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Commencement Bay Sediment Trap Monitoring Program

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Commencement Bay Sediment Trap Monitoring Program

Results of monitoring conducted in Hylebos, Sitcum, and Thea Foss Waterways between June 1991 and June 1995

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Abstract

In November 1988 the Washington State Department of Ecology began a Sediment Trap Monitoring Program in the Nearshore/Tideflats area of Commencement Bay. The program was aimed at evaluating the effectiveness of source control efforts designed to reduce the input of problem chemicals to Thea Foss Waterway. The primary component of this program consisted of a quarterly collection of settling particulate matter (SPM) with the use of moored sediment traps. In-place bottom sediments, current velocity measurements and water column profile data have also been collected periodically as part of the program. Based on the results from Thea Foss Waterway, sediment trap monitoring was expanded in July 1990 to include Hylebos and Sitcum Waterways.

This report presents an update of SPM and bottom sediment monitoring data collected from Hylebos, Sitcum and Thea Foss Waterways between June 1991 and June 1995. Information on the distribution of contaminants, trends in contaminant levels, estimated sedimentation and bottom sediment resuspension rates, and comparisons with the Commencement Bay "Sediment Quality Objectives" is discussed. Recommendations for follow-up work are also presented.

Summary

The spatial distribution of contaminants in settling particulate matter (SPM) from Hylebos, Sitcum, and Thea Foss Waterways was in relatively good agreement with previous monitoring results collected between November 1988 and November 1992. In all three waterways metals concentrations were typically higher at the head of the waterways and decreased moving toward the mouth. A similar pattern was also present for most of the organic compounds; however, concentrations tended to be more variable.

Overall, SPM data collected from Hylebos and Thea Foss Waterways suggest that concentrations of most problem chemicals have not decreased since sediment trap monitoring was started in July 1990 and November 1988, respectively. In contrast, dramatic reductions in contaminant levels have been observed in Sitcum Waterway comparing pre- and post-dredging conditions. It should be noted that metals data collected after May 1994, for all elements except mercury, were not used to evaluate contaminant trends. A shift in analytical methods after May 1994 is the primary reason for excluding these data. The reader should consult the methods section for a complete discussion of data quality.

Gross sedimentation rates (net + resuspension) in each of the waterways tended to be highest during the summer and fall and lowest during the winter and early spring. The highest average sedimentation and resuspension rates were measured in Sitcum followed by Hylebos, and Thea Foss Waterway. The data collected indicate that 60% to 85% of the material collected by the traps could be bottom sediments which have been resuspended. While the exact proportion of "new" versus "old" material collected by the traps cannot be reliably determined with the available data, it is fair to assume that the trapped material is representative of sediments which are mobile in the waterways.

Specific findings for Hylebos, Sitcum, and Thea Foss Waterways are listed in the following sections:

Hylebos Waterway

- In contrast to the general distribution of contaminants associated with SPM mentioned above, lead, tetrachloroethene, hexachlorobenzene, hexachlorobutadiene, and 1,2,4-trichlorobenzene were elevated in the outer portion of Hylebos Waterway adjacent to Occidental Chemical. Occidental Chemical was identified as a source of hexachlorobenzene and hexachlorobutadiene during the Commencement Bay Remedial Investigation. In addition, between 1947 and 1973 tetrachloroethene was produced in commercial quantities at Occidental's Solvent Plant (Tetra Tech, 1986b).

- Fourteen individual chemicals (3 metals and 11 organics) listed below were measured at concentrations exceeding the Commencement Bay Sediment Quality Objectives (SQOs) in SPM. The greatest number of exceedances were present at the head of the waterway in the upper turning basin.

  Metals - arsenic, mercury, and zinc

  Organics - low molecular weight polynuclear aromatic hydrocarbons (LPAH), high molecular weight PAH (HPAH), dibenzofuran, 4-methyl phenol, benzoic acid, di-n-butyl phthalate, dimethyl phthalate, bis(2-ethyl hexyl)phthalate, hexachlorobenzene, hexachlorobutadiene, and total polychlorinated biphenyls (PCB)

- Tributyltin (TBT), which has been used extensively in the past as an active ingredient in antifouling paints, was present at relatively high levels (55-1300 ug/kg, dry) in SPM throughout Hylebos. TBT levels in all of the samples analyzed from the waterway exceeded the Puget Sound Dredge Disposal Analysis (PSDDA) interim screening level (ISL) of 30 ug/kg, dry for TBT.

  The U.S. Environmental Protection Agency (EPA) Region 10 has also recently established a site specific sediment cleanup level of 19,250 ug TBT/kg organic carbon (OC) for Hylebos Waterway. On an OC normalized basis, TBT levels in Hylebos Waterway ranged from 2,800 to 26,000, with a mean of 11,000 ug TBT/kg OC. Only one value exceeded the Hylebos specific cleanup level in SPM.

- A comparison of PCB levels in bottom sediments collected in 1984, 1991, and 1994 suggests that concentrations have not declined since the Remedial Investigation was conducted in 1984. On average, PCB levels in Hylebos Waterway were approximately five times higher then those measured in Thea Foss Waterway.

- A significant decrease in arsenic levels associated with SPM was observed between July 1990 and May 1994 at the mouth of the waterway.

- The average gross sedimentation rate for Hylebos Waterway between December 1991 and June 1995 was 2.4±1.0 g/cm^2/yr (see page 26 for explanation of gross sedimentation).

- Resuspension estimates for bottom sediments ranged from 81% (1.3±0.5 g/cm^2/yr) at the head of Hylebos to 63% (1.9±1.2 g/cm^2/yr) at the mouth of the waterway (see page 55 for explanation of resuspension).

Sitcum Waterway

- Prior to dredging in Sitcum Waterway, 7 individual chemicals (1 metal and 6 organics) listed below, exceeded the SQOs in SPM. After the completion of dredging **no** exceedances of the SQOs were observed for contaminant levels in SPM. Dimethyl phthalate in bottom sediment, near the north corner drain (SI-172), was the only chemical that exceeded the SQOs after dredging was completed.

  Metals - arsenic

  Organics - LPAH, benzoic acid, benzyl alcohol, pentachlorophenol, dimethyl phthalate, and bis(2-ethyl hexyl)phthalate

- Significant decreases in lead (near north corner drain and Terminal 7 @ Berth B) and zinc (Terminal 7 @ Berth B) levels were noted in SPM between July 1990 and December 1993. This finding is consistent with the fact that as of July 1991, off-loading of black ore (lead and zinc) ceased at Terminal 7.

- In contrast to lead and zinc a significant increase in arsenic levels between July 1990 and December 1993 was noted in SPM near the north corner drain. Recent source control work conducted by the City of Tacoma in the summer of 1995 (storm drain cleaning) may have reduced present arsenic loadings to this area of the waterway.

- The average gross sedimentation rate in Sitcum Waterway between June 1991 and June 1995 was 4.8 ± 1.8 $g/cm^2/yr$.

- The highest bottom sediment resuspension rate (85%) for all three waterways was measured at the mouth of Sitcum Waterway.

- Resuspension estimates for Sitcum Waterway ranged from 71% (3.9 ± 1.2 $g/cm^2/yr$) at the mouth to 85% (3.5 ± 1.6 $g/cm^2/yr$) at the head of the waterway. The resuspension rate at the head of Sitcum was the highest measured in the three waterways being monitored.

Thea Foss Waterway

- Mercury and copper concentrations tended to peak in the central portion of Thea Foss Waterway at two locations: near the mouth of Wheeler-Osgood Waterway (copper) and north of the 15th Street drain (mercury). J.M. Martinac Shipbuilding, located near the mouth of Wheeler-Osgood Waterway, has been identified as a copper source near the mouth of Wheeler-Osgood Waterway in past studies. The 15th Street drain, shoreline banks adjoining the Investco Site, and the inactive Surplus Steam Plant #1 have been identified as potential sources of mercury in this area of the waterway.

- Previous monitoring data (November 1988 to November 1992) indicated a significant increase in mercury levels was occurring north of the 15th Street drain and at the head of the waterway. The lack of a significant regression at these two locations when the most recent data set is included might suggest that mercury concentrations are stabilizing in these areas of the waterway.

- A comparison of bottom sediment samples collected between 1984 and 1994 suggests that mercury, HPAH, and TBT (1989 to 1994) levels in much of the waterway have not decreased during this period.

- Fourteen individual chemicals (3 metals and 11 organics) listed below, exceeded the SQOs in SPM. The greatest number of exceedances (11) were present at the head of the waterway. Mercury, HPAH, PCBs, and benzoic acid were at problem levels throughout the waterway.

  Metals - mercury, nickel, and zinc

  Organics - LPAH, HPAH, 2-methyl naphthalene, benzoic acid, benzyl alcohol, dimethyl phthalate, di-n-butyl phthalate, di-n-octyl phthalate, butyl benzyl phthalate, bis(2-ethyl hexyl)phthalate, and total PCBs

- TBT levels were elevated (100% of samples at or above the PSDDA ISL of 30 ug/kg) in SPM throughout Thea Foss Waterway, ranging from 30-790 ug/kg. The highest concentrations were measured in the upper portion of the waterway adjacent to the City Marina (station TF-1A). Recent sampling by inspectors at Ecology's Southwest Regional Office has identified high concentrations of TBT (up to 1,400,000 ug/kg) in sediments from catch basins which drain the Picks Cove Marina boat yard in the vicinity of station TF-1A.

- PCB concentrations in SPM ranged from 280 to 610 ug/kg, with a mean of 500 ug/kg. The highest levels were measured north of the 15th Street drain.

- Based on means, the highest concentrations of total organic carbon, mercury, lead, zinc, LPAH, and HPAH were measured in Thea Foss SPM compared to Hylebos and Sitcum Waterways.

- Gross sedimentation in Thea Foss Waterway between November 1992 and June 1995 averaged 1.5±0.9 g/cm^2/yr..

- During the March to June 1995 collection period a three-fold increase in gross sedimentation was noted at the head of the waterway. The observed increase in this area is probably related to higher bottom sediment resuspension rates caused from bridge construction activities. In March 1995 pile driving was started for the new SR-509 bridge which crosses Thea Foss Waterway at the head.

- Resuspension estimates for bottom sediments in Thea Foss Waterway ranged from 60% (0.6±0.4 g/cm^2/yr) at the mouth to 82% (1.4±0.9 g/cm^2/yr) at the head of the waterway.

