		594
4,4'-DDD	TDDT	0.00008	604
4,4'-DDE	TDDT	0.000007	604
4,4'-DDT	TDDT	0.00001	602
Chlordane,alpha (cis)	TChlordane	1	601
Chlordane,gamma (trans)	TChlordane	1	601
Chlordane,oxy-	TChlordane		596
Nonachlor, cis-	TChlordane		597
Nonachlor, trans-	TChlordane		599
Aldrin	Aldrin/Dieldrin	0.001	596
Dieldrin	Aldrin/Dieldrin	0.0000006	603
Endrin	Endrin	0.002	597
Endrin aldehyde	Endrin		597
Endrin ketone	Endrin		597
HCH, alpha	THCH	0.002	603
HCH, beta	THCH	0.007	596
HCH, delta	THCH	0	47
HCH, gamma	THCH	0.008	604
Heptachlor	Heptachlor	0.0002	596
Heptachlor epoxide	Heptachlor	0.0003	599
Endosulfan, alpha	Endosulfan	0.001	597
Endosulfan, beta	Endosulfan	0.001	597
Endosulfan sulfate	Endosulfan		603
Hexachlorobenzene	HCB	0.00003	604
Methoxychlor	Methoxychlor	0.03	601
Mirex	Mirex	0.000001	596

Data Quality

Data quality is a complex evaluation. Tables 85 and 86 show for each pesticide the number of non-detections (ND); the number of occasions where the recovered mass was more than 10 times the detection level (GD, “Good DL”); occasions where the percent recovery in the associated sample delivery group (SDG) was either greater than 150% or less than 50% (GDV, “Good DL, LCS Violation”); occasions where the recovered mass was not greater than 10 times the detection level (HD, “High DL”); occasions where detection limits were relatively high and where the percent recoveries were out of bounds (HDV, “High DL, LCS Violation); occasions where analyte was detected in the associated method blank but at levels less than one fifth of the analyte (NSB, “Non-Sig Blank”); occasions where blanks were not significant but the recoveries were out of bounds (NSBV, Non-Sig Blank, LCS Violation”); and lastly, occasions where blanks were not less than one fifth the mass of the sample (SB, “Sig. Blanks”). These tables allow evaluation of the objective of consistent detection of all analytes at all sites in both media.

Table 85. Number of analyses in each category. Glass fiber cartridges.

PARAM	ND	GD	GDV	HD	HDV	NSB	NSBV	SB	Total
2,4'-DDD	17	144	2	34					197
2,4'-DDE	51	65	1	79	1				197
2,4'-DDT	33	111	2	51					197
4,4'-DDD	16	143		16		20	2		197
4,4'-DDE	15	156		21		3	2		197
4,4'-DDT	24	140	2	26		5			197
Aldrin	71	37	1	72	1	17			199
HCH, alpha	64	21		104	2	6			197
HCH, beta	80	16		85	2	14			197
HCH, delta	13			3					16
HCH, gamma	40	54		66		34	2	1	197
Chlordane,alpha (cis)	16	113	2	26		39		1	197
Chlordane,gamma (trans)	12	125	2	26		32			197
Chlordane,oxy-	83	37	2	70		5			197
Dieldrin	14	143	2	29		11		2	201
Endosulfan sulfate	33	37		49		35		45	199
Endosulfan, alpha	133	13		50	1				197
Endosulfan, beta	116	16		65					197
Endrin	111	13	3	69	5				201
Endrin aldehyde	142	6		49	2			3	202
Endrin ketone	101	17		77	4				199
Heptachlor	52	73	1	52		18		1	197
Heptachlor epoxide	31	108	8	46	1	5			199
Hexachlorobenzene	9	3		14		115	2	64	207
Methoxychlor	46	42	2	80		29		1	200
Mirex	38	72		64		23			197
Nonachlor, cis-	35	88	2	60		12			197
Nonachlor, trans-	18	114	2	32		34		1	201
Grand Total	1414	1907	34	1415	19	457	8	119	5373
	18%	24%	0.43%	18%	0.24%	5.8%	0.10%	1.5%	

Table 86. Number of analyses in each category, XAD.

PARAM	ND	GD	GDV	HD	HDV	NSB	NSBV	SB	Totals
2,4'-DDD	45	124		115		3			287
2,4'-DDE	175	17		93	2				287
2,4'-DDT	143	35		102					280
4,4'-DDD	27	165		88		3		4	287
4,4'-DDE	79	84		119		3		2	287
4,4'-DDT	106	72		104		2		2	286
Aldrin	160	30		91		2		6	289
HCH, alpha	20	183		41		43			287
HCH, beta	44	141		77		25			287
HCH, delta	21								21
HCH, gamma	9	170		40		77			296
Chlordane,alpha (cis)	23	156	5	68		45			297
Chlordane,gamma (t)	25	162		76		34			297
Chlordane,oxy-	133	38	4	105	4	1		1	286
Dieldrin	11	214		43		22			290
Endosulfan sulfate	21	85		86		98		6	296
Endosulfan, alpha	199	5		84					288
Endosulfan, beta	193	9		86					288
Endrin	173	16		97	2	1		1	290
Endrin aldehyde	226			64	7	4	1	1	303
Endrin ketone	108	44		123		13			288
Heptachlor	93	79		88	1	25		1	287
Heptachlor epoxide	38	165		60		24		3	290
Hexachlorobenzene	17	4		21	4	118		138	302
Methoxychlor	70	49		171		9			299
Mirex	201	10		76		3		6	296
Nonachlor, cis-	96	61	4	109	1	16			287
Nonachlor, trans-	53	125	4	87	1	20			290
Grand Total	2509	2243	17	2314	22	591	1	171	7868
	32%	29%	0.22%	29%	0.28%	7.5%	0.01%	2.2%	

Table 86 underestimates the true success of XAD in collecting pesticides. In 32% of the samples, the two XAD columns exposed in series were analyzed separately. Detection of an analyte on the first but not the second column should be recorded as a success. Since each analyte in each analysis had its own detection level, it is not possible to create a table like Table 86 for the lumped XAD data. Table 87 shows the overall success (detection versus non-detection) of pesticides by lumped XAD.

Table 87. Overall success rate of XAD in capturing pesticides. Number of analyses in each category.

Analyte	ND	Detection	Success Rate
2,4'-DDD	28	207	88%
2,4'-DDE	130	105	45%
2,4'-DDT	108	127	54%
4,4'-DDD	16	219	93%
4,4'-DDE	47	188	80%
4,4'-DDT	69	166	71%
Aldrin	122	113	48%
HCH, alpha	17	218	93%
HCH, beta	41	194	83%
HCH, delta	21	0	0%
HCH, gamma	6	229	97%
Chlordane,alpha (cis)	21	214	91%
Chlordane,gamma (trans)	24	211	90%
Chlordane,oxy-	97	138	59%
Dieldrin	11	224	95%
Endosulfan sulfate	20	215	91%
Endosulfan, alpha	152	83	35%
Endosulfan, beta	141	94	40%
Endrin	131	104	44%
Endrin aldehyde	170	65	28%
Endrin ketone	84	151	64%
Heptachlor	74	161	69%
Heptachlor epoxide	35	200	85%
Hexachlorobenzene	20	215	91%
Methoxychlor	56	178	76%
Mirex	158	77	33%
Nonachlor, cis-	72	163	69%
Nonachlor, trans-	43	192	82%
Grand Total	1914	4451	70%

Some pesticides are more significant than others. The primary pesticides in CARP are the DDTs and dieldrin. Both of these appeared in more than 90% of the samples. Chlordane (and Nonachlor) data are also useable. Others, such as delta HCH, endrin aldehyde, and mirex were never or rarely quantitated. BHCs appear to be satisfactory but may have problems. New York Bight concentrations of BHCs are scarcely different from concentrations at sites where other analytes occur at concentrations orders of magnitude greater.

Sample Findings

Table 88, using data that have adequate detection limits and are not affected by blanks, shows average concentrations of the five significant pesticide homologues (Aldrin/Dieldrin, total heptachlor, total HCH, total Chlordane, and total DDT) by sample type. The sample types are ambient water from Long Island Sound/New York Bight (AMB-clean); ambient Hudson River samples taken below Troy (AMB-Hudson); ambient water samples from the western part of New York Harbor (AMB-Kills); ambient water samples from other parts of the harbor (AMB-Non Kills); wet weather influent to wastewater treatment plants (CSO); high and base-line flow event samples from the upper Hudson, Mohawk, and Wallkills (Major-TRIB); samples from the Bronx River, Sawmill Creek (Westchester), and the Gowanus Canal (Minor-TRIB); and final effluent samples from wastewater treatment plants (POTW). Sample types with the highest mean concentrations are highlighted.

Table 88. Mean pesticide concentration by sample type. Maxima are highlighted (good data).

	Aldrin/Dieldrin	HCB	Heptachlor	THCH	Tchlordane	TDDT
CSO	2.8	2	2.3	2.9	80	48
Landfill leachate	0.94	0.26	0.5	1.3	1.7	9.7
Major tributaries	3.9	0.13	0.44	0.26	2.8	45
WPCF	0.95	0.22	0.31	7.3	1.5	1.4
AMB-Kills	0.61	0.26	0.34	1.5	0.84	2.8
Minor tributaries	0.88	0.059	0.38	0.95	1.1	0.43
AMB-Non_Kills	0.2	0.043	0.066	1.3	0.19	0.4
AMB-Hudson	0.34	0.03	0.074	0.78	0.099	0.66
AMB-clean	0.047	0	0.017	0.97	0.028	0.09

Concentrations of the pesticides are, with the exception of THCH, lowest in the areas though to be cleanest. Total BHCs show the least variation between sites. This is suspicious. THCH will not be discussed further.

Table 89 shows mean concentrations of the targeted pesticides in the tributaries. The highest concentrations of all the pesticides, except heptachlor, occurred in the Wallkill.

Table 89. Mean total pesticide concentrations in major and minor tributaries, ng/L (good data).

	Aldrin/Dieldrin	HCB	Heptachlor	Tchlordane	TDDT
Wallkill (New Paltz)	5.6	0.28	0.63	3.5	82
Bronx River, below zoo	1	0.078	0.67	1.4	0.68
Saw Mill River (Yonkers)	1.3	0.072	0.37	1.3	0.35
Bronx River at Botanical Garden	0.16	0.024	0.03	0.65	0.49
Gowanus Canal	0.14	0.038	0.048	0.12	0.25
Mohawk R. (Cohoes)	0.041	0.016	0.0078	0.039	0.198
Hudson R. (Pleasantdale)	0.035	0.01	0.019	0.014	0.17

Wallkill Trackdown

In 1997, sampling was conducted at tributaries to the Hudson River using passive samplers (PISCES). PISCES contain hexane and a polyethylene window through which hydrophobic substances pass. Passive samples are only weakly quantitative but they have the advantage of quickly and easily integrating contaminants over a span of a few weeks. Calibrations based on membrane area and water temperature were derived for PCBs and then applied to the pesticides. Figure 74 summarizes the average "concentrations" of total DDT and dieldrin from the sites.

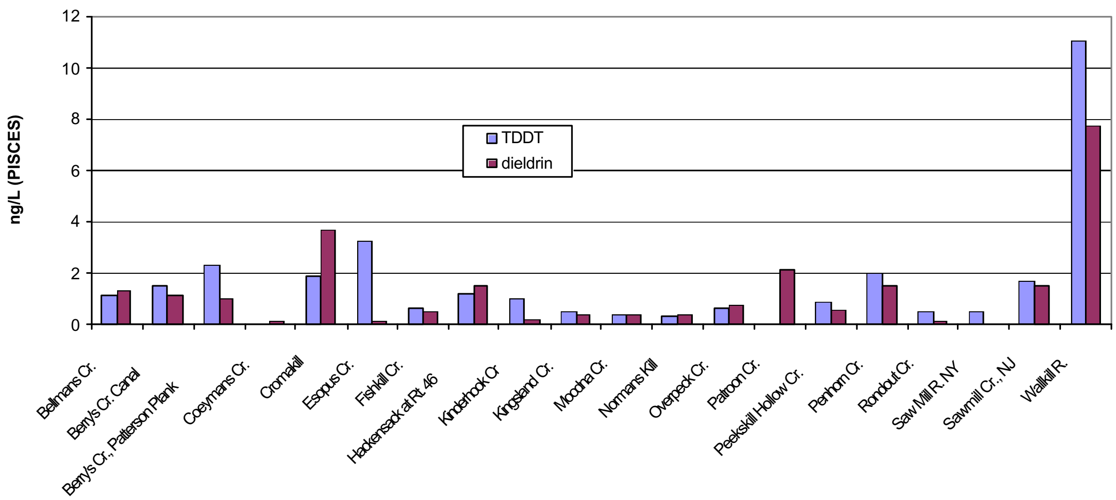


Figure 74. PISCES data, Spring of 1997.

These data pointed to the Wallkill as a pesticide source. Further investigation using PISCES, TOPS, and sediment samples, demo nstrated that the pesticide source was an intensively farmed (onions, lettuce, and carrots) area around the Wallkill just north of New Jersey. This zone, called the Black Dirt, is a dried lakebed crossed by numerous drainage channels.

A sediment core taken near the mouth of the Wallkill (the Wallkill discharges to Rondout Creek and Roundout Creek empties into the Hudson River immediately below Kingston, New York) at Sturgeon Pool indicated that the highest DDT concentrations were on the surface (Figure 75).

