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New York State Department of Environmental Conservation

Hudson River Sediment and Biological Survey

Division of Water

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Introduction

In 1997, the Division of Water submitted a proposal to the Hudson River Estuary Management Program (HREMP) to conduct biological monitoring within the lower Hudson River. The biological monitoring would occur at sites where sediment cores were to be evaluated for chemical and physical parameters that were funded under a different proposal under HREMP.

Sediment and benthic samples were collected in the fall of 1998, between Albany (140.5 river mile) and Peekskill, NY (42 river mile).

Objective and Scope

The objective of this project was to characterize sediment quality using the triad approach. This approach uses sediment chemistry, toxicity results, and benthic assessments to describe the sediments. This approach has also been used to develop chemical specific sediment quality criteria (Chapman, 1986[i]; Long, 1998[ii]).

Two sediment cores were collected at six locations from Albany to Peekskill. These areas represent depositional zones within the river and salinity gradients from freshwater at Albany to Newburgh and "Oligohaline" (0.5 – 5.0 psu) between Newburgh and Peekskill. The locations were from south to north, Lents Cove (LC), Iona Island (II), Foundry Cove (FC), Inbocht Bay (IB), Athens (At), and the Turning Basin (TB). Sampling locations are shown in Figures 1 and 2.

Figure 1: Sampling Locations - North

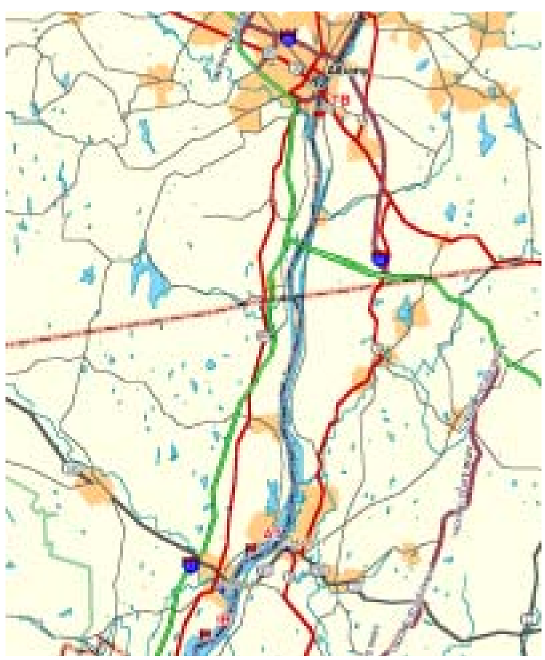

Figure 2: Sampling Locations - South

One core was used for analytical results, while the other was used for dating through radio isotopic analysis. Sediments were analyzed for physical and chemical parameters from varying horizontal strata within the core. The sites were selected randomly and without any prior information on the characteristics or contaminants at these sites, with the exception of Foundry Cove.

Foundry Cove had historically high levels of cadmium, nickel and cobalt from a former nickel-cadmium battery manufacturing factory located nearby. In 1993, a remediation project was conducted to remove 12 metric tons of the estimated 22 metric tons calculated to be there.

At each of these sediment-sampling points, benthic samples were collected to count and identify macroinvertebrates. Ponar samples were sieved and preserved for processing by DEC personnel according to the Stream Biomonitoring SOP.

A third sample was collected from each site and submitted for toxicity testing. These samples were submitted to a private laboratory for acute freshwater toxicity testing using the 10-day *Chironomus tentans* and the *Hyalella azteca* tests.

The results from the physical and chemical analysis of the sediments would be compared to the benthic and toxicity results to determine if any relationships were observed. This will also give an overall assessment of the sediments.

The sample results were compiled and compared to MacDonald's consensus-based numerical sediment quality guidelines (SQGs) for 28 chemicals for freshwater sediments.[iii] These represent the latest values derived from an expanded database of freshwater sediment chemistry and toxicity results. The threshold effect concentration (TEC) and probable effects concentration (PEC) were calculated from the geometric means of the SQGs. The TECs represent the concentrations below which adverse effects on sediment-dwelling organisms are not expected to occur. The PECs represent the concentration above which adverse effects on sediment-dwelling organisms are likely to be observed.