Recommendations

Based on the results of information collected during this monitoring program the following recommendations are made:

- Remedial designs and natural recovery evaluations for Hylebos and Thea Foss Waterways should focus on chemicals which exceeded the SQOs in SPM and bottom sediments.

- TBT should be added to the list of chemicals of concern in Hylebos and Thea Foss Waterways based on a comparison of concentrations in SPM and bottom sediments with the Puget Sound Dredge Disposal Analysis (PSDDA) Interim Screening Level (ISL) of 30 ug/kg, dry. Under PSDDA, sediments with TBT concentrations above the ISL would need to undergo biological testing. EPA Region 10 has recently established a site specific sediment cleanup level of 19,250 ug TBT/kg OC for Hylebos Waterway based on a review of the available information concerning the toxicity of TBT to aquatic life. For consistency, EPA should consider adoption of a site wide criteria for TBT in all Commencement Bay problem areas where TBT is a concern.

- Re-evaluate potential sources of PCBs and TBTs in Hylebos and Thea Foss Waterways prior to selecting the final remedial designs for these waterways.

- Continue to include PCBs as a target analyte for SPM analysis in Thea Foss Waterway.

- Continue to monitor arsenic levels at the head of Sitcum Waterway near the north corner drain to see if source control work performed in the summer of 1995 has reduced arsenic levels in SPM in this area of the waterway.

- In-water construction activities, which are planned for heavily contaminated areas, should be designed to minimize disturbance of bottom sediments. This will reduce the potential to redistribute contaminated sediments to other areas of the waterways.

- Determine the comparability of X-Ray Fluorescence and Inductively Coupled Plasma methods for metals by analyzing split samples of SPM during the next routine collection of sediment trap samples. This information will allow trend evaluations for metals other than mercury to be performed in the waterways over a longer time series.

- Conduct seasonal analysis of ^{210}Pb levels in SPM and adjacent bottom sediments at selected stations in each waterway. This information would be used to help identify the relative importance of the various factors (plankton blooms, vessel traffic, and input of sediment from surface runoff) contributing to resuspension of bottom sediments.

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Many individuals have made valuable contributions to the Commencement Bay Sediment Trap Monitoring Program. The author wishes to extend special thanks to:

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- Jim Cubbage assisted in statistical analyses of the data
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Project Overview

Hylebos, Sitcum, and Thea Foss Waterways, shown in Figure 1, are three of seven waterways, which along with the Puyallup River mouth make up the tideflats portion of the Commencement Bay Nearshore/Tideflats Superfund Site. Contamination of bottom sediments in the nearshore area of Commencement Bay with a variety of chemicals was documented (Tetra Tech, 1985) during the Commencement Bay Nearshore/Tideflats Remedial Investigation (CBRI).

As a result of the remedial investigation and subsequent studies, source control programs aimed at reducing contaminant loadings to several problem areas in Commencement Bay were implemented by the Department of Ecology, City of Tacoma, and the Tacoma-Pierce County Health Department. The schedule for implementing source identification and control at the Commencement Bay site is described in Appendix C of the Commencement Bay Nearshore/Tideflats Record of Decision (EPA, 1989a).

In 1988 Ecology's Commencement Bay Urban Bay Action Team (UBAT) requested that the Toxics Investigations Section conduct a sediment trap monitoring study to track the progress of source control activities in Thea Foss Waterway. The primary objectives of this monitoring program are:

- Determine the concentrations of problem chemicals associated with settling particulate matter (SPM) entering the waterway
- Estimate present sedimentation rates in the waterway
- Periodically determine problem chemical concentrations in bottom sediments at each of the sediment trap monitoring stations

Based on results obtained in Thea Foss Waterway between November 1988 and May 1989, sediment trap monitoring was expanded to include Hylebos and Sitcum Waterways in 1990.

Problem chemicals for Hylebos, Sitcum, and Thea Foss Waterways were first identified during the CBRI. The list of problem chemicals has subsequently been clarified by EPA Region 10 after re-evaluating the data collected during the CBRI (EPA, 1992). Chemical analysis for the Sediment Trap Monitoring Program focused on the revised list of problem chemicals shown in Table 1. The reader should note that EPA currently requires that each problem chemical identified for the Commencement Bay site meets the associated sediment quality objective regardless of whether the chemical is listed for that waterway (Ngo, 1996).

The results from the Sediment Trap Monitoring Program are being used in conjunction with other available information about Commencement Bay to evaluate the effectiveness of source control

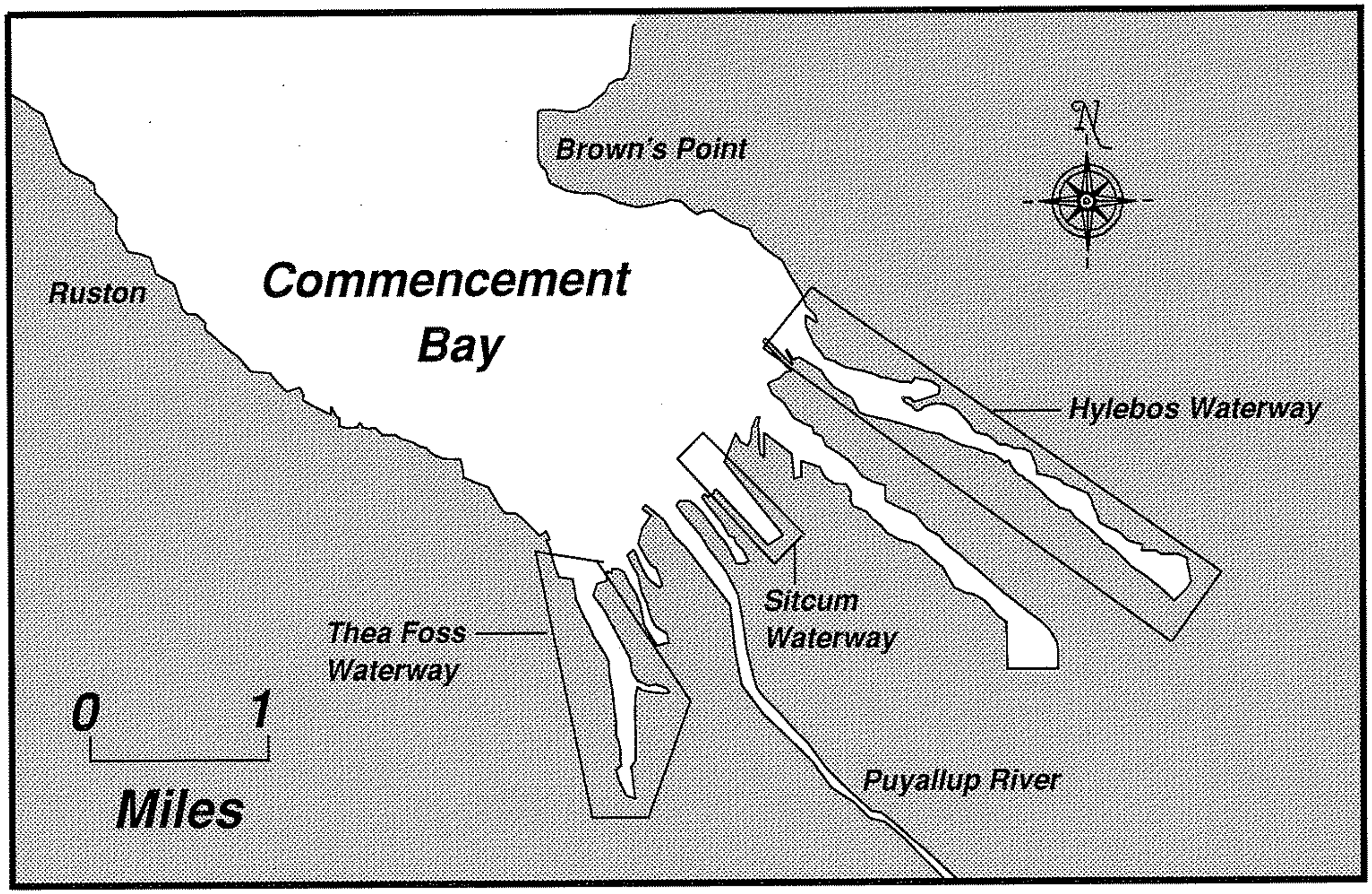


Figure 1: Waterways Included in the Commencement Bay Sediment Trap Monitoring Program, June 1991 to June 1995.

Table 1: Summary of problem chemicals in Hylebos, Sitcum, and Thea Foss Waterways.

Waterway	Hylebos		Sitcum	Thea Foss		
Location	Head	Mouth		Head	Mouth	Wheeler-Osgood
Conventionals						
TOC				1		2
Oil and Grease				2		
Metals						
Antimony	2					
Arsenic	1		2			
Cadmium				2		2
Copper	2	3	2	2		2
Lead	2	2	2	1		2
Mercury	2	3		1	3	
Nickel	2			2		
Zinc	1	3	2	1	3	2
Organics						
Tetrachloroethene	2	2				
Trichloroethene		2				
Ethylbenzene	3	3				
Xylene	3	3				
Chlorinated Benzenes	3	3				
1,2-Dichlorobenzene		2				2
1,3-Dichlorobenzene		2				
1,4-Dichlorobenzene				3		
Hexachlorobenzene		2				
LPAH		3	3	2	2	2
HPAH	1	3	3	2	2	2
Dibenzofuran			3			
Methylpyrene	3	3				
Methylphenanthrene	3	3				
Hexachlorobutadiene		2				
Biphenyl		3			3	2
Aniline				3		
Phenol	2	3		3	3	2
2-Methylphenol				2		
4-Methylphenol				2		2
Dibenzothiophene	3	3			3	
N-Nitrosodiphenylamine			3	3		2
Benzyl Alcohol	3	3		3		
Butyl benzyl phthalate				2		
Bis(2-ethyl hexyl)phthalate	3	3		2		
An Alkylated benzene isomer	3	3	3			
A Diterpenoid hydrocarbon			3			
A Pentachlorcyclopentane isomer		2				
PCBs	1	1			3	

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

1,2,or 3= Priority

efforts in reducing the input of problem chemicals to the waterways, determine when source control has been achieved, model natural recovery potential for bottom sediments and aid in selecting remediation options for sediments in these waterways.