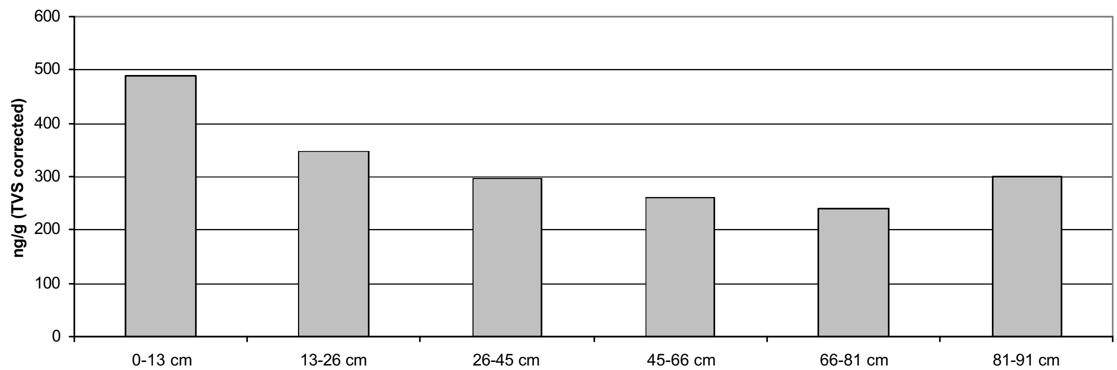


Figure 75. Total volatile solids corrected TDDT concentrations from a sediment core taken at Sturgeon Pool, Wallkill.

A soil sample taken in the Black Dirt shows that parent, unmetabolized p,p'-DDT was the most abundant species (Figure 76).

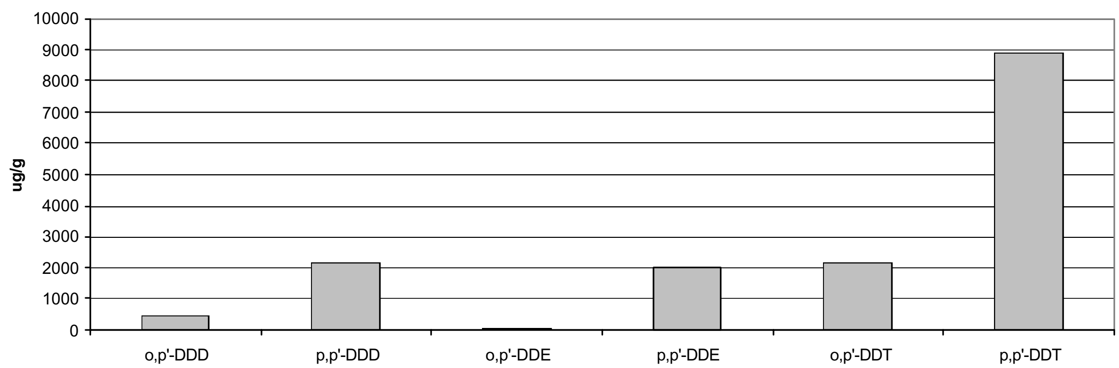


Figure 76. Individual DDTs in a Wallkill Black Dirt drainage ditch soil sample.

While it seems unlikely that DDT is currently being used, the data do not refute this notion.

Figure 77 compares the amounts of TDDT recovered from suspended solids versus XAD (dissolved) from the Wallkill samples. Almost all the TDDT, particularly during high flows, is associated with suspended sediment.

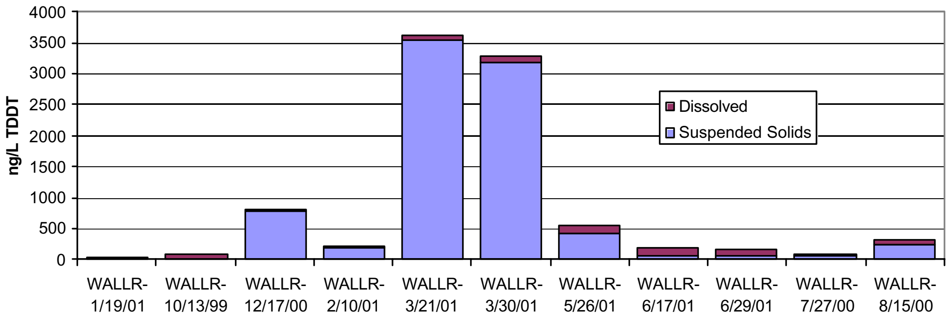


Figure 77. Stacked bars comparing TDDT in the dissolved and suspended sediment phases from Wallkill samples taken at New Paltz.

TOPS pesticide samples

Table 90 shows loadings in g/hr from events on the Hudson, Mohawk, and Wallkill for aldrin/dieldrin, heptachlor, total chlordane, and total DDT.

Table 90. Tributary event loadings (g/hr), good data.

	Aldrin/Dieldrin	Heptachlor	Tchlordane	TDDT
Hudson-3/22/1999 - 3/23/1999	0.096	0.041		0.75
Hudson-3/4/1999 - 3/6/1999	0.081			0.49
Hudson-4/1/1999 - 4/7/1999	0.04			0.052
Hudson-4/8/1999 - 4/12/1999	0.049	0.031		0.088
Mohawk-3/4/1999 - 3/23/1999			0.12	0.41
Mohawk-4/1/1999 - 4/7/1999	0.069	0.013	0.017	0.21
Wallkill-1/19/2001 - 1/23/2001	0.05			0.054
Wallkill-10/13/1999 - 10/27/1999	0.1	0.005	0.05	0.35
Wallkill-12/17/2000 - 12/18/2000	4		5.8	96
Wallkill-2/10/2001 - 2/12/2001	0.28		0.082	2.9
Wallkill-3/21/2001 - 3/25/2001	12	0.76	4.4	230
Wallkill-3/30/2001 - 4/2/2001	7.8	0.61	3.5	200
Wallkill-5/26/2001 - 6/1/2001	0.98	0.11	0.75	7.6
Wallkill-6/17/2001 - 6/19/2001	0.34	0.037	0.14	0.82
Wallkill-6/29/2001 - 6/30/2001	0.22	0.025	0.074	0.45
Wallkill-7/27/2000 - 7/28/2000	0.44		0.035	2.3
Wallkill-8/15/2000 - 8/17/2000	1.2		0.38	9.9

Table 91 (above) indicates CSOs (sampled as wet weather influents to treatment plants) having the highest chlordane concentration. The highest chlordane concentration in CSOs came from Hunts Point in the Bronx .

Table 91. Average pesticide loads in raw wet weather influents to POTWs, ug/hr, good data.

	Aldrin/Dieldrin	HCB	Heptachlor	Tchlordane	TDDT
Hunts Point Influent	8.2	16	29	1600	200
Jamaica Influent	23	4.2	13	130	130
Bowery Bay High Side Interceptor	9.9	3.4	6.5	180	110
26th Ward CSO Low Side	6.4	4.9	1.3	25	62
26th Ward CSO, High Side	2.5	2.7	0.72	15	65
North River Influent	1.8	0.57	0.76	17	64
Manhattan Grit Chamber	2.5	0.76	0.19	5.3	76
Red Hook Influent	2.1	0.85	0.41	15	47
Bowery Bay Low Side Interceptor	0.92		0.47	6.6	8.9

The Hunts Point wet weather influent sample showed high concentrations for all the individual chlordane components:

Table 92. Chlordane components in the Hunts Point Influent sample.

PARAM	Conc, ng/L
Chlordane,alpha (cis)	220
Chlordane,gamma (trans)	220
Nonachlor, trans-	180
Nonachlor, cis-	39
Chlordane,oxy-	0.082

Table 93 shows for each of the treatment plants the average pesticide loading in ug/hr from the treatment plants. The plants are listed in order of the summation of ranks of average pesticide loading.

Table 93. Average pesticide loads in final effluents, ug/hr., good data.

	Aldrin/Dieldrin	HCB	Heptachlor	Tchlordane	TDDT
Newtown Creek WPCF	20.5	6.1	10.1	67.3	129
Owls Head WPCF	22	4.9	11.5	60	30
Hunts Point WPCF	37	4.7	6.4	57	42
Wards Island WPCF	20.3	9.3	7.9	20.7	29.7
Yonkers WPCF	34.9	1.7	7.4	31.3	5
Port Richmond WPCF	8	7.2	5.4	26	10.5
Bowery Bay WPCF	14	2.7	3	14.9	27
Jamaica WPCF	11	1.7	3.7	17	12
Coney Island WPCF	15	1.7	4.1	13	12.4
Tallman Island WPCF	12.6	1.9	3.5	17.1	4.2
26th Ward WPCF	7	3.3	1	8	20
North River WPCF	6	2	0.9	3	21
Oakwood Beach WPCF	2	1.2	3.5	14	0.5
Rockaway WPCF	2.9	0.4	1.7	4.1	2.3
Rockland County WPCF	2.2	1.1	0.7	3.5	1.5
Red Hook WPCF	1.6	0.4	0.5	2.2	4
Poughkeepsie (C) WPCF	1.8	0.2	0.1	0.9	2
Rensselaer WPCF	0.5	0.2	0.2	0.5	1.6

Examination of biosolids (sludge) places Hunts Point in the first rank in terms of total pesticide concentrations (Table 94). Sludges from different facilities are dewatered at Hunts Point so the concentrations there may be affected by discharges in other catchments.

There were two pesticide formulators in the Hunts Point catchment and two in the Owls Heads catchment. A fifth formulated pesticides in Manhattan and is served by North River WPCF.

Table 94. Pesticide concentrations in biosolids (ug/kg).

Site Name	Aldrin/Dieldrin	Heptachlor	HCB	Tchlordane	TDDT
Hunts Point #9	74,000	5,400	16,000	230,000	290,000
Tallman Island	31,000	8,700	4,100	300,000	100,000
Oakwood Beach	41,000	12,000	6,100	290,000	62,000
Port Richmond	24,000	6,600	7,600	250,000	89,000
Bowery Bay	25,000	2,100	4,700	170,000	120,000
Coney Island	28,000	2,800	8,100	120,000	150,000
Jamaica	36,000	7,500	5,200	140,000	88,000
Wards Island, South	17,000	1,600	14,000	68,000	160,000
Hunts Point, #10	13,000	1,000	6,000	91,000	150,000
26th Ward	21,000	2,300	8,600	86,000	130,000
Red Hook	14,000	800	4,300	53,000	130,000
Wards Island, North	17,000	1,100	7,200	49,000	110,000

Ambient water samples show much lower concentrations than raw or treated wastewaters. The areas with the highest concentrations are the Kills (Western New York harbor) and the Hudson. Highest concentrations occurred in areas affected by former pesticide manufacturing in the Passaic/Hackensack Rivers and in the Arthur Kill.

Table 95. Average total pesticide concentrations at 13 ambient sites in the Hudson River and in NY/NJ Harbor (ng/L), good data.

	Aldrin/Dieldrin	HCB	Heptachlor	Tchlordane	TDDT
Passaic River, Mid-Tidal	1.4	0.28	0.68	2	2.5
Passaic R., Mouth, Bottom	0.6	0.21	0.49	0.83	2.3
Hackensack R., Mid-Tidal	0.51	0.73	0.36	0.65	1
Passaic R., Mouth, Surface	0.49	0.26	0.19	1	2.5
Northern Arthur Kill	0.5	0.099	0.27	0.49	9.8
Newark Bay	0.45	0.12	0.18	0.5	1.2
Hackensack R., Mouth	0.43	0.14	0.088	0.27	0.53
Raritan Bay	0.32	0.068	0.13	0.26	0.88
Lower East R., Brooklyn Br. To Hell Gate	0.22	0.07	0.068	0.22	0.45
Jamaica Bay	0.19	0.1	0.081	0.12	0.099
Upper Bay	0.14	0.03	0.032	0.27	0.38
Upper East R., Hell Gate to Throgs Neck	0.2	0.0083	0.051	0.18	0.22
Lower Bay	0.13	0.01	0.037	0.067	0.3

Sediments

Pesticides concentrations appear to be usually higher in biosolids than in sediments. This may be due to the higher organic content of biosolids and that data adjusted for organic carbon would show less difference.

CARP sediment sampling also points to the Arthur Kill as an area of interest for TDDT. Table 96 shows pesticide concentrations in PPB from surficial samples taken throughout the area.

Table 96. Pesticides in surfacial sediment samples, ug/kg.

	Aldrin/Dieldrin	HCB	Heptachlor	THCH	Tchlordane	TDDT
Passaic R.	40	36	6	5.4	370	840
Arthur Kill	18	62	0.4	2.7	88	3900
Newtown Creek	280	33	2.1	0.4	1600	1300
Hackensack R.	27	20.2	1.5	2	99	320
Newark Bay	10	8.7	0.14	1.1	47	350
Raritan Bay	3.9	2	0.15	0.6	16	240
Harlem River	3.4	1.8	0.095	0.31	17	81
Hudson R.	2.3	1.7		0.52	6	50
East River	1.9	0.85	0.018	0.47	17	46
Upper Harbor	1.8	1.3	0.16	0.29	7.8	35
Lower Harbor	0.9	180	0.055	0.25	3.7	20
Long Island Sound	1.6	0.57		0.15	4.9	22
NY Bight		0.88				1.5
Jamaica Bay		0.048				0.21

The highest observed TDDT concentration came from a sediment core (depths .5-1 meter) taken off Staten Island just to the northeast of Prall's Island (Figure 78). Normalization by total volatile solids does not explain away the observation.

