

**Spatial and Temporal Trends in Contaminant Levels in
Settling Particulate Matter: Hylebos Waterway
(Commencement Bay), July 1990 to November 1991**

by

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EXECUTIVE SUMMARY

To evaluate the effectiveness of efforts to control sources of problem chemicals to Hylebos Waterway, samples of settling particulate matter (SPM) and in-place bottom sediments were collected between July 1990 and November 1991. All SPM samples were collected with the use of moored sediment traps. Chemical analyses focused on problem metals and organics, which were identified for Hylebos Waterway during the Commencement Nearshore/Tideflats (CBNT) Remedial Investigation (Tetra Tech, 1985).

Mean concentrations of eight individual problem chemicals in SPM were high enough to adversely affect marine benthic communities based on comparisons with the Commencement Bay Sediment Quality Objectives (SQOs), (EPA, 1989). Arsenic was the only metal that exceeded the SQOs. No volatile organics identified as problem chemicals were measured above the SQOs. PCBs exceeded the SQOs at all locations tested. Based on mean concentrations, problem chemicals exceeding the SQOs are summarized below;

- H-1 (Upper Turning Basin) - Arsenic, Total PCBs
- H-2 - Arsenic, Total PCBs
- H-3 - Arsenic, low molecular weight polynuclear aromatic hydrocarbons (LPAH), high molecular weight PAH (HPAH), phenol, bis(2-ethyl hexyl) phthalate, Total PCBs
- H-4 (Near Lincoln Drain) - Bis (2- ethyl hexyl) phthalate, Total PCBs
- H-5 (Near 11th Street Bridge) - Total PCBs
- H-6 - Hexachlorobenzene, Hexachlorobutadiene, Total PCBs
- H-7 (Mouth) - Total PCBs

In most instances, concentrations of problem chemicals in present (SPM) and historical (bottom sediment) Hylebos Waterway sediments were similar. Problem chemicals that were higher in SPM include:

- H-1 - Arsenic, copper, zinc, LPAH, HPAH
- H-2 - None
- H-3 - Arsenic, LPAH, HPAH, and phenol
- H-4 - LPAH
- H-5 - Tetrachloroethene, Bis (2-ethyl hexyl) phthalate
- H-6 - Arsenic, lead, tetrachloroethene, LPAH, hexachlorobutadiene
- H-7 - Arsenic, HPAH

There are some indications that present levels of antimony, lead, and zinc at station H-2, and antimony near the Lincoln drain and the 11th Street Bridge have decreased.

The data collected suggest that ongoing sources of several problem chemicals may exist in Hylebos Waterway. Comparison of bottom sediment data from 1984 and 1991 suggest PCB levels in the waterway are not improving. These results are not unexpected since very few source controls have been completed in the waterway as of November 1991. The current schedule calls for source control to be completed by September 1995 (Smith, 1992). The observed temporal trends in contaminant levels should be viewed with caution, since they are based on a limited amount of data. Additional data being collected as part of Ecology's ongoing sediment trap monitoring efforts in Hylebos Waterway will be useful in assessing the apparent temporal trends in contaminant levels noted in this study.

Overall, the spatial distribution of most problem chemicals associated with SPM was in relatively good agreement with previous data on sediment contamination in Hylebos Waterway. The highest concentrations of arsenic and copper were measured at station H-1 in the upper turning basin, while mercury and zinc were highest at station H-2 in the upper portion of the waterway. Lead levels were highest at station H-6. The lowest metals concentrations were typically measured at station H-7 at the mouth of the waterway. Problem organics in SPM peaked at two locations in the waterway; in the upper portion at station H-3 (LPAH, HPAH, phenol, and total PCBs) and in the outer portion at station H-6 (trichloroethene, tetrachloroethene, ethylbenzene, xylenes, hexachlorobenzene, and hexachlorobutadiene). One exception was bis (2-ethylhexyl) phthalate which was highest in the upper turning basin at station H-1.

Sedimentation rates for Hylebos Waterway calculated from sediment trap data ranged from 0.7-3.8 g/cm²/yr with a mean of 2.1 ± 0.8 g/cm²/yr. Average bottom sediment resuspension rates were estimated to be 1.1 and 1.0 g/cm²/yr, at the head and mouth of the waterway, respectively. These data suggest that somewhere in the range of 25-45 percent of the material collected by the sediment traps could be resuspended bottom sediments.

Current velocities are generally low in the waterway even during periods of high tidal exchange. However, ship traffic and associated tug-boat activities can have a substantial short-term impact on currents in a localized area. Velocities ≤ 2 cm/sec occur approximately 97% of the time at the head. At the mouth current velocities are more variable, being ≤ 10 cm/sec 43% of the time.

RECOMMENDATIONS

Based on the results of this study the following recommendations are made:

- Re-evaluate predicted natural recovery rates for problem chemicals in Hylebos Waterway bottom sediments, based on the data presented here. This information should be incorporated into the remedial design (RD) for cleaning up contaminated sediments in the waterway. A scope of work for the Hylebos Waterway RD is currently being prepared by EPA Region 10, the lead agency for sediment cleanup activities in Commencement Bay.
- While a number of administrative actions have occurred to begin the process of reducing the input of problem chemicals to the waterway, very few source controls have actually been completed as of November 1991. In addition the data collected here suggests that ongoing sources of several problem chemicals exist in Hylebos Waterway. Any further source control activities (*i.e.*, verify that sources are controlled and unknown sources are not present) in the waterway should focus on areas of the waterway where: 1) SPM concentrations were above the SQO, and 2) SPM concentrations were higher than concentrations in bottom sediments. Chemicals by area meeting these two criteria are summarized below:

Location

Priority Source Control Chemicals

- | | |
|---------------------------------|-----------------------------------|
| ● H-1 (Upper Turning Basin) | - Arsenic |
| ● H-2 | - None |
| ● H-3 | - Arsenic, LPAH, HPAH, and phenol |
| ● H-4 (Near Lincoln Drain) | - None |
| ● H-5 (Near 11th Street Bridge) | - None |
| ● H-6 | - Hexachlorobutadiene |
| ● H-7 (Mouth) | - None |
-
- A second priority for further source control activities would be areas of the waterway where concentrations of problem chemicals in SPM exceeded the Commencement Bay SQOs. These areas are shown below:
- | | |
|-------|--|
| ● H-1 | - Arsenic, Total PCBs |
| ● H-2 | - Arsenic, Total PCBs |
| ● H-3 | - Arsenic, LPAH, HPAH, phenol, bis (2-ethyl hexyl) phthalate, Total PCBs |
| ● H-4 | - Bis (2- ethyl hexyl) phthalate, Total PCBs |
| ● H-5 | - Total PCBs |
| ● H-6 | - Hexachlorobenzene, Hexachlorobutadiene, Total PCBs |
| ● H-7 | - Total PCBs |

- A comprehensive evaluation of PCB levels in bottom sediments should be incorporated into the RD for Hylebos Waterway.
- A limited amount of information is available on net sedimentation rates in Hylebos Waterway. If additional sediment cores are collected during the RD for chemical characterization purposes, net sedimentation rates should also be determined using Pb-210 techniques.

INTRODUCTION

Hylebos Waterway, shown in Figure 1, is one of seven waterways, which along with the Puyallup River mouth make up the tideflats portion of the Commencement Bay Nearshore/Tideflats (CBNT) Superfund Site. Contamination of Hylebos Waterway sediments with a variety of chemicals was documented during the CBNT Remedial Investigation (CBNTRI), (Tetra Tech, 1985). A list of problem chemicals for Hylebos Waterway was also identified during the CBNTRI. This list (Table 1) has recently been clarified by Region 10 of the Environmental Protection Agency (EPA) after reevaluating the data generated during the CBNTRI (EPA, 1992). For informational purposes only, also shown in Table 1 are indicator chemicals. Indicator chemicals were selected from the list of problem chemicals for each waterway to be representative of major sources and show similar geographic trends as other major problem chemicals from the same source. Indicator chemicals were used in the CBNT Feasibility Study (FS) to assess areas and volumes of sediment requiring remediation (EPA, 1992).

As a result of the CBNTRI and subsequent studies source control programs aimed at reducing contaminant loadings to the waterway have been implemented by the Department of Ecology, City of Tacoma and the Tacoma-Pierce County Health Department. The schedule for implementing source identification and control in Hylebos Waterway is described in Appendix C, of the CBNT Record of Decision (ROD), (EPA, 1989). It is worth mentioning that as of November 1991 very few source controls have actually been completed in Hylebos Waterway. It is anticipated that source controls will be completed for all known sources in the waterway by September 1995 (Smith, 1992).

The extent to which these programs will actually reduce inputs of problem chemicals to Hylebos Waterway is not being adequately monitored. In addition, the rate of bottom sediment accumulation after initiation of source control is also not being measured.

Ecology's Commencement Bay Urban Bay Action Team (UBAT) therefore requested that the Toxics, Compliance and Ground Water Investigations Section conduct a sediment monitoring study in Hylebos Waterway with the following objectives:

- Determine the concentrations of problem chemicals associated with settling particulate matter (SPM) that is currently being deposited in Hylebos Waterway; and
- Estimate present sedimentation rates in the waterway.

The results of this investigation will be used, along with other information in Commencement Bay to evaluate the effectiveness of source control efforts in reducing the input of problem chemicals to Hylebos Waterway, determine when source control has been achieved, and aid in selecting remediation options for sediments. This paper reports data from the first 1.5 years of monitoring (July 1990 - November 1991). Results from monitoring conducted after November 1991 will be reported in subsequent updates. Similar monitoring efforts are also

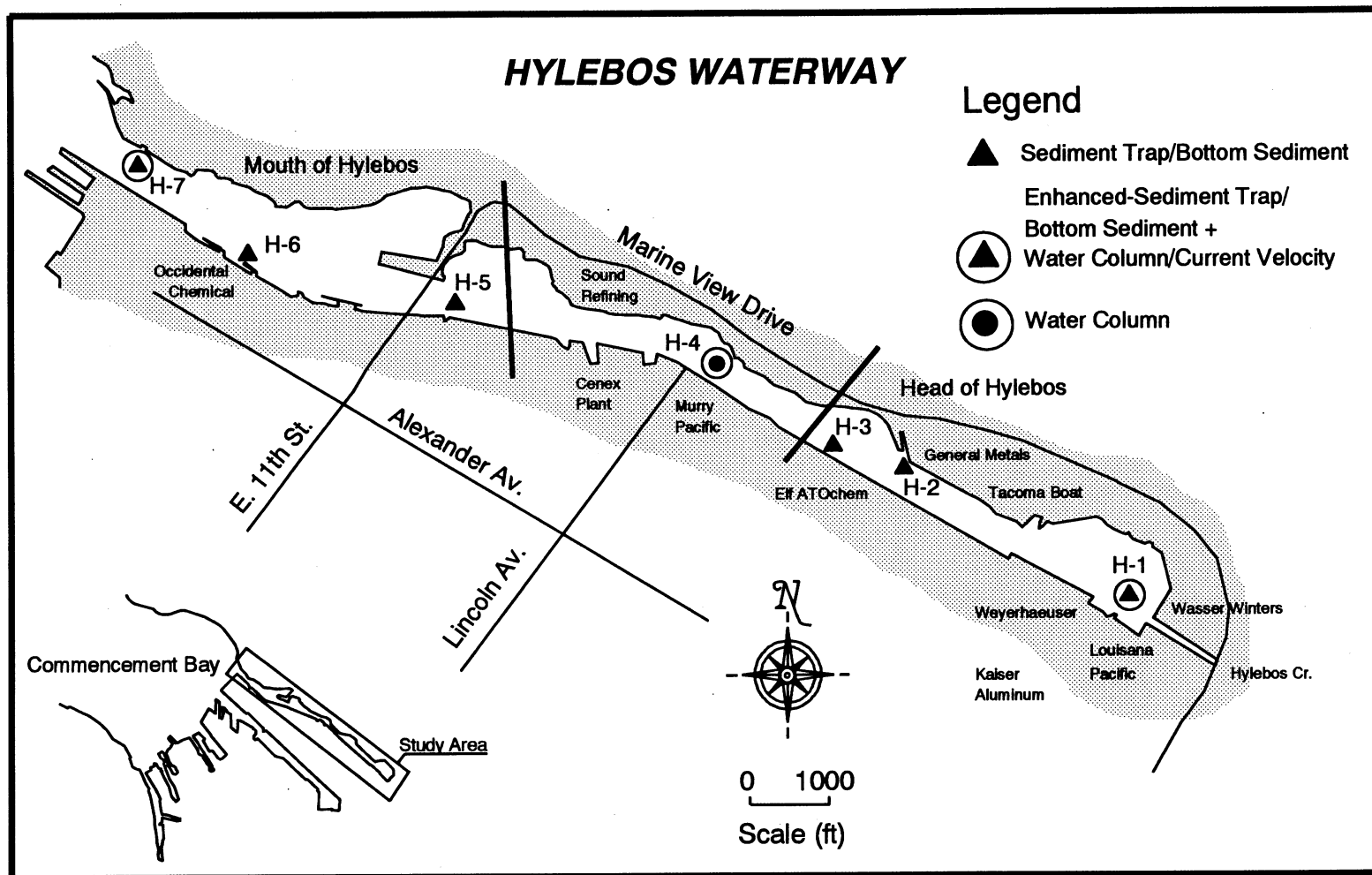


Figure 1: Station locations for Hylebos Waterway sediment trap monitoring project.

Table 1: Summary of problem chemicals(1) in Hylebos Waterway.

I. Head of Hylebos

	Priority		Indicator
1	2	3	Chemicals*
Arsenic	Antimony	Methylpyrene	Arsenic
Zinc	Copper	Methylphenanthrene	HPAH
HPAH	Lead	Dibenzothiophene	PCBs
PCBs	Mercury	Ethylbenzene	
	Nickel	Xylene	
	Phenol	Chlorinated benzenes	
	Tetrachloroethene	Chlorinated butadienes	
		Bis(2-ethyl hexyl) phthalate	
		Benzyl Alcohol	
		An alkylated benzene isomer	

II. Mouth of Hylebos

	Priority		Indicator
1	2	3	Chemicals*
PCBs	Lead	Copper	PCBs
	Hexachlorobenzene	Zinc	Hexachlorobenzene
	Trichloroethene	Mercury	
	Tetrachloroethene	HPAH	
	1,2 Dichlorobenzene	LPAH	
	1,3 Dichlorobenzene	Methylphenanthrene	
	Hexachlorobutadiene	Methylpyrene	
	A pentachlorocyclopentane isomer	Biphenyl	
		Phenol	
		Benzyl Alcohol	

(1)=Problem chemicals identified during the Commencement Bay Remedial Investigation (clarified by EPA, 1992)

*=See text for discussion of indicator chemicals

being conducted by Ecology concurrently in Sitcum and Thea Foss Waterways. Results from monitoring conducted between July 1990 and June 1991 in Sitcum Waterway are currently available (Norton and Barnard, 1992). Data collected from Thea Foss Waterway between November 1988 and May 1992 will be presented in a report scheduled for completion early in 1993.

METHODS

Sample Collection

To characterize present conditions in Hylebos Waterway, water samples, current velocity measurements, SPM, and bottom sediments were collected between July 25, 1990, and November 21, 1991. Sampling locations, shown in Figure 1, were selected to provide a broad spatial coverage of the waterway, and to the extent possible, correspond to major contaminant sources identified during the CBNTRI. Detailed descriptions of each sampling location are provided in Table 2. Station positions were located using a Magellan® Model 11001 Nav 1000 Plus GPS receiver, in conjunction with depth readings.

Water Sampling

To help interpret the distribution of particulates in the waterway, continuous vertical profiles of temperature, salinity, light transmittance and total suspended solids (TSS) were collected quarterly at three mid-channel stations (see Figure 1) during deployment and retrieval of the sediment traps. Temperature, salinity and light transmittance were measured with a Seabird Electronics SEACAT® Model SBE-19 Profiler equipped with a Sea Tech, Inc. 25cm Beam Transmissometer. Samples for TSS determinations were obtained (October 1990 - June 1991) concurrently with a Van Dorn bottle.

Current Velocity Measurements

To characterize current velocities in Hylebos Waterway, two Aanderra® Current Meters Model RCM-4 were deployed for approximately one month (December 27, 1990, - February 5, 1991) at the head and mouth of the waterway. Both meters were moored 3 ft. above the bottom at the locations shown in Figure 1. Deployment of the meters coincided with a period of maximum tidal exchange (spring tidal series) during the study. Each meter was set at a recording interval of 15 minutes. Due to a meter malfunction during the initial deployments, a second deployment was made at the mouth of the waterway between July 2 - August 13, 1991. This was also a period of high tidal exchange.

SPM Sampling

SPM was collected at seven locations in the waterway with the use of moored sediment traps, positioned 3 ft. above the bottom. Total depths at each station ranged from approximately 23

Table 2: Station locations and descriptions for Hylebos Waterway sediment trap monitoring project, July, 1990 to November, 1991.

Station No.	Latitude (deg/min/sec)	Longitude (deg/min/sec)	Description	Water Depth (ft @ MLLW)	Sample Type
H-1	47 15 42	122 21 38	Upper Turning Basin	25	SPM,BS
H-2	47 16 7	122 22 13	Northend of General Metals	32	SPM,BS
H-3	47 16 11	122 22 27	Adjacent to Elf ATOchem	24	SPM,BS
H-4	47 16 25	122 22 47	Near Lincoln Av. Drain	22	SPM,BS
H-5	47 16 37	122 23 28	Near 11th Street Bridge	25	SPM,BS
H-6	47 16 46	122 24 1	Adjacent to Occidental Chemical	30	SPM,BS
H-7	47 17 2	122 24 22	Mouth	31	SPM,BS
HP-1	47 15 44	122 21 35	Midchannel Upper Turning Basin	29	WC,CV
HP-4	47 16 25	122 22 47	Midchannel near Lincoln Av. Drain	24	WC
HP-7	47 17 1	122 24 22	Midchannel @ Mouth	35	WC,CV

SPM= Settling Particulate Matter

BS= Bottom Sediment

WC= Water Column Profile

CV=Current Velocity

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to 31 ft. at mean lower low water (MLLW). The traps were deployed on July 25, 1990, and sampled every three months thereafter.

Sediment traps have been used widely in the oceans to measure the vertical transport of materials with results that are in good agreement with data obtained using different scientific approaches (Buesseler, 1991 and USGOFS, 1989). The traps used in the present study are straight-sided glass cylinders with a collection area of 78.5 cm² and a height-to-width ratio of five. Previous studies have shown that cylindrical sediment traps with these characteristics would provide unbiased samples of the vertical particle flux in current velocities expected to occur in Hylebos Waterway (Butman, 1986; Butman *et al.*, 1986; Baker, *et al.*, 1988; Larsson, *et al.*, 1986). In addition, these traps were used by Ecology between 1988-1992 to monitor contaminant levels in Thea Foss and Sitcum Waterways with excellent results (Norton, 1990; Norton and Barnard, 1992). A schematic of the construction details of the traps and their moorings is presented in Appendix A- Figure A1. At deployment, the traps were filled with two liters of high salinity water (4% NaCl), which contained sodium azide (2%) as a preservative to reduce microbial degradation of the samples. Prior to deployment, the collection cylinders were cleaned with sequential washes of hot tap water/Liquinox[®] detergent, 10 percent nitric acid, distilled/deionized water, and pesticide grade acetone, then air-dried and wrapped in aluminum foil until used in the field.

Upon retrieval of the traps, overlying water in the collection cylinders was removed with a peristaltic pump. The remaining contents were then transferred to half-gallon priority pollutant-cleaned glass jars with teflon-lined lids (supplied by I-Chem, Hayward, CA) and stored at 4°C for transport to the laboratory, where they were frozen within 12 hours of collection pending processing. Processing consisted of first thawing the samples and then centrifuging to isolate the particulate fraction. All nekton >2 cm in size were removed from the samples. In order to obtain sufficient volume for organics analyses, SPM samples from two consecutive collection periods (*i.e.*, semi-annually) were composited. All other analyses were conducted on a quarterly basis. Manipulation of all SPM samples in the laboratory was accomplished with stainless steel spoonulas cleaned as previously described for the collection cylinders.

Bottom Sediment Sampling

Sampling procedures followed Puget Sound Protocols where applicable (Tetra Tech, 1986a). Surface sediments were collected at each of the sediment trap locations on January 23, 1991, using a 0.1 m² stainless steel van Veen grab. To assess field variability for various chemicals, replicate samples (*i.e.*, two separate samples from the same location) were collected at stations H-1, H-3, and H-6. Blind field duplicates (*i.e.*, two samples split from the same homogenate) were also prepared at these locations to assess overall variability (sampling collection + laboratory).

After retrieving the grab, the top 2 cm layer not in contact with the sidewalls of the sampler was transferred to a stainless steel beaker and homogenized by stirring with a stainless steel

spoon. Aliquots for individual analyses, except volatile organics were taken from this homogenate and placed in priority-pollutant cleaned glass jars with teflon-lined lids supplied by I-Chem Hayward, CA, wrapped in polyethylene bags, and stored at 4°C for transport to the laboratory. Samples for volatile organics analysis (VOA) were collected directly into 40ml glass vials with teflon septa. Spoons and beakers were pre-cleaned as previously described for the sediment trap collection cylinders.

Analysis and Quality Assurance

The chemical analyses, analytical methods, and laboratories used in this study are listed in Table 3. The quality of the data was assessed by analysis of method blanks, internal standards, surrogate spikes, duplicate matrix spikes, blind field duplicates and standard reference materials (SRMs).

Results of metals analysis of marine SRMs are shown in Table 4. Excellent accuracy was obtained for all metals being within $\pm 10\%$ of the certified range, except for antimony and arsenic. Somewhat lower accuracy was achieved for antimony (+11% of the certified range) and arsenic (-16% of the certified range). These data indicate that the reported concentrations could slightly overestimate (antimony) and underestimate (arsenic) actual environmental levels.

Analysis of SRMs for polynuclear aromatic hydrocarbons (PAH), and polychlorinated biphenyls (PCBs) are shown in Table 5. Again, as was the case for metals excellent accuracy was obtained for most compounds, being within $\pm 20\%$ of the certified range. An exception was benzofluoranthenes which were outside the certified range by up to 56%. Since benzofluoranthenes on average constituted 17% of the target PAHs in most samples, the lower accuracy obtained should not substantially impact the overall accuracy of the PAH analysis.