Results from sediment trap monitoring conducted by Ecology in Hylebos (July 1990 to November 1991); Sitcum (July 1990 to June 1991); and Thea Foss (November 1988 to November 1992) Waterways have been previously reported (Norton, 1990 and 1993; Norton and Barnard, 1992a,b). The present document updates SPM and bottom sediment monitoring data collected subsequent to these earlier reports. Data from the following time periods are presented in the "Results" section of this document:

Hylebos Waterway	December 1991	to	June 1995
Sitcum Waterway	June 1991	to	June 1995
Thea Foss Waterway	November 1992	to	June 1995

Monitoring data is continuous for the periods listed above with the exception of Sitcum Waterway. Dredging of bottom sediments pursuant to the Sitcum Waterway Consent Decree occurred between December 1993 and July 1994 (Gilmur, 1995). To avoid conflicts with dredging operations no sediment traps were deployed in the waterway between December 1993 and November 1994. Monitoring was resumed in Sitcum Waterway beginning in November 1994. Between November 1988 and June 1995 a total of 299 sediment traps have been deployed in Hylebos, Sitcum, and Thea Foss Waterways. Of the 299 traps deployed 232 have been successfully recovered (78%). The monitoring network, as presently configured, consists of five stations in Hylebos, three in Sitcum, and four in Thea Foss Waterway.

Methods

Site Selection

Sampling locations in Hylebos, Sitcum, and Thea Foss Waterways are shown in Figures 2-4. Sampling points were selected to provide broad spatial coverage of each waterway and, to the extent possible, correspond to major contaminant sources identified during the CBRI and other source studies. Detailed descriptions of each sampling location are provided in Appendix A, Table A1. Station positions were located using a Magellan™ Model 11001 Nav 1000 Plus GPS receiver, in conjunction with depth readings. In addition, station positions were noted with reference to fixed structures in the vicinity. It should be noted that some facility names are shown on tables and figures in the report to aid the reader in locating stations. This is not intended to infer that the facilities listed are the primary source of contaminants at that location. Specific linkages between sources and contaminants in SPM are noted where appropriate.

Based on data collected prior to June 1993 and the desire to reallocate resources, several modifications to the monitoring network were made beginning in July 1993. Stations H-4 (near Lincoln Avenue Drain) and H-5 (near the Cenex Plant) in Hylebos Waterway were discontinued due to relatively few chemicals being detected at problem levels. Similarly, station S-2 (north end of Sealand Terminal) in Sitcum Waterway was discontinued. Between December 1993 and November 1994 stations H-4 and H-5 in Hylebos Waterway were temporarily re-started, and a new station (TF-1A) located in the upper portion of Thea Foss Waterway adjacent to the City Marina was added. These changes were made because dredging operations were underway in Sitcum Waterway and, as a result, no monitoring was occurring in the waterway. Finally, in November 1994 the network was returned to its July 1993 configuration since dredging operations had been completed in Sitcum Waterway. The deployment schedule for sediment traps in Commencement Bay between June 1990 and June 1995 is included in Appendix A, Table A2.

Besides the changes made in spatial coverage of the waterways, the number of target analytes in SPM was also reduced beginning in July 1993. The reader is referred to the data tables in Appendix C to determine target analytes during the various monitoring periods.

Sample Collection

Settling Particulate Matter

SPM was collected at each of the monitoring stations with the use of moored sediment traps, positioned 3 feet above the bottom. The sediment traps were sampled at a three month frequency. Total depths at mean lower low water (MLLW), in the areas sampled ranged as follows: Hylebos 24 to 31 ft., Sitcum 31 to 54 ft., and Thea Foss 18 to 36 ft.

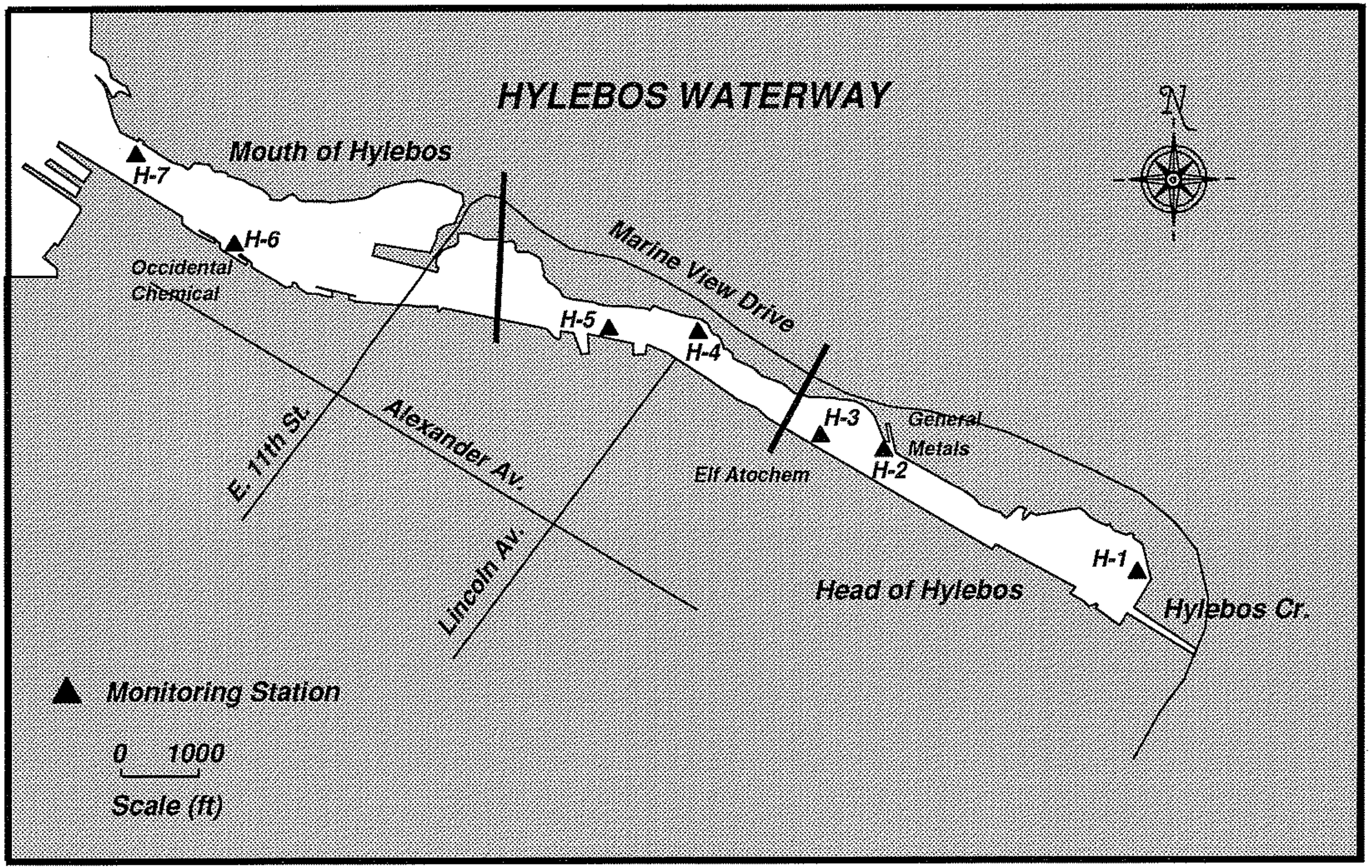


Figure 2: Monitoring Stations in Hylebos Waterway, December 1991 to June 1995.

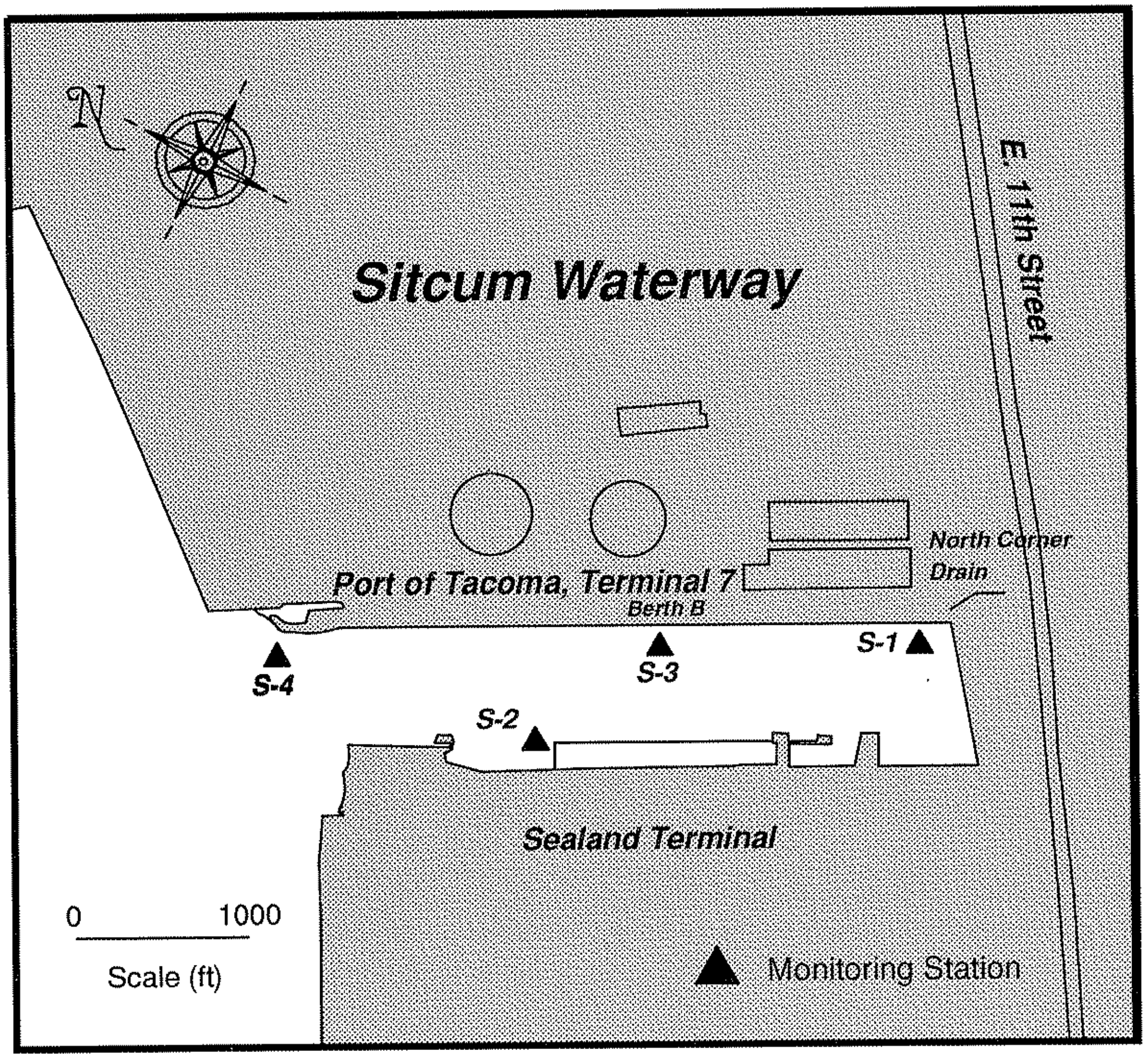


Figure 3: Monitoring Stations in Sitcum Waterway, June 1991 to June 1995.