The Tables presented in this report show only for the surficial samples results, since they will impact the toxicity and benthic community structure. The results for the entire core at each site are attached as Appendix A. The data for the entire data set is based on core segments. The core segments represent depth (in centimeters) from the surface or top of the core. Data cells that are greater than the TEC and less than the PEC are filled in yellow, while cells greater than the PEC are filled in red.

Methods

The analytical procedures used in the physical and chemical results are presented in Table 1.

Table 1: Analytical Methods and QAQC Requirements

PARAMETER	RESPONSIBLE LAB	STANDARD METHOD	PRECISION	ACCURACY	CALIBRATION INITIAL	CALIBRATION ONGOING	BLANKS	DETECTION LIMIT [1]
RADIOISOTOPE DATING 7-BERYILLUM,137-CESIUM, 210-LEAD	RPI	gamma spectroscopy	± 10%	± 5%	ANNUAL	WEEKLY	BIWEEKLY	---
DIOXIN/FURAN - 2,3,7,8-SUBSTITUTED CONGENERS AND TETRA THRU OCTA HOMOLOG TOTALS	Contract Lab	EPA-1613B	± 40% [2]	± 40% [2]	when necessary	DAILY	PER METHOD	---
PCB CONGENERS (MS)	Contract Lab	HRMS-1	± 60%	± 40%	when necessary	DAILY	1/ batch or 20 (max.)	0.4-46 ng/kg
ORGANOCHLORINE PESTICIDES, PCB AROCLORS	Contract Lab	EPA- 8081	± 50% RPD	25-160%	5 pt. crv	EVERY 10 SAMP.	1/ batch or 20 (max.)	---
ORGANOCHLORINE PESTICIDES (MS)	Contract Lab	HRMS-2	± 60%	± 40%	when necessary	DAILY	1/ batch or 20 (max.)	25 ng/kg
METALS								
Al	Contract Lab	EPA-239.2 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	4.5
Sb	Contract Lab	EPA-239.2 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	3.2
As	Contract Lab	EPA-239.2 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	5.3
Ba	Contract Lab	EPA-239.2 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	0.2
Be	Contract Lab	EPA-239.2 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	0.
Cd	Contract Lab	EPA-239.2 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	0.4
Ca	Contract Lab	EPA-239.2 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	1.
Cr	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	0.7
Co	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	0.7
Cu	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	0.6
Fe	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	0.7
Pb	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	4.2
Mg	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	3.
Mn	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	0.2
Hg	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	
Ni	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	1.5
K	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	
Se	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	7.5
Ag	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	0.7
Na	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	2.9
Tl	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	4.
V	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	0.8
Zn	Contract Lab	EPA-200.7 CLPM	± 20% RPD	± 20%	DAILY	EVERY 10 SAMP.	EVERY 10 SAMP.	0.2
Hg (Total)	Contract Lab	EPA-1631	± 20% RPD	± 20%	DAILY	2 per batch	EVERY 10 SAMP.	2 ng/g
Hg (Methyl)	Contract Lab	EPA-1630	± 20% RPD	± 20%	DAILY	2 per batch	EVERY 10 SAMP.	0.005 ng/g
POLYNUCLEAR AROMATIC HYDROCARBONS (MS)	Contract Laboratory	HRMS-3	± 60%	± 40%	when necessary	DAILY	1/ batch or 20 (max.)	0.6 µg/kg
POLYNUCLEAR AROMATIC HYDROCARBONS	Contract Laboratory	EPA-8310	± 20% RPD	30-150%	6 pt. crv	EVERY 10 SAMP.	1/ batch or 20 (max.)	---
TVS	Contract Lab	ASTM D2974	PER METHOD	PER METHOD		NA		0.10%
TOC	Contract Lab	9060 W/LLOYDKAHN	± 20% RPD	± 20%	ICV/CCV 15%			20.
Grain Size	Contract Lab	ASTM D421/D422	PER METHOD	PER METHOD		NA		NA

The laboratories used in this study are listed below:

Metals, TOC and Grain Size:

RECRA Environmental Laboratories
Ms. Judy Stone
208 Welsh Pool Road
Lionville, PA 19341
(610) 280-3000