Estimates of overall precision (sampling collection + laboratory) calculated as relative percent difference (RPD: range as a percent of the mean) using detected compounds in blind field duplicates were as follows:

- SPM: Conventional ($\leq 10\%$); metals ($\leq 20\%$, except cadmium $\leq 31\%$); VOA ($\leq 33\%$, except ethylbenzene 67%); semivolatile organics (low molecular weight PAH (LPAH) $\leq 33\%$, high molecular weight PAH (HPAH) $\leq 6\%$, phenols 23%, and phthalates $\leq 84\%$), and PCBs ($\leq 30\%$)
- Bottom sediment: Conventional ($\leq 10\%$ except total organic carbon (TOC) $\leq 34\%$); metals ($\leq 9\%$); VOA ($\leq 40\%$); semivolatile organics (LPAH 17%, HPAH 11%, phenols 120%, and phthalates 3%); and PCBs (0%).

Results of analyses of blind field duplicates are summarized in Appendix B- Table B1 (metals) and Table B2 (organics). These data indicate that sample handling procedures and

Table 3: Summary of analytical methods for Hylebos Waterway sediment trap monitoring project.

Analysis	Method	Reference	Laboratory
SETTLING PARTICULATE MATTER/SEDIMENT			
Percent Solids	Dry @ 104°C	Tetra Tech, 1986a	Ecology/EPA-Manchester, WA.
Total Organic Carbon	Combustion/CO2 Measurement	" "	AMTEST-Redmond, WA. Sound Analytical Services, Inc.-Tacoma, WA.
Grain Size	Seive and Pipet	Holme and McIntrye, 1971	Soil Technology, Inc.-Winslow, WA.
Metals			
Arsenic, Copper, Nickel, Lead, Zinc	X-Ray Fluoresence	Nielson and Sanders, 1983	Battelle Northwest-Richland, WA.
Cadmium, Antimony	GFAA	Tetra Tech, 1986a	Battelle Northwest-Sequim, WA.
Mercury	CVAA	" "	" " "
Organics			
Volatiles	GC/MS #8240	EPA, 1986	Ecology/EPA-Manchester, WA.
Semivolatiles	GC/MS #8270	" "	Analytical Resources, Inc.-Seattle, WA./ Ecology/EPA-Manchester, WA.
PCBs	GC/ECD #8080	" "	" " "
WATER			
Total Suspended Solids	Gravimetric #205C	APHA, 1985	Ecology/EPA-Manchester, WA.
Temperature/Salinity	Seacat SBE19-CTD	Seabird Electronics	Field
Current Velocity	Aanderaa Current Meter Model RCM-4	Aanderaa Instruments	Field

GFAA=Graphite Furnance Atomic Absorption

CVAA=Cold Vapor Atomic Absorption

Table 4: Results of analysis of certified reference materials for metals in marine sediment (mg/kg,dry).

Material	PACS-1					NIST-1646				
	Certified Range	7-12/90	Battelle Result			Certified Range	7-12/90+	Battelle Result		
Collection Period			1/91	1-6/91*	6-11/91*			1/91	1-6/91*	6-11/91*
Antimony	157-185	-	205	193	195	NC	-	-	-	-
Arsenic	200-222	-	168	172	204	10.3-12.9	10.2	9.2	11.7	12.4
Cadmium	2.36-2.40	-	2.50	2.60	2.52	0.29-0.43	0.39	0.40	0.40	0.37
Copper	436-468	-	441	405	411	15-21	15.8	20.9	20.8	20.3
Lead	384-424	-	438	403	403	26.4-30.0	29.1	30.7	29.0	29.1
Mercury	4.41-4.73	-	4.69	4.88	4.60	0.051-0.075	0.074	0.074	0.050	0.061
Nickel	42.1-46.1	-	49.3	45.3	43.9	29.0-35.0	34.4	36.6	33.1	31.7
Zinc	802-846	-	774	804	799	132-144	128	138	140	132

PACS-1=Trace Metals in Marine Sediment (National Research Council of Canada)

NIST-1646=Estuarine Sediment (National Institute of Standards and Technology)

+ = Reported as mean of duplicate analysis

* = Reported as mean of triplicate analysis

- = Not analyzed

NC = Not Certified


 = Outside certified range by more than 10%

Table 5: Result of analysis of certified reference materials for polynuclear aromatic hydrocarbons (PAH) and polychlorinated biphenyls (PCBs) in Marine sediment (ug/kg, dry).

Standard Collection Period	HS-6	
	6-11/91 Mean+	Certified Range
PAH		
Napthalene	3100	3000-5200
Acenaphthylene	280	140-240
Acenaphthene	130	160-300
Flourene	320	350-590
Phenanthrene	2600	2400-3600
Anthracene	680	700-1500
Flouranthene	2700	2890-4190
Pyrene	2700	2400-3600
Benzo(a)athracene	1700	1500-2100
Chrysene	1800	1700-2300
Benzo(a)pyrene	1700	1800-2600
Benzo(b)flouranthene	5100	2400-3400
Benzo(k)flouranthene	560	1280-1580
Benzo(g,h,i)perylene	1600	1060-2500
Dibenzo(a,h)anthracene	670	330-650
Indeno(1,2,3-cd)pyrene	1700	1370-2530

Material Collection Period	HS-2	
	6-11/91 Mean*	Certified Range
PCBs		
Arochlor 1254	120	109.3-114.3

j=Estimated concentration

+ = Reported as mean of quadruplicate analysis

* = Reported as mean of duplicate analysis

National Research Council of Canada Standards

HS-6= PAH in Marine Sediment

HS-2= PCBs in Marine Sediment

▨ = Exceeds certified range by more than 20%.

laboratory analyses were not major contributors to data variability for most analytes. Exceptions are ethylbenzene and phthalates in SPM, which could vary by a factor of two, and phenol results for bottom sediments, which could vary by a factor of four.

Quality assurance review of the organics data was performed by Dickey Huntamer of the Ecology/EPA Manchester Laboratory. The data were reviewed for qualitative and quantitative accuracy, validity, and usefulness. No major analytical problems were encountered with the analysis of these samples, except for higher quantitation limits on the January - June 1991 SPM sample set which is discussed below. Consequently, the data is considered acceptable for use, with the accompanying qualifiers noted where appropriate.

SPM samples from the January - June 1991 collection period were pre-screened by Gas Chromatography/Flame Ionization Detector (GC/FID) prior to analysis. Samples which had a high hydrocarbon/lipid background were diluted, which resulted in higher quantitation limits for these samples. Case narratives and data reviews for the organics analyses are included in Appendix B- Part 2.

Unless otherwise noted, all metals and organics concentrations in this document are reported on a dry weight basis.

RESULTS

Water Column

Vertical profiles of temperature, salinity and light transmittance collected during deployment and retrieval of the sediment traps (Figure 1), are shown in Figure 2. In general, similar temperature and salinity profiles were measured at each of the water quality stations during concurrent periods. Some differences were noted in light transmittance profiles, with the strongest gradients typically occurring in the upper turning basin. The presence of a turbid surface layer in the upper turning basin is probably related to a number of factors including but not limited to; discharge from Hylebos Creek and log rafting activities. Total suspended solids concentrations (TSS), shown in Appendix C- Table C1 were low and similar throughout the waterway ranging from 2-11 mg/l.

Current Velocity

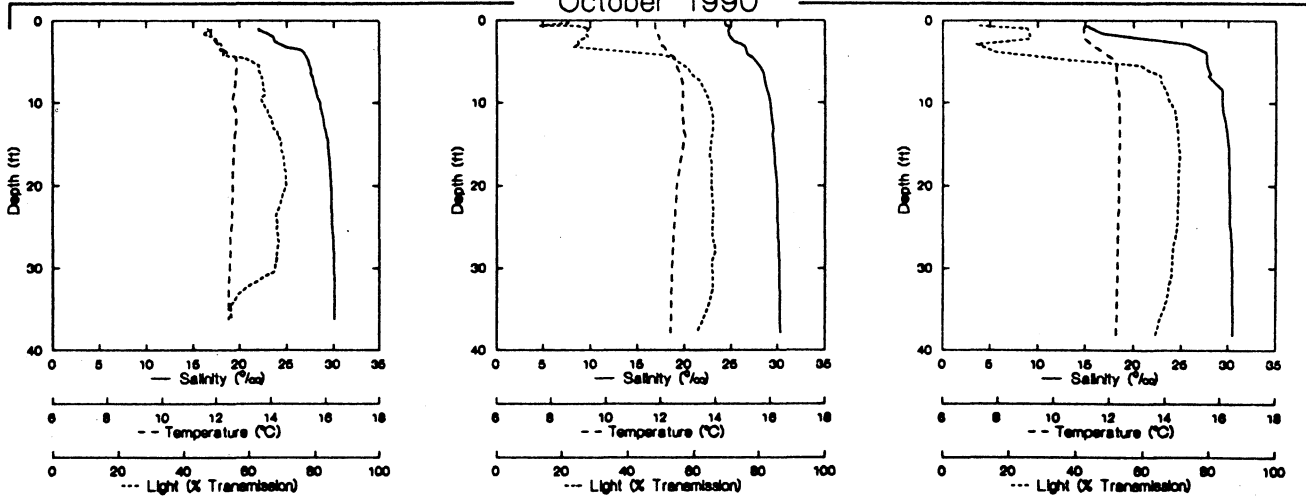
Current velocity distributions for two locations in Hylebos Waterway are presented in Figure 3. Velocities in the waterway ranged from 2-85 cm/sec. The minimum value represents the limit of detection for the instrument. Examination of Figure 3 indicates, that even though mean velocities are quite low at both the head (geometric mean = 2 cm/sec) and mouth (geometric mean = 8.9 cm/sec) of the waterway. The frequency distribution of velocities is substantially different at these locations. Velocities ≤ 2 cm/sec occur approximately 97% of the time in the upper turning basin. At the mouth, velocities are more variable. The

HP1 (Head)

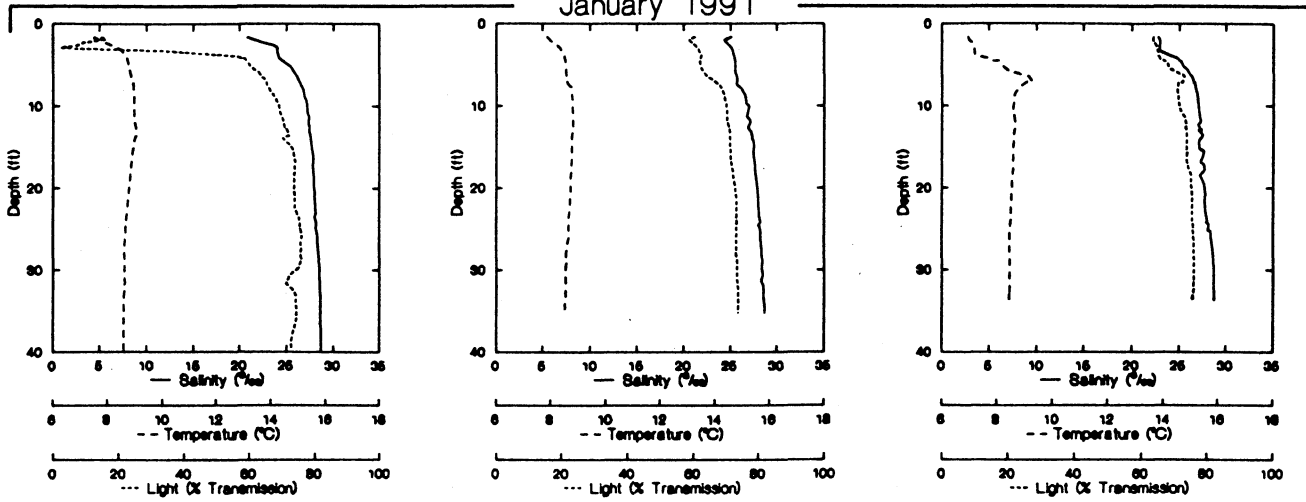
HP4 (Lincoln Drain)

HP7 (Mouth)

October 1990



January 1991



May 1991

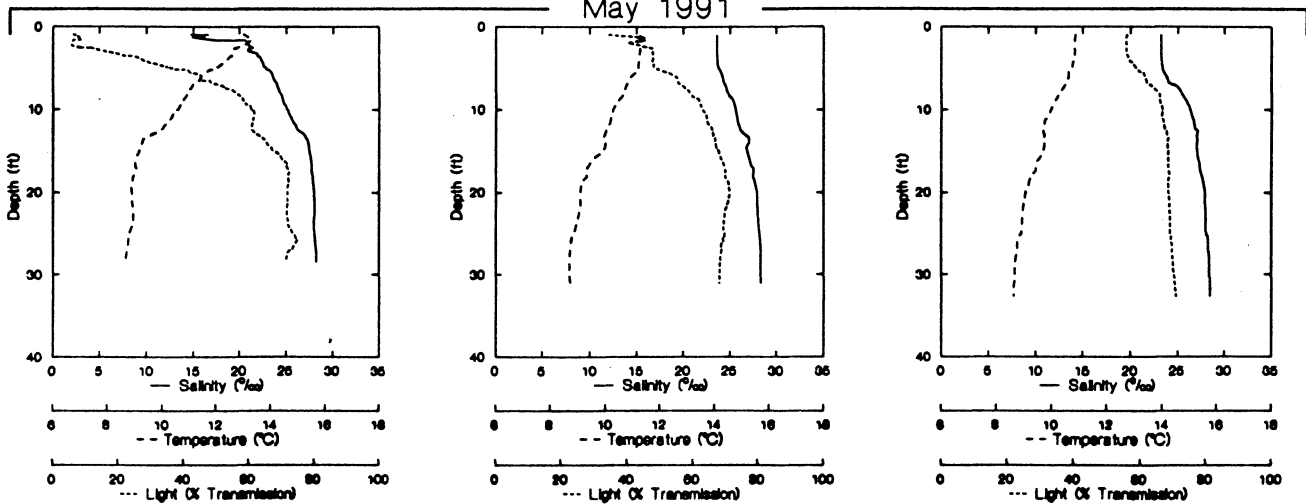


Figure 2: Temperature, salinity and light transmittance profiles for Hylebos Waterway October, 1990 - November, 1991.

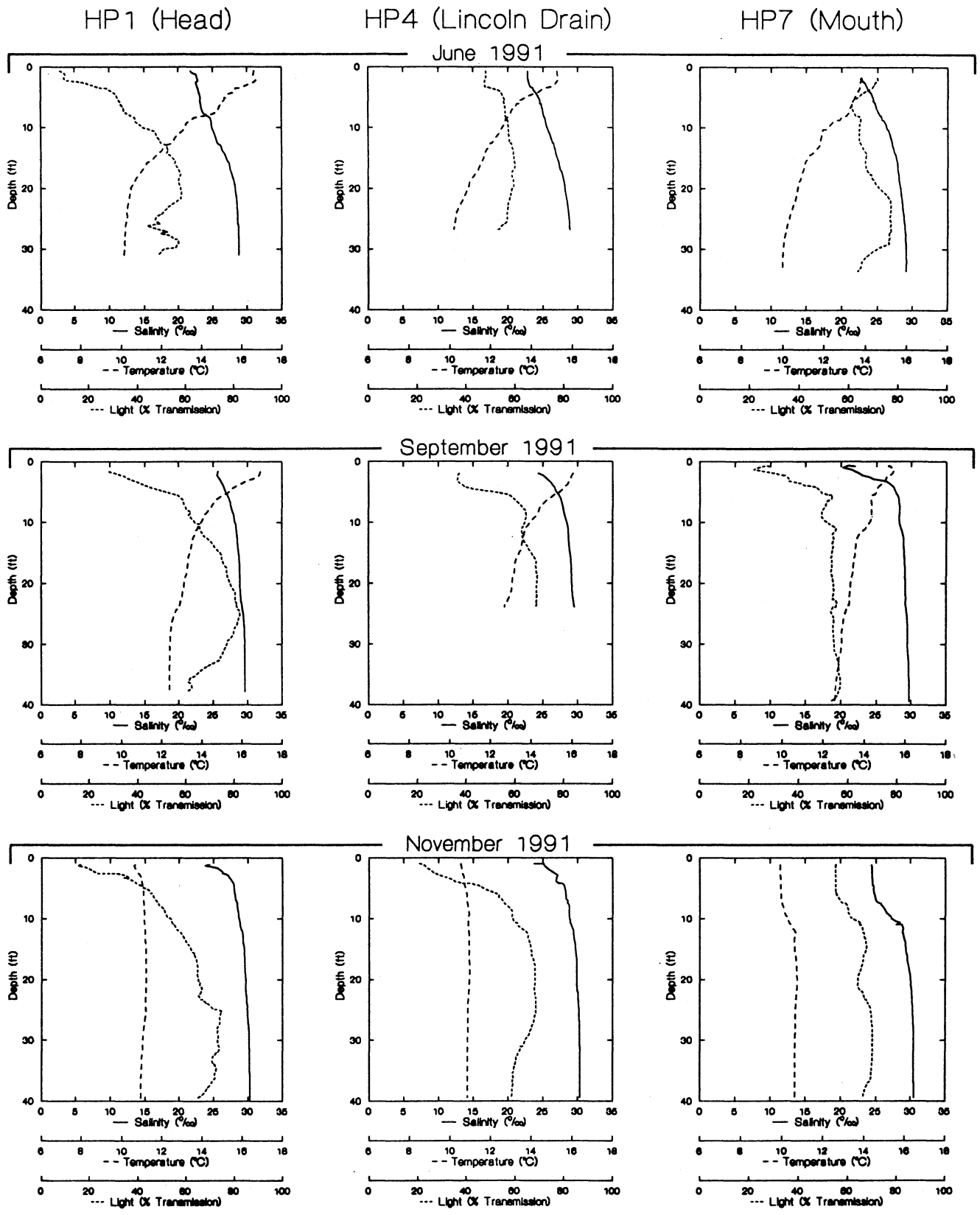


Figure 2 cont.: Temperature, salinity and light transmittance profiles for Hylebos Waterway October, 1990 - November, 1991.

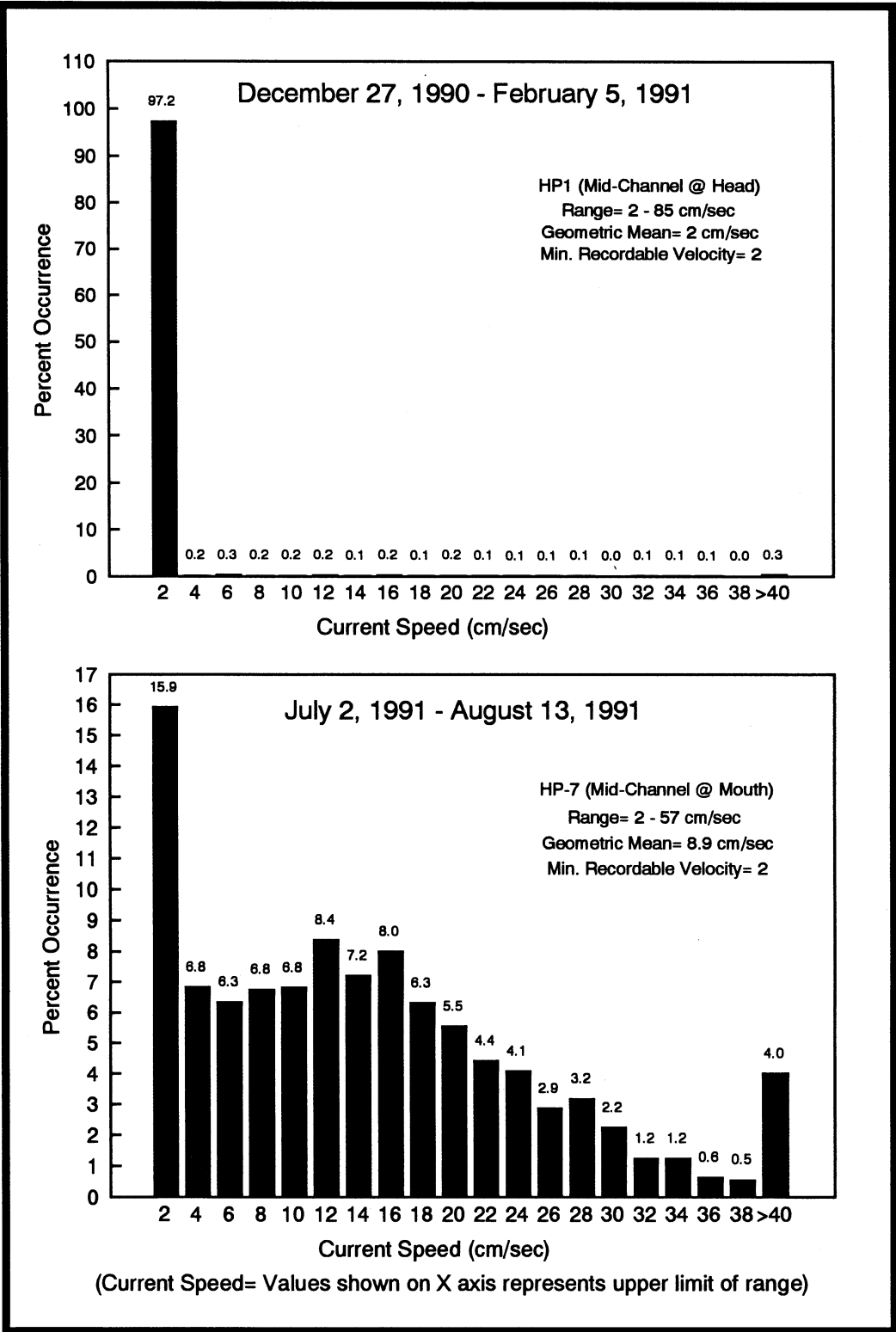


Figure 3: Current velocity distributions for Hylebos Waterway.

frequency distribution of currents at the mouth of Hylebos Waterway was as follows:
0-10 cm/sec= 43%; 10-20 cm/sec= 35%; 20-30 cm/sec= 17%; and >30 cm/sec= 8%.