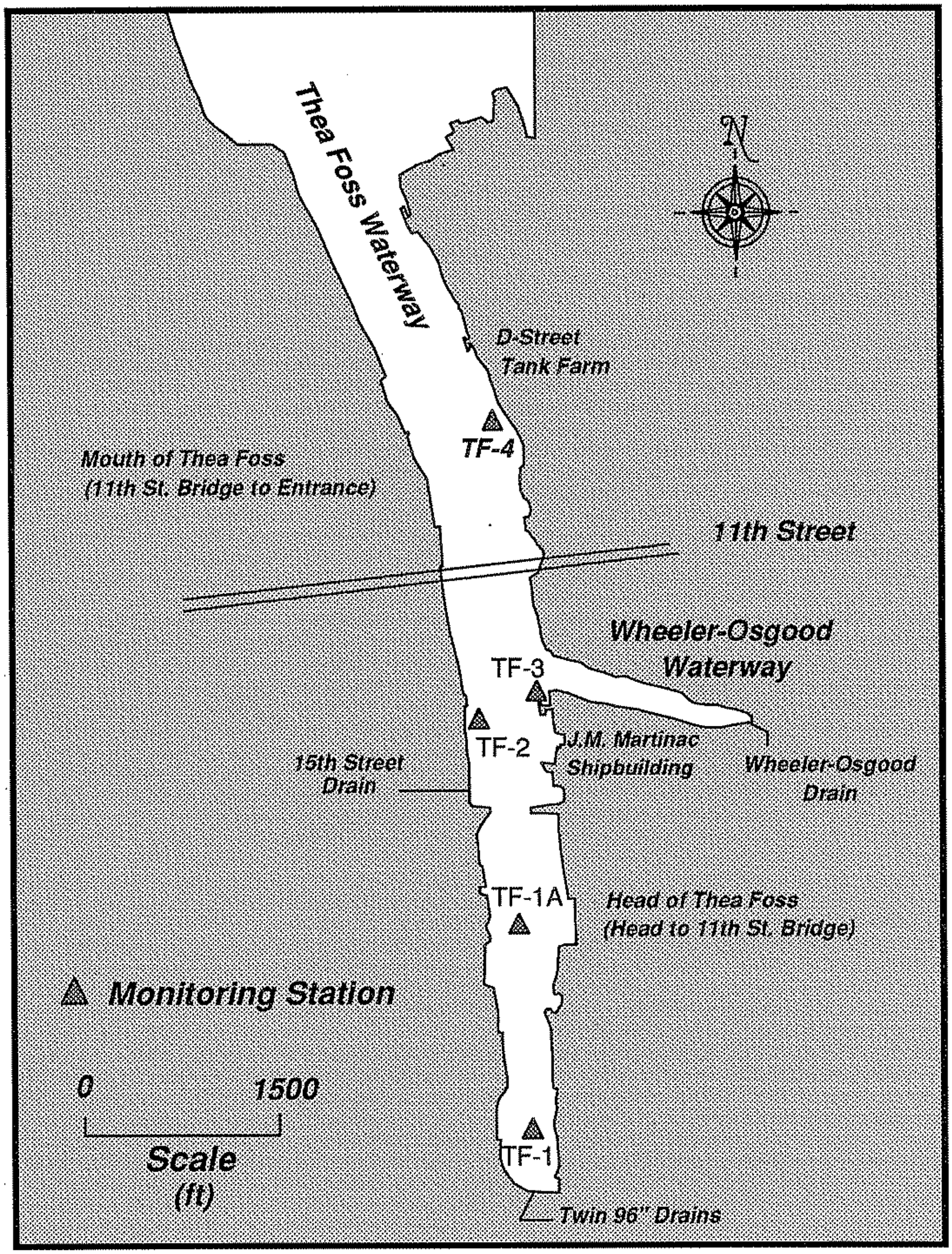


Figure 4: Monitoring Stations in Thea Foss Waterway, November 1992 to June 1995.

The traps used in the present study are straight-sided glass cylinders with a collection area of 78.5 cm^2 and a height-to-width ratio of five. A schematic of the construction details of the traps and their moorings is presented in Figure 5.

At deployment, the traps were filled with two liters of high salinity water (4% NaCl), which contained sodium azide (2%Na_3N) as a preservative to reduce microbial degradation of the samples. Prior to deployment, the collection cylinders were cleaned with sequential washes of hot water/Liquinox detergent, 10% nitric acid, distilled/deionized water, and pesticide-grade acetone. They were then air-dried and wrapped in aluminum foil until used in the field.

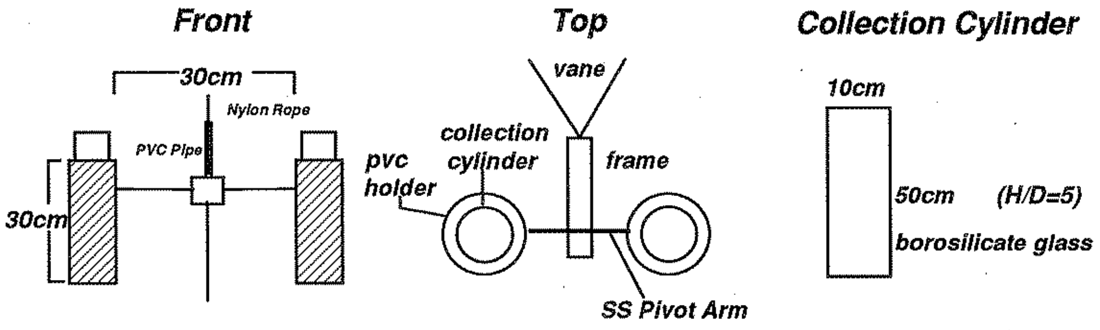
Upon retrieval of the traps, overlying water in the collection cylinders was removed with a peristaltic pump. The remaining contents were then transferred to half-gallon priority pollutant-cleaned glass jars with teflon-lined lids (supplied by I-Chem, Hayward, CA) and stored at 4EC for transport to the laboratory. At the laboratory all samples 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 prior to determining sample weights and conducting physical/chemical analyses. To obtain sufficient volume for organics analyses, 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 procedures followed Puget Sound Protocols where applicable (Tetra Tech, 1986a). Three individual grabs of surface sediments (top 2 cm) were collected and composited at each of the sediment trap locations in November 1994 using a 0.1 m^2 stainless steel van Veen grab. For comparability, sampling locations corresponded to previous sites occupied in December 1989 and January 1991.

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 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. An exception to this procedure was volatiles samples which were collected directly from the grab into appropriate sample containers. Spoons and beakers were pre-cleaned as previously described for the sediment trap collection cylinders.

I. Detailed View of Sediment Trap



II. Sediment Trap Deployment

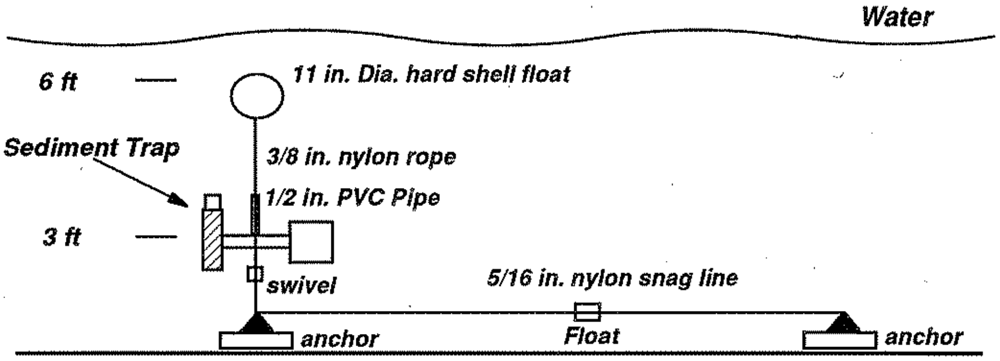


Figure 5: Schematic of Commencement Bay Sediment Traps and Moorings.

Sample Analysis and Quality Assurance

All physical/chemical analyses of samples for this project were conducted using procedures specified in the Puget Sound Protocols (Tetra Tech, 1986a) as amended and updated. In addition, the type and frequency of laboratory quality assurance (QA) samples at a minimum followed those specified in the Ecology/EPA Manchester Laboratory QA manual (Ecology, 1988). A summary of the analytical laboratories and methods used for this project is shown in Table 2.

Quality of the data sets were evaluated with the use of the following sample types: duplicates, matrix spikes, internal standards, surrogate spikes, standard reference materials and method blanks. A summary of QA samples and their frequency of analysis is included in Appendix B, Table B1. Staff at the Ecology/EPA Manchester Laboratory performed detailed QA reviews of each data package. Copies of the case narratives for each data set are included in Appendix B. The reader is referred to the case narratives for specific details concerning data quality.

Overall, few major analytical problems were encountered in the analysis of samples for this project. Notable exceptions to this statement are discussed below. Consequently, the data generated are considered acceptable for use as qualified in the data tables and noted in the case narratives.

Several results for copper, cadmium, and mercury are qualified as estimates due to high results (+20%) obtained on the analysis of certified reference materials. Results qualified for this reason would be expected to slightly overestimate actual environmental levels.

Between November 1988 and May 1994 arsenic, copper, nickel, lead, and zinc determinations were made using X-Ray Fluorescence (XRF) techniques. Beginning in May 1994 the above mentioned metals were analyzed using Inductively Coupled Plasma (ICP) methods. No data are available to evaluate how these two methods compare; however, it is anticipated that XRF would yield higher results since it is a more rigorous analysis. Consequently, data generated using XRF and ICP methods have been separated for temporal analyses in this report. The reader is cautioned about drawing strong conclusions based on concentration differences for elements which were generated using different analytical methods.