Organics:

Axys Analytical Laboratories
Ms. Laurie Phillips
2045 Mills Road
Sidney, B.C. Canada V8L 3S8
(888) 373-0881

Toxicity Testing:

Aquatec Laboratories
Mr. John Williams
75 Green Mountain Drive
S. Burlington, VT 05403
(802) 860-1638

Radio Dating:

Rensselaer Polytechnic Institute (RPI)
Dr. Richard Bopp
West Hall, Room 103
Troy, NY 12180
(518) 276-3075

Core sampling in the Hudson River was performed from the NYSDEC pontoon boat using a PVL vibrocore. DEC personnel performed all vibrocore sampling in accordance with the manufacturer's instructions. New, polycarbonate, 5- or 10-cm core tubes were used for each core. Immediately after each sample was collected, the bottom of the core tube was securely capped, taped and the top marked with site location, date and time. The location was obtained using a hand-held Magellan GPS and post-processed for increased accuracy.

A visual inspection of each capped sediment core tube was performed. The overall core length and individual horizons or strata within each core were measured. These measurements and all significant features were documented in the field notebook along with the date, time, and location of sample collection.

Each sediment core was taken to shore for sample processing. The core sample was examined and sub-sectioned into at least two parts. Sediment core sub-sections were selected for analysis by a visual determination of the depositional strata present in the core. Specifically, a near-surface increment was selected from each core to characterize the sediments at the sediment/water interface. Additional sub-samples were then selected from layers that appeared to be dark in color and rich in organic content. A tubing cutter or sediment extruder apparatus was used to remove sediments from the core tube for analysis.

Teflon-coated disposable spatulas were used to section the sediment cores. All sample material was collected from the center of the core with the new spatula. This technique was employed to avoid sample contamination along the interface of the sediment sample and the tubing, where material can mix with upper layers of sediments during core penetration. Sample material was homogenized in a sample container or in a clean Teflon mixing bowl and then placed in a sample container. All sample containers were labeled using a permanent marker to indicate the date, time, analyses, and sampling location. This information was recorded in a field notebook and on a chain of custody form. All sample bottles were placed in coolers with ice after collection and then refrigerated or shipped immediately upon return to the DEC office. For shipping, the samples were packed in coolers with ice packs and sent via overnight delivery to DEC contract laboratories.

Radiometric samples were collected using the same methods as above except for the use a 5 cm core tube. The entire tube was submitted to RPI for sediment dating. At the lab, the core was extruded in 2 cm increments to 8 cm than every 4 cm to the end of the core. The sediments were then dried and placed in a container awaiting radio nuclei counting.

Surficial samples in the river were collected from the DEC pontoon boat using a standard ponar sampler. The ponar was decontaminated with detergent and rinsed with ambient water prior to each use. For sample collection, the ponar was lowered down to the sediment surface. This was accomplished by hand in shallow waters or with the electric or manual winch in deeper waters. The ponar was then placed on deck and the screen lifted from the top of the sampler to expose the sediments. Sediments were removed through the top of the ponar using a new, disposable spatula. Only sediments not in contact with the sides of the sampler were removed and placed in a new or decontaminated container for homogenizing. These homogenized sediments were then placed in the appropriate containers for laboratory analysis. Ponar samples represent the top 6 to 10 cm of sediments.

Benthic samples were collected using a standard ponar. The contents of the ponar were placed in a bucket with a 600 μm sieve. The sediments were sieved and the material that would not pass through the bucket were placed in a container with a 95% alcohol preservative. Three replicate ponars were collected at each site and labeled with the site name plus A, B or C. The methods followed those found in Quality Assurance Work Plan for the Biological Stream Monitoring in New York State (1996)[iv].

The benthic samples were sorted, counted and identified down to the genus levels by DOW staff.

Toxicity samples were collected using a standard ponar. Three replicate samples were collected and composited in a single container for acute toxicity testing. The sample was refrigerated prior to shipment to the laboratory. The laboratory then homogenized the sample and split into eight replicate samples for each test.