In addition to the general current patterns, short-term velocity increases were measured at both the head and mouth of the waterway. These velocity spikes are probably related to ship traffic and associated tugboat activities in the waterway.

SPM

Out of 42 sediment traps deployed in Hylebos Waterway during the first 1.5 years of monitoring, 23 were successfully recovered. We attribute the majority of these losses to vessel activities in the waterway.

The results of total solids (TS), TOC, and metals analyses of SPM samples from Hylebos Waterway collected between July 1990 and November 1991 are presented in Table 6. TS concentrations ranged from 33.7% to 55.7% (post-centrifugation). TOC values ranged from 1.7% to 7.3% with minimum and maximum concentrations occurring at the mouth and the 11th Street Bridge, respectively.

Concentrations of problem metals in Hylebos Waterway SPM ranged as follows:

- Antimony (1.8-18 mg/kg)
- Arsenic (8.7-100 mg/kg)
- Copper (110-410 mg/kg)
- Lead (48-240 mg/kg)
- Mercury (0.16-0.53 mg/kg)
- Nickel (30-53 mg/kg)
- Zinc (120-370 mg/kg)

The highest concentrations of arsenic, cadmium and copper were measured in the upper turning basin, while mercury and zinc peaked at station H-2. Lead concentrations were at a maximum at station H-6. The lowest metals concentrations were typically present at the mouth of the waterway.

Two longitudinal patterns were evident for most metals in Hylebos Waterway. Arsenic, cadmium, copper, and zinc tended to be higher at the head of the waterway and decrease moving toward the mouth. In contrast, inter-station concentrations of mercury and nickel were fairly constant throughout the waterway. Two unequal peaks were measured for lead. A primary peak occurred at station H-6, and a secondary peak was measured in the vicinity of stations H-2 and H-3. No consistent pattern was evident for antimony.

Temporally, intra-station metals concentrations were quite similar, being within a factor of two in most cases. With a few exceptions, this was especially true for copper, lead, and nickel. Concentration of antimony and arsenic near the 11th Street Bridge varied within a factor of six.

Table 6: Results of conventionals and metals analysis of settling particulate matter from Hylebos Waterway, July, 1990 to November, 1991 (mg/kg, dry weight).

Location Station No.	Upper Turning Basin H-1						-						-						Near Lincoln Drain H-4					
							H-2						H-3											
Sample No.	-	-	-	8342	8568	8536	-	-	-	8345	-	8539	8253/ 54*	8276	8329/ 30*	-	31/32+	-	8272	8277	-	8351	-	-
Quarter	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Collection Period	7/90- 10/90	10/90- 1/91	2/91- 4/91	5/91- 6/91	6/91- 9/91	9/91- 11/91	7/90- 10/90	10/90- 1/91	2/91- 4/91	5/91- 6/91	6/91- 9/91	9/91- 11/91	7/90- 10/90	10/90- 1/91	2/91- 4/91	5/91- 6/91	6/91- 9/91	9/91- 11/91	7/90- 10/90	10/90- 1/91	2/91- 4/91	5/91- 6/91	6/91- 9/91	9/91- 11/91
Solids (%)	-	-	-	37.9	38.9	33.7	-	-	-	41	-	39	45.4	45.0	47.3	-	45.6	-	45.0	47.0	-	47	-	-
TOC (%)	-	-	-	2.4	6.4	5.1	-	-	-	2.1	-	4.6	4.2	5.7	2.2	-	4.5	-	4.2	4.3	-	2.2	-	-
Metals																								
Antimony	-	-	-	12	7.0	8.0	-	-	-	14	-	12	12	12	17	-	12	-	11	12	-	10	-	-
Arsenic	-	-	-	100	84	86	-	-	-	75	-	79	60	74	88	-	67	-	46	58	-	50	-	-
Cadmium	-	-	-	1.1	1.5	1.4	-	-	-	1.3	-	1.4	1.2	0.9	0.7	-	1.1	-	0.9	0.7	-	0.7	-	-
Copper	-	-	-	410	180	150	-	-	-	150	-	180	170	170	150	-	190	-	170	140	-	130	-	-
Mercury	-	-	-	0.25	0.3	0.35	-	-	-	0.45	-	0.53	0.46	0.46	0.49	-	0.43	-	0.32	0.32	-	0.27	-	-
Lead	-	-	-	67	77	75	-	-	-	110	-	100	110	100	110	-	100	-	93	92	-	77	-	-
Nickel	-	-	-	41	43	41	-	-	-	46	-	44	45	51	53	-	45	-	40	43	-	36	-	-
Zinc	-	-	-	290	280	270	-	-	-	370	-	280	230	240	260	-	230	-	200	200	-	190	-	-

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Location Station No.	Near 11th Street H-5						-						Mouth H-7					
							H-6											
Sample No.	-	8278	8333	-	-	8543	8273	8279	8336	8357	-	8546	-	-	8339	8360	-	8550
Quarter	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Collection Period	7/90- 10/90	10/90- 1/91	2/91- 4/91	5/91- 6/91	6/91- 9/91	9/91- 11/91	7/90- 10/90	10/90- 1/91	2/91- 4/91	5/92- 6/91	6/91- 9/91	9/91- 11/91	7/90- 10/90	10/90- 1/91	2/91- 4/91	5/91- 6/91	6/91- 9/91	9/91- 11/91
Solids (%)	-	48.0	44.3	-	-	43.2	51.0	48.0	43.5	41.2	-	49	-	-	55.7	41.6	-	52.5
TOC (%)	-	2.8	-	-	-	7.3	3.2	3.7	2.0	1.8	-	3.2	-	-	1.8	1.7	-	2.3
Metals																		
Antimony	-	3.0	5.3	-	-	18	8.3	4.8	5.8	4.6	-	2.0	-	-	1.8	2.9	-	2.0
Arsenic	-	8.7	40	-	-	55	37	16	32	25	-	30	-	-	26	27	-	19
Cadmium	-	0.6	0.4	-	-	1.0	0.7	0.5	0.6	0.6	-	0.61	-	-	0.4	0.6	-	0.49
Copper	-	150	110	-	-	160	140	140	130	130	-	120	-	-	110	110	-	110
Mercury	-	0.23	0.24	-	-	0.35	0.29	0.23	0.26	0.24	-	0.28	-	-	0.16	0.22	-	0.2
Lead	-	130	65	-	-	94	98	140	170	240	-	160	-	-	48	56	-	50
Nickel	-	34	38	-	-	33	44	40	43	38	-	38	-	-	33	32	-	30
Zinc	-	150	190	-	-	200	190	150	200	190	-	150	-	-	140	170	-	120

*=Reported as mean of two samples

-=No sample (sediment trap was not recovered)

+ =Reported as mean of three samples

■ =Problem chemical (See Table 1)

Table 7 summarizes the results of VOA of SPM. Several volatile organic compounds (VOCs) were identified as problem chemicals in the outer portion of Hylebos Waterway during the CBNTRI. Consequently, VOA analysis was only conducted at stations H-5, H-6, and H-7.

Nineteen VOCs were detected in SPM. Acetone was detected in the highest concentrations ranging from 400 - 900 $\mu\text{g}/\text{kg}$. Acetone was used to clean the sediment trap collection cylinders prior to deployment. The highest levels for the remaining 18 VOCs were measured at station H-6. Detected concentrations of problem VOCs were as follows:

- Trichloroethene (0.7-6 $\mu\text{g}/\text{kg}$)
- Ethylbenzene (2 $\mu\text{g}/\text{kg}$)
- Tetrachloroethene (1-40 $\mu\text{g}/\text{kg}$)
- Total xylenes (0.6-13 $\mu\text{g}/\text{kg}$)

Occidental Chemical was identified as a major source of tetrachloroethene, ethylbenzene, and xylenes in the outer portion of Hylebos Waterway during the CBNTRI (Tetra Tech, 1985). Between 1947 and 1973 tetrachloroethene was produced at Occidental's solvent plant in commercial quantities (Tetra Tech, 1986b). Two additional compounds p-isopropyltoluene (cymene) 5-100 $\mu\text{g}/\text{kg}$, and 2-butanone (methyl ethyl ketone) 80-200 $\mu\text{g}/\text{kg}$ were also present at elevated levels in SPM.

In addition to the target compounds, 33 VOCs were tentatively identified in SPM. Tentatively identified organics are found during mass spectral searches of sample extracts; they represent some of the most prevalent peaks in sample chromatograms that were not among the original target compounds (PSEP, 1988). These compounds, listed in Appendix D- Table D1, were for the most part, present at concentrations < 400 $\mu\text{g}/\text{kg}$ and consisted primarily of solvents and various components of petroleum products (Verschuren, 1983 and Merck, 1983).

The results of semivolatile organic and PCB analysis of Hylebos Waterway SPM is summarized in Table 8. Thirty-four target organics were quantified in SPM during the monitoring period. Detected concentrations of problem chemicals were as follows;

- LPAH (190-75000 $\mu\text{g}/\text{kg}$)
- HPAH (4400-49000 $\mu\text{g}/\text{kg}$)
- Hexachlorobenzene (48-200 $\mu\text{g}/\text{kg}$)
- 1,2,4 Trichlorobenzene (28 $\mu\text{g}/\text{kg}$)
- Hexachlorobutadiene (47-230 $\mu\text{g}/\text{kg}$)
- Bis (2-ethyl hexyl) phthalate (730-4700 $\mu\text{g}/\text{kg}$)
- Total PCBs (130-1900 $\mu\text{g}/\text{kg}$)

Peak concentrations of LPAH, HPAH, phenol, and total PCBs were measured at station H-3. Sources of these chemicals, previously identified in this section of the waterway, include; Elf ATOchem (LPAH), Kaiser ditch (HPAH, phenol), and General Metals (PCBs), (Tetra Tech, 1986b). Hexachlorobenzene, 1,2,4 trichlorobenzene, and hexachlorobutadiene were

Table 7: Summary of volatile organic compounds detected in settling particulate matter from Hylebos Waterway July, 1990 – November, 1991 (ug/kg, dry).

Location Station No.	Near 11th Street H-5			- H-6			Mouth H-7		
	8290 7/90-1/91	8333 1-4/91	8543 9-11/91	8291/ 8306* 7/90-1/91	8364/ 69* 1-6/91	8546/ 47* 9-11/91	- 7/90-1/91	8365 1-6/91	8550 9-11/91
Total Organic Carbon (%)	2.8	-	7.3	3.5	1.9	3.2	-	1.8	2.3
Chloromethane	3 u	7 u	3 j	2 u	5 u	7 j	-	4 u	6 j
Trichlorofluoromethane	3 uj	4 j	4 u	2 u	2 j	4 u	-	1 j	4 u
Acetone	500 jc	100 ujc	900 jc	900 jc	500 jc	700 jc	-	400 jc	600 jc
Vinyl Chloride	3 uj	7 u	4 uj	2 u	0.7 j	4 uj	-	0.1 j	4 uj
Carbon Disulfide	3 u	7 u	4 u	2 u	4 u	4 u	-	4 u	2 j
Cis 1,2 Dichloroethene	3 j	2 j	1 j	5 j	8	4 j	-	1 j	2 j
Trans 1,2 Dichloroethene	3 j	7 u	4 u	2 u	0.5 j	4 u	-	0.1 j	4 u
Trichloroethene	3 j	1 j	0.7 j	6 j	6	3 j	-	0.8 j	1 j
Tetrachloroethene	3 j	2 j	1 j	8 j	12	40	-	1 j	6
Chloroform	3 j	2 j	0.7 j	5 j	17	3 j	-	2 j	0.5 j
2-Hexanone	3 u	7 u	1 j	2 u	5 u	4 u	-	4 u	4 u
2-Butanone	3 u	20 u	80 u	200 j	80	40 u	-	80	90 u
4-methyl-2-Pentanone	3 u	7 u	4 u	3 j	5 u	4 u	-	4 u	4 u
Toluene	3 u	7 u	4 u	3 j	5 u	4 u	-	4 u	4 u
p-Isopropyltoluene	30 j	40	100 j	100 j	10 j	50 j	-	4 u	5 j
Ethylbenzene	3 u	7 u	4 u	2 j	5 u	4 u	-	4 u	4 u
1,2,4-Trimethylbenzene	3 u	7 u	4 uj	9 j	9 j	4 uj	-	4 u	3 j
1,3,5-Trimethylbenzene	3 u	7 u	4 uj	5 j	5 j	4 uj	-	4 u	4 uj
Total Xylenes	3 u	0.6 j	0.9 j	13 j	10 j	4 j	-	3 j	2 j

*=Reported as mean of two samples

-=No sample (Sediment trap was not recovered)

u=Not detected at detection limit shown

j=Estimated concentration

c=Probable contaminant from decontamination procedures

 =Problem chemicals (see Table 1)

Table 8: Summary of semivolatile organics and polychlorinated biphenyls (PCBs) detected in settling particulate matter (SPM) from Hylebos Waterway July, 1990 – November, 1991 (ug/kg, dry)

Location Station No.	Upper Turning Basin			-			-			Near Lincoln Drain		
	H-1			H-2			H-3			H-4		
Sample No. Collection Period	8342 7/90-1/91	8551/ 52* 5-6/91	8551/ 52* 6-11/91	8345 7/90-1/91	8539 5-6/91	8539 9-11/91	8288/ 8304* 7/90-1/91	8361/ 68* 1-4/91	8533 6-9/91	8289 7/90-1/91	8351 1-6/91	- 6-11/91
Total Organic Carbon (%)	-	2.4	5.8	-	2.1	4.6	4.7	2.2	4.5	4.3	2.2	-
Acenaphthene	-	190 j	580	-	110 j	410 u	220	250 j	12000	100	85 j	-
Acenaphthylene	-	1600 u	210 u	-	18000 uj	410 u	26 j	1300 u	270 j	98 u	1000 u	-
Naphthalene	-	82 j	260 j	-	120 j	410 u	100	170 j	6300	58 j	140 j	-
Fluorene	-	250 j	590	-	140 j	190 j	220	300 j	11000	130	1000 u	-
Anthracene	-	1600 u	630	-	1400 u	410 u	230	1300 u	5000 j	180	1000 u	-
Phenanthrene	-	1500 j	3700	-	1400 u	500 u	1100	2100	40000	780	730 j	-
Sum LPAH	-	2000 j	5800 j	-	370 j	190 j	1900 j	2800 j	75000 j	1200 j	4000 j	-
Fluoranthene	-	2200	4900	-	1400 u	2000	2200	3800	20000	1300	1100	-
Benzo(a)anthracene	-	1300 j	2000 j	-	1400 u	820 uj	790	1300 j	5000	600	1000 u	-
Chrysene	-	2400	1900 j	-	1800	1200	2000	3800	3000 j	1300	1300	-
Pyrene	-	2400	1900 j	-	1900	820 j	1600	4200	15000	900	1600	-
Benzo(a)fluoranthene	-	1400 j	4300 j	-	1400 j	1200	2200	1500 j	4500 j	1700	1000 j	-
Benzo(a)pyrene	-	1600 uj	1000 j	-	1400 u	410 u	420	1100 u	1100 j	350	340 j	-
Dibenzo(a,h)anthracene	-	4200 u	650 u	-	3500 u	1100 u	120 j	3200 u	640 u	110 j	2600 u	-
Indeno(1,2,3-cd)pyrene	-	1600 u	680 j	-	330 j	410 u	300 j	490 j	520 j	320 j	1000 u	-
Benzo(g,h,i)perylene	-	1600 u	530 j	-	430 j	410 u	40 j	610 j	250 u	29 j	1000 u	-
Sum HPAH	-	9700 j	17000 j	-	5900 j	5200 j	9700 j	16000 j	49000 j	6600 j	5300 j	-
Total PAH	-	12000 j	23000 j	-	6300 j	5400 j	12000 j	19000 j	120000 j	7800 j	9300 j	-
1-methylnaphthalene	-	95 j	240 j	-	1400 u	410 u	NA	130 j	5800	NA	71 j	-
2-methylnaphthalene	-	100 j	240 j	-	1400 u	410 u	120 j	120 j	7100	68 j	63 j	-
Dibenzofuran	-	1600 u	460	-	1400 u	410 u	160	1300 u	8100	100	1000 u	-
Carbazole	-	8500 u	1500 uj	-	7000 u	2100 uj	NA	3500 u	3600 j	NA	5300 u	-
Isophrone	-	1600 u	260 u	-	71 j	410 u	63 u	1300 u	250 u	98 u	1000 u	-
Retene	-	1600 u	260 u	-	1400 u	410 uj	na	1300 u	250 u	na	na	-
Phenol	-	1600 u	260 u	-	1400 u	410 u	170	1300 u	3000	200 u	1000 u	-
Pentachlorophenol	-	8500 u	1300 uj	-	7000 u	2100 u	320 u	6600 u	1300 uj	490 u	5300 u	-
4-methylphenol	-	1600 u	260 u	-	1400 u	250 j	63 u	1300 u	98 j	98 u	480 j	-
Benzoic Acid	-	14000 j	4000 j	-	3600 j	3700 uj	1100	4900 j	2100 j	1600	680 j	-
Hexachloroethane	-	1600 u	260 u	-	1400 u	410 u	130 u	1300 u	nar	200 u	1000 u	-
Hexachlorobenzene	-	1600 u	260 u	-	1400 u	410 u	63 u	1300 u	250 u	98 u	1000 u	-
1,2,4-Trichlorobenzene	-	1600 u	260 u	-	1400 u	410 u	63 u	1300 u	250 uj	98 u	1000 u	-
Hexachlorobutadiene	-	4200 u	650 u	-	3500 u	1100 u	130 u	3200 u	640 uj	200 u	2600 u	-
Dimethylphthalate	-	1600 u	260 u	-	1400 u	410 u	58 u	1300 u	250 u	98 u	1000 u	-
Butylbenzylphthalate	-	4200 u	650 u	-	1400 u	1100 uj	63 u	3200 u	640 uj	100	2600 u	-
Di-n-butylphthalate	-	1600 u	260 u	-	1400 u	410 u	63 u	1300 u	250 u	98 u	1000 u	-
Bis(2-ethylhexyl)phthalate	-	2400 u	4700 j	-	1800 u	2700 uj	1400	3400 u	2000 j	1500	4100 u	-
PCBs												
1254	-	200 j	570	-	560	1000	1100	750	1500	810	440	-
1260	-	160 j	160	-	400	380	400	500	420	360 u	550	-
Total PCB'S	-	360 j	730	-	960	1400	1500	1300	1900	810	990	-

*=Reported as mean of two samples
 --=No sample (Sediment trap was not recovered)

na=Not analyzed
 nar=No analytical result

u=Not detected at detection limit shown
 j=Estimated concentration

=Problem chemicals (see Table 1)

Table 8: (continued)- semivolatile organics and PCBs in SPM from Hylebos Waterway July, 1990 - November, 1991 (ug/kg, dry).

Location Station No. Sample No. Collection Period	Near 11th Street H-5			- H-6			Mouth H-7		
	8290 7/90-1/91	1-4/91	8543 9-11/91	8291 7/90-1/91	8364 1-6/91	8546 9-11/91	- 7/90-1/91	8365 1-6/91	8550 9-11/91
Total Organic Carbon (%)	2.8	ns	7.3	3.5	1.9	3.2	-	1.8	2.3
Acenaphthene	120	ns	130 j	150	330 j	150 j	-	130 j	61 j
Acenaphthylene	48	ns	92 j	25	61 j	36 j	-	68 j	37 j
Naphthalene	62	ns	220	52	280 j	140 j	-	230 j	110 j
Fluorene	230	ns	160 j	170	420	250 j	-	150 j	80 j
Anthracene	710	ns	360	240	560	270 j	-	1200 u	190 j
Phenanthrene	1400	ns	910	910	2300	1100	-	1300 u	530
Sum LPAH	2600	ns	1900 j	1500	4000	1900 j	-	470 j	1000 j
Fluoranthene	2100	ns	1800	1200	2800	1400	-	1900	890
Benzo(a)anthracene	810	ns	850	500	780	510	-	740 j	480
Chrysene	1600	ns	760	810	1300	630	-	1000 j	710
Pyrene	1500	ns	1200	780	2100	800	-	2000	970
Benzofluoranthenes	1600	ns	2400	980	910 j	890 j	-	860 j	690 j
Benzo(a)pyrene	420	ns	610	260	350 j	250 j	-	370 j	260
Dibenzo(a,h)anthracene	93 j	ns	110 j	62 j	960 u	930 u	-	1200 u	540 u
Indeno(1,2,3-cd)pyrene	270	ns	340	160	380 u	370 u	-	1200 u	380
Benzo(g,h,i)perylene	39 j	ns	340	20 u	210 j	370 u	-	290 j	210 u
Sum HPAH	8400 j	ns	8400 j	4800 j	8500 j	4500 j	-	7200 j	4400 j
Total PAH	11000 j	ns	10000 j	6300 j	13000 j	6400 j	-	7700 j	5400 j
1-methylnaphthalene	na	ns	91 j	na	180 j	87 j	-	120 j	63 j
2-methylnaphthalene	85 j	ns	71 j	67 j	180 j	82 j	-	100 j	45 j
Dibenzofuran	150	ns	140 j	130	310 j	170 j	-	1200 u	76 j
Carbazole	na	ns	140 j	na	890 j	1900 uj	-	6000 u	89 j
Isophrone	28 u	ns	220 u	20 u	120 j	370 u	-	1200 u	210 u
Retene	na	ns	330	na	380 u	280 j	-	1200 u	570
Phenol	32 j	ns	220 u	77	380 u	370 u	-	1200 u	210 u
Pentachlorophenol	140 u	ns	1100 u	41 j	2000 u	1900 u	-	6000 u	1100 uj
4-methylphenol	84 j	ns	120 j	1300	870 j	370 u	-	1200 u	77 j
Benzoic Acid	280 u	ns	2600 j	51 j	750 j	4800 uj	-	15000 u	840 j
Hexachloroethane	56 u	ns	220 u	23 j	47 j	370 u	-	1200 u	210 u
Hexachlorobenzene	28 u	ns	220 u	48	200 j	370 u	-	1200 u	110 j
1,2,4-Trichlorobenzene	28 u	ns	220 u	20 u	28 j	370 u	-	1200 u	210 u
Hexachlorobutadiene	56 u	ns	550 u	37 j	200 j	230 j	-	2900 u	67 j
Dimethylphthalate	28 u	ns	220 u	16 j	380 u	370 u	-	1200 u	210 u
Butylbenzylphthalate	28 u	ns	550 u	20 u	960 u	930 u	-	2900 u	540 u
Di-n-butylphthalate	28 u	ns	220 u	20 u	560	370 u	-	1200 u	210 u
Bis(2-ethylhexyl)phthalate	950	ns	1300	730	1700 u	2200 u	-	1500 uj	1800 u
PCBs									
1254	100 u	ns	540	810	280 u	400	-	120 u	200 j
1260	780	ns	670	540	380	750 u	-	130	110
Total PCB'S	780	ns	1200	1400	380	400	-	130	310 j

*=Reported as mean of two samples

--=No sample (Sediment trap was not recovered)

na=Not analyzed

u=Not detected at detection limit shown

j=Estimated concentration

ns=Not analyzed (insufficient sample volume)

=Problem chemicals (See Table 1)

primarily detected at station H-6, although hexachlorobenzene and hexachlorobutadiene were also detected in one of two samples from the mouth of the waterway. Maximum concentrations of bis (2-ethyl hexyl) phthalate occurred in the upper turning basin.