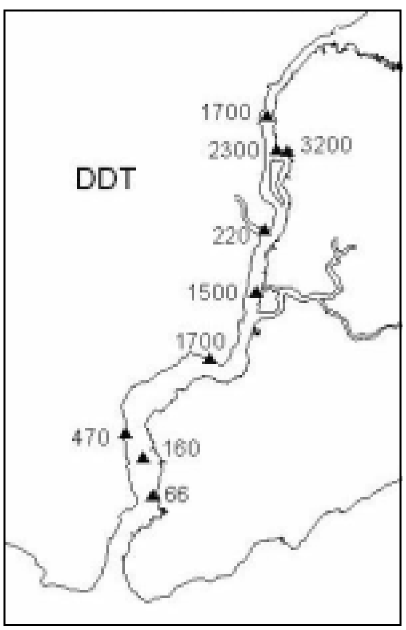
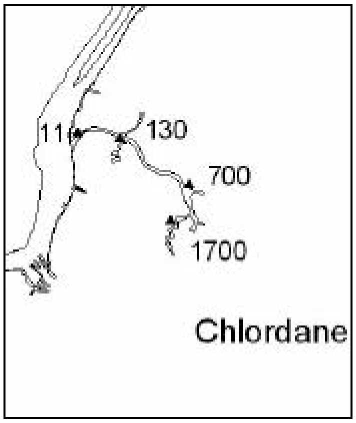


Figure 78. Average total DDT concentrations (ug/kg) in Arthur Kill core and surface grab samples.

The highest sediment concentrations of total chlordane and dieldrin occurred in Newtown Creek (Figure 79).



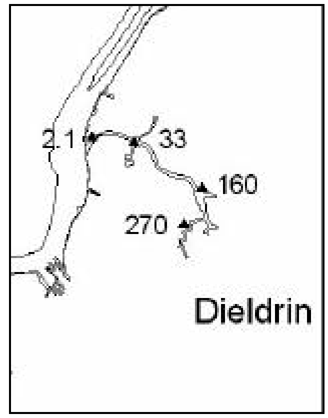


Figure 79. Total chlordane and dieldrin in Newtown Cr. and English Kill.

Next Steps

Highly contaminated particles in the Wallkill might be reduced through better stream management practices. NYSDEC is currently supporting a study on particle sources in the Black Dirt zone. In the 1930s, the Wallkill was straightened and this unnatural stream modification may be contributing to its instability. There is controversy as to the origin of the current sediment load. Some observers claim that it comes from bank erosion and the numerous drainage channels in the Black Dirt area while others profess that sediment loads come from upstream housing development. Another theory is that wind blown soils are significant.

Pesticide sources to the New York City wastewater treatment plants may be from former pesticide manufacturers. Trackdown investigations informed by the locations of these sites may be helpful. Pesticide concentrations in the Passaic River and Arthur Kill are possibly due to former manufacturing facilities. The extent to which the pesticides are still coming from terrestrial sources or are being recycled in sediments is not known.

PAHs

Polynuclear aromatic hydrocarbons (PAHs) occur as by-products of incomplete combustion. They are found in petroleum, soils, smoke, and urban wastestreams.

PAHs may be treated collectively in three ways; as summations of concentrations, molar sums, or as PAH TEQs. Molar sums are the sum of the concentrations of individual PAHs divided by their molecular weights. PAH TEQs are the sum of the products of PAH TEFs and the PAHs they relate to. TEFs for PAHs are based on values from Nisbet and LaGoy[5]. These values relate carcinogenicity of 17 PAHs to that of benzo(a)pyrene.

[5] Nisbet, I.C.T., and P.K. LaGoy. 1992. Toxic equivalency factors (TEFs) for polycyclic aromatic hydrocarbons (PAHs). Regulatory Toxicology and Pharmacology. 16:290-3000.

Table 97. PAHs measured in CARP.

PARAM	PAH_CLASS	Mol_Wt	PAH_TEF	WQS, ug/L
Naphthalene	PAH-light	128.2	0.001	16
1-Methylnaphthalene*	PAH-light	142.2	0.001	
2-Methylnaphthalene*	PAH-light	142.2	0.001	
C1 Naphthalenes	PAH-light	142.2	0.001	
Acenaphthylene	PAH-light	152.2	0.001	
Acenaphthene	PAH-light	154.21	0.001	6.6
Biphenyl	PAH-light	154.21		
2,6-Dimethylnaphthalene*	PAH-light	156.23		
C2 Naphthalenes	PAH-light	156.23		
Fluorene	PAH-light	166.22	0.001	2.5
2,3,5-Trimethylnaphthalene*	PAH-light	170.26		
C3 Naphthalenes	PAH-light	170.26		
Anthracene	PAH-medium	178.2	0.01	
Phenanthrene	PAH-medium	178.24	0.001	1.5
1-Methylphenanthrene*	PAH-medium	192.26		
C1 Phenanthrenes/Anthracenes	PAH-medium	192.26		
Pyrene	PAH-medium	202	0.001	
Fluoranthene	PAH-medium	202.26	0.001	
3,6-Dimethylphenanthrene*	PAH-medium	206.28		
C2 Phenanthrenes/Anthracenes	PAH-medium	206.28		
Benz[a]anthracene	PAH-heavy	228.29	0.1	
Chrysene	PAH-heavy	228.3	0.01	
Benzo[a]pyrene	PAH-heavy	252.3	1	0.0006
Benzo[b/j/k]fluoranthenes	PAH-heavy	252.3	0.1	
Benzo[b]fluoranthene	PAH-heavy	252.3	0.1	
Benzo[k]fluoranthene	PAH-heavy	252.3	0.1	
Benzo[e]pyrene	PAH-heavy	252.32		
Perylene	PAH-heavy	252.32		
Benzo[ghi]perylene	PAH-heavy	276.34	0.01	
Indeno[1,2,3-cd]pyrene	PAH-heavy	276.34	0.1	
Dibenz[a,h]anthracene	PAH-heavy	278.36	5	

* Some lab reports show specific methylated PAHs (for example “1-methylnaphthalene”) and others report homologue totals, for example “C1 naphthalene”. Some Axys data show both homologue totals and specific methylated PAHs. Data users must recognize this to avoid counting the same substances twice.

PAH Quality

TEF weighting makes some PAHs far more important than others. PAH TEQs are only calculated if the difference between assigning values of 0 or half the detection limit results in differences of less than 10%. Through the application of this screen, most of the dissolved phase PCBs become ineligible. There were 196 TOPS samples where PAHs were measured from glass fiber cartridges. Accompanying them were 135 aqueous phase PAHs samples. Because of inherent contamination with methyl naphthalenes and methyl phenanthrenes, XAD cannot be used to concentrate aqueous phase PAHs. In CARP, particle phase PAHs were captured on glass fiber filter cartridges and aqueous phase (dissolved) PAHs were collected as part of the waste stream from TOPS. The waste stream is water that has passed through the glass fiber cartridge filter.

Evaluation of PAHs was done in three steps. The first was by analyte; the second was by sample, and the third was by sampling event. The individual analytes may have been not detected (non-detect, ND); detected at masses more than 10 times the sample specific detection level (good detection, GD); detected but at a mass less than 10 times the SPDL (high detection level, HD); found at masses more than 10 times the SPDL and more than 5 times the relevant method blank (non-significant blank, NSB); or found at more than 10 times the SPDL but less than 5 times the relevant method blank (significant blank, SB). The relevant method blank was from the same sample delivery group. Tables 98, 99, and 100 present the success (quality evaluations of GD and NSB) for each analyte in each of three media.

Table 98. PAH Data Quality, Total

	GD	HD	ND	NSB	SB	Grand Total	Good Analyses
Naphthalene		12	7	26	17	62	42%
C1 Naphthalenes		11	2	14	4	31	45%
1-Methylnaphthalene	1	11	9	20	13	54	39%
2-Methylnaphthalene		11	8	21	14	54	39%
C2 Naphthalenes	7	10	5	20	9	51	53%
C3 Naphthalenes	9	12	17	20	4	62	47%
Acenaphthylene	4	20	27	11		62	24%
Acenaphthene	10	17	17	15	3	62	40%
Biphenyl	1	17	18	19	7	62	32%
Fluorene	1	17	18	21	5	62	35%
Anthracene	4	22	20	15	1	62	31%
Phenanthrene		18	10	23	11	62	37%
C1 Phenanthrenes/Anthracenes	3	15	13	13	2	46	35%
Pyrene	6	12	9	28	7	62	55%
Fluoranthene	5	14	8	29	6	62	55%
Benz[a]anthracene	5	19	14	19	5	62	39%
Chrysene	3	18	12	21	8	62	39%
Benzo[a]pyrene	7	18	18	13	6	62	32%
Benzo[e]pyrene	6	18	18	14	6	62	32%
Benzo[ghi]perylene	4	16	19	15	8	62	31%
Benzo[b/j/k]fluoranthenes	4	13	1	19	10	47	49%
Benzo[b]fluoranthene		3	12			15	0%
Benzo[k]fluoranthene		3	12			15	0%
Perylene	5	19	26	8	4	62	21%
Indeno[1,2,3-cd]pyrene	4	19	20	13	6	62	27%
Dibenz[a,h]anthracene	2	14	35	5	6	62	11%
Grand Total	91	379	375	422	162	1429	36%

Table 99. PAH Data Quality, Dissolved Phase

Chemical Name	GD	HD	ND	NSB	SB	Grand Total	Good Analyses
Naphthalene		35	1	42	73	151	28%
C1 Naphthalenes	10	36	16	34	20	116	38%
1-Methylnaphthalene		7	1	22	32	62	35%
2-Methylnaphthalene	7	6		23	26	62	48%
C2 Naphthalenes	43	18	47	15	15	138	42%
C3 Naphthalenes	29	19	56	29	18	151	38%
Acenaphthylene	6	38	99	3	5	151	6%
Acenaphthene	31	48	51	14	7	151	30%
Biphenyl	16	53	49	18	15	151	23%
Fluorene	27	51	47	13	13	151	26%
Anthracene	8	60	66	9	8	151	11%
Phenanthrene	10	55	24	31	31	151	27%
C1 Phenanthrenes/Anthracenes	29	31	40	23	6	129	40%
Pyrene	14	35	17	70	15	151	56%
Fluoranthene	7	53	25	51	15	151	38%
Benz[a]anthracene	11	64	56	13	7	151	16%
Chrysene	23	61	38	11	18	151	23%
Benzo[a]pyrene	9	47	87	1	7	151	7%
Benzo[e]pyrene	13	50	75	1	12	151	9%
Benzo[ghi]perylene	4	83	53	1	10	151	3%
Benzo[b/j/k]fluoranthenes	11	44	56	4	20	135	11%
Benzo[b]fluoranthene		0	13			13	0%
Benzo[k]fluoranthene		0	13			13	0%
Perylene	4	28	113		6	151	3%
Indeno[1,2,3-cd]pyrene	5	60	76	2	8	151	5%
Dibenz[a,h]anthracene	2	13	127	1	8	151	2%
Grand Total	319	995	1246	431	395	3386	22%

Table 100. PAH Data Quality, Cartridge Filters

Chemical Name	GD	HD	ND	NSB	SB	Grand Total	Good Analyses
Naphthalene	9	44	2	106	30	191	60%
C1 Naphthalenes	49	45	2	58	11	165	65%
1-Methylnaphthalene*	6	25	1	13	12	57	33%
2-Methylnaphthalene*	3	20		24	10	57	47%
C2 Naphthalenes	104	19	11	33	8	175	78%
C3 Naphthalenes	92	33	19	40	7	191	69%
Acenaphthylene	63	84	28	13	3	191	40%
Acenaphthene	56	90	29	11	5	191	35%
Biphenyl	52	88	11	25	15	191	40%
Fluorene	77	62	13	29	10	191	55%
Anthracene	65	68	15	39	4	191	54%
Phenanthrene	94	24	3	66	4	191	84%
C1 Phenanthrenes/Anthracenes	115	29	7	33	1	185	80%
Pyrene	124	15	3	47	2	191	90%
Fluoranthene	112	20	4	53	2	191	86%
Benz[a]anthracene	120	36	6	28	1	191	77%
Chrysene	127	21	7	34	2	191	84%
Benzo[a]pyrene	111	44	11	22	2	190	70%
Benzo[e]pyrene	120	42	9	18	2	191	72%
Benzo[ghi]perylene	99	39	6	43	4	191	74%
Benzo[b/j/k]fluoranthenes	114	24	7	21	2	168	80%
Benzo[b]fluoranthene	12	8				20	60%
Benzo[k]fluoranthene	10	10				20	50%
Perylene	97	60	24	6	3	190	54%
Indeno[1,2,3-cd]pyrene	109	44	6	27	2	188	72%
Dibenz[a,h]anthracene	55	74	40	19	3	191	39%
Grand Total	1995	1068	264	808	145	4280	65%

The second level of evaluation addresses the suitability of an individual sample to be treated as a collective. Suitability was evaluated by assigning non-detection values of either zero or half the detection level. If the ratio of the two different summations was less than 90%, the sample was deemed unusable. Of 456 PAH samples, 402 (88%) were useable. Useable PAH samples were re-evaluated against "Good" analyses. There were 213 samples where the non-detections resulted in minor changes to the calculated nmoles/L and the quantitated analytes were present in amounts well above the detection level (10 times) and well above any method blanks (5 times). Of 465 samples, 213 are useful for evaluating nmoles/L. In the end, 186 samples are relevant. The difference between "useful" and "relevant" is that 27 otherwise useful samples were for quality control.