The principal analytical problem encountered in the organics analyses was directly related to chromatographic interferences. When encountered, these interferences were typically caused by the presence of high levels of fats and lipids in the samples. In addition, high native concentrations of PCBs and butyltins in several instances reduced the usefulness of some of the matrix spike information. Both these situations resulted in several compounds being qualified as estimates and produced variable detection limits between sampling periods.

Unless otherwise noted all concentrations in this document are reported on a dry weight basis. Butyltins were determined as butyltin chloride. A summary of the results of physical/chemical

Table 2: Summary of Analytical Methods for Commencement Bay Sediment Trap Monitoring Project, June 1991 to June 1995.

Analysis	Method	Reference	Laboratory
Conventionals			
Percent Solids	Dry @ 104°C	Tetra Tech, 1986a	Ecology/EPA-Manchester, WA.
Total Organic Carbon	Combustion/CO2 Measurement	Tetra Tech, 1986a	Analytical Resources, Inc.-Seattle, WA. Laucks Laboratories- Seattle, WA. AMTEST-Redmond, WA. Sound Analytical Services, Inc.-Tacoma, WA. Weyerhaeuser Technology Center, Tacoma, WA.
Grain Size	Seive and Pipet	Tetra Tech, 1986a	Soil Technology, Inc.-Winslow, WA.
Metals (6/91-5/94)			
Arsenic,Copper, Nickel,Lead,Zinc	XRF	Nielson and Sanders, 1983	Battelle Northwest-Richland, WA.
Antimony,Cadmium	GFAA	Tetra Tech, 1986a	Battelle Northwest-Sequim, WA.
Mercury	CVAA	Tetra Tech, 1986a	Battelle Northwest-Sequim, WA.
Metals (5/94-6/95)			
Arsenic,Copper, Lead,Zinc	ICP	Tetra Tech, 1986a	Ecology/EPA-Manchester, WA.
Mercury	CVAA	Tetra Tech, 1986a	Ecology/EPA-Manchester, WA.
Organics			
Volatiles	GC/MS #8240	EPA, 1986	Ecology/EPA-Manchester, WA.
Semivolatiles	GC/MS #8270	EPA, 1986	Ecology/EPA-Manchester, WA.
PCBs	GC/ECD #8080	EPA, 1986	Ecology/EPA-Manchester, WA.
Butyltins	GC/MS-SIM	Tetra Tech, 1986a	Ecology/EPA-Manchester, WA.

Metals

XRF= X-Ray Flourescence
GFAA= Graphite Furnace Atomic Absorption
ICP= Inductively Coupled Plasma
CVAA= Cold Vapor Atomic Absorption

Organics

GC/MS= Gas Chromatography/Mass Spectroscopy
GC/ECD= Gas Chromatography/Electron Capture Detector
GC/MS-SIM= Gas Chromatography/Mass Spectroscopy-Selective Ion Monitoring

analyses of SPM and bottom sediments from each of the waterways monitored is included in Appendix C and D, respectively.

Results

Hylebos Waterway

Chemicals in SPM

Between December 1991 and June 1995 89 sediment traps were deployed in Hylebos Waterway. Of these traps 69 (78%) were successfully recovered.

The results of conventionals and metals analysis of SPM from Hylebos Waterway are tabulated in Appendix C, Table C1. Total organic carbon (TOC) levels ranged from 1.9% to 8.5% in Hylebos SPM with a mean of 4.1%. Based on means, TOC levels at the head of the waterway were elevated by a factor of 3 compared to concentrations at the mouth.

Concentrations (mg/kg) of selected metals associated with SPM from Hylebos Waterway between December 1991 and June 1995 are:

Metal	Range	Mean	C.V.	Detection Frequency	N
Arsenic	9.6-130	48	57%	100%	77
Copper	62-180	130	23%	100%	77
Lead	28-250	81	40%	100%	77
Mercury	0.16-0.93	0.41	39%	100%	77
Zinc	66-520	200	38%	100%	77

C.V.= Coefficient of Variation (SD/Mean) * 100
N= Number of Samples

Metals concentrations were fairly low in Hylebos SPM over the current monitoring period with the exception of arsenic and mercury in the upper portion of the waterway. As shown in Figure 6, arsenic and mercury levels within one mile from the head were somewhat elevated compared to the remainder of the waterway. The highest concentrations of zinc and copper were also measured in this section of the waterway. Longitudinally, concentrations of most metals in Hylebos SPM tended to peak within one mile of the head of the waterway and decrease moving towards the mouth.

In contrast, lead concentrations were fairly consistent throughout the waterway with a primary peak occurring at station H-6 approximately one-half mile from the mouth of the waterway. The lowest concentrations for all metals were typically present at the mouth of the waterway. Temporally, intra-station metals concentrations tended to be similar, being within a factor of 2-3 in most cases.

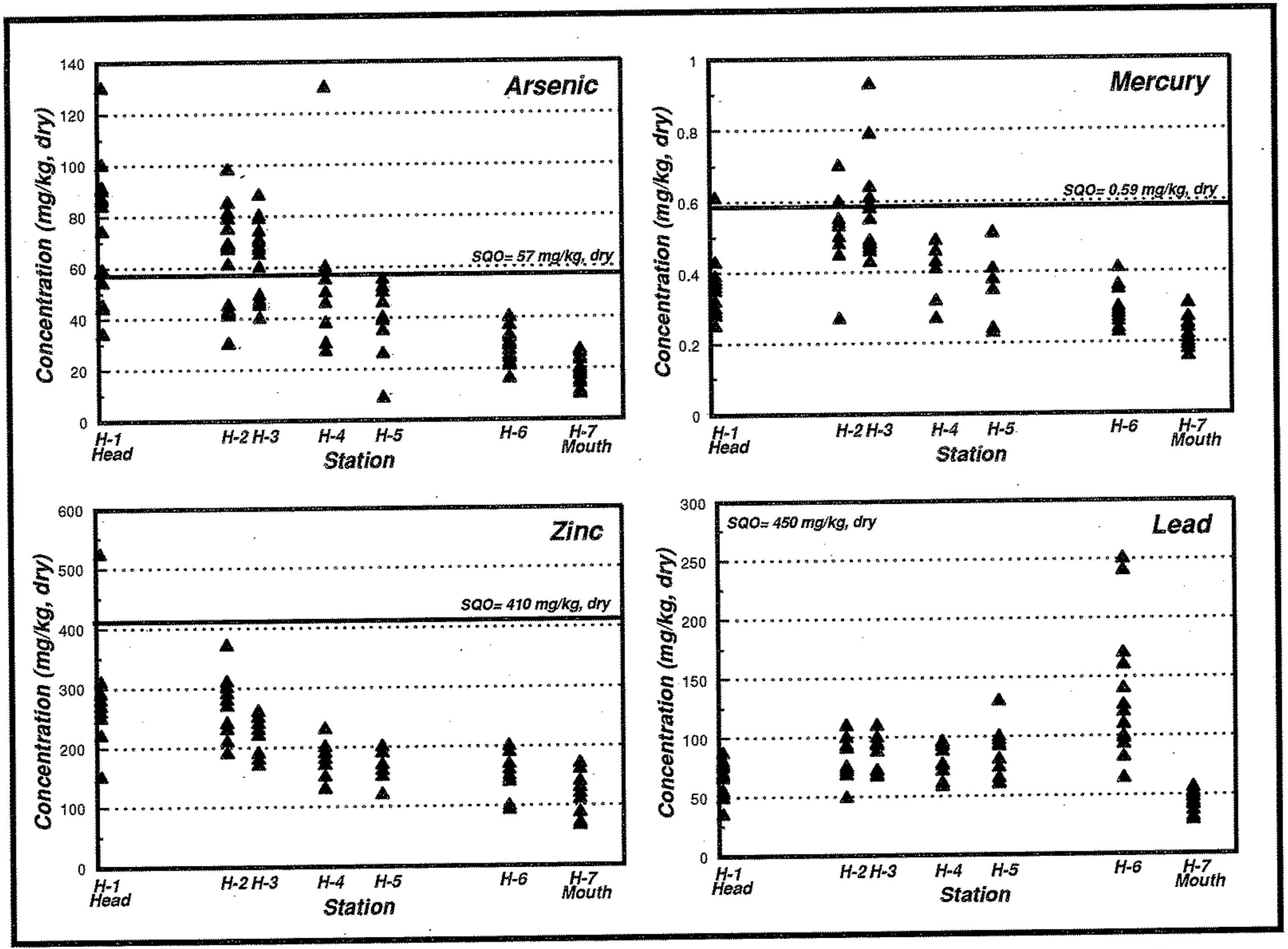


Figure 6: Selected metals in settling particulate matter from Hylebos Waterway, December 1991 to June 1995.

Several volatile organic compounds (VOCs) were identified as problem chemicals in the outer portion of Hylebos Waterway (Tetra Tech, 1985). Consequently, VOC analysis was only conducted at stations H-5, H-6, and H-7, which are located in the outer portion of the waterway. The results of volatile organics analyses of Hylebos Waterway SPM are tabulated in Appendix C, Table C2. Concentrations (ug/kg) of selected volatiles are:

Compound	Range	Mean	C.V.	Detection Frequency	N
Trichloroethene	0.8-23	4.5	150%	71%	12
Tetrachloroethene	0.53-33	7.7	150%	94%	16
Ethylbenzene	0.4-4.5	0.75	65%	53%	9
Total Xylenes	1.2-16	5.5	96%	65%	11
2-Butanone	22-230	100	63%	65%	11
Isopropyltoluene	4.9-300	98	85%	94%	16

C.V.= Coefficient of Variation (SD/Mean) * 100
N= Number of Samples with detected concentrations

Thirty VOCs were detected in SPM. Acetone was detected in the highest concentrations, which ranged up to 400 ug/kg. The presence of acetone is in all probability related to the fact that it was used to clean the sediment trap collection cylinders prior to deployment. Levels of most VOCs in SPM were typically under 30 ug/kg. Two solvents, isopropyltoluene and 2-butanone (methyl ethyl ketone), were measured at levels exceeding 100 ug/kg. Isopropyltoluene was consistently detected at all three stations at concentrations ranging from 4.9 to 300 ug/kg. 2-Butanone was detected in 65% of the samples analyzed. The highest concentrations of isopropyltoluene were usually present at station H-5, while the highest levels of 2-butanone occurred at H-6.