In contrast to metals, few clear longitudinal gradients were evident for the semivolatile organics. In general, PCBs tend to peak at station H-3 in the upper portion of the waterway and decrease moving towards either the head or mouth of the waterway. During one monitoring period (July 1990 - January 1991), a secondary peak for PCBs was also measured at station H-6. Temporally, intra-station concentrations of these compounds tended to be somewhat variable. However, differences in quantitation limits between monitoring periods and missing data points hinder interpretations of temporal trends (see quality assurance section).

Several additional compounds, not listed as problem chemicals, were also quantified in SPM. Benzoic acid was detected throughout the waterway at concentrations ranging from 51-14000 $\mu\text{g}/\text{kg}$. In general, the remaining twelve compounds were present at levels < 1000 $\mu\text{g}/\text{kg}$. Exceptions were 1-methylnaphthalene, 2-methylnaphthalene, dibenzofuran, and carbazole at station H-3, which were in the range of 1000-10000 $\mu\text{g}/\text{kg}$. Chemically, these four compounds are closely related to the PAHs.

In addition to the target organics, forty semivolatile organic compounds were also tentatively identified in SPM samples. The majority of these compounds were fatty acids (Appendix D-Table D2). Fatty acids commonly occur in many organisms and are routinely reported in recent estuarine sediments (PSEP, 1988).

Sediment accumulation rates for Hylebos Waterway determined from sediment trap data are shown in Table 9. Two types of accumulation rates have been calculated. Mass accumulation ($\text{g}/\text{cm}^2/\text{yr}$), which is the measured sediment flux into the traps, and accumulation rate (cm/yr), which is calculated to represent the actual thickness of new sediments once the particulates have consolidated on the bottom. Both these values should be viewed as estimates of gross sedimentation (*i.e.* net sedimentation + resuspension) in the waterway. Consequently, the values reported here overestimate net sedimentation in the waterway. Sedimentation rate calculations are shown at the bottom of Table 9.

Mass accumulation rates for Hylebos Waterway, on a dry weight basis, ranged from 0.7-3.8 $\text{g}/\text{cm}^2/\text{yr}$ with a mean of $2.1 \pm 0.8 \text{ g}/\text{cm}^2/\text{yr}$. The highest sedimentation rates in the waterway were measured at station H-3 (mean = $2.7 \pm 0.8 \text{ g}/\text{cm}^2/\text{yr}$). In general, these data suggest that sedimentation in most of the waterway tends to be highest during the summer and fall (June to November), and lowest during the winter and early spring (January to April). Predicted accumulation rates ranged from 0.9-7.2 cm/yr with a mean of $3.1 \pm 1.5 \text{ cm}/\text{yr}$.

Table 9: Gross sedimentation rates for Hylebos Waterway from available sediment trap data July, 1990 – November, 1991.

Station Number	Location	Deployment Period	Number Days Deployed	Sedimentation	
				Mass Accumulation (g/cm ² /yr)	Accumulation Rate (cm/yr)
H-1	Upper Turning Basin	5-6/91	43	1.7	2.6
		6-9/91	89	1.6	2.4
		9-11/91	56	0.9	1.4
		Mean=		1.4	2.1
H-2	-	5-6/91	43	2.1	3.8
		9-11/91	56	1.5	2.8
		Mean=		1.7	2.9
H-3	-	8-10/90	77	2.4	4.4
		10/90-1/91	96	2.6	4.8
		1-4/91	99	1.9	3.6
		6-9/91	89	3.8	7.2
		Mean=		2.7	5.0
H-4	Near Lincoln Drain	8-10/90	77	1.3	2.0
		10/90-1/91	96	0.7	1.1
		4-6/91	49	3.4	5.4
		Mean=		1.8	2.8
H-5	Near 11th Street	10/90-1/91	87	2.5	3.5
		1-4/91	96	0.7	0.9
		9-11/91	56	2.6	3.7
		Mean=		1.9	2.7
H-6	-	7-10/90	84	2.7	3.5
		10/90-1/91	96	2.2	2.9
		1-4/91	96	1.4	1.8
		4-6/91	49	1.8	2.4
		9-11/91	64	2.5	3.2
		Mean=		2.1	2.8
H-7	Mouth	2-6/91	83	2.4	2.2
		4-6/91	49	1.7	1.6
		9-11/91	55	3.3	3.1
		Mean=		2.5	2.3
Waterway mean(range)=				2.1 (0.7-3.8)	3.1 (0.9-7.2)

Sedimentation Rate Calculations

- Mass Accumulation (g/cm²/yr)= [(P/A)/D] x Y

P= Amount of material collected (dry grams)

A= Collection area of sediment trap cylinders (cm²)

D= No. of days sediment trap was deployed

Y= No. of days in a year

- Accumulation Rate (cm/yr)= [Mass Accumulation (g/cm²/yr)/dry density (g/cm³)

Wet Density= Estimated from Puget Sound Density Model (Crecelius, 1989) using % solids data from in-situ bottom sediments.

Dry Density= [Wet Density x (Bottom Sediment % solids/100)]

Bottom Sediments

The result of conventional and metals analyses of bottom sediments, collected January 23, 1991, from each of the sediment trap stations in Hylebos Waterway are shown in Table 10. TOC concentrations ranged from 1.8-5.3%. TOC concentrations were fairly consistent between the upper turning basin and the 11th Street Bridge, ranging from 4.0-5.3%. Somewhat lower concentrations were measured at station H-6 (2.7%) and at the mouth (1.8%). Grain size analysis indicated that most of the sediments collected consisted primarily of silt and clay size particles. Sediments near the Lincoln Av. Drain and 11th Street Bridge tended to have a higher sand content.

Concentrations of problem metals in Hylebos waterway bottom sediments are summarized below:

- Antimony (3.8-42 mg/kg)
- Arsenic (15-86 mg/kg)
- Copper (93-220 mg/kg)
- Lead (43-160 mg/kg)
- Mercury (0.16-0.46 mg/kg)
- Nickel (26-53 mg/kg)
- Zinc (120-540 mg/kg)

In general, similar gradients were observed for all metals in Hylebos bottom sediments. Concentrations were at a maximum at station H-2 in the upper portion of the waterway and declined moving toward the mouth. A secondary peak for lead was also measured in the outer portion of the waterway at station H-6. The lowest concentrations for all metals occurred at the mouth of the waterway.

Organics analyses of Hylebos Waterway bottom sediments are summarized in Table 11. Thirty-five compounds were detected in bottom sediments. Detected concentrations of problem chemicals were as follows;

- Trichloroethene (1-2 $\mu\text{g}/\text{kg}$)
- Tetrachloroethene (0.8-2 $\mu\text{g}/\text{kg}$)
- LPAH (410-3600 $\mu\text{g}/\text{kg}$)
- HPAH (1800-9800 $\mu\text{g}/\text{kg}$)
- Phenol (17-170 $\mu\text{g}/\text{kg}$)
- Hexachlorobenzene (34-87 $\mu\text{g}/\text{kg}$)
- Hexachlorobutadiene (46 $\mu\text{g}/\text{kg}$)
- Bis (2-ethylhexyl) phthalate (300-1200 $\mu\text{g}/\text{kg}$)
- Total PCBs 150-3000 $\mu\text{g}/\text{kg}$)

Low levels of six VOCs were detected, primarily at station H-6. Again, as was the case for SPM, the presence of acetone in bottom sediments is probably related to its use in the cleaning of sampling equipment. The highest concentrations of four problem chemicals trichloroethene, tetrachloroethene, hexachlorobenzene, and hexachlorobutadiene were measured at station H-6. Occidental Chemical was identified as a major source of these compounds in Hylebos Waterway during the CBNTRI (Tetra Tech, 1985).

Table 10: Results of conventionals and metals analysis of bottom sediments from Hylebos Waterway, January, 1991.

Location Station No.	Upper Turning Basin H-1		- H-2	- H-3	Lincoln Drain H-4	Near 11th Street H-5	- H-6	Mouth H-7
	8205/ 06*	8207 Rep	8208	8209	8212	8213	8214	8216
Total Solids (%)	46.6	45.3	41.0	40.8	45.8	49.0	52.1	63.8
Total Organic Carbon (%)	4.4	4.6	5.2	4.3	4.0	5.3	2.7	1.8
Grain Size (%)								
Gravel (>2mm)	2	0	0	0	2	16	0	0
Sand (2mm-62um)	26	19	28	22	45	38	32	50
Silt (62um-4um)	46	60	39	45	31	26	42	44
Clay (<4um)	27	21	33	33	22	20	26	16
Metals (mg/kg, dry)								
Antimony	9.0	10	42	14	17	9.0	3.9	2.2u
Arsenic	62	56	86	49	52	37	18	15
Cadmium	0.7	0.9	1.5	0.8	0.7	0.6	0.4	0.3
Copper	93	120	220	150	150	120	120	98
Mercury	0.22	0.26	0.46	0.45	0.30	0.28	0.23	0.16
Lead	55	69	160	97	92	84	100	43
Nickel	44	47	53	49	42	36	40	26
Zinc	190	230	540	210	200	160	140	120

*=Reported as mean of two samples

u=Not detected at detection limit shown

=Problem chemicals (see Table 1)

Table 11: Summary of organic compounds detected in bottom sediments from Hylebos Waterway, January, 1991.

Location Station No.	Upper Turning Basin H-1		- H-2	- H-3		Lincoln Drain H-4	Near 11th Street H-5	- H-6		Mouth H-7
	8205/ 06*	8207 Rep	8208 1/91	8209/ 10*	8211 Rep	8212 1/91	8213 1/91	8214/ 15*	8308 Rep	8216 1/91
Collection Date	1/91	Rep	1/91	1/91	Rep	1/91	1/91	1/91	Rep	1/91
Depth @ MLLW (ft)	23	-	28	31	-	23	19	31	-	31
Total Organic Carbon (%)	4.4	4.6	5.2	4.2	4.3	4.0	5.3	2.6	2.8	1.8
Volatiles (ug/kg, dry)										
Acetone	-	-	-	-	-	-	90 j	15 u	2 u	17 uj
Carbon Disulfide	-	-	-	-	-	-	1 j	1 j	1 j	0.6 j
Cis 1,2 Dichloroethene	-	-	-	-	-	-	1 j	2	2	1 u
Trichloroethene	-	-	-	-	-	-	1 j	2 j	2	1 u
Tetrachloroethene	-	-	-	-	-	-	0.8 j	2 j	1 j	1 u
Chloroform	-	-	-	-	-	-	2 u	2 j	0.8 j	1 u
Semivolatiles (ug/kg, dry)										
Acenaphthene	32 j	80 u	94 u	29 j	-	31 j	320	41 j	-	17 j
Acenaphthylene	28 j	33 j	36 j	23 j	-	23 j	47 j	26 j	-	20 j
Naphthalene	80 u	80 u	94 u	50 j	-	42 j	120	61	-	26 j
Fluorene	46 j	27 j	40 j	54	-	48	360	70	-	26 j
Anthracene	170	170	240	170	-	130	850	200	-	97
Phenanthrene	230	180	350	320	-	330	1900	410	-	290
Sum LPAH	510 j	410 j	670 j	650 j	-	600 j	3600 j	810 j	-	480 j
Fluoranthene	790	930	1300	1200	-	750	2300	900	-	430
Benzo(a)anthracene	340	400	660	580	-	390	1300	410	-	170
Chrysene	730	820	1800	1500	-	810	1800	730	-	300
Pyrene	550	740	1400	1400	-	680	1700	640	-	220 j
Benzo(a)fluoranthene	870	1100	2300	2100	-	1100	1700	920	-	380
Benzo(a)pyrene	170	210	400	390	-	210	430	240	-	100
Dibenzo(a,h)anthracene	80 u	58	130 j	140	-	79	160	75	-	53 j
Indeno(1,2,3-cd)pyrene	120	190	300	310	-	210	360	220	-	110
Benzo(g,h,i)perylene	61 u	80 u	47 j	59 j	-	33	68 j	41 j	-	30 u
Sum HPAH	3600	4400	8300 j	7700 j	-	4300	9800 j	4200 j	-	1800 j
Total PAH	4100 j	4800 j	9000 j	8400 j	-	4900 j	13000 j	5000 j	-	2300 j
Phenol										
Phenol	170 j	120	190 u	44 j	-	33 j	40 j	72 j	-	17 j
Pentachlorophenol	300 u	400 u	470 u	230 u	-	210 u	180 u	89 j	-	150 u
2-methylnaphthalene	80 u	80 u	94 u	33 j	-	23 j	190	45	-	12 j
Hexachloroethane	120 u	160 u	190 u	48	-	80 u	73 u	62	-	61 u
Hexachlorobenzene	61 u	80 u	94 u	34 j	-	41 u	37 u	87	-	30 u
Hexachlorobutadiene	120 u	160 u	190 u	93 u	-	82 u	73 u	46 j	-	61 u
Benzoic Acid	610 u	800 u	940 u	210 j	-	410 u	230 j	200 j	-	300 u
Dibenzofuran	80 u	80 u	94 u	37 j	-	35 j	180	59	-	23 j
Dimethylphthalate	27 j	80 u	94 u	39 j	-	34 j	29 j	36 j	-	30 u
Butylbenzylphthalate	80 u	80 u	100	46 u	-	40 j	37 u	38 u	-	30 u
Di-n-butylphthalate	61 u	80 u	94 u	27 j	-	34 j	37 u	38 u	-	30 u
Bis(2-ethylhexyl)phthalate	650	790	1200	820	-	630	360	460	-	300
PCB										
1254	220	-	790	1100	1700	660	270	310	-	63 u
1260	83 u	-	96 u	460	1300	420	1100	280	-	150
Total PCB'S	220	-	790	1600	3000	1100	1400	590	-	150

*=Reported as mean of two samples u=Not detected at detection limit shown

--=Not analyzed

j=Estimated concentration

=Problem chemicals (see Table 1)

In contrast, the highest concentrations of phenol (H-1), bis (2-ethylhexyl) phthalate (H-2), and total PCBs (H-3) were present in the upper portion of the waterway. PAHs were detected throughout the waterway, with the highest levels occurring in the vicinity of the 11th Street Bridge. The lowest levels of most organics were measured at the mouth of the waterway. Concentrations of the remaining compounds, not identified as problem chemicals, were $<250 \mu\text{g}/\text{kg}$.

Twenty organics were also tentatively identified in bottom sediments. These compounds, listed in Appendix D- Table D3, were dominated by unresolved hydrocarbons and to a lesser extent fatty acids.

For perspective, concentrations of arsenic, HPAH, and total PCBs in Hylebos surface sediments (top 2 cm) collected in 1984 and 1991 are compared in Figure 4. In most instances, arsenic and HPAH levels were similar in both years. In contrast, total PCB levels in 1991 are higher than those measured in 1984 at approximately similar areas in the waterway. These data suggest that PCB concentrations have not gone down in bottom sediments despite the passage of seven years and in fact, may actually be getting worse. It should be noted that factors such as spatial and analytical differences between these studies may be contributing to the apparent trend in PCB concentrations. In addition, source controls in Hylebos Waterway are not expected to be completed until 1995. However, the evidence is strong enough to warrant further investigation into unknown sources.

DISCUSSION

Contaminant Trends

Concentrations of arsenic, HPAH, hexachlorobenzene, and total PCBs associated with SPM and bottom sediments from Hylebos Waterway are compared in Figure 5. In the majority of cases, concentrations of arsenic and HPAH were higher in SPM than those measured in bottom sediments at the same location. This difference was especially marked in the upper turning basin at station H-1, station H-3, and at station H-7 at the mouth of the waterway. This was also the case for hexachlorobenzene. However, variable quantitation limits between monitoring periods for hexachlorobenzene in SPM limit the ability to make strong comparisons with bottom sediments. In contrast, with a few exceptions, total PCB concentrations in SPM were similar or lower than bottom sediments.

Tables 12 (metals) and 13 (organics) compare present (reflected by SPM) and historical (bottom sediments) levels of problem chemicals in Hylebos Waterway in an attempt to ascertain if source control efforts are succeeding in reducing inputs of these chemicals to the waterway. Summarized at the bottom of these tables are subjective criteria developed to evaluate differences in chemical concentrations between SPM and bottom sediments. These criteria were based primarily on the overall precision and accuracy of the data set (see quality assurance section) measured during the present study. This information indicates that concentration differences of ≥ 30 percent for metals and ≥ 80 percent for organics, between

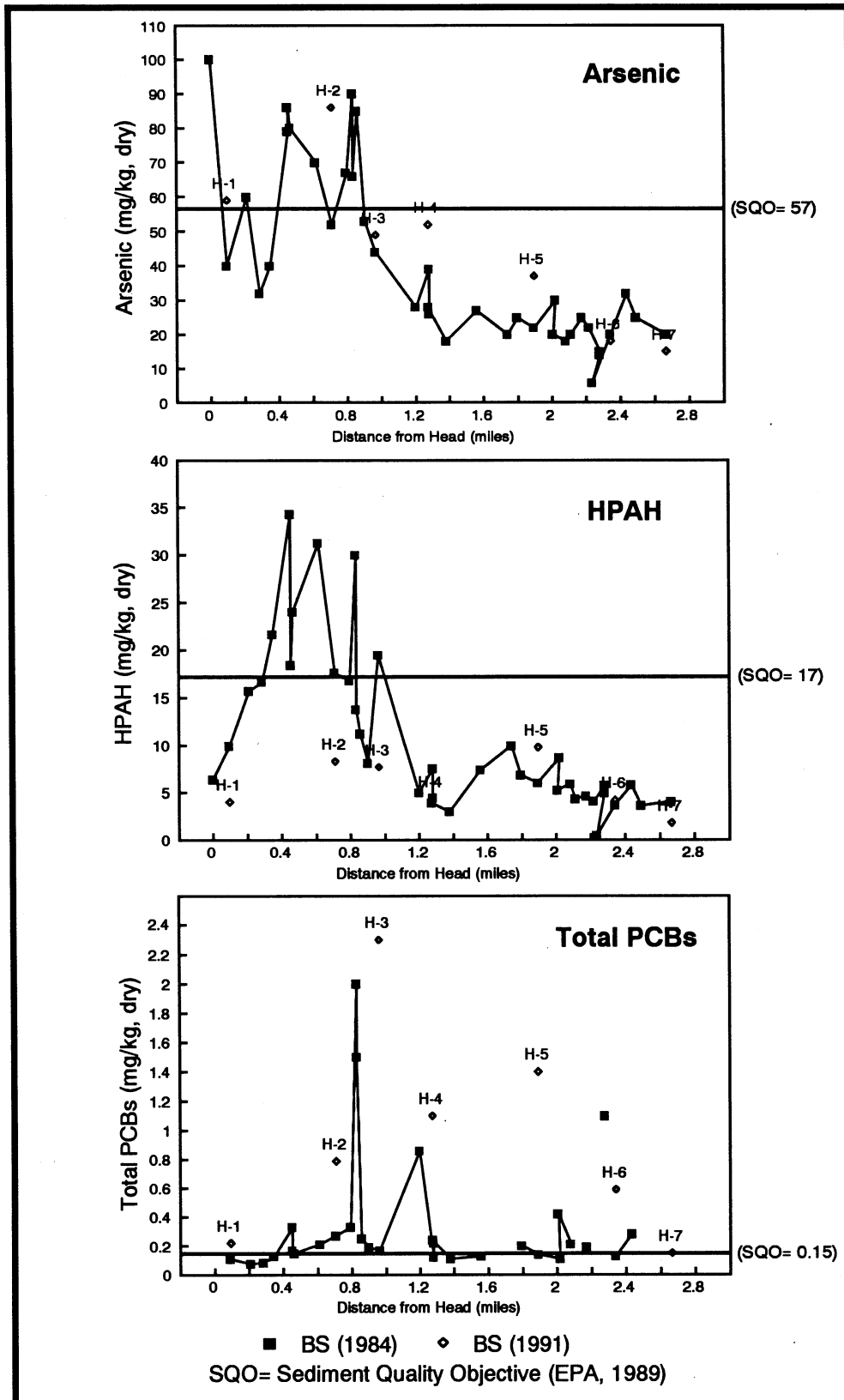


Figure 4: Comparison of arsenic, HPAH, and total PCBs in bottom sediments from Hylebos Waterway in 1984 and 1991.