PAH Samples, Biosolids

On 11 occasions biosolids were analyzed for PAHs. Some the individual PAHs failed the 10 times detection level screen but they had little impact on the molar totals. The highest

PAH concentrations in sludges were seen in the industrial Hunts Point sludges and the lowest were from suburban Oakwood Beach sample.

Table 101. Collective PAHs in municipal biosolids.

Site	Raw Sum, ppm	PAH, mMoles/kg	PAH, ppm TEQ
Hunts Point WPCF #10 Sludge	230	1.3	3.4
Hunts Point WPCF #9 Sludge	220	1.2	5
26th Ward WPCF, Sludge	160	0.89	2.9
Wards Island WPCF, South, Sludge	150	0.86	3.1
Wards Island WPCF, North, Sludge	120	0.64	2.7
Bowery Bay WPCF, Sludge	110	0.62	3.6
Coney Island WPCF, Sludge	110	0.59	2.3
Port Richmond WPCF, Sludge	100	0.57	3.4
Red Hook WPCF, Sludge	100	0.56	3.2
Tallman Island WPCF, Sludge	98	0.54	4.3
Jamaica WPCF Sludge	81	0.46	2
Oakwood Beach WPCF, Sludge	42	0.22	1.9

The relatively large range in PAH concentrations is offset by the high consistency of PAH contributions. Figure 80 shows relative abundances of molecular weight fractions.

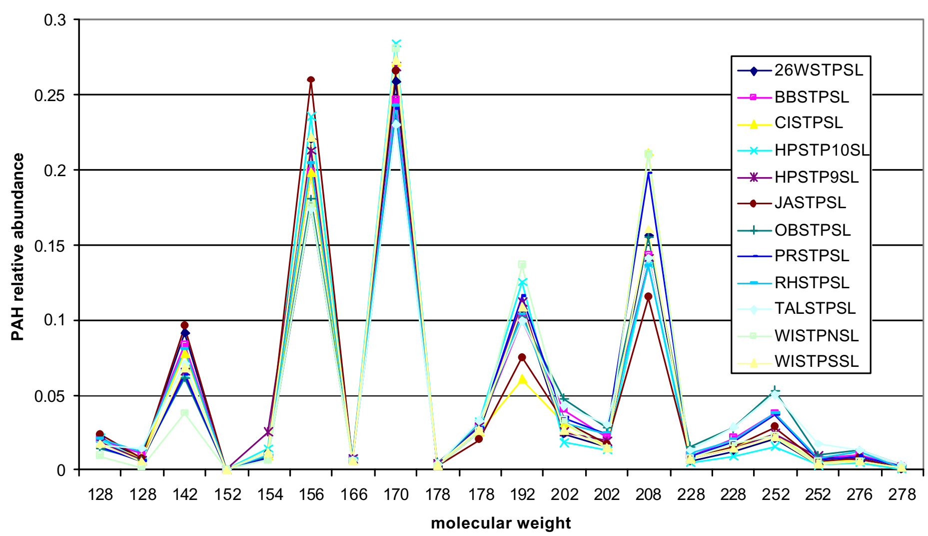


Figure 80. Relative abundances of PAHs in sludges.

About 80% of the total molar PCB mass (from sludges in the CARP analyte list) come from tri- di-, and mono-methyl naphthalenes and phenanthrenes/anthracenes.

PAHs In Water

There were two kinds of water samples, unfiltered whole water (U) and phase-separated filtered water (F). Whole water samples are easier to collect, less expensive to analyze, and possibly less susceptible to contamination. Table 102 compares samples of raw concentration (sum of all PAHs), molar concentration (nMoles/L), and raw concentration (ng/L), and B(a)P TEQs (ng/L). The labs performing the analyses are also distinguished. Samples are ranked within type by nM/L and maxima for each type are highlighted.

All samples are shown due to the difficulty of averaging. There may be large lab to lab differences and the media (filtered and unfiltered) may or may not be significant. As indicated above, the quality of these data is poor.

Only data with good detection limits were used.

Seven samples (indicated by asterisks in the Type field) were taken by the USEPA and analyzed under CARP in the investigation of the World Trade Center disaster. Two of these (CSO*, Rector St. run-off) were a slurry of dust and ash being washed off Rector St. The other 5 samples were from points just off the WTC site, at the George Washington Bridge, and off South St. in the lower East River.

Table 102. Collective PAHs in Whole Water Samples.

Type	Site	Raw, ng/L	nM/L	TEQ, ng/kg	QC	Media	LAB	Date
AMB	Hudson R. at Pough.	5700	35	280	SA	U	AAS	4/16/99
AMB	Passaic River, Mid-Tidal	3800	18	550	SA	F	AAS	10/18/00
AMB	Hackensack R., Mouth	2500	16	6	SA	F	AAS	2/8/99
AMB	Hudson R. at Pough.	2600	15	82	SA	U	AAS	3/28/99
AMB	Passaic River, Mid-Tidal	1100	6.5	45	SA	F	AAS	8/25/99
AMB	Passaic River, Mid-Tidal	1000	6	50	SA	F	AAS	8/25/99
AMB*	East River, South St.	1000	5.7	37	SA	U	AAS	9/20/01
AMB*	Hudson River, North	900	4.9	110	SA	U	AAS	9/20/01
AMB	Northern Arthur Kill	840	4.2	90	SA	F	AAS	7/8/99
AMB*	Hudson River West	730	4.1	13	SA	U	AAS	9/20/01
AMB*	GW Bridge	610	3.1	110	SA	U	AAS	9/20/01
AMB	Passaic River, Mid-Tidal	410	2.7	2.4	SA	F	AAS	3/16/99
AMB	Hackensack R., Mid-Tidal	420	2.5	14	SA	F	AAS	10/12/99
AMB	Newark Bay	260	1.4	5.8	SA	F	AAS	1/27/99
AMB*	Hudson River South	200	1.1	4.4	SA	U	AAS	9/20/01
AMB	Hudson R. S. of Harlem R.	170	1	15	SA	U	WSU	6/14/00
AMB	Hudson R. below Kingston	150	0.97	2.6	SA	F	AAS	10/7/99
AMB	Passaic R., Surface	130	0.68	6.1	SA	F	AAS	6/17/99
AMB	New York Bight	100	0.66	0.1	SA	F	AAS	12/9/98
AMB	Upper Bay	110	0.61	0.35	SA	F	AAS	8/11/99
AMB	Hudson R. S. of Harlem R.	96	0.55	2.6	SA	F	AAS	8/12/99
AMB	Upper Bay	77	0.44	0.48	SA	F	AAS	12/15/98
AMB	Upper Bay	58	0.38	0.071	DU	F	AAS	12/15/98
AMB	Passaic R., Surface	50	0.26	0.3	SA	F	AAS	11/13/98
CSO	Newtown Creek Influent	800000	4600	17000	SA	U	AAS	1/30/01
CSO	SWO-Jamaica, Ind.	430000	2500	3000	SA	U	AAS	10/16/00
CSO*	Rector St. run-off	290000	1500	21000	SA	U	AAS	9/14/01
CSO	Manhattan Pump Station	120000	720	2700	SA	U	AAS	2/5/01
CSO*	Rector St. run-off	120000	650	5200	SA	U	AAS	9/20/01
CSO	Manhattan Grit Chamber	78000	410	21000	SA	F	AAS	9/24/01
CSO	Red Hook Influent	56000	380	61	SA	F	AAS	8/27/01
CSO	Owls Head Influent	45000	270	370	SA	U	AAS	11/9/00
CSO	Jamaica Influent	20000	130	16	SA	F	AAS	9/20/01
CSO	Hunts Point Influent	7800	50	9.7	SA	U	AAS	7/8/01
CSO	SWO-Jamaica, Comm.	5000	26	470	SA	U	WSU	6/22/00
Ind. Eff	Clean Waters of NY	15000	94	4.7	SA	F	AAS	9/20/99
Ind. Eff	Clean Waters of NY	3700	23	0.82	SA	F	AAS	4/29/99
Ind. Eff	FK Plant Effluent	130	0.78	2.1	SA	F	AAS	10/25/00
Leachate	1E-HMDC	450000	3100	4700	SA	F	AAS	9/14/01
Leachate	FK LF, 1/9 "B"	140000	970	780	SA	U	WSU	5/11/00
Leachate	FK LF, 1/9 "F"	81000	560	460	SA	U	WSU	5/11/00
Leachate	Pelham Bay	75000	450	370	SA	F	AAS	11/6/98
Leachate	FK LF, 1/9 Comp.	64000	430	440	SA	U	WSU	5/11/00

Table 102 continued.

Type	Site	Raw, ng/L	nM/L	TEQ, ng/kg	QC	Media	LAB	Date
Leachate	1A-HMDC	17000	120	31	SA	U	WSU	6/22/00
Leachate	1E-HMDC	20000	120	200	SA	U	WSU	6/22/00
Leachate	FK LF, 6/7 Comp.	14000	86	130	SA	U	WSU	5/11/00
Leachate	FK LF, 1/9 Comp.	11000	68	58	SA	F	AAS	10/25/00
Leachate	FK LF, 6/7 Comp.	6200	42	6.3	SA	F	AAS	7/25/01
Leachate	FK LF, 6/7 Comp.	5700	38	7.3	SA	F	AAS	8/9/01
Leachate	FK LF 3/4	5500	37	35	SA	U	WSU	5/11/00
Leachate	1D-HMDC	7100	37	740	SA	F	AAS	9/14/01
Leachate	FK LF, 6/7 Comp.	1700	11	2.8	SA	F	AAS	10/25/00
Leachate	1D-HMDC	230	1.1	32	SA	U	WSU	6/22/00
Leachate	Pelham Bay	48	0.24	1.6	SA	F	AAS	1/29/01
Tributary	Saw Mill River (Yonkers)	4000	24	5.8	SA	F	AAS	5/5/99
Tributary	Gowanus Canal	1100	6.4	7.5	SA	F	AAS	8/24/99
Tributary	Saw Mill River (Yonkers)	780	4.5	8.1	SA	F	AAS	11/10/98
Tributary	Mohawk R. (Cohoes)	490	3.3	1.4	SA	U	AAS	4/1/99
Tributary	Gowanus Canal	500	2.8	19	SA	U	AAS	9/28/00
Tributary	Bronx River	430	2.6	1.2	SA	F	AAS	7/27/99
Tributary	Wallkill (New Paltz)	350	2.3	3.1	SA	U	AAS	10/13/99
Tributary	Bronx River	360	2.3	3.9	SA	F	AAS	10/26/99
Tributary	Hudson R. (Pleasantdale)	290	2.1	0.66	SA	U	AAS	4/8/99
Tributary	Hudson R. (Pleasantdale)	280	1.8	2.6	SA	U	AAS	4/1/99
Tributary	Hudson R. (Pleasantdale)	240	1.5	2.5	SA	U	AAS	3/22/99
Tributary	Wallkill (New Paltz)	78	0.5	0.14	SA	U	AAS	5/26/01
WPCF	Newtown Creek	64000	400	46	DU	F	AAS	9/28/99
WPCF	Newtown Creek	63000	400	38	SA	F	AAS	9/28/99
WPCF	Newtown Creek	51000	320	25	SA	F	AAS	6/22/99
WPCF	26th Ward	34000	210	9.1	SA	F	AAS	5/5/99
WPCF	Port Richmond	26000	170	22	SA	F	AAS	10/20/99
WPCF	Hunts Point	23000	130	240	SA	U	AAS	2/1/01
WPCF	Oakwood Beach	16000	100	5.6	SA	F	AAS	8/18/99
WPCF	Poughkeepsie City	16000	93	200	SA	F	AAS	8/19/99
WPCF	Rockland County	14000	84	290	SA	F	AAS	8/19/99
WPCF	Tallman Island	14000	81	29	SA	F	AAS	9/6/00
WPCF	Tallman Island	12000	66	23	DU	F	AAS	9/6/00
WPCF	Owls Head	7700	43	30	SA	F	AAS	8/23/00
WPCF	Rensselaer	6500	41	8.9	SA	F	AAS	1/12/99
WPCF	Rockaway	4700	30	9	SA	F	AAS	8/11/99
WPCF	Poughkeepsie City	3300	23	8.1	SA	F	AAS	4/1/99
WPCF	Wards Island	3700	23	2.6	SA	F	AAS	1/20/99
WPCF	North River	3300	20	6.9	SA	F	AAS	9/1/99
WPCF	Poughkeepsie City	3400	19	24	SA	U	AAS	12/5/00
WPCF	Bowery Bay	2900	17	12	SA	F	AAS	11/5/98
WPCF	Port Richmond	2400	15	2.2	SA	F	AAS	8/25/99
WPCF	Red Hook	2100	13	3	SA	F	AAS	2/3/99

Table 102 continued.