Tetrachloroethene was consistently detected (3.4-35 ug/kg) at station H-6 located adjacent to Occidental Chemical. Between 1947 and 1973 tetrachloroethene was produced in commercial quantities at Occidental's solvent plant (Tetra Tech, 1986b).

In addition to the VOCs, 37 target semivolatile organics and PCBs were detected in Hylebos SPM. A complete list of detected compounds is included in Appendix C, Table C3. A summary of detected concentrations of selected organics (ug/kg) is shown below:

Compound	Range	Mean	C.V.	Detection Frequency	N
HPAH	830-22000	10000	49%	100%	41
Hexachlorobenzene	40-130	72	46%	20%	8
Hexachlorobutadiene	18-200	76	73%	44%	18
Bis(2EH)phthalate	810-44000	8400	190%	17%	7
Total PCBs	230-73000	3000	400%	90%	37
Benzoic Acid	780-5400	2000	59%	29%	12

C.V.= Coefficient of Variation (SD/Mean) * 100
N= Number of Samples with detected concentrations

Concentrations of most organics in Hylebos SPM tended to be quite variable (c.v.= 46-400%) over the monitoring period. Polynuclear aromatic hydrocarbons (PAH) were the predominate group of organic compounds quantified in Hylebos SPM. The distribution of high molecular weight PAH (HPAH) is shown in Figure 7. The highest concentrations of HPAH were measured at station H-3 in the upper portion of the waterway. The lowest concentrations were typically measured at the mouth of the waterway.

At all stations, the sum of HPAH exceeded the sum of low molecular weight PAH (LPAH). This enrichment of HPAH in SPM is expected since weathering processes such as evaporation, photochemical oxidation, dissolution, and microbial degradation can preferentially remove PAHs with molecular weights less than that of fluoranthene (Merill and Wade, 1985). The apparent enrichment of HPAHs relative to LPAHs would suggest that historical sources of PAHs have played an important role in the PAH contamination observed in Hylebos SPM.

Hexachlorobenzene, hexachlorobutadiene, and 1,2,4-trichlorobenzene -- which have all been identified as problem chemicals in Hylebos -- were primarily detected at station H-6, located adjacent to Occidental Chemical. Occidental Chemical was identified as a source of hexachlorobenzene and hexachlorobutadiene during the CBRI (Tetra Tech, 1985). Maximum concentrations of Bis(2-ethyl hexyl)phthalate (44,000 ug/kg) occurred in the central portion of the waterway at station H-5.

Several additional compounds, not listed as problem chemicals were also quantified in Hylebos SPM. Benzoic acid was identified throughout the waterway at concentrations ranging from 780-5,400 ug/kg. 4-Methyl phenol concentrations ranged from 49-11,000 ug/kg. The remaining semivolatile organics were typically present at <1,000 ug/kg.

The distribution of total PCBs in Hylebos SPM is also shown in Figure 7. PCBs peaked at stations H-2 and H-3 in the upper portion of the waterway and decreased moving toward either the head or mouth. Total PCB concentrations at stations H-2 and H-3 were significantly higher than levels measured at both the head and mouth of the waterway (Tukey Post Hoc, $P<0.001$). A secondary peak for PCBs was also observed near station H-6 in the outer portion of the waterway. The current pattern of PCB contamination in Hylebos Waterway is similar to that observed during earlier monitoring, July 1990 to December 1991 (Norton and Barnard, 1992b).

One extremely high value for PCB-1242 of 73,000 ug/kg was measured between December 1991 and May 1992, at station H-2, which is located adjacent to General Metals. Aside from the high concentration, the unusual aspect of this result is that PCB-1242 has been infrequently detected in Hylebos Waterway. One noteworthy exception was a screening study of storm drains which discharge to the waterway (Stinson et al., 1987). In this study PCB-1242 was detected in several catch basin sediments at General Metals. Since this sampling was performed in 1986 a stormwater collection system has been installed at General Metals. Given the unusual type of PCB detected and the fact that it has not been detected at this location (H-2) in three years of subsequent monitoring, this result does not appear to indicate an ongoing problem.

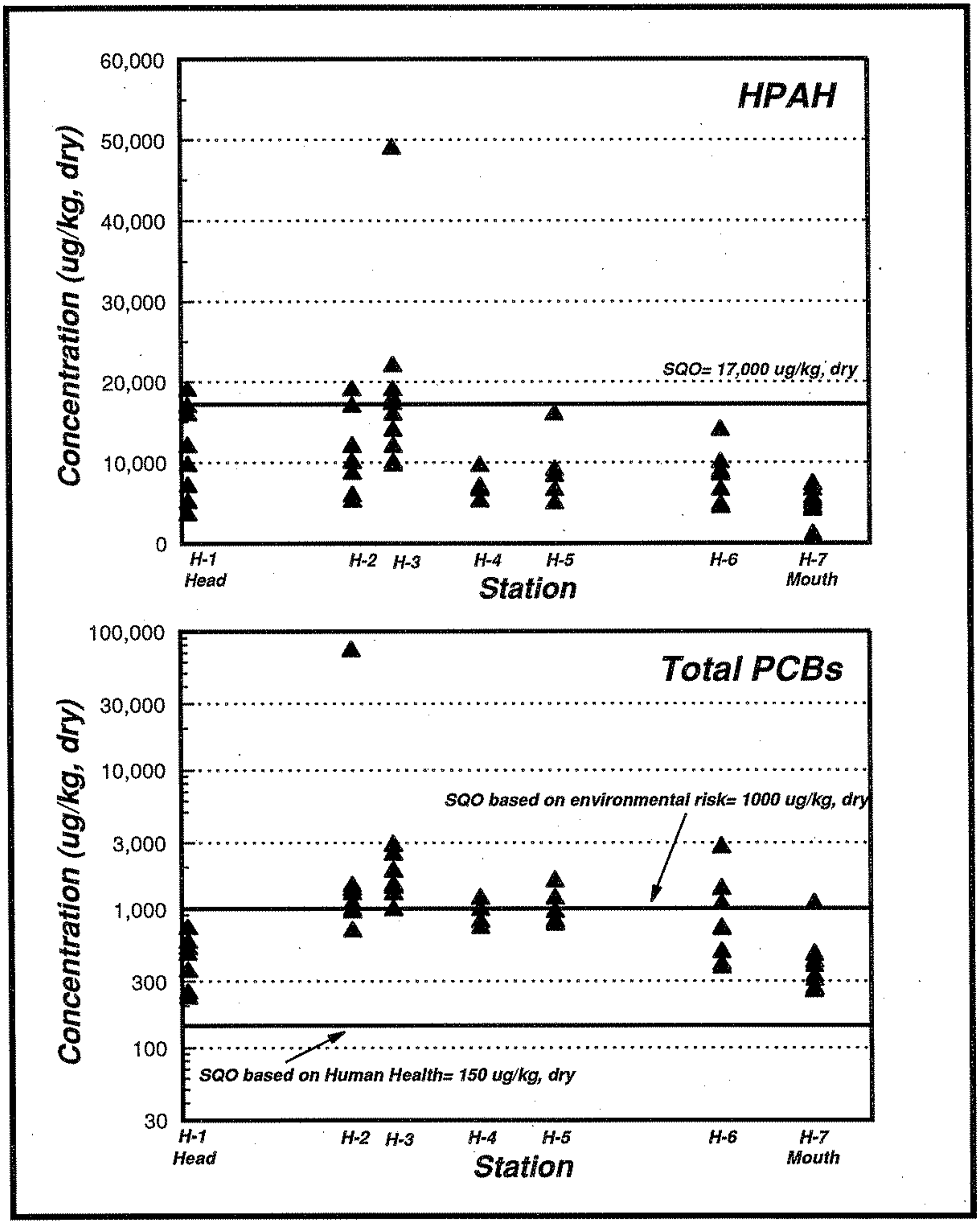


Figure 7: Total PCB and HPAH concentrations in Hylebos Waterway settling particulate matter, December 1991 to June 1995.

Tributyltin (TBT) has been used extensively in the past as an active ingredient in antifouling paints for private and commercial vessels. Due to concerns over the lack of information on TBT levels in Hylebos Waterway, butyltins were added to the list of target chemicals for the sediment trap program in May 1994. The results of butyltin analysis of SPM are summarized in Appendix C, Table C4.

TBT was detected in 100% of the samples analyzed at concentrations ranging from 55-1,300 ug/kg (mean= 450 ug/kg). Two breakdown products of TBT, monobutyltin (MBT) and dibutyltin (DBT), were also detected extensively throughout the waterway with the following exceptions. MBT and DBT were not detected at the mouth of the waterway. MBT was also not detected in the upper turning basin.

Chemicals in Bottom Sediment

The results of conventionals and metals analysis of bottom sediments collected in January 1991 and November 1994 at each of the sediment trap monitoring stations in Hylebos Waterway are listed in Appendix D, Table D1. TOC levels ranged from 1.7 to 12%, with the highest concentrations occurring at H-5. The lowest values were present at the mouth of the waterway. Grain size analysis indicated that most of the sediments sampled consistent of primarily silt and clay size particles. Sediments from H-4 (near Lincoln drain) and the mouth of the waterway tended to have a higher sand content.

Metals concentration were fairly low and consistent throughout the waterway. As was the case for SPM, the lowest concentrations of all metals were typically measured at the mouth. Unlike SPM, strong longitudinal gradients were not observed in bottom sediments for most metals, with the possible exception of arsenic and zinc. These two metals tended to be higher at the head and decreased moving toward the mouth.

Forty-six organic compounds were detected in bottom sediments from Hylebos Waterway. A complete list of organics detected in bottom sediments is included in Appendix D, Table D2. Volatiles were infrequently detected in bottom sediments. When present, concentrations were typically <2 ug/kg, dry. An exception was isopropyltoluene which was measured at 58 ug/kg in the central part of the waterway (station H-5).