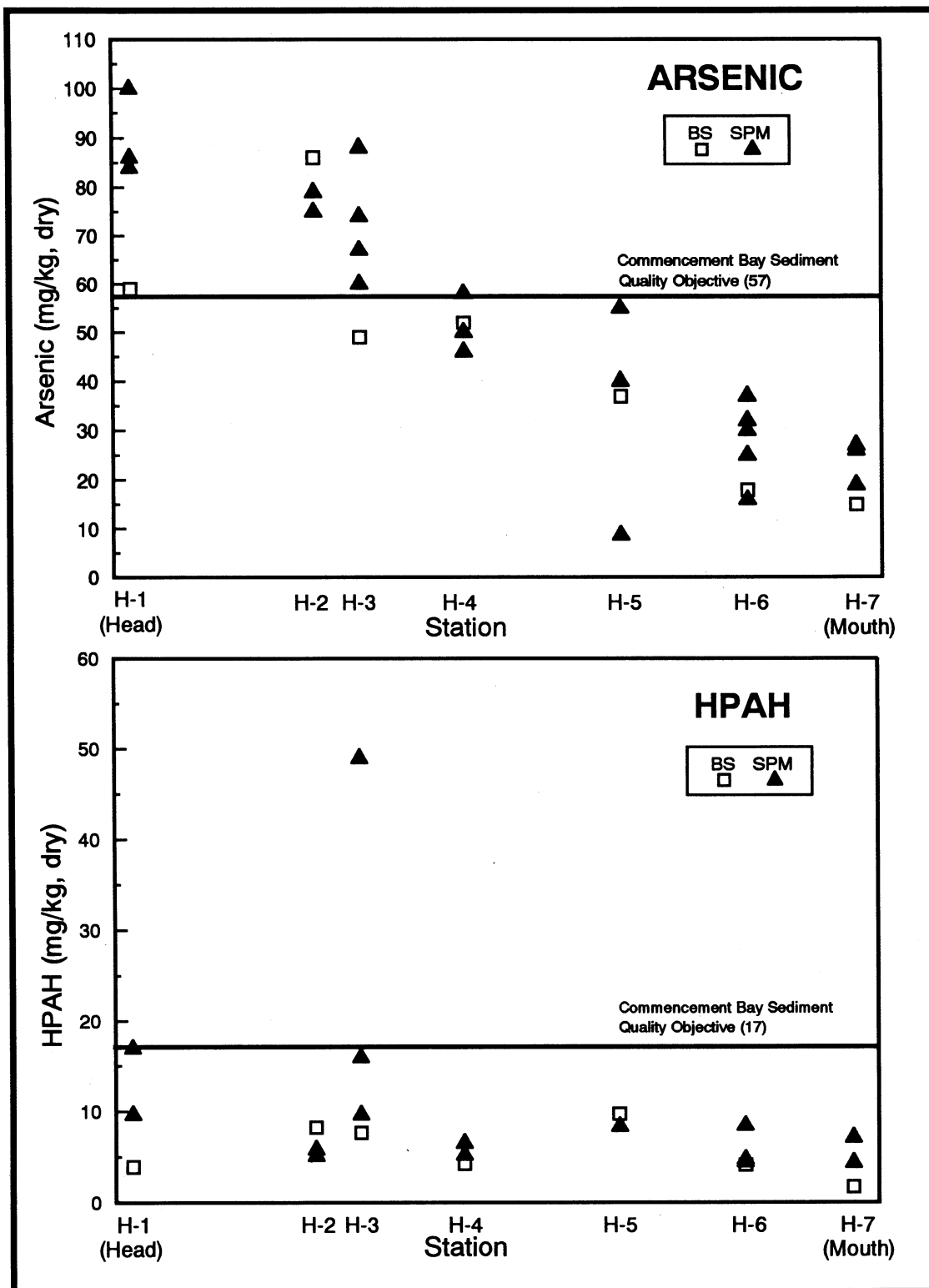


Figure 5: Arsenic and HPAH in settling particulate matter (SPM) and bottom sediments (BS) from Hylebos Waterway July, 1990 to November, 1991.

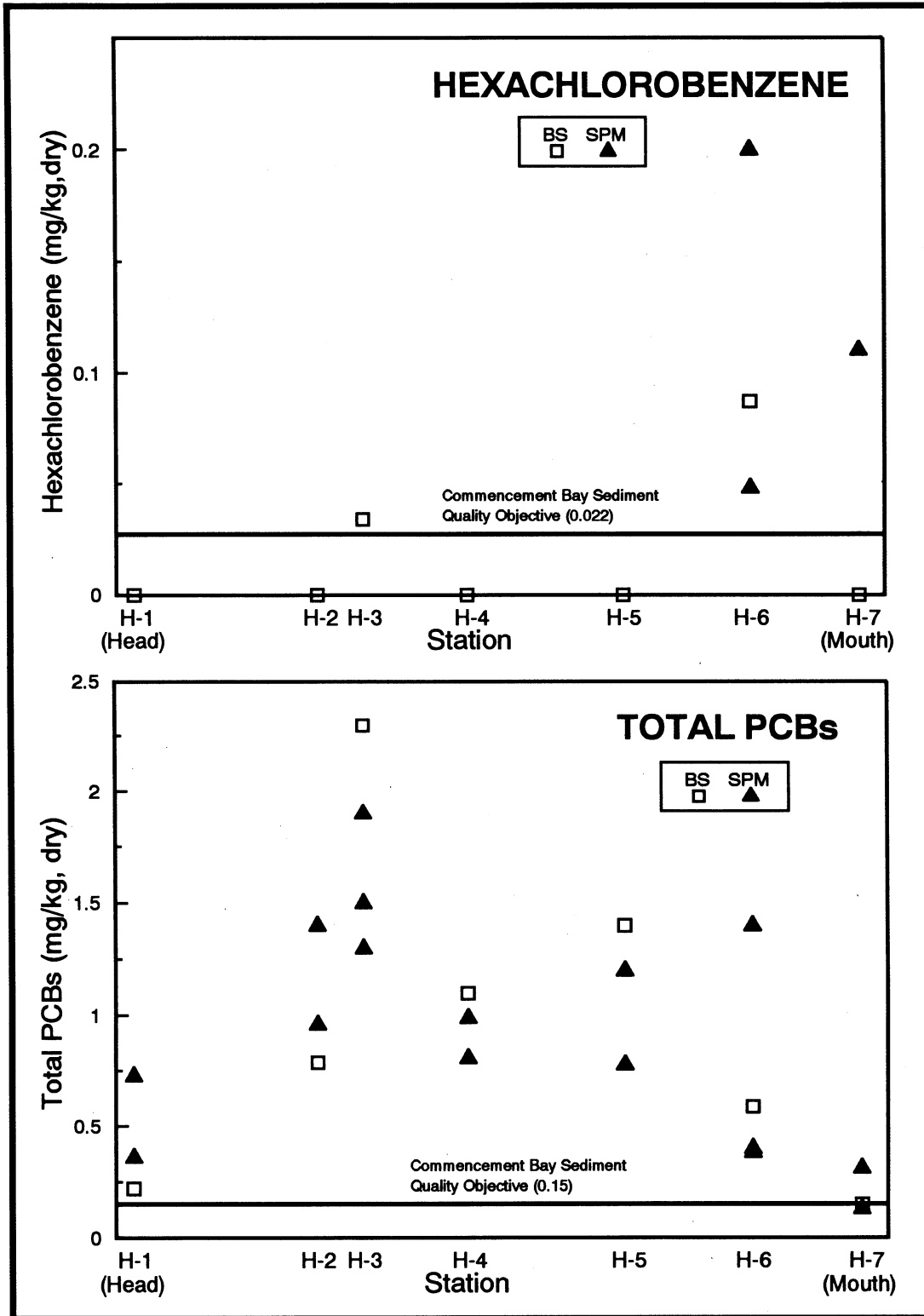


Figure 5 (cont.): Hexachlorobenzene and total PCBs in settling particulate matter (SPM) and bottom sediments (BS) from Hylebos Waterway July, 1990 to November, 1991.

Table 12: Comparison of problem metals(1) in settling particulate matter (SPM) and bottom sediments (BS) from Hylebos Waterway, matrix of change indicators.

Station Quarter	H-1						H-2						H-3						H-4					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Antimony	*	*	*	?	-	?	*	*	*	-	*	-	?	?	?	*	?	*	-	?	*	-	*	*
Arsenic	*	*	*	+	+	+	*	*	*	?	*	?	?	+	+	*	+	*	?	?	*	?	*	*
Copper	*	*	*	+	+	+	*	*	*	-	*	?	?	?	?	*	?	*	?	?	*	?	*	*
Mercury	*	*	*	?	?	+	*	*	*	?	*	?	?	?	?	*	?	*	?	?	*	?	*	*
Lead	*	*	*	?	?	?	*	*	*	-	*	-	?	?	?	*	?	*	?	?	*	?	*	*
Nickel	*	*	*	?	?	?	*	*	*	?	*	?	?	?	?	*	?	*	?	?	*	?	*	*
Zinc	*	*	*	+	+	?	*	*	*	-	*	-	?	?	?	*	?	*	?	?	*	?	*	*

Station Quarter	H-5						H-6						H-7					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Antimony	*	-	-	*	*	+	+	?	+	?	*	?	*	*	¿	¿	*	¿
Arsenic	*	-	?	*	*	+	+	?	+	+	*	+	*	*	+	+	*	?
Copper	*	?	?	*	*	+	?	?	?	?	*	?	*	*	?	?	*	?
Mercury	*	?	?	*	*	?	?	?	?	?	*	?	*	*	?	+	*	?
Lead	*	+	?	*	*	?	?	+	+	+	*	+	*	*	?	+	*	?
Nickel	*	?	?	*	*	?	?	?	?	?	*	?	*	*	?	?	*	?
Zinc	*	?	?	*	*	?	+	?	+	-	*	?	*	*	?	+	*	?

(1)=Problem metals (see Table 1)

*=No data

¿=Compound was not detected in SPM and/or BS with similar detection limits

SPM vs BS Calculation

$$\text{Change (\%)} = \frac{(\text{SPM} - \text{BS})}{\text{BS}} \times 100$$

Legend of Change Indicators (SPM vs BS)

+/- = >30% Likely Change

? = <30% Uncertain

+ = SPM > BS

- = SPM < BS

Table 13: Comparison of problem organics(1) in settling particulate matter (SPM) and bottom sediments (BS) from Hylebos Waterway, matrix of change indicators.

Station Quarter	H-1			H-2			H-3			H-4			H-5			H-6			H-7		
	1-2	3-4	4-6	1-2	3-4	4-6	1-2	3-4	4-6	1-2	3-4	4-6	1-2	3-4	4-6	1-2	3-4	4-6	1-2	3-4	4-6
Tetrachloroethene	na	na	na	na	na	na	na	na	na	na	na	na	+	+	?	+	+	+	*	nd	nd
Ethylbenzene	na	na	na	na	na	na	na	na	na	na	na	na	nd	na	nd	nd	nd	nd	*	nd	nd
Total Xylenes	na	na	na	na	na	na	na	na	na	na	na	na	nd	na	nd	nd	nd	nd	*	nd	nd
LPAH	*	+	+	*	?	-	+	+	+	+	+	*	?	na	?	+	+	+	*	?	+
HPAH	*	+	+	*	?	?	?	+	+	?	?	*	?	na	?	?	-	?	*	+	+
Phenol	*	nd	nd	*	nd	nd	+	nd	+	nd	nd	*	?	na	na	?	nd	na	*	nd	nd
Hexachlorobenzene	*	nd	nd	*	nd	nd	nd	nd	nd	nd	nd	*	¿	na	nd	?	+	nd	*	nd	nd
Hexachlorobutadiene	*	nd	nd	*	nd	nd	¿	nd	nd	nd	nd	*	¿	na	nd	?	+	+	*	nd	¿
Bis(2-ethylhexyl)phthalate	*	nd	+	*	nd	nd	?	nd	+	+	nd	*	+	na	+	?	nd	nd	*	nd	nd
Total PCBs	*	?	+	*	?	?	?	?	?	?	?	*	?	na	?	+	?	?	*	?	+

(1)= Problem organics (see Table 1)

*=No data

nd=Compound was not detected in SPM and/or BS, differences in detection limits do not allow comparisons to be made

¿=Compound was not detected in SPM and/or BS with similar detection limits

na=Not analyzed

SPM vs BS calculation

$$\text{Change (\%)} = \frac{(\text{SPM} - \text{BS})}{\text{BS}} \times 100$$

Legend of Change Indicators (SPM vs BS)

+/- = >80% Likely Change

? = <80% Uncertain

+ = SPM > BS

- = SPM < BS

SPM and bottom sediments are real, rather than due to sampling and/or analytical variability. In addition, because these comparisons are based on a limited amount of data (particularly for the organics), and resuspension can obscure possible trends (see discussion on comparison of sedimentation rates) these conclusions should be viewed with caution.

Examination of Table 12 suggests, that for most sites, little change is evident between present and historical levels of problem metals. Noteworthy exceptions which appear to be higher in SPM were as follows:

- H-1 (Upper Turning Basin) - Arsenic, copper, zinc
- H-2 - None
- H-3 - Arsenic
- H-4 - None
- H-5 - None
- H-6 - Arsenic, lead
- H-7 (Mouth) - Arsenic

There are some indications that present levels of antimony, lead, and zinc at station H-2, and antimony near the Lincoln drain and the 11th Street Bridge have decreased.

As was the case for problem metals, Table 13 suggests that in most instances present levels of problem organics are similar to historical levels. Problem organics which showed evidence of higher levels in SPM are summarized by station below:

- H-1 - LPAH, HPAH
- H-2 - None
- H-3 - LPAH, HPAH, Phenol
- H-4 - LPAH
- H-5 - Tetrachloroethene, Bis (2-ethylhexyl) phthalate
- H-6 - Tetrachloroethene, LPAH, Hexachlorobutadiene
- H-7 - HPAH

Higher concentrations of LPAH in SPM compared to bottom sediments is not unexpected, since weathering processes such as evaporation, photochemical oxidation, dissolution, and microbial degradation can preferentially remove PAHs with molecular weights less than that of fluoranthene (*i.e.* LPAH), (Merill and Wade, 1985). In addition, lower concentrations of tetrachloroethene would be expected in older sediments due to volatilization. However, the presence of a volatile compound such as tetrachloroethene in recent sediments, suggests an ongoing source.

In general, these data suggest that ongoing sources of several problem chemicals may exist in Hylebos Waterway. Given the fact that very few source controls were in place as of November 1991, this result is not unanticipated. Additional data being collected as part of

Ecology's ongoing sediment trap monitoring efforts in Hylebos Waterway will be useful in assessing the apparent trends in contaminant levels over time.

Comparisons to Commencement Bay Sediment Quality Objectives

Of particular concern to source control efforts are chemicals which, in addition to showing evidence of higher concentrations in SPM, are also above the CBNT Sediment Quality Objective (SQO), (EPA, 1989) in SPM.

Problem chemicals and selected non-priority chemical concentrations in SPM are compared to the SQOs sediment quality values in Appendix E- Tables E1 (metals) and E2 (organics). Sediment quality values are estimates of contaminant concentrations above which deleterious effects would always be observed in marine benthic communities.

Table 14 summarizes problem chemical concentrations in SPM, averaged over the first 1.5 years of monitoring, which exceeded the SQO. Mean concentrations were selected for emphasis, to be more representative of average conditions in the waterway during the study. Arsenic was the only metal that exceeded the SQOs in SPM. In addition, none of the VOCs identified as problem chemicals were measured above the SQOs. Six individual problem chemicals in SPM at station H-3 exceeded the SQOs. Total PCB concentrations were above the SQOs at all of the sites tested. It should be noted that in several instances, detection limits for phenol, hexachlorobenzene, hexachlorobutadine, and bis(2-ethylhexyl) phthalate were above the SQOs. The reader is again reminded to refer to Appendix E for a complete list of chemicals exceeding the SQOs.

In addition to the problem chemicals, four non-priority chemicals (benzoic acid, 2-methylnaphthalene, dibenzofuran, and 4-methylphenol) were detected in SPM at levels above the SQOs listed in Appendix E- Table E2. Again, as was the case for the problem chemicals, the greatest number of exceedences were observed at station H-3.

Problem chemicals in bottom sediments from each of the sediment trap stations are compared to SQOs in Appendix E- Tables E3 (metals) and E4 (organics). Compared to SPM, fewer chemicals exceeded the sediment quality values in bottom sediments. Arsenic and zinc were the only metals exceeding the SQOs in bottom sediments. As was the case for SPM, concentrations of total PCBs were above the SQOs at all of the locations tested.

Exceedences of the SQOs in bottom sediments are summarized below:

- H-1 (Upper Turning Basin) - Arsenic, Total PCBs
- H-2 - Arsenic, Zinc, Total PCBs
- H-3 - Hexachlorobenzene, Total PCBs
- H-4 - Total PCBs
- H-5 - Total PCBs
- H-6 - Hexachlorobenzene, Hexachlorobutadiene, Total PCBs
- H-7 (Mouth) - Total PCBs

Table 14: Summary of metals and organic compounds exceeding the Commencement Bay Sediment Quality Objectives in Hylebos Waterway settling particulate matter.

I. Problem Chemicals* exceeding SQOs.

Station	Location	Chemical
H-1	Upper Turning Basin	Arsenic Total PCBs
H-2	-	Arsenic Total PCBs
H-3	-	Arsenic LPAH HPAH Phenol Bis(2-ethylhexyl)phthalate Total PCBs
H-4	Near Lincoln Drain	Bis(2-ethylhexyl)phthalate Total PCBs
H-5	Near 11th Street	Total PCBs
H-6	-	Hexachlorobenzene Hexachlorobutadiene Total PCBs
H-7	Mouth	Total PCBs

II. Non-Priority chemicals exceeding SQOs.

Station	Location	Chemical
H-1	Upper Turning Basin	Benzoic Acid
H-2	-	None
H-3	-	2-Methylnaphthalene Dibenzofuran Benzoic Acid
H-4	Near Lincoln Drain	Benzoic Acid
H-5	Near 11th Street	Benzoic Acid
H-6	-	4-Methylphenol
H-7	Mouth	None

*=Problem chemicals (see Table 1)

SQO=Commencement Bay Sediment Cleanup Objectives (EPA, 1989)

The co-occurrence of concentration differences between SPM and bottom sediments at station H-3 for LPAH, HPAH, and phenol; and the fact that a substantially different suite of problem chemicals exceeded SQOs in SPM vs bottom sediments, suggests that the material collected by the traps is not just resuspended bottom sediments and therefore reflects some recent inputs. Consequently, the potential exists that an ongoing source(s) of several problem chemicals exists in the vicinity.

As previously mentioned, of particular concern to source control efforts are areas of the waterway where: 1) concentrations in SPM were above the SQOs, and 2) problem chemicals were also elevated in SPM compared to bottom sediments. Given these criteria, the primary focus of further (*i.e.* verify that sources are controlled and unknown sources are not present) source control efforts should be on the areas and chemicals listed below:

- H-1 (Upper Turning Basin) - Arsenic
- H-2 - None
- H-3 - Arsenic, LPAH, HPAH, phenol
- H-4 - None
- H-5 - None
- H-6 - Hexachlorobutadiene
- H-7 (Mouth) - None

Problem Chemicals in Hylebos Waterway SPM vs other Areas of Commencement Bay and Puget Sound

Shown in Table 15, is a comparison of problem chemicals in Hylebos SPM with contaminant levels in SPM from Sitcum and Thea Foss Waterways. For perspective, also included are data on contaminant levels associated with muddy sediments from depositional areas in the central basin of Puget Sound (Tetra Tech, 1989, and PTI, 1991). Sediments from the central basin were included to reflect chemical concentrations associated with fine grained material removed from urban bays (*i.e.* reference areas).

TOC levels in Hylebos Waterway were somewhat higher than those measured in Sitcum and fall within the range of values measured in Thea Foss Waterway. Median arsenic concentrations in Hylebos were approximately two times higher than those measured in Sitcum. Copper and nickel were similar in all the waterways tested. Hylebos had the lowest median levels of mercury, lead, and zinc. LPAH and HPAH levels in Hylebos waterway were much lower than those measured in Thea Foss Waterway and similar to those seen in Sitcum. The lowest levels of bis (2-ethylhexyl) phthalate were seen in Sitcum Waterway.

Compared to muddy sediments from the central basin of Puget Sound, median concentrations of arsenic, copper, and lead were 4-5 times higher, while mercury and zinc were two times higher in Hylebos SPM. Nickel concentrations were similar in both areas. Median concentrations of all problem organics listed, were elevated by 1-2 orders of magnitude in Hylebos waterway SPM.

Table 15: Comparison of selected problem chemicals(1) detected in settling particulate matter (SPM) from Hylebos Waterway during the present study with other available data on contaminant levels associated with SPM from Sitcum and Thea Foss Waterways and bottom sediments (BS) from the Central Puget Sound Basin.

Location	Hylebos	Sitcum	Thea Foss	Central Basin*
Sample Type	SPM	SPM	SPM	BS
Collection Period	7/90-11/91	7/90-6/91	6/89-6/91	3/89-3/90
Number of Samples	16-27	10-17	12-22	11
Total Organic Carbon (%)	3.2 (1.7-7.3)	1.8 (1.4-3.7)	5.8 (2.1-9.5)	1.8 (1.6-2.5)
Metals (mg/kg, dry)				
Antimony	8.3 (1.8-18)	-	-	-
Arsenic	50 (8.7-100)	26 (6-57)	-	10 (6.7-15)
Copper	150 (110-410)	130 (66-190)	170 (120-340)	38 (34-53)
Mercury	0.29 (0.16-0.53)	-	0.61 (0.35-0.90)	0.13 (0.11u-0.21)
Lead	98 (48-240)	270 (52-370)	240 (120-400)	22j (18j-40)
Nickel	41 (30-53)	-	39 (28-81)	40 (36-43)
Zinc	200 (120-370)	510 (100-580)	310 (170-460)	99 (89-110j)
Organics (ug/kg, dry)				
Tetrachloroethene	5j (1j-40)	-	-	0.085j (0.06j-0.094)
Total Xylenes	3uj (0.6j-13j)	-	-	0.81u (0.25-2.7uj)
LPAH	1900j (190j-15000j)	2200j (320-8600j)	5500j (2500j-32000j)	130j (110j-180j)
HPAH	7800j (4400j-49000j)	6900j (880-21000j)	18000 (13000j-120000j)	380j (240j-850j)
Bis(2-ethylhexyl)phthalate	1800u (730-4700j)	1000 (220-140000j)	5200 (800u-54000u)	280j (38-740j)
Total PCBs	890 (130-1900)	-	-	70u (6.0j-80u)

median (range)

(1)=Problem chemicals (see Table 1)

*=Central basin muddy sediments (>67% fines) from deep areas (>150m), includes stations 24, 29, and 38.

--No data

u=Not detected at detection limit shown

j=Estimated concentration

Data Sources

Hylebos- Present Study

Sitcum- Norton and Barnard, 1992. Spatial and Temporal Trends in Contaminant Levels Associated with SPM in Sitcum Waterway (Commencement Bay) July 1990 to June 1991.