Type	Site	Raw, ng/L	nM/L	TEQ, ng/kg	QC	Media	LAB	Date
WPCF	Owls Head	2000	12	2.3	SA	F	AAS	9/15/98
WPCF	Jamaica	2000	12	33	SA	U	AAS	2/15/01
WPCF	Wards Island	1500	9.2	2.7	DU	F	AAS	8/10/00
WPCF	Yonkers	930	5.6	8.5	SA	F	AAS	8/18/99
WPCF	Rockland County	890	5.4	5.4	SA	F	AAS	4/20/99
WPCF	Owls Head	620	3.7	3.4	SA	F	AAS	7/7/99
WPCF	Tallman Island	570	3.4	0.35	SA	F	AAS	2/12/99
WPCF	Tallman Island	370	2.2	0.68	SA	F	AAS	7/20/99
WPCF	Wards Island	320	1.9	0.57	SA	F	AAS	8/10/00
WPCF	Yonkers	210	1.3	0.086	SA	F	AAS	4/22/99
WPCF	Rensselaer	170	0.99	0.86	SA	F	AAS	8/11/99
WPCF	26th Ward	180	0.99	1.4	SA	F	AAS	1/27/99
WPCF	Oakwood Beach	120	0.78	0.1	SA	F	AAS	2/11/99
WPCF	Jamaica	79	0.49	0.13	SA	F	AAS	2/5/99

Total PAHs

Attempts to perform phase separation on PAH samples were disappointing. Tables 103, 104, and 105 shows site averages of B(a)P TEQ, total nMoles/L, and raw total summations from filtered grab samples, unfiltered grab samples, and TOPS glass fiber cartridge samples. Data are screened to show only samples where assigning non-detections the value of the sample specific detection limit or zero results in a difference of less than 10%. Only data passing the screen for good detections are used. Ultimately, very few dissolved phase samples survive the quality screens. This has a profound impact in that where it is possible to compare phases on the same samples, much or most of the PAH is on the dissolved phase.

Table 103. B(a)P TEQ in aqueous and suspended particulate samples, site averages, ng/L. Censored data.

Sample	Filtered	Particulate	Unfiltered	Total
Amb: Passaic River, Mid-Tidal	550	2400		2950
Amb: Hudson R. at Poughkeepsie		800	280	1080
Amb: Passaic R., Mouth, Bottom		1000		1000
Amb: Passaic R., Mouth, Surface		960		960
Amb: Hackensack R., Mid-Tidal		700		700
Amb: Northern Arthur Kill	90	270		360
Amb: Hudson R. South of Harlem R.		340	15	355
Amb: Hudson R. below Tappen Zee		290		290
Amb: Hackensack R., Mouth		230		230
Amb: Lower East R.		230		230
Amb: Newark Bay		230		230
Amb: Upper Bay		170		170
Amb: Haverstraw Bay		150		150
Amb: Upper East R.		140		140
Amb: WTC George Washington Bridge			110	110
Amb: WTC Hudson River, North			110	110
Amb: Hudson R. below Kingston		42		42
Amb: Raritan Bay		34		34
Amb: Jamaica Bay		29		29
Amb: Lower Bay		28		28
Amb: Long Island Sound		16		16
CSO: Manhattan Grit Chamber	21000	2100		23100
CSO: Newtown Creek Influent			17000	17000
CSO: Red Hook Influent		7200		7200
CSO: Jamaica Influent		3000		3000
CSO: SWO-Jamaica, Industrial			3000	3000
CSO: Manhattan Pump Station			2700	2700
CSO: Hunts Point Influent		2400		2400
CSO: SWO-Jamaica, Commercial			470	470
CSO: Owls Head Influent			370	370
Industrial effluent: Clean Waters of New York		5.8		5.8
Industrial effluent: FK Plant Effluent	2.1			2.1
Landfill leachate: 1E-HMDC	4700		200	4900
Landfill leachate: FK LF, 1/9 "B"			780	780
Landfill leachate: 1D-HMDC	740		32	772
Landfill leachate: FK LF, 1/9 Comp.	58		440	498
Landfill leachate: FK LF, 1/9 "F"			460	460
Landfill leachate: FK LF, 6/7 Comp.			130	130
Landfill leachate: FK LF 3/4			35	35
Landfill leachate: 1A-HMDC			31	31
Tributary: Bronx River		580		580
Tributary: Wallkill (New Paltz)		530		530
Tributary: Hudson R. (Pleasantdale)		290		290
Tributary: Mohawk R. (Cohoes)		270		270

Table 103, continued.

Sample	Filtered	Particulate	Unfiltered	Total
Tributary: Gowanus Canal		240	19	259
Tributary: Saw Mill River (Yonkers)		220		220
WPCF: Hunts Point		340	240	580
WPCF: Rockland County	290	40		330
WPCF: Rensselaer		180		180
WPCF: Poughkeepsie City		160		160
WPCF: Jamaica		80	33	113
WPCF: 26th Ward		98		98
WPCF: Red Hook		97		97
WPCF: Bowery Bay		96		96
WPCF: Newtown Creek		90		90
WPCF: Tallman Island		63		63
WPCF: Rockaway		48		48
WPCF: Port Richmond		45		45
WPCF: Yonkers		37		37
WPCF: Wards Island		33		33
WPCF: Oakwood Beach		17		17
WPCF: North River		8.1		8.1
WPCF: Owls Head		6.3		6.3

Table 104. Total molar PAHs (ng/L) by phase. Good detection limits and the difference between assigning non-detections values of zero and the detection limit is less than 10%.

Sample	Filtered	Particulate	Unfiltered	Total
Amb: Passaic River, Mid-Tidal	10	66		76
Amb: Hudson R. at Poughkeepsie		31	25	56
Amb: Passaic R., Mouth, Bottom		35		35
Amb: Passaic R., Mouth, Surface	0.68	29		29.68
Amb: Hackensack R., Mid-Tidal	2.5	22		24.5
Amb: Hackensack R., Mouth	16	7		23
Amb: Hudson R. South of Harlem R.	0.55	11	1	12.55
Amb: Northern Arthur Kill	4.2	8.3		12.5
Amb: Hudson R. below Tappen Zee		11		11
Amb: Lower East R.		7.8		7.8
Amb: Newark Bay		7.3		7.3
Amb: Upper Bay	0.53	5.6		6.13
Amb: WTC East River, South St.			5.7	5.7
Amb: Haverstraw Bay		5.6		5.6
Amb: WTC Hudson River, North			4.9	4.9
Amb: Upper East R.		4.2		4.2
Amb: WTC Hudson River West			4.1	4.1
Amb: WTC George Washington Bridge			3.1	3.1
Amb: Hudson R. below Kingston	0.97	1.7		2.67
Amb: Raritan Bay		1.1		1.1
Amb: Jamaica Bay		0.76		0.76
Amb: Lower Bay		0.74		0.74
Amb: New York Bight	0.66	0.0078		0.6678
Amb: Long Island Sound		0.45		0.45
CSO: Newtown Creek Influent			4600	4600
CSO: SWO-Jamaica, Industrial			2500	2500
CSO: WTC Rector St. run-off			1100	1100
CSO: Red Hook Influent	380	380		760
CSO: Manhattan Pump Station			720	720
CSO: Manhattan Grit Chamber	410	130		540
CSO: Jamaica Influent	130	200		330
CSO: Owls Head Influent			270	270
CSO: Hunts Point Influent		150	50	200
CSO: SWO-Jamaica, Commercial			26	26
Ind. Eff.: Clean Waters of New York	59	1.1		60.1
Ind. Eff.: FK Plant Effluent	0.78	15		15.78
Leachate: 1E-HMDC	3100		120	3220
Leachate: FK LF, 1/9 "B"			970	970
Leachate: FK LF, 1/9 "F"			560	560
Leachate: FK LF, 1/9 Comp.	68		430	498
Leachate: Pelham Bay	230			230
Leachate: 1A-HMDC			120	120
Leachate: FK LF, 6/7 Comp.	30		86	116

Table 104 continued.

Sample	Filtered	Particulate	Unfiltered	Total
Leachate: 1D-HMDC	37		1.1	38.1
Leachate: FK LF 3/4			37	37
Tributary: Saw Mill River (Yonkers)	14	7		21
Tributary: Wallkill (New Paltz)		17	1.4	18.4
Tributary: Gowanus Canal	6.4	8.8	2.8	18
Tributary: Bronx River	2.4	14		16.4
Tributary: Mohawk R. (Cohoes)		8.1	3.3	11.4
Tributary: Hudson R. (Pleasantdale)		7.9	1.9	9.8
WPCF: Newtown Creek	370	29		399
WPCF: 26th Ward	210	15		225
WPCF: Hunts Point		22	130	152
WPCF: Oakwood Beach	100	1.7		101.7
WPCF: Port Richmond	92	3.7		95.7
WPCF: Poughkeepsie City	58	11	19	88
WPCF: Tallman Island	50	5		55
WPCF: Rockland County	45	3.4		48.4
WPCF: Rockaway	30	3.8		33.8
WPCF: Rensselaer	21	7.6		28.6
WPCF: North River	20	1.9		21.9
WPCF: Bowery Bay	17	4		21
WPCF: Owls Head	20	0.88		20.88
WPCF: Jamaica		3.4	12	15.4
WPCF: Red Hook	13	2.2		15.2
WPCF: Wards Island	11	1.4		12.4
WPCF: Yonkers	5.6	4.5		10.1
WPCF: Coney Island		0.53		0.53

Table 105. Total PAH concentrations. ng/L. Data censored for high detection levels.

Sample	Filtered	Particulate	Unfiltered	Total
Ambient: Passaic River, Mid-Tidal	1600	14000		15600
Ambient: Hudson R. at Poughkeepsie		6500	4200	10700
Ambient: Passaic R., Mouth, Bottom		7400		7400
Ambient: Passaic R., Mouth, Surface	89	6300		6389
Ambient: Hackensack R., Mid-Tidal	420	4700		5120
Ambient: Hackensack R., Mouth	2500	1500		4000
Ambient: Hudson R. South of Harlem R.	96	2400	170	2666
Ambient: Northern Arthur Kill	840	1800		2640
Ambient: Hudson R. below Tappen Zee		2300		2300
Ambient: Newark Bay	260	1500		1760
Ambient: Lower East R.		1600		1600
Ambient: Upper Bay	81	1200		1281
Ambient: Haverstraw Bay		1200		1200
Ambient: WTC East River, South St.			1000	1000
Ambient: WTC Hudson River, North			900	900
Ambient: Upper East R.		880		880
Ambient: WTC Hudson River West			730	730
Ambient: WTC George Washington Bridge			610	610
Ambient: Hudson R. below Kingston	150	350		500
Ambient: Raritan Bay		230		230
Ambient: WTC Hudson River South			200	200
Ambient: Jamaica Bay		160		160
Ambient: Lower Bay		160		160
Ambient: New York Bight	100	1.5		101.5
Ambient: Long Island Sound		97		97
CSO: Newtown Creek Influent			800000	800000
CSO: SWO-Jamaica, Industrial			430000	430000
CSO: WTC Rector St. run-off			210000	210000
CSO: Red Hook Influent	56000	75000		131000
CSO: Manhattan Pump Station			120000	120000
CSO: Manhattan Grit Chamber	78000	26000		104000
CSO: Jamaica Influent	20000	39000		59000
CSO: Owls Head Influent			45000	45000
CSO: Hunts Point Influent		30000	7800	37800
CSO: SWO-Jamaica, Commercial			5000	5000
Ind. Eff: Clean Waters of New York	9300	210		9510
Ind. Eff: FK Plant Effluent	130	3000		3130
Leachate: 1E-HMDC	450000		20000	470000
Leachate: FK LF, 1/9 "B"			140000	140000
Leachate: FK LF, 1/9 "F"			81000	81000
Leachate: FK LF, 1/9 Comp.	11000		64000	75000
Leachate: Pelham Bay	38000			38000
Leachate: FK LF, 6/7 Comp.	4600		14000	18600
Leachate: 1A-HMDC			17000	17000
Leachate: 1D-HMDC	7100		230	7330

Table 105 continued.

Sample	Filtered	Particulate	Unfiltered	Total
Leachate: FK LF 3/4			5500	5500
Tributaries: Wallkill (New Paltz)		3700	220	3920
Tributaries: Saw Mill River (Yonkers)	2400	1500		3900
Tributaries: Bronx River	390	3200		3590
Tributaries: Gowanus Canal	1100	1800	500	3400
Tributaries: Mohawk R. (Cohoes)		1700	490	2190
Tributaries: Hudson R. (Pleasantdale)		1700	270	1970
WPCF: Newtown Creek	59000	5400		64400
WPCF: Hunts Point		4600	23000	27600
WPCF: 26th Ward	17000	2900		19900
WPCF: Poughkeepsie City	9500	2300	3400	15200
WPCF: Port Richmond	14000	730		14730
WPCF: Oakwood Beach	8200	340		8540
WPCF: Rockland County	7500	670		8170
WPCF: Tallman Island	6800	700		7500
WPCF: Rockaway	4700	750		5450
WPCF: Rensselaer	3400	1600		5000
WPCF: Bowery Bay	2900	820		3720
WPCF: Owls Head	3500	170		3670
WPCF: North River	3300	220		3520
WPCF: Jamaica	79	700	2000	2779
WPCF: Red Hook	2100	470		2570
WPCF: Wards Island	1800	290		2090
WPCF: Yonkers	570	810		1380
WPCF: Coney Island		110		110

The quality of the PAH data are clearly problematic, particularly for the more critical dissolved phase. The source of the problem is in large measure due to inadequate field concentration. There may be problem with field contamination in some cases. Data are significantly better when the results are expressed in molar units than in B(a)P equivalents. Much of the B(a)P-like material was poorly captured in the dissolved phase samples resulting in numerous non-detections. The molar summations preferentially weights toward lighter PAHs more likely to be found in the dissolved phase but also more likely to be the result of sample contamination. Fewer problems are encountered in total PAH data but this statistic is perhaps less meaningful.