PAHs were the predominant group of semivolatile organics detected in SPM. HPAH concentrations varied by an order of magnitude in Hylebos Waterway ranging from 1,800 to 18,000 ug/kg. The lowest HPAH levels were consistently measured at the mouth of the waterway. Hexachlorobenzene and hexachlorobutadiene were consistently detected adjacent to Occidental Chemical (station H-6). Most semivolatile organics were present at <1,000 ug/kg with a few exceptions. Benzoic acid was detected sporadically in the waterway at levels ranging from 200 to 1,700 ug/kg. Bis(2-ethyl hexyl)phthalate (1,500 ug/kg) peaked at H-2 in the upper portion of the waterway, while a single high value for retene (8,900 ug/kg) was measured in the central portion of the Hylebos. Retene is a naturally occurring resin-acid derived compound (Prahl and

Carpenter, 1984), that is often found in sediments in association with wood waste debris. One non-target compound, coprostanol, was present throughout the waterway during the November 1994 survey at concentrations between 690-2,300 ug/kg. Coprostanol is produced in the intestine of mammals by the microbial reduction of cholesterol which is the main steroid in the tissues of vertebrates (Verschueren, 1983).

For perspective, concentrations of total PCBs in Hylebos bottom sediments collected in 1984, 1991, and 1994 are compared in Figure 8. Total PCB levels in the 1994 survey ranged from 510 to 3,000 ug/kg. Peak concentrations were present near ELF-ATO Chem (station H-3) in the upper portion of the waterway. Examination of Figure 8 indicates that total PCB levels are higher in both 1991 and 1994 than those measured in 1984 at approximately similar areas in the waterway. In addition, in five of seven cases concentrations increase with each successive year of sampling. These data suggest that PCB concentrations have not gone down in bottom sediments despite the passage of ten years and in fact may be increasing. It should be noted that factors such as spatial and analytical differences between the present study and the work conducted for the remedial investigation in 1984 may be contributing to the apparent trend in PCBs. However, the samples collected in 1991 and 1994 were from similar locations and employed identical analytical techniques.

Butyltins were detected in bottom sediments throughout Hylebos Waterway. The highest concentrations of TBT (820 ug/kg), MBT (35 ug/kg), and DBT (380 ug/kg) were detected in the central portion of the waterway (H-4). As was the case for most other contaminants the lowest butyltin levels were measured at the mouth of the waterway. A summary of butyltin concentrations in Hylebos bottom sediments can be found in Appendix D, Table D3.

Comparison to Commencement Bay Sediment Quality Objectives (SQOs)

Of particular concern to source control and sediment cleanup activities in the Commencement Bay Nearshore/Tideflats site are chemicals which exceeded the SQOs. SQOs based on environmental risk (EPA, 1989) are contaminant concentrations above which deleterious effects would always be observed in marine benthic communities. EPA, the lead agency for sediment remediation activities in Commencement Bay, is using the SQOs based on environmental risk (bioassay and benthic community data) as cleanup objectives for contaminated sediments. For PCBs, the cleanup objective is based on the SQO for the protection of human health. A list of SQOs for chemicals detected in SPM during the Sediment Trap Monitoring Program is presented in Table 3. For completeness, SQOs for individual PAHs are also shown in Table 3. However, to simplify presentation of the data only comparisons with the SQOs for LPAH and HPAH are discussed in the report.

A summary of chemicals exceeding the SQOs in Hylebos SPM and bottom sediments are shown in Table 4. A total of 14 individual chemicals (3 metals, 11 organics) were measured at levels above the SQOs in Hylebos SPM. The greatest number of exceedances (9) were measured at the

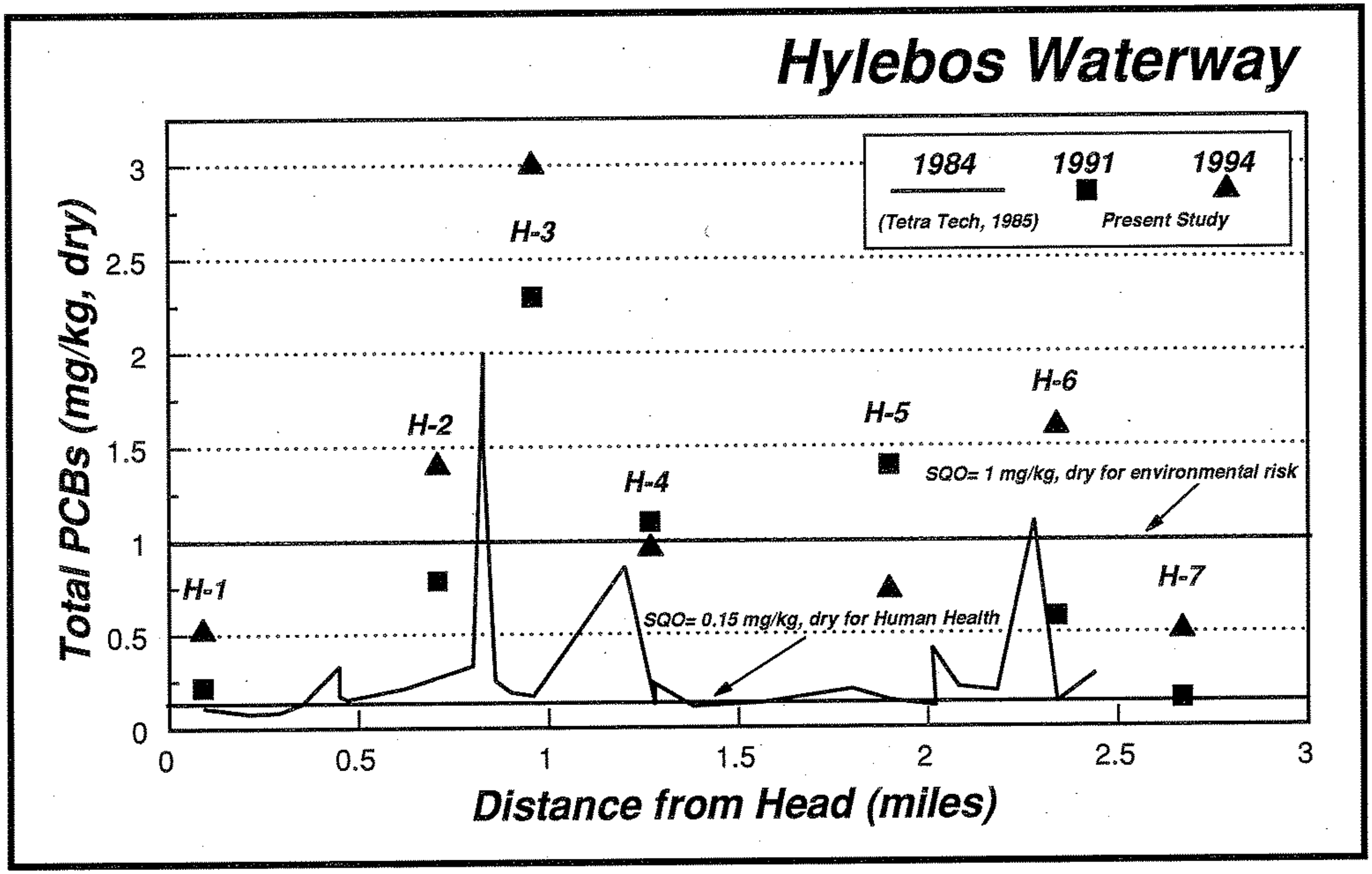


Figure 8: Comparison of Total PCB concentrations in Bottom Sediments from Hylebos Waterway in 1984, 1991, and 1994.

Table 3: Commencement Bay Sediment Quality Values Based on Environmental Risk for Compounds Detected in Hylebos, Sitcum, and Thea Foss Waterway Settling Particulate Matter.

Chemical	Sediment Cleanup Objective+
Metals (mg/kg, dry weight)	
Antimony	150
Arsenic	57
Cadmium	5.1
Copper	390
Lead	450
Mercury	0.59
Nickel	>140
Zinc	410
Organic Compounds (ug/kg, dry weight)	
Polynuclear Aromatic Hydrocarbons	
LPAH	5200
Napthalene	2100
Acenapthalene	1300
Acenapthene	500
Fluorene	540
Phenanthrene	1500
Anthrene	960
2-Methylnapthalene	670
HPAH	17000
Fluoranthene	2500
Pyrene	3300
Benzo(a)anthracene	1600
Chrysene	2800
Benzofluoranthenes	3600
Benzo(a)pyrene	1600
Indeno(1,2,3-cd)pyrene	690
Dibenzo(a,h)anthracene	230
Benzo(g,h,i)perylene	720

+= Commencement Bay Nearshore/Tideflats, Record of Decision (EPA, 1989)

*=Sediment Quality Objective based on human health

Table 3 (cont.): Commencement Bay Sediment Quality Values Based on Environmental Risk for Compounds Detected in Hylebos, Sitcum, and Thea Foss Waterway Settling Particulate Matter.

Chemical	Sediment Cleanup Objective+
Organic Compounds (ug/kg, dry)	
Chlorinated Organics	
1,4 Dichlorobenzene	110
Hexachlorobenzene	22
Total PCBs	1000
Total PCBs	150*
Phthalates	
Dimethylphthalate	160
Diethylphthalate	200
Di-n-butyl phthalate	1400
Butyl benzyl phthalate	900
Bis(2EH)phthalate	1300
Di-n-octyl phthalate	6200
Phenols	
Phenol	420
4-Methyl phenol	670
Pentachlorophenol	360
Misc. Extractables	
Benzyl alcohol	73
Benzoic acid	650
Dibenzofuran	540
Hexachlorobutadiene	11
N-nitrosodiphenylamine	28
Volatile Organics	
Tetrachloroethene	57
Ethylbenzene	10
Total xylenes	40

+= Commencement Bay Nearshore/Tideflats, Record of Decision (EPA, 1989)

*=Sediment Quality Objective based on human health

Table 4: Summary of metals and organic compounds exceeding the Commencement Bay sediment quality objectives (SQO) in settling particulate matter and bottom sediments from Hylebos Waterway, December 1991 to June 1995.