Toxicity samples were run on the midge *Chironomus tentans* and the amphipod *Hyalella azteca*. The toxicity test endpoints were percent survival and weight for the 10-day test. Both tests followed EPA methods 100.1 and 100.2[v].

Total PCBs were calculated by summing all 209 congeners. For those values that were not detected, a value of one-half the detection limit was used. The dioxin/furan toxic equivalent value (TEQ) is the sum of all the chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans that have a 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) toxicity value. These 2,3,7,8 TCDD toxicity values are called the toxicity equivalent factor (TEF). The TEFs used in the calculation of the TEQ comes from the NYS Ambient Water Quality Standards and Guidance Values[vi].

All data that are less than the detection limit are represented with a "ND". Parameters represented with a "NA" were not analyzed, while "NS" indicates not sampled.

Results

Physical

The location and coring information for the six sites are listed in Table 2. The cores ranged in length from 80 cm to 172 cm.

Table 2: Sample Information

Location	Date	Time	County	River Mile	WaterDepth (m)	Lat (DD MM SS)	Long (DD MM SS)	Core length (cm)
Lent's Cove	10/30/1998	14:00	Weshchester	42.	1.	41 16 24.79	73 56 37.94	84.
Iona Island	10/30/1998	13:00	Rockland	45.	1.	41 17 51.27	73 58 01.88	116.
Foundry Cove	10/30/1998	11:30	Putnam	54.	1.3	41 24 36.22	73 57 24.94	172.
Inbocht Bay	10/29/1998	12:00	Greene	108.	0.5	42 10 21.19	73 53 17.96	80.
Athens	10/26/1998	12:10	Greene	116.8	0.7	42 14 42.74	73 50 06.85	96.
Turning Basin	10/21/1998	10:30	Rensselaer	140.5	1.9	42 36 47.98	73 45 26.39	115.5

The percent solids, total organic carbon (TOC) and total volatile solids (TVS) for the surficial samples from the six Hudson River sites are present in Table 3. The TOC ranged from 2.6 to 7.6 percent with a mean of 5. The grainsize data did show differences in percent sand between the three upriver sites, which averaged 17.7 percent, and the downriver sites, which averaged 7 percent. The percent clay varied between 21 and 31 percent. These differences were not considered to have a significant affect on the benthic results.

Table 3: Physical Data for Surficial Samples

PARAMETER	LC	II	FC	IB	At	TB	Units
TOC	7.6	4.9	6.1	5.	2.6	3.8	%
TVS	5.9	3.3	4.3	3.	4.4	5.5	%
GrainSize-%Sand	7.8	5.5	7.9	18.9	17.9	16.4	%
GrainSize-%Silt	66.7	66.2	60.6	60.1	56.	61.8	%
GrainSize- %Clay	25.6	28.4	31.5	21.	26.	21.8	%

Chemical

Metals

The metals results for the surficial results are presented in Table 4. The mercury values at the bottom of the table represent the high-resolution mercury analysis. The total mercury from this method did not always relate that closely to the value obtained in the CLP methods, but is considered a more realistic value. The average relative percent differences between the two total mercury methods was 26 percent, however, two samples had differences as much as 100 percent. The high-resolution method also provides the methyl mercury fraction that is considered the most toxic form of mercury.

Of the eight metals that have consensus-based guidance values, mercury and cadmium have the lowest TEC numbers, indicating the high level of toxicity associated with these two metals.

Inbocht Bay showed the lowest concentrations for nearly all metals measured, with only three metals exceeding the TECs. Two sites, Lents and Foundry Coves, had at least one metal concentration greater than the PEC, which would likely cause adverse biological effects. Chromium was nearly an order of magnitude greater than the PEC value at Foundry Cove indicating the impacts from Marathon Battery still affect this site.