TOPS does not assist in the in-situ concentration for the dissolved phase PAHs because of the background of methylated naphthalenes and phenanthrenes on XAD. These substances are very important for total molar concentration but lack B(a)P TEFs. Proper sampling of PAHs will require experimentation.

Metals

Metal Results, Quality

Metals were analyzed from grab samples in the CARP. Table 106 shows the metals (and the phases), the number of non-detections, and the total number of samples taken.

Table 106. Metals analyzed, number of non-detections and total number of samples.

PARAM	non-detect	total
Ag, dissolved	7	46
Ag, total	3	53
Cd, dissolved	29	237
Cd, total	6	235
Hg, dissolved	2	256
Hg, Methyl, dissolved	45	194
Hg, Methyl, total	1	4
Hg, total	2	256
Pb, dissolved	7	116
Pb, total	1	65

Mercury and cadmium were the original CARP metals of concern. Lead and silver were added later in the program. The numbers of analyses reflect this.

The quality of metals data are evaluated in two parts, for mercury, and for the others. Good data are defined in Table 107.

Table 107. Criteria used to evaluate metals data.

	Hg	Ag, Cd, or Pb	notes
blanks	> 5 x lab SDG blank	> 5 x lab SDG blank	ND is assigned value of 0
spike recovery	< +/- 20%	< +/- 20%	abs diff/mean
duplicates	< +/- 25%	< +/- 20%	abs diff/mean

The sampling and analytical protocol did not provide a full set of quality control information for each analysis. Metals samples were processed quickly and many sample delivery groups had very few samples. The average number of samples in a SDG was 2.7. Hence, duplicate measurements were only made from a subset of SDGs. Also, percent recoveries were usually determined from total metals, not dissolved metals. Therefore, there are fewer data on recovery efficiency from dissolved phase samples.

Table 108 shows the average relative percent recovery from duplicates. The only samples exceeding the criteria were three dissolved methyl mercury sets where the total amount of analyte was very small.

Table 108. Average Relative Percent Difference (RPD) from duplicates.

PARAM	Average RPD
Cd_dissolved	1%
Cd_total	3%
Hg_dissolved	2%
Hg_Methyl_Dissolved	14%
Hg_Methyl_total	13%
Hg_total	2%
Pb_dissolved	1%

Table 109 summarizes the quality of metals data for blanks and spike recovery. Standards are described in Table 107. "Rec_Ind" refers to samples where there were no appropriate recovery statistics.

Table 109. Metals quality statistics.

	Good Blank	Good Blank	Good Blank	High Blank	High Blank	Grand Total
PARAM	Bad Rec	Good Rec	Rec_Ind	Good Rec	Rec_Ind	
Ag_dissolved			29		2	31
Ag_total	2	24		2		28
Cd_dissolved			177		26	203
Cd_total	8	193		10		211
Hg_dissolved		18	207		9	234
Hg_Methyl_Dissolved	22	145		16		183
Hg_total	3	259		3		265
Pb_dissolved			89		6	95
Pb_total	4	34				38
Grand Total	39	673	502	31	43	1288

Of the metals for which we have good statistics, total cadmium and total mercury, quality data appear very good. The weakest data are for methyl mercury. These were most often non-detect, showed the worst reproducibility, and most frequently had blank contamination.

Samples

Table 110 summarizes the metals concentrations by stations. The analytes are abbreviated; D= dissolved, T=total, and M=methyl. Missing values occur when the analyte was not measured.

Table 105. Summary of station averages, ng/L

Sample	Ag, D	Ag, T	Cd, D	Cd, T	Hg, D	Hg, DM	Hg, T	Pb, D	Pb, T
Amb-clean: Long Island Sound			41	45	0.54	0.012	1.5	12	
Amb-clean: New York Bight			23	21	0.39	0.045	0.63		
Amb-Hudson: Haverstraw Bay			27	46	2.3	0.054	6.7	99	
Amb-Hudson: Poughkeepsie			11	150	1.4	0.11	26	120	
Amb-Hudson: below Kingston			12	23	1.4	0.081	11	220	
Amb-Hudson: below Tappen Zee			68	100	2.4	0.034	29	57	
Amb-Hudson: S. of Harlem R.	13	49	83	83	1.6	0.017	11	100	1200
Amb-Kills: Hackensack R., MT			36	100	2.7	0.089	160	690	
Amb-Kills: Hackensack R., M.			56	70	1	0.043	22	160	
Amb-Kills: Newark Bay			67	88	1.6	0.02	33	130	
Amb-Kills: Northern Arthur Kill			77	83	0.85	0.025	33	130	
Amb-Kills: Passaic R., M., Bot.			61	150	1.7	0.027	87	380	
Amb-Kills: Passaic R., M., Sur			94	110	1.7	0.029	31	130	
Amb-Kills: Passaic River, MT	0	130	35	160	1.5	0.05	82	410	11000
Amb-Non_Kills: Jamaica Bay			38	43	1.1	0.019	3.4	93	
Amb-Non_Kills: Lower Bay			51	49	2.5	0.045	3.6	740	
Amb-Non_Kills: Lower East R.			56	65	0.76	0.017	14	130	
Amb-Non_Kills: Raritan Bay			58	61	1.5	0.016	7.7	100	
Amb-Non_Kills: Upper Bay			43	87	0.98	0.024	11	88	
Amb-Non_Kills: Upper East R.			78	70	2.7	0.0052	7.4	510	
CSO: Bowery Bay High Side	1,400	29,000	88	5,700	8.8		2,900	2,400	340,000
CSO: Bowery Bay Low Side	100	240	95	1,200	11	0.11	680	2,600	80,000
CSO: Coney Island Influent		210		540			400		39,000
CSO: Hunts Point Influent	87	3,000	21	1,100	8.9		720	1,200	100,000
CSO: Jamaica Influent	780	3,100	52	500	20	1.5	410	2,000	32,000
CSO: Manhattan Grit Chamber	55	860	4	350	3.5	0.63	180	580	42,000
CSO: Manhattan Pump Station	790	2,500	140	640	12	0.33	690	1,900	3,200
CSO: Newtown Creek Influent	110	1,400	150	2,200	10	0.16	620	4,000	150,000
CSO: North River Influent	1,600	20,000	70	1,400	9.7		1,500	2,600	310,000
CSO: Owls Head Influent		340		660			930		57,000
CSO: Port Richmond Influent	60	230	43	270	12		150	2,700	26,000
CSO: Red Hook Influent	110	3,700	11	1,100	16		750	850	88,000
CSO: SWO-Jamaica, Comm.			72	900	11		120	6,200	
CSO: SWO-Jamaica, Ind.	0	36	240	3,700	5.6		78	4,000	93,000
Ind eff: Clean Waters of NY			46	63	0.4	0.041	0.54		
Ind eff: FK Plant Effluent	110	120	140	170	29	0.24	37	640	1500
LF leachate: 1A-HMDC			24		23			1,300	
LF leachate: 1D-HMDC	380		710		290	1.7		66,000	
LF leachate: 1E-HMDC	50		45		50	0.88		11,000	
LF leachate: FK LF 3/4				160			8.8	13,000	
LF leachate: FK LF, 1/9 "B"				780			46	41,000	
LF leachate: FK LF, 1/9 "F"				230			11	2,300	
LF leachate: FK LF, 1/9 Comp.	150	290	660	750	1900	0.29	31	4,300	6800
LF leachate: FK LF, 6/7 Comp.	91	130	20	94	1.6	0.17	3	610	150
LF leachate: Pelham Bay			11		2.6			420	

Table 110 continued.

Sample	Ag, D	Ag, T	Cd, D	Cd, T	Hg, D	Hg, DM	Hg, T	Pb, D	Pb, T
Major tributary: Hudson R.			8.3	140	1.6	0.045	14	110	
Major tributary: Mohawk R.			14	180	2	0.035	26	160	7,900
Major tributary: Wallkill	14	160	9.5	290	4.3	0.059	42	150	6,300
Minor tributary: Bronx River			25	43	1.8	0.023	5.6	160	
Minor tributary: Gowanus Canal			37	64	1.1	0.15	11	170	
Minor tributary: Saw Mill River			26	37	3.5	0.055	3.5		
WPCF: 26th Ward	71	430	43	49	5.3	0.036	19	920	3,800
WPCF: Bowery Bay			48	61	2.7	0.081	12		
WPCF: Coney Island			19	23	3.5	0.08	9.3	570	
WPCF: Hunts Point	86	260	49	66	2.6	0.035	9.3	350	790
WPCF: Jamaica	150	690	57	170	2.5	0.11	38	450	1,700
WPCF: Newtown Creek	750	2,900	300	430	6.9	0.5	41	1,100	2,300
WPCF: North River			140	140	3.9	0.092	15	1,300	1,600
WPCF: Oakwood Beach			40	48	2.5	0.042	2.7	250	
WPCF: Owls Head			30	42	10	0.063	18	690	
WPCF: Port Richmond	110	390	94	95	3.4	0.05	11	680	1,400
WPCF: Poughkeepsie City	180	0	100	160	4.6	0.27	41	1,100	1,700
WPCF: Red Hook			74	75	2.3	0.13	8.6		
WPCF: Rensselaer			40	61	5.3	0.086	16		
WPCF: Rockaway			29	48	3.4	0.057	14	330	
WPCF: Rockland County			30	39	15	0.52	64	310	
WPCF: Tallman Island			75	88	1.8	0	9.6	270	
WPCF: Wards Island			37	38	2.5	0.023	7.9	420	
WPCF: Yonkers			51	75	4.7	0.097	61	1,100	

Average station instantaneous loads (g/hr) are shown in Table 111. These are the average of the loads measured on a sample per sample basis. This suggests that the Mohawk River is the greatest metals source. Of the treated effluents, Newtown Creek is the dominant source. Three CSOs, Bowery Bay, Jamaica, and Newtown Creek, may also be important local sources of total mercury and total lead.

Table 106. Instantaneous metal loads in g/hr.

Site	Ag, D	Ag, T	Cd, D	Cd, T	Hg, D	Hg, DM	Hg, T	Pb D	Pb, T
CSO; Bowery Bay High Side	2.9	60	0.18	12	0.018		6.0	4.9	700
CSO; Bowery Bay Low Side	0.21	0.50	0.19	2.4	0.023	0.00023	1.4	5.3	160
CSO; Coney Island Influent		0.33		0.85			0.63		62
CSO; Hunts Point Influent	0.21	7.2	0.050	2.5	0.021		1.7	3.0	240
CSO; Jamaica Influent	3.8	15	0.25	2.5	0.099	0.0072	2.0	9.6	150
CSO; Manhattan Grit Chamber	0.092	1.4	0.0062	0.59	0.0058	0.0011	0.29	0.97	69
CSO; Manhattan Pump Station	1.7	5.5	0.29	1.4	0.025	0.00071	1.5	4.1	7.0
CSO; Newtown Creek Influent	0.24	3.1	0.32	4.8	0.022	0.00036	1.3	8.6	320
CSO; North River Influent	1.3	16	0.055	1.1	0.0077		1.2	2.0	240
CSO; Owls Head Influent		0.50		0.96			1.4		84
CSO; Port Richmond Influent	0.010	0.037	0.0071	0.044	0.0019		0.024	0.45	4.3
CSO; Red Hook Influent	0.062	2.2	0.0064	0.64	0.0090		0.43	0.50	51
Industrial effluent; FK Plant Eff.	0.012	0.013	0.014	0.016	0.0021	0.000015	0.0029	0.058	0.15
Major tributary; Hudson R.			24	300	3.3	0.11	38	270	
Major tributary; Mohawk R.			53	930	7.4	0.12	112	660	17,000
Major tributary; Wallkill	8.8	101	5.5	140	4.8	0.035	44	76	4,000
Minor tributary; Bronx River			0.42	0.43	0.032	0.000018	0.065	0.12	
Minor tributary; Saw Mill River			0.069	0.082	0.014	0.00010	0.006		
WPCF; 26th Ward	0.74	4.3	0.47	0.54	0.061	0.00042	0.22	11	39
WPCF; Bowery Bay			0.99	1.3	0.058	0.0017	0.27		
WPCF; Coney Island			0.28	0.34	0.056	0.0013	0.15	7.8	
WPCF; Hunts Point	1.9	5.7	1.1	1.4	0.055	0.00075	0.20	8.2	18
WPCF; Jamaica	2.0	9.6	0.80	2.6	0.036	0.0016	0.57	6.2	24
WPCF; Newtown Creek	41	150	13	19	0.31	0.021	1.7	58	120
WPCF; North River			3.5	3.5	0.095	0.0023	0.36	31	38
WPCF; Oakwood Beach			0.17	0.22	0.011	0.00018	0.013	1.5	
WPCF; Owls Head			0.54	0.76	0.19	0.0014	0.37	12	
WPCF; Port Richmond	0.73	2.5	0.66	0.69	0.025	0.00050	0.083	6.2	9.7
WPCF; Poughkeepsie City	0.12		0.079	0.12	0.004	0.00021	0.033	0.77	1.2
WPCF; Red Hook			0.52	0.52	0.014	0.00089	0.053		
WPCF; Rensselaer			0.11	0.17	0.014	0.00022	0.043		
WPCF; Rockaway			0.095	0.17	0.011	0.00018	0.048	0.97	
WPCF; Rockland County			0.082	0.11	0.046	0.0015	0.19	1.1	
WPCF; Tallman Island			0.33	0.35	0.014		0.064	1.7	
WPCF; Wards Island			1.2	1.2	0.076	0.0007	0.25	15	
WPCF; Yonkers			0.72	1.1	0.067	0.0013	0.90	16	

Table 112 shows results of biosolids that were composited over the month of February, 2001. Not all of the 14 NYCDEP treatment plants treat sludges and those which do, may treat material from different facilities. Material from a particular facility often includes sludge from other plants

Table 107. Dewatered sludges, ng/g.