Thea Foss- Ecology, 1991b. Unpublished data from sediment trap monitoring in Thea Foss Waterway.

Central Basin- PSAMP (Puget Sound Ambient Monitoring Program) Tetra Tech, 1989 and PTI, 1991.

Sedimentation Rates in Hylebos Waterway vs other Areas of Commencement Bay and Puget Sound

To place sedimentation rates for Hylebos Waterway into perspective, Table 16 summarizes rates reported for other parts of Commencement Bay and Puget Sound. Mean sedimentation rates for Hylebos, Sitcum, and Thea Foss Waterways determined from sediment trap data (gross sedimentation) agreed within a factor of two. The highest average rates were measured in Sitcum Waterway (3.5 ± 1.2 g/cm²/yr), followed by Hylebos (2.1 ± 0.8 g/cm²/yr), and then Thea Foss Waterway (1.6 ± 1.0 g/cm²/yr).

Based on two Pb-210 dated cores collected during the CBNTRI, net sedimentation in Hylebos Waterway was estimated to be 0.33 g/cm²/yr in the upper turning basin and 1.1 g/cm²/yr at the mouth near station H-6 (EPA, 1992). The uncertainty associated with these measurements was not reported.

Based on a comparison of means, net sedimentation rates agree within a factor of 2.5 at the head and 1.4 at the mouth of Hylebos Waterway compared to net sedimentation rates (0.81 ± 0.5 g/cm²/yr) reported for other Commencement Bay Waterways from Pb-210 dated cores. In addition, net sedimentation rates in Hylebos are generally within a factor of 2.5 compared to mean rates reported for various parts of Puget Sound.

Comparison of sedimentation rates from sediment traps (gross sedimentation) and rates from Pb-210 dated cores (net sedimentation) have been used in other investigations to estimate bottom sediment resuspension rates (Baker, *et al.*, 1991). Comparing net sedimentation rates in the upper turning basin (0.33 g/cm²/yr) and at the mouth (1.1 g/cm²/yr) to gross sedimentation at the nearest sediment trap locations (H-1 = 1.4 ± 0.4 g/cm²/yr and H-6 = 2.1 ± 0.5 g/cm²/yr), indicates that resuspension is approximately 1.1 g/cm²/yr and 1.0 g/cm²/yr at the head and mouth, respectively. These rates are approximately one-half of the resuspension rates reported for Sitcum Waterway (2.2 to 2.9 g/cm²/yr), (Norton and Barnard, 1992). In addition, they fall within the range of values (0.4-3.6 g/cm²/yr) reported by Patmont and Crecelius (1991) for other urban embayments in Puget Sound. Resuspension estimates for Hylebos Waterway suggest that somewhere in the range of 25-45 percent of the material collected by the sediment traps could be resuspended bottom sediments.

CONCLUSIONS

Although the spatial distribution of contaminants measured in both SPM and bottom sediments is generally consistent with the current understanding of sediment contamination in Hylebos Waterway, several results deserve special attention. Mean concentrations of eight individual problem chemicals in SPM were high enough to adversely affect marine benthic communities, based on comparisons with the Commencement Bay Sediment Quality Objectives (SQOs). In addition, there is some evidence to suggest that ongoing sources of several problem chemicals exist in the waterway. This result is consistent with the fact that very few source controls were completed in the waterway as of November 1991. The

Table 16: Comparison of sediment accumulation rates for Hylebos Waterway obtained from sediment traps with values reported for other parts of Commencement Bay and Puget Sound.

Source	Location	Method	Sedimentation Rate(1)	
			(g/cm ² /yr)	(cm/yr)
Present Study	Hylebos WW	Sediment Trap	2.1 (0.7-3.8)	3.1 (0.9-7.2)
Ecology, 1991b	Thea Foss WW	Sediment Trap	1.6 (0.2-3.9)	2.4 (0.3-6.5)
	Sitcum WW	" "	3.5 (2.1-5.7)	3.7 (2.3-5.7)
Tetra Tech and PTI, 1987 (3)	Head of Hylebos WW	Pb-210 cores (4)	0.33	0.77
	Mouth of Hylebos WW	Pb-210 cores (4)	1.1	1.8
	CMB Waterways(2)	Pb-210 cores (4)	0.81 (0.22-1.4)	1.1 (0.27-1.8)
Carpenter et al., 1985	Near Browns Pt.	Pb-210 cores	0.24 (0.2-0.28)	0.42 (0.25-0.58)
	Puget Sound	" "	0.43 (0.046-1.2)	0.68 (0.04-2.4)
Lavelle et al., 1986	Puget Sound	Pb-210 cores	0.72 (0.26-1.2)	1.4 (0.53-2.48)
Bloom and Crecelius, 1987	Puget Sound	Pb-210 cores	0.64 (0.27-1.4)	-

(1)=Mean(range)

(2)=Includes- Thea Foss, Middle, St. Paul, Milwaukee, and Sitcum Waterways

(3)= Original Report- Re-calculated and reported in (EPA, 1992).

(4)=Estimated values

--=No data

current schedule for Hylebos Waterway calls for source controls to be completed by September 1995.

The major findings of the first 1.5 years of sediment monitoring in Hylebos Waterway are summarized below:

- In most instances, little change is evident between present (SPM) and historical (bottom sediment) concentrations of problem metals and organics in Hylebos Waterway. Problem chemicals which did show evidence of higher levels in SPM were as follows;
 - H-1 (Upper Turning Basin) - Arsenic, copper, zinc, LPAH, HPAH
 - H-2 - None
 - H-3 - Arsenic, LPAH, HPAH, phenol
 - H-4 - LPAH
 - H-5 - Tetrachloroethene, bis (2-ethylhexyl) phthalate
 - H-6 - Arsenic, lead, tetrachloroethene, LPAH, hexachlorobutadiene
 - H-7 (Mouth) - Arsenic, HPAH

In addition, there is evidence to suggest that current levels of antimony, lead, and zinc near General Metals, and antimony near Lincoln Drain and the 11th Street Bridge have decreased.

- Based on comparison of bottom sediment data from 1984 and 1991 there is some reason to believe that PCB concentrations have not gone down in bottom sediments despite the passage of seven years and in fact, concentrations may actually be getting worse.
- Mean concentrations, of eight individual problem chemicals in SPM were high enough to adversely affect marine benthic communities, based on comparisons with the Commencement Bay SQOs. The greatest number of exceedences (6) were measured at station H-3, in the upper portion of the waterway. Problem chemicals with average concentrations exceeding the SQOs in SPM were as follows:
 - H-1 - Arsenic, Total PCBs
 - H-2 - Arsenic, Total PCBs
 - H-3 - Arsenic, LPAH, HPAH, phenol, bis (2-ethyl hexyl) phthalate, Total PCBs
 - H-4 - Bis (2- ethyl hexyl) phthalate, Total PCBs
 - H-5 - Total PCBs
 - H-6 - Hexachlorobenzene, Hexachlorobutadiene, Total PCBs
 - H-7 - Total PCBs

In addition, average concentrations of four non-priority chemicals (benzoic acid, 2-methylnaphthalene, dibenzofuran, and 4-methylphenol) were also measured at concentrations above the SQOs.

- The highest concentrations of arsenic, cadmium, and copper in SPM were measured at station H-1, in the upper turning basin. Mercury and zinc peaked at station H-2. The lowest concentrations for all metals were generally present at the mouth of the waterway.
- The highest concentrations of problem organics in Hylebos SPM were measured at station H-3 in the upper portion of the waterway (LPAH, HPAH, phenol, and total PCBs) and at station H-6 in the outer portion of the waterway (trichloroethene, tetrachloroethene, ethylbenzene, xylenes, hexachlorobenzene, and hexachlorobutadiene). An exception was bis (2-ethylhexyl) phthalate, where the highest concentration was measured at station H-1 in the upper turning basin.
- Median arsenic concentrations in Hylebos SPM were approximately two times higher than those measured in Sitcum Waterway SPM. Median concentrations of the remaining problem chemicals analyzed were at or below levels measured in SPM from Sitcum and Thea Foss Waterways.
- Sedimentation rates for Hylebos Waterway calculated from sediment trap data ranged from 0.7-3.8 g/cm²/yr with a mean of 2.1±0.8 g/cm²/yr. Based on comparison of gross (sediment traps) and net (Pb-210 cores) sedimentation rates, estimated bottom sediment resuspension rates were 1.1 and 1.0 g/cm²/yr, at the head and mouth of the waterway, respectively. These data suggest that somewhere in the range of 25-45 percent of the material collected by the sediment traps could be resuspended bottom sediments.
- Current velocities are generally low at the head (geometric mean= 2 cm/sec) and mouth of the waterway (geometric mean= 8.9 cm/sec) even during periods of high tidal exchange. However, ship traffic and associated tug-boat activities can have a substantial short-term impact on currents in a localized area. Velocities ≤2 cm/sec occur approximately 97% of the time at the head. At the mouth, current velocities were more variable, being ≤10 cm/sec 43% of the time.

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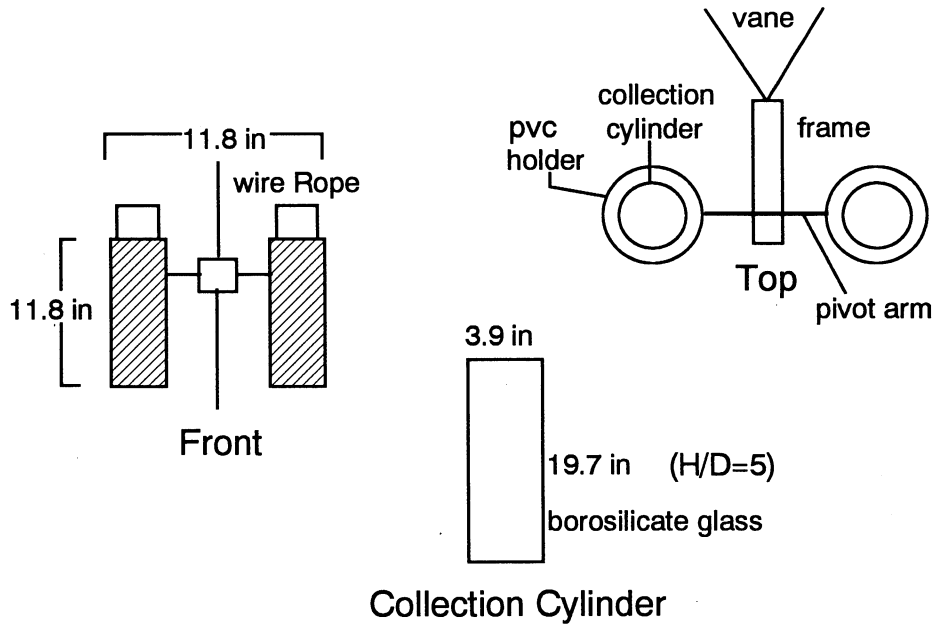
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Appendix A: Sediment Trap Design

I. Detailed View of Sediment Trap



II. Sediment Trap Deployment

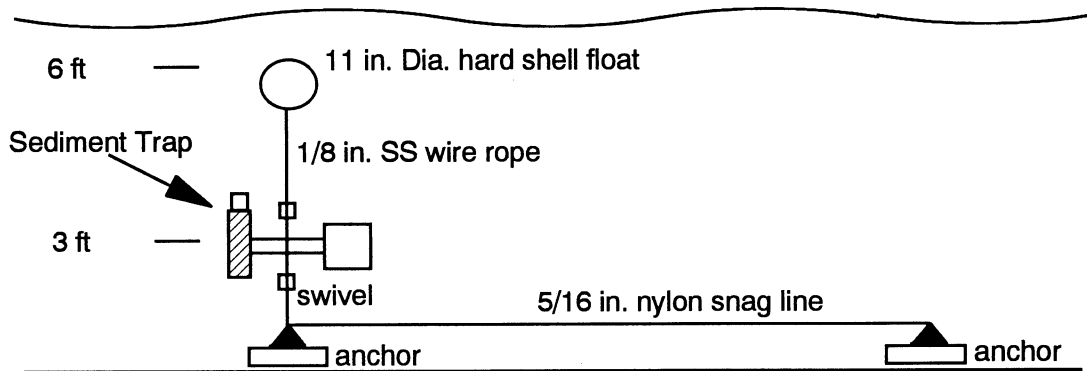


Figure A1: Schematic of Hylebos Waterway sediment traps.

Appendix B: Quality Assurance Data

Table B1: Summary of blind field duplicate results(1) for metals in settling particulate matter (SPM) and bottom sediments (BS) from Hylebos Waterway July, 1990 – November, 1991 (mg/kg, dry).

Sample No.	88276	88300		268377	268396		518531	518529		48205	48206	
Collection Date	7/90-1/91	-		2-6/91	-		6-11/91	-		1/91	-	
Sample Type	SPM	SPM	RPD	SPM	SPM	RPD	SPM	SPM	RPD	BS	BS	RPD
Antimony	12	13	8	-	-	-	13	11	17	8.9	9.0	1
Arsenic	74	74	0	27	29	7	66	67	2	60	63	5
Cadmium	0.93	0.94	1	-	-	-	1.8	1.2	31	0.7	0.7	0
Copper	170	170	0	120	130	8	210	210	0	93	93	0
Mercury	0.46	0.54	16	-	-	-	0.39	0.43	10	0.21	0.23	9
Lead	100	100	0	290	290	0	100	100	0	54	55	2
Nickle	51	57	11	-	-	-	45	45	0	42	45	7
Zinc	240	240	0	450	370	20	240	230	4	190	180	5

RPD=Relative Percent Difference= $[(x-y)/((x+y)/2)]*100$

--No data

(1)=All samples analyzed by Battelle Northwest Sequim, Wa.

Table B2: Summary of blind field duplicate results for organic problem chemicals(1) detected in settling particulate matter (SPM) and bottom sediments (BS) from Hylebos Waterway July, 1990 – November, 1991 (ug/kg, dry).

Sample No.(volatiles)	88291	88306		268364	268369		518546	518547		48214	48215	
Sample No.(semivolatiles)	88288	88304		268361	268368		518551	518552		48205	48206	
Sample No. (PCBs)	88288	88304		268351	268362		518540	518543		48209	48210	
Collection Date	7/90-1/91	-	RPD	2-6/91	-	RPD	6-11/91	-	RPD	1/91	-	RPD
Sample Type	SPM	SPM	(%)	SPM	SPM	(%)	SPM	SPM	(%)	BS	BS	(%)
Volatiles												
Laboratory	Manchester			Manchester			Manchester			Manchester		
Ethyl Benzene	1 j	2	67	-	-	-	-	-	-	-	-	-
Trichloroethene	7 j	7 j	0	6	6	0	2 j	3 j	33	0.9 J	0.9 J	0
Tetrachloroethene	9 j	10 j	10	12	12	0	37	38	3	0.9 J	0.6 J	40
Hexachlorobutadiene	12 j	15 j	22	21 j	21 j	0	35 j	39 j	11	-	-	-
Total Xylenes	12 j	13 j	8	9 J	12 J	31	4 j	4 j	0	-	-	-
Semivolatiles												
Laboratory	ARI			Manchester			Manchester			ARI		
Sum LPAH	1900 j	1800 j	5	2700	2700	0	4800 j	6700 j	33	380 j	450 j	17
Sum HPAH	9600 j	9500	1	8900	8700	2	16000 j	18000 j	6	3800 j	3400 j	11
Sum Phenols	150	190	23	-	-	-	-	-	-	270	68	120
Sum Phthalates	1300	1400	7	910 j	-	-	2700	6600 j	84	690	670	3
PCBs												
Laboratory	Manchester			Manchester			Manchester			Manchester		
Total PCBs	1700	1300	27	900	1100	20	1200	800	30	1500	1500	0

RPD=Relative Percent Difference= $[(x-y)/((x+y)/2)]*100$

-=Not detected

j=Estimated concentration

(1)=Problem chemicals (see Table 1)

Manchester=Ecology/EPA Manchester Laboratory Manchester, Wa.

ARI=Analytical Resources Inc. Seattle, Wa.

Table B3: Quality Assurance Data Reviews for Organics Analyses.

STATE OF WASHINGTON DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive E., Port Orchard, WA 98366


DATA REVIEW


May 1, 1991

Project: City Waterway Phase III

Samples: 91 - 048205, 048206, 048207, 048208, 048209, 048212, 048213, 048214, 048216, 048217, 91 - 048218, 048219, 0482220, 048221 and 048222.

Laboratory: Analytical Resources, Inc.

By: Dickey D. Huntamer 

Through: Stuart Magoon 

CASE SUMMARY

These analyses were reviewed for qualitative and quantitative accuracy, validity and usefulness. Sample analysis for both matrices used SW846 procedures. Extraction and cleanup methods were consistent with SW 846 Methods for soil samples. Specific methods used and problems incurred during the analysis of these samples are detailed in the case narrative and will not be addressed here. Analytical problems associated with QA/QC will be noted and referenced to the case narrative where appropriate.

There is no need to assimilate the "dilution factor" or "sample wt/vol" into the final values reported; these calculations have already been figured into the reported values. The results are calculated on a dry weight basis.

BNA FRACTION

Method: SW 846 8270

Matrix: Sediment

Holding times

All samples were extracted and analyzed within the recommended holding times.

Surrogates:

All surrogate recoveries for the samples were within acceptable QC limits.

Matrix Spike and Matrix Spike Duplicate (MS/MSD):

Sample 048216 was used for the matrix spike. The spike consisted of the normal CLP spike compounds and recoveries ranged from 63% to 95%. The Relative Percent Difference (RPD), ranged from 0.4% to 9%. All percent recoveries and RPD's were within QC limits. Only the limited set of CLP spike compounds was analyzed for the MS/MSD, however most of the target analytes

detected in 048216 were also detected in the spikes and consequently this data can be used as a triplicate analysis for compounds not added as matrix spike analytes.

Sample Data:

An organic tin compound was tentatively identified in sample, 048221, (stannane, chlorotris(2-methylpropyl)-), but was not detected any other sample.

Additional "J" qualifiers were added to those compounds which exceeded the Continuing Calibration % deviation (%D) limit of 25 % for the low level standards. The "M" qualifier was also added to some compounds due to poor spectral match with the target compound library. The data is acceptable for use with the additional qualifiers.

DATA QUALIFIER DEFINITIONS

- U - The analyte was analyzed for, but was not detected at or above the reported value.
- J - The analyte was analyzed for, and positively identified. The associated numerical value is an estimate.
- UJ - The analyte was analyzed for, but not detected at or above the reported estimated value.
- D - Signifies that the associated value was derived from a secondary dilution.
- E - This qualifier is used when the concentration of the associated value exceeds the known calibration range. (ARI uses a "k")
- R - The data are unusable for all purposes. The analyte was analyzed for, but the presence of the analyte has not been verified.
- M - Indicates poor mass spectral match.

Note: If this data is entered into some other format an "N" flag should be added to the compounds reported as tentatively identified compounds. The "N" flag indicates that there is presumptive evidence that the analyte is present in this sample.

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**STATE OF WASHINGTON DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive E., Port Orchard, WA 98366**

**DATA REVIEW
May 1, 1991**

Project: Commencement Bay

Samples: 91 - 088274, 088288, 088289, 088290, 088291, 088293, 088295, 088296, 0882304,
91 - 0882307.

Laboratory: Analytical Resources, Inc.

By: Dickey D. Huntamer *(Eck)*

Through: Stuart Magoon *Sm*

CASE SUMMARY

These analyses were reviewed for qualitative and quantitative accuracy, validity and usefulness. Sample analysis for both matrices used SW846 procedures. Extraction and cleanup methods were consistent with SW 846 Methods for soil samples. Specific methods used and problems incurred during the analysis of these samples are detailed in the case narrative and will not be addressed here. Analytical problems associated with QA/QC will be noted and referenced to the case narrative where appropriate.

There is no need to assimilate the "dilution factor" or "sample wt/vol" into the final values reported; these calculations have already been figured into the reported values. The results are calculated on a dry weight basis for samples 0882304, 088291, 088290, 088289, and 088288. The remaining samples are reported on a wet weight basis, because insufficient sample was available for dry weight determination.

BNA FRACTION

Method: SW 846 8270

Matrix: Sediment

Holding times

All samples were extracted and analyzed within the recommended holding times.

Surrogates:

All surrogate recoveries for the samples were within acceptable QC limits.

Matrix Spike and Matrix Spike Duplicate (MS/MSD):

Sample 088296 was used for the matrix spike. The spike consisted of the normal CLP spike compounds and recoveries ranged from 43% to 84%. The Relative Percent Difference (RPD), ranged from 0% to 22%. All percent recoveries and RPD's were within QC limits. Only the limited set of CLP spike compounds was analyzed for the MS/MSD, however most of the target analytes detected in 088296 were also detected in the spikes and consequently this data can be used as a triplicate analysis for compounds not added as matrix spike analytes.

Sample Data:

One Tentatively Identified Compound (TIC), sterol isomer was deleted from the TIC list for sample 088307. The spectral match was not close enough and it was changed to, Unknown. An organic tin compound was tentatively identified in sample, 088295, (stannane, chlorotris(2-methylpropyl)-), but was not detected in any other sample.

Additional "J" qualifiers were added to those compounds which exceeded the Continuing Calibration (%D) limit of 25% for the low level standards. The "M" qualifier was also added to some compounds due to poor spectral match with the target compound library. The data is acceptable for use with the additional qualifiers.

DATA QUALIFIER DEFINITIONS

- U - The analyte was analyzed for, but was not detected at or above the reported value.
- J - The analyte was analyzed for, and positively identified. The associated numerical value is an estimate.
- UJ - The analyte was analyzed for, but not detected at or above the reported estimated value.
- D - Signifies that the associated value was derived from a secondary dilution.
- E - This qualifier is used when the concentration of the associated value exceeds the known calibration range. (ARI uses a "K")
- R - The data are unusable for all purposes. The analyte was analyzed for, but the presence of the analyte has not been verified.
- M - Indicates poor mass spectral match.

Note: If this data is entered into some other format an "N" flag should be added to the compounds reported as tentatively identified compounds. The "N" flag indicates that there is presumptive evidence that the analyte is present in this sample.