Table 4: Metals Results for Surficial Samples

PARAMETER	TEC	PEC	LC Surf	II Surf	FC Surf	IB Surf	At Surf	TB Surf	Units
Aluminum			13,600.	12,800.	14,900.	10,100.	11,400.	10,500.	ppm
Antimony			3.3	1.5	1.	0.7	1.5	1.9	ppm
Arsenic	9.79	33.	22.9	21.3	19.8	11.6	14.7	12.9	ppm
Barium			354.	72.8	92.1	80.	97.	101.	ppm
Beryllium			0.86	0.87	0.91	0.61	0.69	0.64	ppm
Cadmium	0.99	4.98	4.24	1.91	34.5	0.64	0.59	0.82	ppm
Calcium			7,070.	4,610.	5,240.	4,820.	6,020.	10,500.	ppm
Chromium	43.4	111.	53.3	47.7	55.8	29.8	30.1	37.6	ppm
Cobalt			13.9	13.2	17.4	11.7	12.9	12.5	ppm
Copper	31.6	149.	171.	47.1	59.6	33.6	36.	42.2	ppm
Iron			25,600.	27,500.	32,400.	21,800.	23,600.	24,200.	ppm
Lead	35.8	128.	890.	50.9	61.8	27.8	30.8	36.9	ppm
Magnesium			7,120.	6,300.	6,720.	4,630.	5,590.	6,080.	ppm
Manganese			315.	954.	903.	464.	667.	1,040.	ppm
Mercury	0.18	1.06	0.87	0.34	0.22	0.2	0.15	0.27	ppm
Nickel	22.7	48.6	29.8	27.9	47.9	21.4	23.5	22.8	ppm
Potassium			1,510.	1,710.	2,020.	1,310.	1,340.	1,320.	ppm
Selenium			0.45	0.3	0.88	0.31	0.33	0.32	ppm
Silver			3.62	1.4	2.3	1.5	1.5	1.7	ppm
Sodium			2,710.	1,650.	1,440.	631.	762.	465.	ppm
Thallium			12.2	7.98	3.9	2.87	2.5	3.83	ppm
Vanadium			21.2	21.4	24.2	16.	17.7	18.5	ppm
Zinc	121.	459.	493.	154.	187.	115.	126.	136.	ppm
Percent Solids			30.4	45.1	33.7	43.9	42.8	45.4	%
Total Mercury	180.	1060.	1,450.	435.	463.	148.	215.	188.	ppb
Methyl Mercury			5.48	0.87	0.51	0.85	1.13	1.89	ppb

Lents Cove had copper, lead, mercury and zinc exceed the PEC guidance value. Only the high-resolution mercury exceeded the PEC. Methyl mercury had the highest concentration at this site and on the surficial layer. Methyl mercury levels actually decreased by half in the interval just below the surface.

Most heavy metals increase in concentrations the further down-river the Hudson you travel. Within the cores, the maximum concentrations of the eight metals with guidance values varied from site to site. Maximum concentrations were found in the lower segments in the Turning Basin and Inbocht Bay. Iona Island had higher concentrations at or near the surface. The other sites were varied over time.

Pesticides

There are six consensus guidance values for pesticides. The results for the surficial samples are presented in Table 5. The only TEC guidance values exceeded were total DDT and total chlordane. Total DDT is the sum of DDE, DDD and DDT. Total chlordane is composed of the sum of oxychlordane, alpha and gamma chlordane and cis and trans nanochlor. There were no exceedences of the PEC values for any pesticides.

The highest concentrations in the surficial sediments of DDT and chlordane were found in Lents Cove. For all samples collected, the highest concentration of total DDT was found in the core segment 26-46 cm from Foundry Cove.

Table 5: Pesticide Results for Surficial Samples.