	Ag, T	Cd, T	Hg, T	Pb, T
SLUDGE: 26th Ward	34,000	4,900	2,600	250,000
SLUDGE: Bowery Bay	120,000	11,000	2,200	310,000
SLUDGE: Coney Island	53,000	4,200	2,800	240,000
SLUDGE: Hunts Point #10	92,000	10,000	4,100	110,000
SLUDGE: Hunts Point #9	57,000	7,600	2,000	340,000
SLUDGE: Jamaica	35,000	4,800	2,300	190,000
SLUDGE: Oakwood Beach	62,000	1,900	1,600	110,000
SLUDGE: Port Richmond	50,000	3,500	1,500	230,000
SLUDGE: Red Hook	89,000	6,500	2,300	350,000
SLUDGE: Tallman Island	88,000	6,400	2,600	200,000
SLUDGE: Wards Island, North	61,000	3,600	1,700	220,000
SLUDGE: Wards Island, South	180,000	5,700	2,600	340,000

Trackdown

Trackdown investigations attempted to discover the mercury source at the Rockland County WPCF. Samples were taken on March 8, 2000 and July 10, 2002 from sewers at sites selected by county personnel as capturing the major areas of the catchment (Figure 81). These failed to find clear evidence of a single source. A similar effort in the Newtown Creek area (February 15,2000 and January 18, 2001) may have found pipes worth exploring but follow-up sampling has not been done.

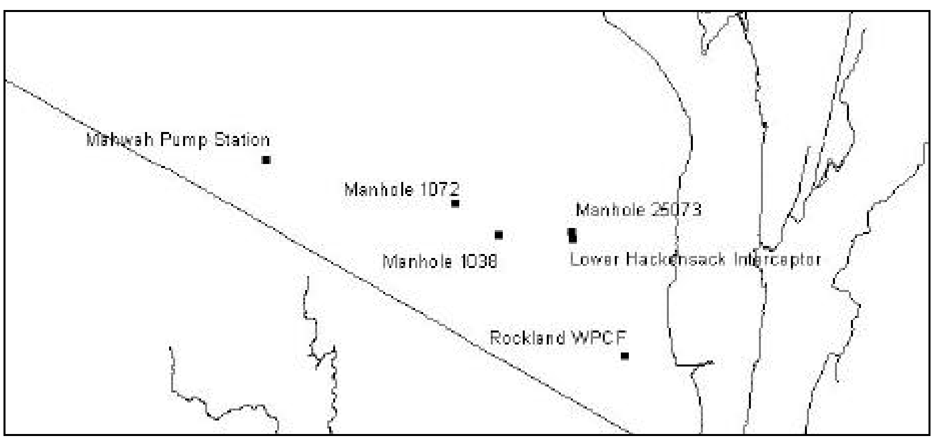


Figure 81. Locations of mercury trackdown sites in Rockland County.

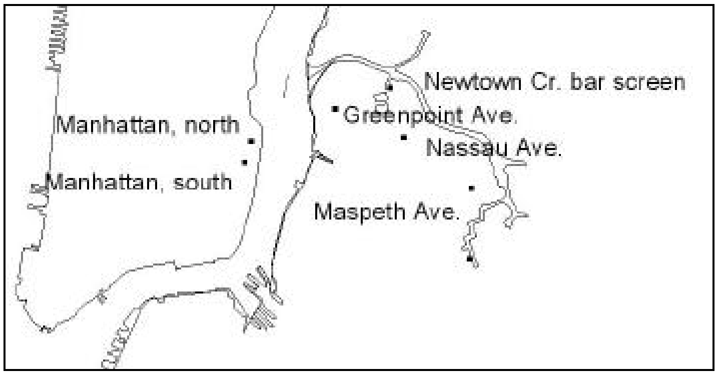


Figure 82. Mercury trackdown sites in the Newtown Creek area.

Table 108. Mercury trackdown at Newtown Creek and Rockland County.

Newtown Creek WPCF	Hg, dissolved	Hg, total
Greenpoint Ave.: 1/18/2001	16.1	
Greenpoint Ave.: 2/15/2000		69.2
Johnson Ave.: 1/18/2001	25.5	
Johnson Ave.: 2/15/2000		112
Manhattan, north: 1/18/2001	14.7	
Manhattan, north: 2/15/2000		192
Manhattan, south: 1/18/2001	31.3	
Manhattan, south: 2/15/2000		66.7
Maspeth Ave. & Verick St.: 1/18/2001	11.2	
Maspeth Ave. & Verick St.: 2/15/2000		236
Nassau Ave.: 1/18/2001	37.8	
Newtown Cr. WPCF, bar screen: 1/18/2001	31	
Rockland County		
Lower Hackensack Interceptor: 7/10/2002		456
Mahwah Pump Station: 3/8/2000	2.34	
Mahwah Pump Station: 7/10/2002		395
Manhole 1038: 3/8/2000	3.46	
Manhole 1038: 7/10/2002		245
Manhole 1072: 3/8/2000	4.29	
Manhole 1072: 7/10/2002		223
Manhole 25073: 3/8/2000	1.24	
Manhole 25073: 7/10/2002		493
Rockland WPCF, after screen: 7/10/2002		308
Rockland WPCF, bar screen: 3/8/2000	3.58	

Accessory Parameters

Particulate Organic Carbon (POC)

Hydrophobic contaminants are preferentially transported on particles, particularly the organic fraction. Particulate organic carbon (POC) is a measure of the organic content of filterable particles.

POC information is important in modeling transport of hydrophobic contaminants. To help in evaluating the data, duplicate samples (more than one analysis from a single sample) and replicates (more than one sample from a cruise or visit to a point source) were analyzed. The results were evaluated as relative percent differences (RPDs) where the range (maximum minus minimum) was divided by the average. Table 114 shows averages, counts, and standard deviations of RPDs groups by time (duplicates), events (replicates) and sites. Counts are the number of RPDs, not the number of samples involved.

Table 109. RPDs (as percents) comparing duplicates, replicates, and multiple samples at a site

	Average	Count	StDev
Time (duplicates)	39	36	37
Sampling event (replicates)	57	31	61
Sites	140	45	83

This analysis shows that multiple analyses taken from the same sample are more similar than samples taken from a location at different times which are, in turn, more similar than samples taken from the same site on different days. This table also illustrates the difficulties in measuring POC.

Table 115 shows the general trends in POC concentrations of the various sample types investigated by CARP.

Table 110. POC concentrations by sample type.

Sample type	Average	Count	StDev
CSO/SWO	24	4	31
WPCF	3.4	51	5.8
Major Tribs	3.3	37	3.7
AMB-Kills	0.95	28	0.76
AMB-Non_Kills	0.82	23	0.5
Minor Tribs	0.72	13	0.6
AMB-Hudson	0.56	16	0.27
Treated Leachate	0.3	4	0.11
AMB-Clean	0.13	8	0.049

The averages range over two orders of magnitude between the Long Island Sound/New York Bight samples and CSOs/SWOs. Generally, the range of POC concentrations across sites is much smaller than those for chemicals. Some of this may be due to very different types of organic carbon. For example, the organic carbon in the Bight may be largely due to plankton, where as that in the rivers may be largely due to suspended sediments. This relationship will be explored when we compare POC with suspended sediment.

Some of the sample types show relatively high variabilities. The highest variability is from CSOs and SWOs. Major tributaries, ambient samples, and POTW final effluents also have standard deviations greater than the mean. Tables 116, 117, and 118 show, respectively, more detail for these particular sample types.

Table 111. POC in Major Tributaries

	Average	Count	StDev
Wallkill (New Paltz)	4.6	12	5.3
Mohawk R. (Cohoes)	3	12	2.9
Hudson R. (Pleasantdale)	2.1	11	1.6

Table 112. POC in Ambient Waters

	Average POC	Count	StDev
Hudson R. at Poughkeepsie	2.5	8	0.75
Passaic River, Mid-Tidal	1.5	4	1.1
Hackensack R., Mid-Tidal	1.5	4	1
Lower Bay	1.1	4	0.74
Jamaica Bay	1	4	0.31
Passaic R., Mouth, Bottom	1	4	0.59
Raritan Bay	0.94	4	0.62
Hackensack R., Mouth	0.89	4	0.8
Lower East R.	0.86	4	0.41
Northern Arthur Kill	0.74	4	0.17
Hudson R. S. of Tappen Zee	0.74	4	0.14
Passaic R., Mouth, Surface	0.58	3	0.81
Hudson R. South of Harlem R.	0.5	5	0.27
Hudson R. below Kingston	0.49	3	0.22
Haverstraw Bay	0.49	4	0.4
Upper East R.	0.49	4	0.36
Newark Bay	0.47	5	0.18
Upper Bay	0.41	3	0.28
Long Island Sound	0.17	3	0.051
New York Bight	0.099	5	0.021

Table 113. POC in POTW final effluents.

	Average	Count	StDev
Poughkeepsie (C)	16	3	20
Newtown Creek	8.7	3	5.4
Rockland County	4.4	3	4
Yonkers	4.3	3	5
Port Richmond	4	3	2.6
Jamaica	3	3	3.2
Owls Head	2.7	3	1.9
Rensselaer	2.3	3	1.8
Red Hook	2.2	2	0.36
Bowery Bay	1.9	3	2.8
26th Ward	1.8	3	1
Coney Island	1.6	3	1.2
Hunts Point	1.5	3	1.7
Tallman Island	1.5	3	0.75
Oakwood Beach	1.1	2	0.16
North River	1.1	3	0.65
Wards Island	0.85	3	0.74
Rockaway	0.39	2	0.08

Dissolved Organic Carbon (DOC)

DOC is filtered and acidified in the field. Relative to POC, there is much less handling and hence, there is less opportunity for contamination. Furthermore, the sample, filtered water, is more homogeneous than subsamples of a filter. This is reflected in the small relative percent differences from replicates (multiple samples taken during a cruise or visit).

Table 114. DOC concentrations by sample type.

Sample type	Average	Count	StDev
LANDF	450	10	490
CSO	300	2	57
INDEF	63	3	98
WPCF	32	44	120
Minor_TRIB	7.4	9	3.3
AMB-Kills	7	27	3.2
AMB-Hudson	4.8	14	2
Major_TRIB	4.7	35	1.6
AMB-clean	4.5	9	5.5
AMB-Non_Kills	4.4	23	3.2

Table 115. DOC concentrations in tributaries

	Average	Count	StDev
Wallkill (New Paltz)	6.2	12	1.9
Hudson R. (Pleasantdale)	3.9	11	0.59
Mohawk R. (Cohoes)	3.9	12	0.42

Table 116. DOC concentrations in ambient sites.

	Average	Count	StDev
Northern Arthur Kill	10	3	7.4
Hackensack R., Mid-Tidal	9.7	4	2.9
Upper East R.	7.3	4	6.8
Passaic R., Mouth, Bottom	6.9	4	1.9
Hackensack R., Mouth	6.9	4	1.7
Hudson R. S. of Tappen Zee	6.8	5	3.5
Passaic R., Mouth, Surface	6.3	4	1.3
Passaic River, Mid-Tidal	5.9	3	1.1
New York Bight	5.6	5	7.6
Upper Bay	5.2	4	2.7
Hudson R. below Kingston	4.8	3	1.3
Hudson R. S. of Harlem R.	4.4	4	1.6
Newark Bay	4.3	5	1.1
Haverstraw Bay	4.3	3	0.62
Jamaica Bay	3.9	4	1.1
Hudson R. at Poughkeepsie	3.7	8	0.61
Raritan Bay	3.3	4	0.71
Lower East R.	3.3	3	0.53
Long Island Sound	3.2	4	0.94
Lower Bay	3.2	4	0.81

Table 117. DOC concentrations in final WPCF effluents.