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive SE , Port Orchard Washington 98366

CASE NARRATIVE


September 8, 1991

Subject: Commencement Bay

Samples: 91- 268342, -268345, -268351, -268361, -268362, -268364, -268365

Case No. DOE-020P

Officer: Dale Norton

By: Dickey D. Huntamer 
Organics Analysis Unit

POLYCHLORINATED BIPHENYLS

ANALYTICAL METHODS:

The soil samples were Soxhlet extracted with acetone and analyzed by EPA Method 8080 using capillary GC/ECD analysis.

HOLDING TIMES:

All sample extraction and analysis holding times were met.

BLANKS:

No significant blank contamination was detected.

SURROGATES:

Surrogate spike recoveries ranged from 46% to 135% for 4,4-Dibromooctafluorobiphenyl (DBOB), 51% to 159% for dibutylchlorodate (DBC) and 68% to 194% for Decachlorobiphenyl (DCB). One of the laboratory blanks had approximately a 30% extract loss during sample preparation, and this is reflected in the lower surrogate spikes recoveries for the blank. The last surrogate, DCB, suffered from interference from co-eluting peaks and consequently recoveries could not be determined for samples, 268351, 268361, 268362, 268364, 268365. No additional data qualifiers were added based on surrogate recoveries.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spikes were analyzed on sample 268364 using PCB Arochlors 1242 and 1260. Spike recoveries ranged from 100% to 116% for PCB-1242 and 119% to 123% for PCB-1260. The Relative Percent Difference (RPD) was 15% and 3% respectively.

SPECIAL ANALYTICAL PROBLEMS:

No significant problems were encountered in the analysis of these samples.

DATA QUALIFIER CODES:

- U - The analyte was not detected at or above the reported value.
- J - The analyte was positively identified. The associated numerical value is an estimate.
- UJ - The analyte was not detected at or above the reported estimated result.
- REJ - The data are unusable for all purposes.
- EXP - The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3×10^6 .
- NAF - Not analyzed for.
- N - For organic analytes there is evidence the analyte is present in this sample.
- NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.
- E - This qualifier is used when the concentration of the associated value exceeds the known calibration range.
- * - The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

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MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive SE , Port Orchard Washington 98366

CASE NARRATIVE
September 17, 1991

Subject: Commencement Bay

Samples: 91 - 268333, -268364, -268365 and 268369

Case No. DOE-020P

Officer: Dale Norton

By: Dickey D. Huntamer *(Signature)*
Organics Analysis Unit

VOLATILE ORGANIC ANALYSIS

ANALYTICAL METHODS:

Volatile organic compounds were analyzed using Manchester modification of the EPA CLP and SW 846 Method 8240 purge-trap procedure with capillary GC/MS analysis. Normal CLP QA/QC procedures were performed on the samples.

BLANKS:

Low levels of the common laboratory solvents Acetone and Methylene Chloride were detected in the laboratory blanks. The EPA 5 times rule was applied to all target compounds which were found in the blank. Compounds that were found in the sample and in the blank were considered real and not the result of contamination if the levels in the sample are greater than or equal to five times the amount of compounds in the associated method blank.

SURROGATES:

Surrogate recoveries were within CLP limits for all of the samples except for 1,2-Dichloroethane-d₄ in samples 268333 which was 1% above the CLP limit. No data qualifiers were added based on surrogate recoveries. QC limits for 1-Bromo-2-fluoroethane and 1,2 Dichlorobenzene-d₄ are advisory only.

HOLDING TIMES:

All samples were analyzed within the recommended 14 day holding time except for the matrix spikes which were analyzed on the fifteenth day. Since matrix spikes are primarily to see if the sample matrix interferes with the analysis, exceeding the holding times does not significantly affect the sample analysis. Consequently no data qualifiers were added based on holding times.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spikes were within acceptable QC limits for both percent recovery and RPD.

SPECIAL ANALYTICAL PROBLEMS:

No analytical problems were encountered in the analysis.

DATA QUALIFIER CODES:

- U - The analyte was not detected at or above the reported value.
- J - The analyte was positively identified. The associated numerical value is an estimate.
- UJ - The analyte was not detected at or above the reported estimated result.
- REJ - The data are unusable for all purposes.
- EXP - The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3×10^6 .
- NAF - Not analyzed for.
- N - For organic analytes there is evidence the analyte is present in this sample.
- NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.
- E - This qualifier is used when the concentration of the associated value exceeds the known calibration range.
- * - The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive SE , Port Orchard Washington 98366

CASE NARRATIVE


September 20, 1991

Subject: Commencement Bay

Samples: 91 - 268313, 268320, 268322, 268327, 268342, 268345, 268351, 268361, 268364, 268365, 268368, 268374, 268380, 268392, 268394 and 268398

Case No. DOE-020P

Officer: Dale Norton

By: Dickey D. Huntamer 
Organics Analysis Unit

SEMIVOLATILE ORGANICS

ANALYTICAL METHODS:

The semivolatile soil sample was Soxhlet extracted with acetone following the Manchester modification of the EPA CLP and SW 846 8270 procedure with capillary GC/MS analysis of the sample extracts. Normal QA/QC procedures were performed with the analyses. All data is reported on a wet weight basis except for samples, 268313, 268342, 268345, 268351, 268374, 268380 and 268394. Percent solids for the samples, were 33.8%, 38.4%, 42.7%, 42.8%, 55.5%, 65.1% and 58.5% respectively.

HOLDING TIMES:

All sample and extraction holding times were within the recommended limits.

BLANKS:

Low levels of fluoranthene, pyrene and some phthalates were detected in some of the blanks. The EPA Five times rule was applied to all target compounds which were found in the blank. Compounds that were found in the sample and in the blank were considered real and not the result of contamination if the levels in the sample are greater than or equal to five times the amount of compounds in the associated method blank. Any target compound failing this criteria is given a "UJ" data qualifier.

SURROGATES:

The normal CLP surrogates were added to the sample prior to extraction. Most surrogate spike recoveries were within acceptable QC limits, however eight samples exceeded the recommended limits for 2-Fluorobiphenyl, three exceeded limits for Phenol-d5 and one exceeded limits for 2-Fluorophenol. No data qualifiers were added because of the high surrogate recoveries. The majority of the target compounds detected were Polynuclear Aromatic Hydrocarbons (PAH) and both the Pyrene-d10 and Terphenyl-d14 surrogates which represent this class of compounds were all within acceptable recovery limits. One laboratory blank, WBS1213B, had low surrogate recoveries for all but, Pyrene-d10 and

Terphenyl-d14 indicating that it was concentrated down too low. Consequently all of the that blank data was given the "R" or "REJ" data qualifier. This blank only applied to sample 268394 for re-extraction.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spike recoveries and Relative Percent Differences (RPD) were within acceptable QC limits for most of the compounds in the samples. No additional qualifiers were added to the data based on matrix spike recoveries.

SPECIAL ANALYTICAL PROBLEMS:

Almost all of the samples were prescreened by Gas Chromatography/Flame Ionization Detector, GC/FID, prior to analysis to optimize the analytical conditions. Those samples which had a high hydrocarbon/lipid background were diluted and this is reflected in the higher quantitation limits reported for those samples. Insufficient sample precluded percent solid determinations on all of the samples. Where practical, percent solids were taken from the metals and general chemistry aliquots when they corresponded to the organic samples.


DATA QUALIFIER CODES:

- U - The analyte was not detected at or above the reported value.
- J - The analyte was positively identified. The associated numerical value is an estimate.
- UJ - The analyte was not detected at or above the reported estimated result.
- REJ - The data are unusable for all purposes. (Also R)
- EXP - The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3×10^6 .
- NAF - Not analyzed for.
- N - For organic analytes there is evidence the analyte is present in this sample.
- NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.
- E - This qualifier is used when the concentration of the associated value exceeds the known calibration range.
- * - The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive SE , Port Orchard Washington 98366

CASE NARRATIVE

February 4, 1992

Subject: Sediment Traps - Commencement Bay
Samples: 91 - 518533, -518539, -518543, -518546, -518550, -518551, and -518571
Case No. DOE-020Q
Officer: Dale Norton
By: Dickey D. Huntamer 
Organics Analysis Unit

POLYCHLORINATED BIPHENYLS-PCB

ANALYTICAL METHODS:

The sediment trap samples were Soxhlet extracted using acetone as the solvent. Analysis was done by EPA Method 8080 using dual column capillary GC analysis with Electron Capture Detectors (ECD).

HOLDING TIMES:

The sediment samples were composited samples acquired over a period of time. The samples were stored frozen between collections. After compositing and prior to analysis the samples were kept frozen following Puget Sound Estuary Program guidelines. The samples were thawed, then analyzed within the recommended 14 day holding time. No data qualifiers were added due to holding times.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

Soil surrogate recoveries ranged from 79% to 189% for decachlorobiphenyl (DCB) and 77% to 120% for 4,4'-dibromooctafluorobiphenyl (DBFB). All surrogate spike recoveries for DBFB were within acceptable QC limits. Three surrogate recoveries for DCB exceeded 150%. These high values were most likely caused by interference from coeluting peaks. No additional data qualifiers were added based on surrogate recoveries.

MATRIX SPIKE AND MATRIX SPIKE :

The soil matrix spikes recoveries ranged from 84% to 118%. The Relative Percent Differences (RPD) ranged from 1% to 5%. All recoveries and RPD were within acceptable QC limits.

SPECIAL ANALYTICAL PROBLEMS:

There were no significant problems with the PCB analysis. All results are reported on a dry weight basis.

Sample Number	% Solids
91- 518533	43.8
91 - 518539	39.5
91 - 518543	43.5
91 - 518546	45.5
91 - 518550	51.7
91 - 518551	37.0
91 - 518571	100

DATA QUALIFIER CODES:

- U - The analyte was not detected at or above the reported value.
- J - The analyte was positively identified. The associated numerical value is an estimate.
- UJ - The analyte was not detected at or above the reported estimated result.
- REJ - The data are unusable for all purposes.
- EXP - The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3×10^6 .
- NAF - Not analyzed for.
- N - For organic analytes there is evidence the analyte is present in this sample.
- NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.
- E - This qualifier is used when the concentration of the associated value exceeds the known calibration range.
- * - The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE


March 6, 1992

Subject: Sediment Traps - Commencement Bay

Samples: 91 - 518540 and 518543

Case No. DOE-020Q

Officer: Dale Norton

By: Dickey D. Huntamer 
Organics Analysis Unit

POLYCHLORINATED BIPHENYLS (PCB)

ANALYTICAL METHODS:

Both samples were Soxhlet extracted using acetone as the solvent. Sample 518540 was extracted for PCB and 518543 was extracted for semivolatile organics. Consequently no PCB surrogate compounds were added to 518543. Analysis was done by EPA Method 8080 using dual column capillary GC analysis with Electron Capture Detectors (ECD).

HOLDING TIMES:

Both samples were extracted within the recommended holding times. Sample 518540 was analyzed for PCB within the extract holding time but sample 518543 was analyzed seven days past the recommended 40 day holding time. Given the long term stability of the PCB this should have no discernible effect upon the results.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

All surrogate spike recoveries were within acceptable QC limits for 518540. No PCB surrogates were present in 518543 since the extract for the semivolatile analysis was used.

SPECIAL ANALYTICAL PROBLEMS:

Confusion on the desired tests requested resulted in a failure to analyzed sample 518543 for PCB. It was analyzed for semivolatiles but was also intended to be the duplicate sample for 518540 (PCB only). Consequently the semivolatile extract was analyzed for PCB since it involves the same extraction procedure. No PCB surrogate recoveries are available for the semivolatile extract, but the semivolatile surrogate recoveries are available in the semivolatile data. The results are listed in the table below along with the Relative Percent Difference (RPD). The data is acceptable for use as qualified.

	PCB	1254	1260	RPD
518540		540 ug/Kg	670 ug/Kg	43%
518543		350 ug/Kg	450 ug/Kg	39%

DATA QUALIFIER CODES:

- U - The analyte was not detected at or above the reported value.
- J - The analyte was positively identified. The associated numerical value is an estimate.
- UJ - The analyte was not detected at or above the reported estimated result.
- REJ - The data are unusable for all purposes.
- EXP - The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3×10^6 .
- NAF - Not analyzed for.
- N - For organic analytes there is evidence the analyte is present in this sample.
- NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.
- E - This qualifier is used when the concentration of the associated value exceeds the known calibration range.
- * - The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE


March 6, 1992

Subject: Sediment Traps - Commencement Bay

Samples: 91 - 518524 to 518527, - 518533, - 518539, - 518543, - 518546, - 518550 to 518552
- 518555, - 518556, -518560 , -518561, -518567, -518569 and -518572.

Case No. DOE-020Q

Officer: Dale Norton

By: Dickey D. Huntamer 
Organics Analysis Unit

SEMIVOLATILE ORGANICS

ANALYTICAL METHODS:

The semivolatile soil samples were Soxhlet extracted with acetone following the Manchester modification of the EPA CLP and SW 846 8270 procedure with capillary GC/MS analysis of the sample extracts. Normal QA/QC procedures were performed with the analyses.

HOLDING TIMES:

The sediment samples were composited samples acquired over a period of time. The samples were stored frozen between collections. After compositing and prior to analysis the samples were kept frozen following Puget Sound Estuary Program guidelines. The samples were thawed, extracted and analyzed within the recommended holding times. No data qualifiers were added due to holding times.

BLANKS:

Low levels of some target compounds were detected in the laboratory blanks. The EPA five times rule was applied to all target compounds which were found in the blank. Compounds that were found in the sample and in the blank were considered real and not the result of contamination if the levels in the sample are greater than or equal to five times the amount of compounds in the associated method blank.

SURROGATES:

The normal CLP surrogates were added to the sample prior to extraction. Most surrogate spike recoveries were within acceptable QC limits except for six samples which each had one out of the recommended limits. All surrogates were out in sample, 518524 due to interferences and problems with spiking. Consequently all the data is reported as "REJ", rejected except for the tentatively identified compounds. Sample data was salvaged by using one of the matrix spikes which serendipitously was not spiked with the target compounds but had the surrogates added. This is reported as a duplicate analysis for 518524.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Three sets of matrix spikes were analyzed with these samples. These were on samples 518524, 518533 and 518555. One of the matrix spike samples for 518524 was not available due to a problem with spiking. All of the spikes had problems with matrix interferences and the high native concentrations of some target compounds complicated calculating the corrected recoveries. This was particularly true for sample 518533.

SPECIAL ANALYTICAL PROBLEMS:

The requirement for low level analysis resulted in analysis of the smallest possible extract volume. This caused rapid deterioration of the capillary column resulting in frequent column reconditioning and some column changes. Most of the samples exhibited large "humps" of eluting material loosely referred to as "biogenic yuck", which appeared to consist of mixtures of fatty acid, steroids, assorted biological molecules along with the usual petroleum hydrocarbons. The tentatively identified compounds reported consisted primarily of unidentifiable hydrocarbons or compounds along with sterols and fatty acids. In sample 518543 some possible resin acids were also detected.

A Canadian reference sample was analyzed in duplicate with this sample set. 518572 and 518572D. These were analyzed as blind samples without having the "true" values and we would appreciate receiving a copy of the actual values for comparison.

The data is acceptable for use as qualified.

DATA QUALIFIER CODES:

- U - The analyte was not detected at or above the reported value.
- J - The analyte was positively identified. The associated numerical value is an estimate.
- UJ - The analyte was not detected at or above the reported estimated result.
- REJ - The data are unusable for all purposes.
- EXP - The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3×10^6 .
- NAF - Not analyzed for.
- N - For organic analytes there is evidence the analyte is present in this sample.
- NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.
- E - This qualifier is used when the concentration of the associated value exceeds the known calibration range.
- * - The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

Appendix C: Water Column Profile Data

Table C1: Water column profile data for Hylebos Waterway October, 1990 – June, 1991.

Location Station No. Level	Upper Turning Basin HP-1			Near Lincoln Drain HP-4			Mouth HP-7		
	Surface	Mid	Bottom	Surface	Mid	Bottom	Surface	Mid	Bottom
October 17, 1991									
Sample No. 42-	8267	8268	8269	8270	8271	8272	8273	8274	8275/76*
Depth (ft)	0	19	34	0	20	36	0	20	40
Temp (°C)	12	12.7	12.5	11.2	12.5	12.4	11.2	12.4	12.4
Salinity (o/oo)	15.7	30.1	30.3	24.1	29.9	30.3	15.0	29.9	30.3
TSS (mg/l)	6	2	4	3	3	4	7	3	4
January 22, 1991									
Sample No. 4-	8229	2830	8231	8232	8233	8234	8235/36*	8237	8238
Depth (ft)	0	20	40	0	18	36	0	18	34
Temp (°C)	7.9	8.8	8.7	7.8	8.7	8.7	7.0	8.5	8.5
Salinity (o/oo)	12.3	30.3	28.9	24.3	28.7	28.9	22.8	28.0	28.9
TSS (mg/l)	5	3	4	11	3	10	5	5	4
May 1, 1991									
Sample No. 18-	8205/06*	8207	8208	8209	2810	8211	8212	8213	8214
Depth (ft)	0	15	28	0	17	32	0	16	33
Temp (°C)	13.5	9.5	8.9	11.4	9.7	9.0	11.2	9.7	8.9
Salinity (o/oo)	14.5	27.3	28.2	24.1	27.1	28	23.6	27.1	18.7
TSS (mg/l)	9	4	4	3	3	3	4	3	4
June 18, 1991									
Sample No. 26-	8294/95*	8296	8297	8298	8299	8300	8301	8302	8303
Depth (ft)	0	15	30	0	13	25	0	17	33
Temp (°C)	16.8	11.6	10.4	15.3	12.4	11.2	13.8	11.3	-
TSS (mg/l)	5	5	4	4	5	5	5	4	5

*=Reported as mean of two samples

Appendix D: Tentatively Identified Organic Compounds

Table D1: Summary of tentatively identified volatile organic compounds detected in settling particulate matter from Hylebos Waterway July, 1990 – November, 1991 (ug/kg, dry).

Location Station No.	Near 11th Street H-5			- H-6			Mouth H-7		
	8290 7/90-1/91	8333 1-4/91	8543 9-11/91	8291/ 8306* 7/90-1/91	8364/ 69* 1-6/91	8546/ 47* 9-11/91	- 7/90-1/91	8365 1-6/91	8550 9-11/91
1-Methyl-2-(1-methyl) benzene	nd	nd	nd	60 j	4 j	nd	-	nd	nd
1-Methyl-1,2-methyl benzene	nd	nd	nd	nd	nd	nd	-	1 j	nd
1-Ethyl-3-methyl benzene	nd	nd	nd	100 j	9 j	nd	-	4 j	nd
1-Ethyl-4-methyl benzene	nd	nd	nd	nd	1 j	nd	-	1 j	nd
2-Ethynyl-1,4-dimethyl benzene	nd	nd	nd	nd	2 j	nd	-	nd	nd
1,2,3-Trimethyl benzene	nd	nd	nd	4.0 j	20 j	nd	-	nd	nd
3,4-dichloro cyclobutene	nd	nd	nd	nd	5 j	nd	-	nd	nd
2,5,5-Trimethyl 1,3,6-heptatriene	nd	nd	20 j	nd	10 j	nd	-	nd	nd
3,7 Dimethyl-1,3,6-octatriene	nd	nd	200 j	nd	nd	90 j	-	nd	30 j
2,6,7-Trimethyl decane	nd	nd	nd	20 j	nd	20 j	-	nd	nd
2,6,8-Trimethyl decane	nd	nd	nd	60 j	nd	nd	-	nd	nd
6-Ethyl-2-methyl decane	nd	nd	nd	nd	nd	nd	-	nd	nd
6,6-Dimethyl-2-heptane	nd	nd	100 j	20 j	nd	nd	-	nd	5 j
4,5 Dimethyl nonane	nd	nd	nd	10 j	nd	nd	-	nd	nd
2,7 Dimethyl octane	nd	nd	nd	nd	nd	nd	-	nd	7 j
Pentachloro 1,3-butadiene	nd	nd	nd	nd	nd	20 j	-	nd	20 j
1,1,3,4 Tetra 1,3 butadiene	nd	nd	nd	nd	nd	60 j	-	nd	30 j
1-Methyl-4-(methyl) cyclohexene	200 j	nd	nd	20 j	20 j	nd	-	nd	nd
1-Methyl 1,4-cyclohexadiene	200 j	nd	nd	nd	nd	nd	-	nd	nd
Heptyl hexyl ether	nd	nd	nd	10 j	nd	nd	-	nd	nd
1-(3-methoxyphenyl) ethanone	50 j	nd	nd	nd	nd	nd	-	nd	nd
1, Bicyclo [2.1.1] hept-2-ene	nd	nd	30 j	nd	nd	nd	-	nd	nd
3, Bicyclo [3.1-1] hept-2-ene	300 j	nd	nd	200 j	nd	nd	-	3 j	nd
3, Bicyclo [4.1.-1] hept-2-ene	nd	nd	9 j	nd	nd	60 j	-	nd	nd
Benzonitrile	nd	nd	nd	nd	nd	10 j	-	nd	nd
Dodecane	nd	nd	nd	nd	nd	10 j	-	nd	nd
Benzaldehyde	nd	nd	nd	nd	nd	nd	-	nd	nd
Camphene	nd	nd	nd	10 j	nd	nd	-	nd	nd
Thiobis methane	nd	nd	100 j	100 j	100 j	50 j	-	100 j	nd
3-Carene	400 j	nd	30 j	4000 j	nd	nd	-	nd	20 j
Hexachloroethane	nd	nd	nd	nd	nd	100 j	-	nd	nd
Dimethyl disulfide	nd	nd	nd	50 j	5 j	nd	-	3 j	nd
Dimethyl trisulfide	nd	nd	nd	6 j	nd	nd	-	nd	nd

*=Reported as mean of two samples

nd=Not detected at unspecified detection limit

=No sample (Sediment trap was not recovered)

j=Estimated concentration, based on presumptive evidence of material

Table D2: Summary tentatively identified semivolatile organic compounds detected in settling particulate matter from Hylebos Waterway July, 1990 – November, 1991 (ug/kg, dry).