Parameter	TEC	PEC	LC Surf	IL Surf	FC Surf	IB Surf	At Surf	TB Surf	Units
Heptachlor Epoxide	2,470.	16,000.	45.	4.4	8.8	ND	ND	ND	ppt
alpha-Endosulphan (I)			ND	ND	ND	ND	ND	ND	ppt
Dieldrin	1,900.	61,800.	500.	120.	92.	ND	122.	130.	ppt
Endrin	2,220.	207,000.	ND	6.3	4.5	ND	ND	ND	ppt
beta-Endosulphan (II)			91.	170.	ND	ND	ND	ND	ppt
Endrin Aldehyde			ND	ND	ND	ND	ND	ND	ppt
Endosulphan Sulphate			130.	63.	78.	89.	86.7	89.2	ppt
Endrin Ketone			ND	ND	ND	ND	ND	ND	ppt
Methoxychlor			ND	ND	ND	ND	38.7	48.7	ppt
Hexachlorobenzene			1,200.	380.	640.	309.	350.	556.	ppt
alpha HCH			34.	36.	31.	22.	ND	37.4	ppt
beta HCH			70.	67.	64.	ND	ND	61.7	ppt
gamma HCH	2,370.	4,990.	ND	35.	38.	ND	ND	50.9	ppt
Heptachlor			ND	4.1	6.3	ND	ND	4.6	ppt
Aldrin			88.	60.	52.	18.	ND	56.9	ppt
Oxychlordane			ND	ND	ND	ND	ND	ND	ppt
gamma-Chlordane (trans-)			4,600.	220.	210.	125.	140.	225.	ppt
alpha-Chlordane (cis-)			5,500.	230.	260.	134.	190.	277.	ppt
o,p'-DDE			400.	160.	ND	47.	76.	89.9	ppt
p,p'-DDE			11,000.	5,900.	6,200.	2,570.	2,600.	2,850.	ppt
trans-Nonachlor			2,300.	110.	120.	73.	91.	147.	ppt
cis-Nonachlor			1,200.	130.	87.	56.	ND	106.	ppt
o,p'-DDD			1,300.	470.	560.	145.	160.	416.	ppt
p,p'-DDD			6,800.	2,600.	3,000.	714.	730.	1,150.	ppt
o,p'-DDT			370.	170.	ND	83.	69.	106.	ppt
p,p'-DDT			2,000.	940.	780.	382.	340.	519.	ppt
Mirex			49.	6.8	6.5	7.	15.	18.	ppt
Total DDT	**5,280.**	**572,000.**	**21,870.**	**10,240.**	**10,540.**	**3,941.**	**3,975.**	**5,130.9**	**ppt**
Total Chlordane	**3,240.**	**17,600.**	**13,600.**	**690.**	**677.**	**388.**	**421.**	**755.**	**ppt**

PAHs

There are seven consensus guidance values for polynuclear aromatic hydrocarbons, (PAHs). The results are for the surficial samples are presented in Table 6. All results but one exceeded the TEC values. Four PAHs exceeded the PEC values at Lents Cove. The total PAH at Lents Cove was over twice the next highest concentration, which was at Foundry Cove.

Table 6: PAHs Result for Surficial Sediments

Parameter	TEC	PEC	LC Surf	IL Surf	FC Surf	IB Surf	AT Surf	TB Surf	Units
Naphthalene			170.	91.	100.	72.	60.	120.	ppb
Biphenyl			43.	30.	34.	21.	20.	41.	ppb
Acenaphthylene			89.	32.	37.	24.	4.2	13.	ppb
Acenaphthene			62.	23.	55.	23.	16.	33.	ppb
Fluorene			130.	51.	94.	38.	42.	73.	ppb
Phenanthrene	204.	1,170.	1,000.	310.	580.	230.	230.	430.	ppb
Anthracene			200.	81.	150.	70.	63.	97.	ppb
Fluoranthene	423.	2,230.	3,300.	800.	1,400.	460.	410.	740.	ppb
Pyrene	195.	1,520.	2,300.	620.	880.	340.	390.	640.	ppb
Benz[a]anthracene	108.	1,050.	1,200.	320.	460.	190.	200.	300.	ppb
Chrysene	166.	1,290.	1,600.	420.	560.	280.	280.	430.	ppb
Benzo[b/j/k]fluoranthenes			2,600.	940.	1,200.	400.	480.	890.	ppb
Benzo[e]pyrene			1,100.	300.	360.	160.	180.	320.	ppb
Benzo[a]pyrene	150.	1,450.	1,400.	400.	490.	200.	220.	380.	ppb
Perylene			710.	840.	960.	450.	430.	270.	ppb
Dibenz[ah]anthracene			220.	57.	67.	31.	33.	66.	ppb
Indeno[1,2,3-cd]pyrene			950.	280.	330.	140.	160.	290.	ppb
Benzo[ghi]perylene			960.	240.	280.	120.	ND	260.	ppb
C1 Naphthalenes			300.	120.	170.	120.	65.	110.	ppb
C2 Naphthalenes			390.	150.	230.	130.	73.	160.	ppb
C3 Naphthalenes			410.	130.	230.	87.	83.	120.	ppb
C1 Phenanthrenes/Anthracenes			1,300.	340.	620.	230.	210.	320.	ppb
Total PAH	**1,610.**	**22,800.**	**20,434.**	**6,575.**	**9,287.**	**3,816.**	**3,649.2**	**6,103.**	ppb