	Average	Count	StDev
Red Hook	420	2	580
Newtown Creek	24	3	3.9
Rensselaer	22	2	4.3
Rockland County	21	3	6.9
Poughkeepsie (C)	20	2	13
Port Richmond	17	3	3.2
Yonkers	13	3	5
North River	11	2	1.2
Jamaica	11	1	
Oakwood Beach	9.9	3	0.97
Bowery Bay	9.4	3	1.7
Hunts Point	9.4	2	0.43
Owls Head	9	1	
26th Ward	8.8	3	1.7
Tallman Island	8.5	2	0.26
Rockaway	8.2	3	0.88
Coney Island	8.1	3	0.59
Wards Island	7	3	1.1

The unusually high concentration at Red Hook is due to a single sample taken on February 3, 1999 and having a reported value of 837 mg/L. One other DOC sample from Red Hook (April 14, 1999) had a reported concentration of 12 mg/L.

Dissolved organic carbon concentrations were greatest in landfill leachate, CSOs, and one POTW final effluent sample. The mean of the DOC field blanks was 1.6 (StDev=1.4).

Suspended Sediments (SS)

Suspended sediments were processed by USGS (major tributaries and Hudson River at Poughkeepsie) by weighing the entire contents of the sample bottles. The alternative approach, usually called "TSS" (total suspended solids) takes a well-stirred aliquot from the sample container. TSS is an appropriate parameter for samples that have no dense particles that might settle out between mixing and pouring. TSS is commonly used to evaluate WPCF effluent when sand grains, for example, are unlikely to be present. Suspended sediment is the appropriate parameter for surface waters. During CARP, filtration was performed in the field using either continuous pumping through a filter or grab samples that were poured through a vacuum filter. Distilled water was subsequently pumped through the filter to remove salts. In essence, all samples are "suspended sediment".

The reproducibility of suspended sediments within a survey was assessed by replicates (several samples taken in a survey). The mean and median relative percent differences (RPDs) were 44% and 23% respectively.

Table 123. Area averages, suspended sediments.

	Average	Count	StDev
CSO	220	6	110
Major_TRIB	95	35	130
AMB-Hudson	34	24	62
AMB-Kills	23	34	19
INDEF	17	4	13
AMB-Non_Kills	14	27	12
WPCF	12	61	14
Minor_TRIB	7.5	14	8
AMB-clean	4.8	10	2.5

Table 118. Suspended sediment averages from major tributaries.

	Average	Count	StDev
Mohawk R. (Cohoes)	110	12	130
Wallkill (New Paltz)	100	12	160
Hudson R. (Pleasantdale)	72	11	81

Table 119. Suspended sediments from ambient sites.

	Average	Count	Std Dev
Haverstraw Bay	120	3	170
Hudson R. at Poughkeepsie	90	8	28
Hackensack R., Mid-Tidal	43	4	9.6
Hudson R. S. of Tappen Zee	34	3	17
Passaic R., Mouth, Bottom	33	3	18
Lower East R.	25	4	23
Passaic River, Mid-Tidal	24	4	17
Hudson R. S. of Harlem R.	18	6	15
Jamaica Bay	17	4	13
Hudson R. below Kingston	17	3	10
Upper East R.	14	3	9.8
Lower Bay	13	3	9.8
Passaic R., Mouth, Surface	13	4	9
Northern Arthur Kill	12	3	8.7
Hackensack R., Mouth	11	4	9.4
Newark Bay	11	4	9
Upper Bay	9.8	4	5.6
Raritan Bay	8.2	4	4.7
Long Island Sound	6.3	3	2.2
New York Bight	5.1	4	3.2

Table 120. Suspended sediments from WPCFs.

	Average	Count	StDev
Poughkeepsie	37	3	42
Newtown Creek	29	4	13
Hunts Point	18	4	20
Jamaica	13	4	5
Yonkers	13	4	10
Owls Head	12	4	10
Rockland County	11	3	7
Port Richmond	9.5	3	6.6
Rensselaer	9.4	3	5.4
Rockaway	9.4	3	7.8
Bowery Bay	8.1	3	7.7
26th Ward	7.8	4	3.7
Red Hook	7.4	2	0.5
North River	5.6	4	1.8
Coney Island	5.1	4	3.5
Oakwood Beach	4.2	3	2
Tallman Island	3.7	3	0.4
Wards Island	3.3	3	1.3

Loads

Average instantaneous loads of the three accessory parameters are given for the tributaries and the WPCFs, all in metric tons per hour (mT/hr). Of the major tributaries, the Mohawk appears to be the greatest source. Newtown Creek is the largest source among the WPCFs for POC and SS but Red Hook seems the largest WPCF source of DOC. The value should be considered in light of the very small sample size (two observations) and the disparity between the two observations.

Table 121. Loads (in metric tons/hour) of accessory parameters.

Site	POC mT/hr	DOC mT/hr	SS mT/hr
Major tributary: Hudson R.	6.3	7.9	228
Major tributary: Mohawk R.	8.8	8.0	339
Major tributary: Wallkill	4.7	2.1	124
Minor tributary: Bronx River	0.0005	0.055	0.040
Minor tributary: Saw Mill River	0.0038	0.081	0.079
WPCF: 26th Ward	0.012	0.090	0.073
WPCF: Bowery Bay	0.041	0.17	0.17
WPCF: Coney Island	0.017	0.12	0.062
WPCF: Hunts Point	0.029	0.21	0.75
WPCF: Jamaica	0.088	0.14	0.19
WPCF: Newtown Creek	0.39	1.0	1.1
WPCF: North River	0.035	0.27	0.11
WPCF: Oakwood Beach	0.0044	0.044	0.018
WPCF: Owls Head	0.034	0.16	0.12

WPCF: Port Richmond	0.030	0.14	0.07
WPCF: Poughkeepsie City	0.022	0.018	0.049
WPCF: Red Hook	0.012	2.2	0.040
WPCF: Rensselaer	0.0071	0.068	0.032
WPCF: Rockaway	0.0013	0.027	0.036
WPCF: Rockland County	0.010	0.060	0.027
WPCF: Tallman Island	0.0079	0.061	0.027
WPCF: Wards Island	0.028	0.21	0.10
WPCF: Yonkers	0.047	0.17	0.17

CONCLUSIONS AND RECOMMENDATIONS

The compilation shown here only begins to display the CARP data. Loading calculations and mass transport still require a great deal of further effort. Furthermore, more work will go into integrating results from the biota and sediment programs with the water section. Much of the focus of the present discussion has been on sources. The major tributaries seem to be the dominant loading sources for all of the analytes but some congener evidence suggests, for PCBs and dioxins, significant unidentified sources. The efficiency of transport of toxic substances through 150 miles of estuary still needs research. This has begun.

For the most part, areas of the harbor thought to be cleanest are freest of the target substances and those areas thought to be most contaminated, are. Perhaps the weakest element in sampling was the CSOs. These should have been sampled more intensively but the logistics of CSO sampling, even wet-weather influents, are formidable. Tributary sampling can also be improved. The Wallkill New Paltz site may have been too far from the river's mouth. The timing of the upper Hudson samples may have been somewhat inappropriate in that CARP concentrated on high flow periods to the neglect of times when biopertubation may have resulted in significant loads. Too much effort may have gone into sampling wastewater treatment plants. They do not appear to be particularly significant loading sources.

One of the most unexpected discoveries was the prevalence of a hither to unknown PCB congener, 3,3'-dichlorobiphenyl. Trackdown work has both confirmed the source and opened questions (the source of and disappearance of IUPAC 77) that have yet to be resolved. While very important in a few sewage treatment plant outfalls, 3,3'DiCB is probably not a significant component of sediments or of biota. CARP has confirmed significant loadings from the upper Hudson River. However, downstream PCB loads are apparent in the changing congener distributions between upstream and downstream areas. A clear PCB source is seen in the 26th Ward WPCF in Brooklyn. However, the impact of this source on the receiving body, Jamaica Bay, is not apparent. There is also not a clear route to the remediation of the 26th Ward Aroclor 1260. Initial trackdown work at the Newtown Creek WPCF suggests the desirability of tracking PCBs back on two sewer mains. This has not yet been done.

Dioxin/furan "fingerprints" have turned out to be stable and perhaps diagnostic. Reduction in harbor dioxin concentrations will require gaining a much better understanding of the sources of some of the non-2,3,7,8-TCDD congeners. There may be a significant source of 2,3,4,7,8-PeCDF in the lower Hudson. Some other dioxins might turn out to be characteristic of urban wastewater. Related investigations from the World Trade Center disaster suggest that other dioxin-like substances should be addressed. These other substances include the co-planar PCBs and the brominated dioxins/furans. Better analytical methods and a great deal of toxicological work are required before routine monitoring of some of these dioxin-like materials becomes practical.

An early discovery of CARP was the significance of the Wallkill as a source of DDTs and dieldrin. Control of this source will require attention of sediment transport and sediment loading. Mechanisms for doing this have yet to be revealed. The actual impact of the Wallkill pesticides on the Hudson River and on the Harbor ma y be confused by the location of the sampling point, upstream of a deposition area (Sturgeon Pool).

Among the weakest parts of CARP was PAH sampling. The problems of addressing at least two very different models of PAH impact were not sufficiently appreciated at the beginning and were not corrected during CARP. There also needs to be a better toxicological understanding of the impact of PAHs on benthic test organisms. Further sampling might be postponed until the toxicology is better understood and the sampling problems are corrected. We lack a good way to field-concentrate dissolved PAHs. CARP has shown that some of the methylated PAHs are very abundant.

Metal loading appears to be largely driven by the major tributaries, but there are exceptions. Mercury trackdown at Rockland WPCF was unsuccessful, but that work should be completed. Metals sources to the Newtown Creek WPCF appear numerous but success in identifying and reducing sources will be challenging. Some of the CSOs may also be significant metals sources but the limited sampling calls the ultimate value of the loadings into question. There should be more work done on metals from CSOs and SWOs. Portable low-level mercury analyzers may play a useful role in describing mercury sources and in ultimate remediation.

Perhaps the most fruitful area for follow up will be the accessory parameters, particularly suspended sediment and POC. These very inexpensive parameters may yield important information on the behavior of the overall estuarine/harbor system. Sampling for the accessory parameters was weak as the numerous holes in the database attest. Effort is underway to begin developing suspended sediment data from the Hudson (ny.usgs.gov/projects/poused/index.html), Schoharie Creek, and the Wallkill. This should lead to better information about loadings of sediment to the basin which, in turn, may help in reducing the sediments.

CARP has been very successful in the development of field and analytical methods, particularly for PCBs, chlorinated dioxins/furans, and some of the chlorinated pesticides. Substances often reported as non-detected or simply ignored because of detection limits were routinely quantitated. The measurement of trace organic chemicals in the open ocean is perhaps unique. CARP has led to the development of powerful data management systems without which the volume of data would have utterly swamped the investigators.

This report is the conclusion of the first phase of CARP. Subsequent work could include addressing areas of weakness, follow-up on chemical source identification, and the design and implementation of a cost-effective long term monitoring program that would document effective clean-up and timely identification of emerging pollutants.

ABBREVIATIONS

Table 122. Abbreviations and acronyms.

abbr.	full name
AAS	Axys Analytical Services, a contract laboratory
Ag	silver
AMB	abbreviation for "ambient"
BAF	bioaccumulation factor
CARP	Contaminant Assessment Reduction Project
CCMP	Comprehensive Conservation Management Plan
Cd	cadmium
CFS	cubic feet per second
CSO	combined sewer overflow
DOC	dissolved organic carbon
DU	duplicate
EB	equipment blank
Eff.	effluent
EPA	US Environmental Protection Agency
FB	field blank
FGS	Frontier Geoscience, a contract lab
FK	Fresh Kills
HCB	hexachlorobenzene
HCH	hexachlorocyclohexane
HEP	Harbor Esturary Program
Hg	mercury
HMDC	Hackensack Meadowlands Development Commission
HpCDD	heptachlorodibenzo dioxin
HpCDF	heptachlorodibenzo furan
HRGC	high resolution gas chromatography
HRMS	high resolution mass spectrometry
HxCDD	hexachlorodibenzo dioxin
HxCDF	hexachlorodibenzo furan
Inf	influent
IUPAC	International Union of Applied and Physical Chemistry
mg	milligram
mg/L	milligram per liter, part per million
MGD	million gallons per day
ng	nanogram
ng/L	nanogram/liter, or part per trillion
NYCDEP	New York City Department of Environmental Protection
NYCDOS	New York City Department of Sanitation
NYSDEC	New York State Department of Environmental Conservation
OCDD	octachlorodibenzo dioxin
OCDF	octachlorodibenzo furan
PAH	polynuclear aromatic hydrocarbon
Pb	lead

Table 129 continued.

abbr.	full name
PCB	polychlorinated biphenyl
PeCDD	pentachlorodibenzo dioxin
PeCDF	pentachlorodibenzo furan
pg	picogram
pg/L	picogram per liter (part per quadrillion)
PISCES	Passive In-Situ Chemical Extraction Sampler
POC	particulate organic carbon
PVSC	Passaic Valley Sewerage Commissioners
QTS	Quanterra, now called Severn Trent Laboratories, a contract lab
SA	sample
SDG	sample delivery group
SS	suspended sediment
SWO	storm water outfall
TCDD	tetrachlorodibenzo dioxin
TCDF	tetrachlorodibenzo furan
TDDT	total DDT
TEF	toxic equivalency factor
TEQ	toxic equivalence
TSS	total suspended solid
USACOE	US Army Corps of Engineers
USGS	US Geological Survey
WHO	World Health Organization
WPCF	water pollution control facility
WQS	water quality standard
WSU	Wright State University, acting as a contract lab
XAD	XAD, not an abbreviation.