Location Station No.	Upper Turning Basin			-			-			Near Lincoln Drain		
	H-1			H-2			H-3			H-4		
Sample No.	8342	8551/ 52*		8345	8539		8288/ 8304*	8361/ 8368*	8533	8289	8351	-
Collection Period	7/90-1/91	5-6/91	6-11/91	7/90-1/91	5-6/91	9-11/91	7/90-1/91	1-4/91	6-9/91	7/90-1/91	1-6/91	6-11/91
1,1 Biphenyl	-	nd	nd	-	nd	nd	nd	nd	1200 j	nd	nd	-
Methyl tridecanoic acid	-	3600 j	nd	-	nd	nd	nd	nd	nd	nd	nd	-
Pentadecanoic acid	-	nd	nd	-	nd	5600 j	nd	3800 j	nd	nd	nd	-
Tetradecanoic acid	-	36000 j	150000 j	-	14000 j	19000 j	nd	20000 j	13000 j	3600 j	20000 j	-
Hexadecanoic acid	-	86000 j	470000 j	-	26000 j	230000 j	7750 j	38000 j	42000 j	11000 j	23000 j	-
Octadecanoic acid	-	19000 j	320000 j	-	nd	2600 j	nd	nd	11000 j	nd	nd	-
Hexadecenoic acid	-	41000 j	240000 j	-	11000 j	51000 j	nd	23000 j	12000 j	nd	17000 j	-
Methyl hexadecanoic acid	-	nd	nd	-	1500 j	nd	nd	nd	nd	nd	nd	-
Methyl tetradecanoic acid	-	nd	nd	-	1400 j	21000 j	nd	nd	350 j	nd	nd	-
Methyl ester decanoic acid	-	4800 j	nd	-	nd	13000 j	nd	nd	nd	nd	3900 j	-
Ethyl ester dodecanoic acid	-	nd	nd	-	nd	nd	nd	nd	nd	nd	3600 j	-
Phenylacetic acid	-	4400 j	nd	-	nd	nd	nd	2000 j	nd	nd	nd	-
Benzenedicarboxylic acid	-	nd	nd	-	400000 j	nd	nd	nd	nd	nd	nd	-
Oleic acid	-	nd	nd	-	nd	190000 j	nd	nd	39000 j	nd	nd	-
Cyclopenta (DEF) phenanthrene	-	nd	nd	-	nd	nd	nd	nd	1000 j	nd	nd	-
2-methyl anthracene	-	nd	nd	-	nd	nd	nd	nd	520 j	nd	nd	-
Benzo (a) fluorene	-	nd	nd	-	nd	nd	nd	nd	1900 j	nd	nd	-
Decahydro methanoazulene	-	nd	nd	-	nd	nd	nd	300 j	nd	nd	3200 j	-
Dimethyl cyclohexenone	-	nd	13000 j	-	nd	nd	nd	nd	nd	nd	nd	-
Dimethylethyl oxirane	-	nd	39000 j	-	nd	nd	nd	nd	nd	nd	nd	-
Beta-phellandrene	-	nd	nd	-	nd	920 j	nd	nd	nd	nd	nd	-
Gamma sitosterol	-	nd	34000 j	-	nd	nd	nd	nd	nd	nd	nd	-
Cholesterol	-	nd	84000 j	-	nd	nd	7100 j	nd	35000 j	14000 j	nd	-
2,2-D cholestenol	-	nd	nd	-	nd	nd	nd	nd	13000 j	nd	nd	-
Unknown hydrocarbons	-	nd	330000 j	-	nd	nd	7800 j	nd	8400 j	11000 j	nd	-
Sterol isomer	-	nd	nd	-	nd	nd	11000 j	nd	nd	8100 j	nd	-

*=Reported as mean of two samples

nd=Not detected at unspecified detection limit

--No sample (Sediment trap was not recovered)

j=Estimated concentration, based on presumptive evidence of material

Table D2 (continued): Summary of tentatively identified semivolatile organic compounds detected in settling particulate matter from Hylebos Waterway July, 1990 – November, 1991 (ug/kg, dry).

Location Station No.	Near 11th Street H-5			- H-6			Mouth H-7		
	8290	-	8543	8291	8364	8546	-	8365	8550
Collection Period	7/90-1/91	1-4/91	9-11/91	7/90-1/91	1-6/91	9-11/91	7/90-1/91	1-6/91	9-11/91
Dichlorobutadiene	nd	-	nd	nd	12 j	nd	-	nd	nd
Tetrabutadiene	nd	-	nd	nd	850 j	nd	-	510 j	nd
Pentachlorobutadiene	nd	-	nd	nd	130 j	nd	-	nd	nd
Docosanic acid	nd	-	76000 j	nd	nd	6900 j	-	nd	nd
Dihydroabietic acid	nd	-	15000 j	nd	nd	nd	-	nd	nd
Tetradecanoic acid	nd	-	nd	1300 j	6400 j	32000 j	-	13000 j	10000 j
Pentadecanoic acid	nd	-	nd	nd	nd	nd	-	2300 j	nd
Hexadecanoic acid	4000 nj	-	73000 j	2700 j	40000 j	120000 j	-	35000 j	41000 j
Octadecanoic acid	nd	-	17000 j	1200 j	21000 j	21000 j	-	6600 j	20000 j
Hexadecenoic acid	nd	-	26000 j	nd	nd	42000 j	-	12000 j	33000 j
Phenylacetic acid	nd	-	nd	nd	2800 j	nd	-	1500 j	nd
Methyl pentadecanoic acid	nd	-	2100 j	nd	nd	nd	-	nd	nd
Methyl ester decanoic acid	nd	-	nd	nd	1300 j	nd	-	2300 j	1400 j
Ethyl ester nonadecanoic acid	nd	-	65000 j	nd	nd	nd	-	nd	nd
Tetradecene	nd	-	nd	nd	nd	20000 j	-	nd	20000 j
Tricosene	nd	-	nd	nd	nd	2700 j	-	nd	nd
Chlorotris stannane	nd	-	nd	nd	220 j	nd	-	nd	nd
Cholesterol	nd	-	2000 j	nd	nd	39000 j	-	nd	35000 j
Tetradecyl oxirane	nd	-	nd	nd	nd	15000 j	-	nd	nd
Beta stigmastanol	nd	-	54000 j	nd	nd	nd	-	nd	12000 j
Dihydrocyclopent(a)indene	nd	-	25000 j	nd	nd	nd	-	nd	nd
4-methoxy-3-pentone	nd	-	5100 j	nd	nd	nd	-	nd	nd
Dodecatrienol	nd	-	nd	nd	nd	nd	-	nd	3300 j
Pentatriacontene	nd	-	nd	nd	nd	nd	-	nd	4700 j
Unknown hydrocarbons	12000 j	-	nd	nd	nd	nd	-	nd	8800 j
Sterol isomers	3900 j	-	nd	9000 j	nd	nd	-	nd	nd

*=Reported as mean of two samples

--=No sample (Sediment trap was not recovered)

j=Estimated concentration, based on presumptive evidence of material

nd=Not detected at unspecified detection limit

Table D3: Summary of tentatively identified volatile and semivolatile organic compounds detected in bottom sediments from Hylebos Waterway January, 1991 (ug/kg, dry).

Location	Upper Turning Basin		-	-		Lincoln Drain	Near 11th Street	-		Mouth
Station No.	H-1		H-2	H-3		H-4	H-5	H-6		H-7
Sample No.	8205/06*	8207	8208	8209/10*	8211	8212	8213	8214/15*	8308	8216
Collection Date	1/91	Rep	1/91	1/91	Rep	1/91	1/91	1/91	Rep	1/91
Depth @ MLLW (ft)	23	-	28	31	-	23	19	31	-	31
Volatiles										
Thiobis methane	na	na	na	na	-	na	20 j	6 j	-	0.9 j
2,6-Dimethyl heptadecane	na	na	na	na	-	na	9 j	nd	-	nd
3,7-Dimethyl 1,3,6-octatriene	na	na	na	na	-	na	nd	2 j	-	nd
Acetic acid	na	na	na	na	-	na	nd	3 j	-	nd
Alpha.-phellandrene	na	na	na	na	-	na	1 j	nd	-	nd
Dimethyl disulfide	na	na	na	na	-	na	3 j	nd	-	nd
Semivolatiles										
Hexadecanoic acid	1000 j	900 j	1000 j	1000 j	-	700 j	1000 j	2000 j	-	400 j
Trimethyl dodecane	1000 j	nd	nd	nd	-	nd	nd	nd	-	nd
Octahydro phenanthrene	nd	1000 j	nd	600 j	-	nd	1000 j	600 j	-	nd
Octahydro 2-phenanthrenol	nd	nd	nd	nd	-	nd	nd	nd	-	300 j
Cholesterol	4000 j	7000 j	nd	nd	-	nd	nd	4000 j	-	nd
PNA Isomers	nd	nd	10000 j	700 j	-	600 j	2000 j	nd	-	400 j
Sub. Phenanthrenol isomer	nd	nd	nd	nd	-	nd	2000 j	nd	-	nd
Coeluting Hydrocarbon	900 j	nd	nd	500 j	-	nd	nd	nd	-	nd
Unk (bp m/e 41-315)	20000 j	9000 j	10000 j	20000 j	-	20000 j	20000 j	20000 j	-	8000 j
Unk hydrocarbon (bp m/e 57)	3000 j	7000 j	1000 j	nd	-	nd	nd	nd	-	nd
Long chain HC or FA	4000 j	nd	nd	2000 j	-	nd	nd	nd	-	nd
Unk (Sterol isomer)	6000 j	1000 j	1000 j	nd	-	700 j	nd	nd	-	2000 j

*=Reported as mean of two samples

j=Estimated concentration, based on presumptive evidence of material

-=No sample (Sediment trap not recovered)

na=Not analyzed

nd=not detected at unspecified detection limit

**Appendix E: Problem Chemicals in Settling Particulate Matter
vs Commencement Bay Sediment Quality Objectives**

Table E1: Comparison of problem metals(1) in settling particulate matter from Hylebos Waterway to Commencement Bay Sediment Quality Objectives (mg/kg, dry).

Location Station No. Quarter	Upper Turning Basin H-1							-							-							Near Lincoln Drain H-4						
	1	2	3	4	5	6	Mean	1	2	3	4	5	6	Mean	1	2	3	4	5	6	Mean	1	2	3	4	5	6	Mean
	Antimony	-	-	-	12	7.0	8.0	9.0	-	-	-	14	-	12	13	12	12	17	-	12	-	11	11	12	-	10	-	-
Arsenic	-	-	-	100	84	86	90	-	-	-	75	-	79	77	60	74	88	-	67	-	72	46	58	-	50	-	-	51
Copper	-	-	-	410	180	150	250	-	-	-	150	-	180	170	170	170	150	-	190	-	170	170	140	-	130	-	-	150
Mercury	-	-	-	0.25	0.3	0.35	0.3	-	-	-	0.45	-	0.53	0.49	0.46	0.46	0.49	-	0.43	-	0.46	0.32	0.32	-	0.27	-	-	0.3
Lead	-	-	-	67	77	75	73	-	-	-	110	-	100	110	110	100	110	-	100	-	110	93	92	-	77	-	-	87
Nickel	-	-	-	41	43	41	42	-	-	-	46	-	44	43	45	51	53	-	45	-	49	40	43	-	36	-	-	40
Zinc	-	-	-	290	280	270	280	-	-	-	370	-	280	330	230	240	260	-	230	-	240	200	200	-	190	-	-	200

Location Station No. Quarter	Near 11th Street H-5							-							Mouth H-7							CMB SQO
	1	2	3	4	5	6	Mean	1	2	3	4	5	6	Mean	1	2	3	4	5	6	Mean	
	Antimony	-	3.0	5.3	-	-	18	8.8	8.3	4.8	5.8	4.6	-	2.0	5.1	-	-	1.8	2.9	-	2.0	
Arsenic	-	8.7	40	-	-	55	35	37	16	32	25	-	30	28	-	-	26	27	-	19	24	57
Copper	-	150	110	-	-	160	140	140	140	130	130	-	120	130	-	-	110	110	-	110	110	390
Mercury	-	0.23	0.24	-	-	0.35	0.27	0.29	0.23	0.26	0.24	-	0.28	0.26	-	-	0.16	0.22	-	0.2	0.19	0.59
Lead	-	130	65	-	-	94	96	98	140	170	240	-	160	160	-	-	48	56	-	50	51	450
Nickel	-	34	38	-	-	33	35	44	40	43	38	-	38	41	-	-	33	32	-	30	32	>140
Zinc	-	150	190	-	-	200	180	190	150	200	190	-	150	180	-	-	140	170	-	120	140	410

(1)=Problem metals (see Table 1)

--=No sample (sediment trap was not recovered)

CMB SQO=Commencement Bay Sediment Quality Objective, based on environmental risks (EPA, 1989).

☐=Exceeds Sediment Quality Objective

Table E2: Comparison of problem(1) and selected additional organics in settling particulate matter from Hylebos Waterway to Commencement Bay Sediment Quality Objectives (mg/kg, dry).

Location Station No. Quarter	Upper Turning Basin H-1				- H-2				- H-3				Near Lincoln Drain H-4				CMB SQO
	1-2	3-4	5-6	Mean	1-2	3-4	5-6	Mean	1-2	3-4	5-6	Mean	1-2	3-4	5-6	Mean	
	PROBLEM ORGANICS																
LPAH	-	2.0 j	5.8 j	3.9 j	-	0.37 j	0.19 j	0.28 j	1.9 j	2.8 j	75 j	27 j	1.2 j	4.0 j	-	2.6 j	5.2
HPAH	-	9.7 j	17 j	13 j	-	5.9 j	5.2 j	5.6 j	9.7 j	16 j	49 j	25 j	6.6 j	5.3 j	-	6.0 j	17
Phenol	-	1.6 u	0.26 u	0.93 u	-	1.4 u	0.41 u	0.91 u	0.17	1.3 u	3.0	1.6 j	0.20 u	1.0 u	-	0.6 u	0.42
Hexachlorobenzene	-	1.6 u	0.26 u	0.93 u	-	1.4 u	0.41 u	0.91 u	0.063 u	1.3 u	0.25 u	0.54 u	0.098 u	1.0 u	-	0.55 u	0.022
Hexachlorobutadiene	-	4.2 u	0.65 u	2.4 u	-	3.5 u	1.1 u	2.3 u	0.13 u	3.2 u	0.64 u	1.3 u	0.20 u	2.6 u	-	1.4 u	0.011
Bis(2-ethylhexyl)phthalate	-	2.4 u	4.7 j	3.6 u	-	1.8 u	2.7 u	2.3 u	1.4	3.4 u	2.0 j	2.2 j	1.5	4.1 u	-	1.5 j	1.3
Total PCB'S	-	0.36 j	0.73	0.55 j	-	0.96	1.4	1.2	1.5	1.3	1.9	1.6	0.81	0.99	-	0.9	0.15*
NON-PRIORITY ORGANICS																	
4-methylphenol	-	1.6 u	0.26 u	0.93 u	-	1.4 u	0.25 j	0.25 j	0.63 u	1.3 u	0.098 j	0.68 u	0.10 u	0.48 j	-	0.29 u	0.67
2-methylnaphthalene	-	0.10 j	0.24 j	0.17 j	-	1.4 u	0.41 u	0.91 u	0.12 j	0.12 j	7.1	2.4 j	0.07 j	0.063 j	-	0.067 j	0.67
Dibenzofuran	-	1.6 u	0.46	0.46 u	-	1.4 u	0.41 u	0.91 u	0.16	1.3 u	8.1	3.2 j	0.10	1.0 u	-	0.1 j	0.54
Benzoic Acid	-	14 j	4.0 j	9.0 j	-	3.6 j	3.7 u	3.7 u	1.1	4.9 j	2.1 j	2.7 j	1.6	0.68 j	-	1.1 j	0.65

(1)=Problem organics (see Table 1)

-=No sample (Sediment trap was not recovered)

j=Estimated concentration

u=Not detected at detection limit shown

*=Based on human health risk from bioaccumulation potential

CMB SQO- Commencement Bay Sediment Quality Objective, based on environmental risks (EPA, 1989).

=Exceeds Sediment Quality Objective

Table E2: (continued)– comparison of problem(1) and selected additional organics in settling particulate matter from Hylebos Waterway to Commencement Bay Sediment Quality Objectives (mg/kg, dry).

Location Station No. Quarter	Near 11th Street H-5				- H-6				Mouth H-7				CMB SQO
	1-2	3-4	5-6	Mean	1-2	3-4	5-6	Mean	1-2	3-4	5-6	Mean	
PROBLEM ORGANICS													
Trichloroethene	0.003 j	0.001 j	0.0007 j	0.002 j	0.006 j	0.006	0.003 j	0.005 j	-	0.0008 j	0.001 j	0.009 j	-
Tetrachloroethene	0.003 j	0.002 j	0.001 j	0.002 j	0.008 j	0.012	0.04	0.02 j	-	0.001 j	0.006	0.004 j	0.057
Ethyl benzene	0.003 u	0.007 u	0.004 u	0.005 u	0.002 j	0.005 u	0.004 u	0.004 uj	-	0.004 u	0.004 u	0.004 u	0.01
Total Xylenes	0.003 u	0.0006 j	0.0009 j	0.004 j	0.013 j	0.010 j	0.004 j	0.009 j	-	0.003 j	0.002 j	0.003 j	0.04
LPAH	2.6	na	1.9 j	2.3 j	1.5	4.0	1.9 j	2.5 j	-	0.47 j	1.0 j	0.74 j	5.2
HPAH	8.4 j	na	8.4 j	8.4 j	4.8 j	8.5 j	4.5 j	5.9 j	-	7.2 j	4.4 j	5.8 j	17
Phenol	0.032 j	na	0.22 u	0.13 uj	0.077	0.38 u	0.37 u	0.28 uj	-	1.2 u	0.21 u	0.71 u	0.42
Hexachlorobenzene	0.028 u	na	0.22 u	0.12 u	0.048	0.20 j	0.37 u	0.21 j	-	1.2 u	0.11 j	0.66 uj	0.022
Hexachlorobutadiene	0.056 u	na	0.55 u	0.30 u	0.037 j	0.20 j	0.23 j	0.16 j	-	2.9 u	0.067 j	1.5 uj	0.011
Bis(2-ethylhexyl)phthalate	0.95	na	1.3	1.1	0.73	1.7 u	2.2 u	1.5 uj	-	1.5 uj	1.8 u	1.7 uj	1.3
Total PCB'S	0.78	na	1.2	0.99	1.4	0.38	0.40	0.73	-	0.13	0.31 j	0.22 j	0.15*
NON-PRIORITY ORGANICS													
4-methylphenol	0.084 j	na	0.12 j	0.10 j	1.3	0.87 j	0.37 u	0.85 j	-	1.2 u	0.077 j	0.64 uj	0.67
2-methylnaphthalene	0.085 j	na	0.071 j	0.08 j	0.067 j	0.18 j	0.082 j	0.11 j	-	0.10 j	0.045 j	0.073 j	0.67
Dibenzofuran	0.15	na	0.014 j	0.08 j	0.13	0.31 j	0.17 j	0.20 j	-	1.2 u	0.076 j	0.64 uj	0.54
Benzoic Acid	0.28 u	na	2.6 j	1.4 j	0.051 j	0.75 j	4.8 uj	0.40 j	-	15 u	0.84 j	7.9 uj	0.65

(1)=Problem organics (see Table 1)

--=No sample (Sediment trap was not recovered)

na=Not analyzed–insufficient sample volume

j=Estimated concentration

u=Not detected at detection limit shown

*=Based on human health risk from bioaccumulation potential

CMB SQO= Commencement Bay Sediment Quality Objective, based on environmental risks (EPA, 1989)

 =Exceeds Sediment Quality Objective

Table E3: Comparison of problem metal(1) in bottom sediments from Hylebos Waterway to Commencement Bay Sediment Quality Objectives (mg/kg, dry).

Location Station No.	Upper Turning Basin H-1	- H-2	- H-3	Lincoln Drain H-4	Near 11th Street H-5	- H-6	Mouth H-7	CMB SQO
Antimony	10	42	14	17	9.0	3.9	2.2u	150
Arsenic	59	86	49	52	37	18	15	57
Copper	110	220	150	150	120	120	98	390
Mercury	0.24	0.46	0.45	0.30	0.28	0.23	0.16	0.59
Lead	62	160	97	92	84	100	43	450
Nickel	46	53	49	42	36	40	26	>140
Zinc	210	540	210	200	160	140	120	410

(1)=Problem metals (see Table 1)

u=Not detected at detection limit shown

CMB SQO= Commencement Bay Sediment Quality Objective, based on environmental risks (EPA, 1989).


 =Exceeds Sediment Quality Objective

Table E4: Comparison of problem organics(1) detected in bottom sediments from Hylebos Waterway to Commencement Bay Sediment Quality Objectives (mg/kg, dry).

Location Station No.	Upper Turning Basin H-1	- H-2	- H-3	Lincoln Drain H-4	Near 11th Street H-5	- H-6	Mouth H-7	CMB SQO
Tetrachloroethene	-	-	-	-	0.0008 j	0.002 j	0.001 u	0.057
LPAH	0.46 j	0.67 j	0.65 j	0.60 j	3.6 j	0.81 j	0.48 j	5.2
HPAH	4.0	8.3 j	7.7 j	4.3	9.8 j	4.2 j	1.8 j	17
Phenol	0.15 j	0.19 u	0.044 j	0.033 j	0.04 j	0.072 j	0.017 j	0.42
Hexachlorobenzene	0.071 u	0.09 u	0.03 j	0.04 u	0.04 u	0.09	0.03 u	0.022
Hexachlorobutadiene	0.14 u	0.19 u	0.09 u	0.08 u	0.07 u	0.05 j	0.06 u	0.011
Bis(2-ethylhexyl)phthalate	0.72	1.2	0.82	0.63	0.36	0.46	0.30	1.3
Total PCB'S	0.22	0.79	2.3	1.1	1.4	0.59	0.15	0.15*

(1)=Problem chemicals (see Table 1)

u=Not detected at detection limit shown

j=Estimated concentration

--=Not analyzed

*=Based on human health risk from bioaccumulation potential

CMB SQO= Commencement Bay Sediment Quality Objective, based on environmental risks (EPA, 1989)

=Exceeds Sediment Quality Objective