PCBs

All six sites exceeded the PEC for total polychlorinated biphenyls, or PCBs. The results are presented in Table 7. The total PCB was calculated from the sum of the 209 congeners. For those values that were not detected, a value of one-half the detection limit was used.

The lowest concentrations in the surficial sediments were found in Inbocht Bay and Athens. The highest concentration in all samples analyzed was from Foundry Cove. This site had a concentration of 8.3 ppm in the core section from 26-46 cm below the surface, which was the highest concentration found in any of the samples analyzed.

In general, the surficial PCB concentrations were decreasing from past levels found further down in the core at all sites.

Table 7: Total PCBs for Surficial Sediments

	TEC	PEC	LC	Il	FC	IB	At	TB	Units
Total PCB	0.06	0.68	1.89	1.46	1.72	0.97	0.93	1.87	ppm

Dioxins/Furans

The dioxin and furans were summarized to their TCDD equivalents (TEQs). The results are presented in Table 8. The lowest TEQs were found in Athens and Inbocht Bay, while the highest TEQs were found at Lents Cove.

The results show that TEQs generally went up the further downriver. The highest TEQ found in all samples was from the 26 to 46 cm segment from Foundry Cove, 47.9 ppt.

Table 8: Dioxin/Furan TEQs for Surficial Sediments

Depth	TEF	LC	II	FC	IB	At	TB	Units
2,3,7,8-TCDD	1.	1.17	1.05	1.3	0.51	0.27	0.6	ppt
1,2,3,7,8-PeCDD	0.5	4.38	1.73	1.94	0.72	0.48	1.28	ppt
1,2,3,4,7,8-HxCDD	0.1	5.88	3.18	3.53	1.35	0.86	2.49	ppt
1,2,3,6,7,8-HxCDD	0.1	25.1	17.8	17.3	6.52	3.74	8.7	ppt
1,2,3,7,8,9-HxCDD	0.1	10.7	10.8	10.4	3.95	2.51	5.32	ppt
1,2,3,4,6,7,8-HpCDD	0.01	450.	341.	372.	136.	95.5	216.	ppt
OCDD	0.001	3690.	2810.	2890.	1450.	1140.	2400.	ppt
2,3,7,8-TCDF	0.1	21.8	20.7	21.2	7.59	4.99	5.86	ppt
1,2,3,7,8-PeCDF	0.05	5.41	3.41	2.91	0.05	0.98	1.65	ppt
2,3,4,7,8-PeCDF	0.5	14.7	9.3	10.4	3.41	1.8	3.25	ppt
1,2,3,4,7,8-HxCDF	0.1	10.2	5.42	4.08	1.95	1.58	3.22	ppt
1,2,3,6,7,8-HxCDF	0.1	9.79	3.63	3.67	1.6	1.1	2.67	ppt
1,2,3,7,8,9-HxCDF	0.1	0.72	0.28	0.	0.17	0.	0.	ppt
2,3,4,6,7,8-HxCDF	0.1	8.26	2.48	2.51	1.2	0.68	2.01	ppt
1,2,3,4,6,7,8-HpCDF	0.01	113.	63.9	85.1	27.8	16.3	45.2	ppt
1,2,3,4,7,8,9-HpCDF	0.01	7.51	2.77	3.2	1.11	1.05	2.6	ppt
OCDF	0.001	250.	91.9	107.	43.9	36.9	91.8	ppt
TEQs		**27.9**	**19.36**	**20.61**	**7.83**	**5.09**	**10.53**	**ppt**

Toxicity

The results for the 10-day *Hyalella* and *Chironomus* test are presented in Tables 9 and 10. The lab control results met the test requirements. No significant differences were observed in the results from either test between any of the samples and the lab control results. The results from both tests shows the lab control had the lowest weight for any of the sampling locations.

Table 9: Hyalella Toxicity Test Results

Site ID	Species	Mean Survival (%)	Mean Dry Weight (mg)
TB	*Hyalella azteca*	95	0.083
At	*Hyalella azteca*	93	0.098
IB	*Hyalella azteca*	100	0.091
FC	*Hyalella azteca*	99	0.098
II	*Hyalella azteca*	93	0.099
LC	*Hyalella azteca*	95	0.101
Lab Cont	*Hyalella azteca*	98	0.062

Table 10: Chironomus Toxicity Test Results

Site ID	Species	Mean Survival (%)	Mean Dry Weight (mg)
TB	*Chironomus tentans*	88	2.3
At	*Chironomus tentans*	98	2.31
IB	*Chironomus tentans*	94	2.37
FC	*Chironomus tentans*	95	2.17
II	*Chironomus tentans*	99	2.15
LC	*Chironomus tentans*	98	2.01
Lab Cont	*Chironomus tentans*	91	1.18

The complete test results are attached as Appendix B.

Benthic Survey Results

The results of the benthic survey as presented in Table 11. The biological interpretation represents a number that is derived from a matrix on five indices. These indices include the total number of organisms, the pollution tolerance of the species, the diversity of species, the species dominance, and how similar this site would be to a non-impacted site. These indices have been developed for fast flowing waters within the State and are being adapted for lakes and slow moving waters. Therefore, these indices and numbers are subject to change as more data is added and the indices get refined.

The results indicate a severe impact at the three downriver sites. The only site that was observed to have no impact was Inbocht Bay. It was not clear what impact salinity may play in the impacts to the lower three sampling sites, but cannot be ruled out as an important effect on species composition and dominance, although all species found are considered freshwater. The results from the Athens site may be misleading. The chemical data indicate this was one of the cleanest sites sampled, with the exception of PCBs. This may be more a function of grain size and organic carbon levels.

Table 11: Benthic Invertebrate Community Results

Site ID	Benthic Survey Results
TB	Slightly impacted
At	moderately impacted
IB	non-impacted
FC	severly impacted
II	severly impacted
LC	severly impacted

The complete results are presented as Appendix C.

Quality Assurance/Quality Control

There were no duplicate nor blank data provided with the RECRA metals results, therefore no QA/QC information can be derived.

For the mercury, the data was presented in three data packages. The first data pack, SDG10181, all lab control samples and duplicates were within acceptable ranges. In SDG10251, one laboratory control sample for methyl mercury was outside the ± 20 percent range (55.1 %). The duplicate samples were within QA/QC guidelines. The last data pack, SDG10252, had two laboratory control samples outside acceptable limits, 79.8 and 79.5 percent. One of the duplicate samples was outside the ± 20 percent range, with a relative percent difference of 28.6 percent.

For the organics, only duplicate data was reviewed for relative percent differences. The dioxins had one sample with duplicate information. All results were within the ± 40 percent range. The pesticides had five duplicate samples and only one parameter exceeded the ± 60 percent range, 103.6 percent. PAHs had four duplicate samples and two chemicals exceeded the acceptable range with a relative percent recovery of 104 and 182.7 percent. Finally, four PCB samples had duplicate data from two sites. Although each sample had 209 congeners reported, due to coelutions and non-detects, only about 100 congeners had results that could have the RPD calculated. The two sets of replicates from one site had no values outside the ± 60 percent RPD, while the other site had one replicate with two congeners outside the limits and the other set of duplicates had 8 congeners outside the limits.

Summary

The chemical results showed that Lents Cove had the highest surficial concentrations of most contaminants than any of the other five sites. The toxicity results showed no impacts from these contaminants on the two test species from this site, nor any other site. The benthic survey results showed sever impacts at the three downriver sites. These three sites did have some of the highest metals and pesticides than the three upriver sites. The physical characteristics of these sites indicated more fine-grained material, and slightly higher organic carbon for Lents and Foundry coves, but not significantly different from the other three sites.

Of the three upriver sites, Inbocht Bay and Athens appeared to have better sediment quality than the Turning Basin.

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