Station	H-1	H-2	H-3	H-4	H-5	H-6	H-7
Location	Head	@ General Metals	@ Elf Atochem	Near Lincoln Drain	Near Cenex	@ Occidental Chemical	Mouth
Metals							
Arsenic	64*$_{11}$	62*$_{13}$	62$_{13}$	28$_{8}$			
Mercury	11$_{9}$	18$_{11}$	56$_{9}$				
Nickel	bs					bs	
Zinc	9$_{11}$	bs					
Organics							
LPAH						33$_{6}$	
HPAH	17$_{6}$	29$_{7}$	57$_{7}$				
Dibenzofuran						17$_{6}$	
4-Methyl phenol	17$_{6}$	14$_{7}$	14$_{7}$	50$_{4}$	50$_{4}$	33$_{6}$	
Benzoic acid	33*$_{6}$	60$_{5}$	33$_{3}$	50$_{2}$		100$_{2}$	60$_{5}$
Diethyl phthalate	bs						
Di-n-butyl phthalate		14$_{7}$	bs				
Dimethyl phthalate	20$_{5}$						
Bis(2-ethyl hexyl)phthalate	100$_{1}$	100*$_{1}$			33$_{3}$		33$_{6}$
N-Nitrosophenylamine		bs					
Hexachlorobenzene			100*$_{1}$		100$_{2}$	100*$_{4}$	100*$_{3}$
Hexachlorobutadiene			100*$_{2}$		bs	100*$_{6}$	100*$_{6}$
PCBs+	100*$_{6}$	100*$_{7}$	100*$_{7}$	100*$_{4}$	100*$_{4}$	100*$_{5}$	100*$_{7}$

Values shown are percent of total SPM samples collected that exceeded the sediment quality objectives

Subscript= Number of samples

*=SQO also exceeded in bottom sediment

bs= Chemical only exceeded SQO in bottom sediments

+= SQO for PCBs based on protection of human health head of the waterway in the upper turning basin. Two stations (H-4 and H-5) in the central portion of the waterway had the fewest number of exceedances. PCBs were the only chemical that exceeded the SQO in 100% of the samples tested.

TBT is the most toxic of the butyltins. While no SQO has been established for TBT, the Puget Sound Dredge Disposal Analysis (PSDDA) has adopted a Interim Screening Level (ISL) of 30 ug/kg, dry (PSDDA, 1989). Sediments with TBT concentrations above the ISL are required to undergo biological toxicity testing. TBT concentrations in Hylebos SPM ranged from 55-660 ug/kg, with a mean of 450 ug/kg.

At the request of the Hylebos Cleanup Committee, EPA Region 10 has evaluated an appropriate sediment cleanup levels for TBT in Hylebos Waterway. Based on a review of available literature concerning the toxicity of TBT to aquatic organisms, EPA has selected a concentration of 19,250 ug TBT/kg organic carbon (OC) as a site specific sediment cleanup level for Hylebos Waterway. It is anticipated that this level would protect many aquatic organisms from most acute and some chronic effects (EPA, 1996). On an OC normalized basis, TBT levels in Hylebos Waterway ranged from 2,800 to 26,000, with a mean of 11,000 ug TBT/kg OC.

Compared to SPM, fewer chemicals (12) exceeded the SQOs in bottom sediments. Again, PCBs were above the SQO established for the protection of human health at all stations. The highest number of exceedances were present in the upper portion of the waterway, within one mile from the head. As was the case for SPM, 100% of the bottom sediments analyzed (150-820 ug/kg) exceeded the PSDDA ISL of 30 ug/kg for TBT. Only one of seven bottom sediment concentrations exceeded the Hylebos Waterway cleanup level for TBT.

Gross Sedimentation Rates

A complete list of sediment accumulation rates for Hylebos Waterway determined from sediment trap data is included in Appendix C, Table C5. Two types of accumulation rates have been calculated: gross accumulation ($g/cm^2/yr$) 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. Calculations used to generate the reported sedimentation rates are shown below:

- Gross Accumulation ($g/cm^2/yr$)= $[(P/A)/D] \times Y$

  P= Amount of material collected (dry grams)
  A= Collection area of cylinder (cm^2)
  D= Number of days sediment trap was deployed
  Y= Number of days in a year (365)

- Accumulation Rate (cm/yr)= Mass accumulation ($g/cm^2/yr$)/Dry density (g/cm^3)

  Dry density= [Wet density x (Bottom Sediment % solids/100)]
  Wet density= Estimated from Puget Sound Density Model using % solids data
  from in-situ bottom sediments (Crecelius, 1989)

Gross accumulation rates (dry weight) for Hylebos Waterway between December 1991 and June 1995 are shown in Figure 9. Gross rates ranged from 0.5-5.5 $g/cm^2/yr$, with a mean of 2.4±1.0 $g/cm^2/yr$. The highest sedimentation rates in the waterway typically occurred in the central portion of the waterway at station H-5 (mean= 3.4±1.2 $g/cm^2/yr$), and at the mouth (mean= 3.1±1.2 $g/cm^2/yr$). Significantly lower rates (ANOVA, $P<0.05$) were measured at stations H-1, H-2, and H-6, compared to the two locations (H-5 and H-7) with the highest rates. Temporally, the data collected suggest that sedimentation in most of the waterway tends to be highest during the late summer and fall, and lowest during the winter and spring. Predicted accumulation rates ranged from 0.6-7.4 cm/yr with a mean of 3.4±1.3 cm/yr.

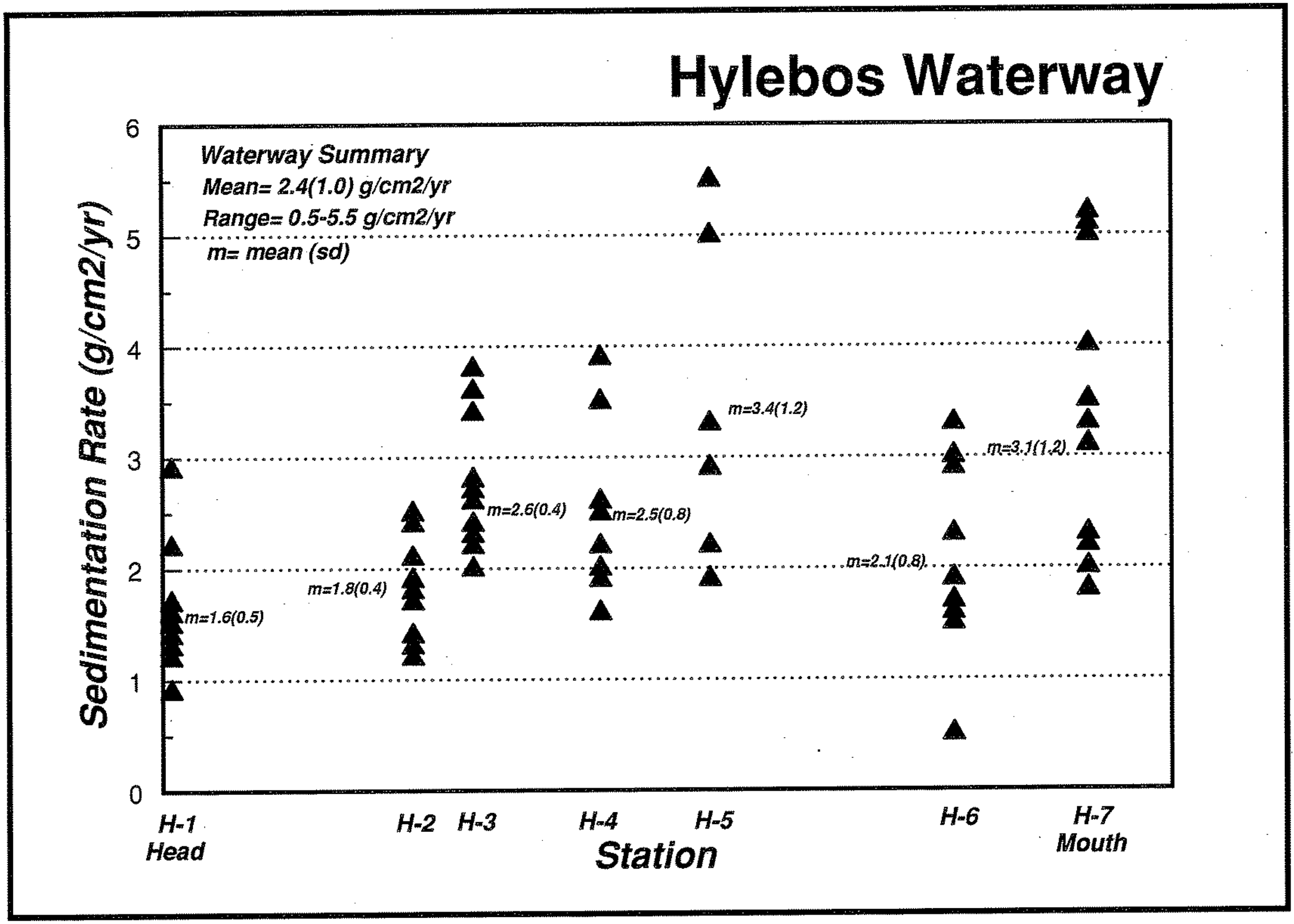


Figure 9: Gross Sedimentation Rates for Hylebos Waterway, December 1991 to June 1995.

Sitcum Waterway

Chemicals in SPM

Between June 1991 and June 1995 44 sediment traps were deployed in Sitcum Waterway. Of these traps 39 (89%) were successfully recovered. Sediment trap monitoring in Sitcum was temporarily interrupted for a period of 11 months between December 1993 and November 1994 while dredging operations were underway.

The results of conventionals and metals analysis of Sitcum Waterway SPM are summarized in Appendix C, Table C6. TOC levels were fairly low and consistent in Sitcum ranging from 1.2 to 3.0% (mean= 2.0%).

Concentrations of selected metals (mg/kg) associated with SPM from Sitcum Waterway between June 1991 and June 1995 are summarized below. Data collected before and after May 1994 have been separated in this summary due to a shift in analytical methods (see sample analysis and quality assurance section). In addition the two data sets represent pre- and post-dredging conditions in the waterway.

June 1991 to December 1993 (Pre-dredging)

Metal	Range	Mean	C.V.	Detection Frequency	N
Arsenic	11-83	37	51%	100%	33
Copper	64-180	120	30%	100%	33
Lead	44-320	170	49%	100%	33
Zinc	91-450	220	41%	100%	33

November 1994 to June 1995 (Post-dredging)

Metal	Range	Mean	C.V.	Detection Frequency	N
Arsenic	8.1-24	17	34%	100%	4
Copper	41-99	75	29%	100%	4
Lead	21-160	110	49%	100%	4
Zinc	50-190	120	41%	100%	4

C.V.= Coefficient of Variation (SD/Mean)
N= Number of Samples

Arsenic concentrations, shown in Figure 10, illustrate the characteristic distribution of all metals in Sitcum SPM. Peak concentrations for all metals were measured at the head of the waterway near the north corner drain. A secondary peak was also present along Terminal 7, at Berth B. The lowest concentrations for all metals were measured at the mouth of the waterway.

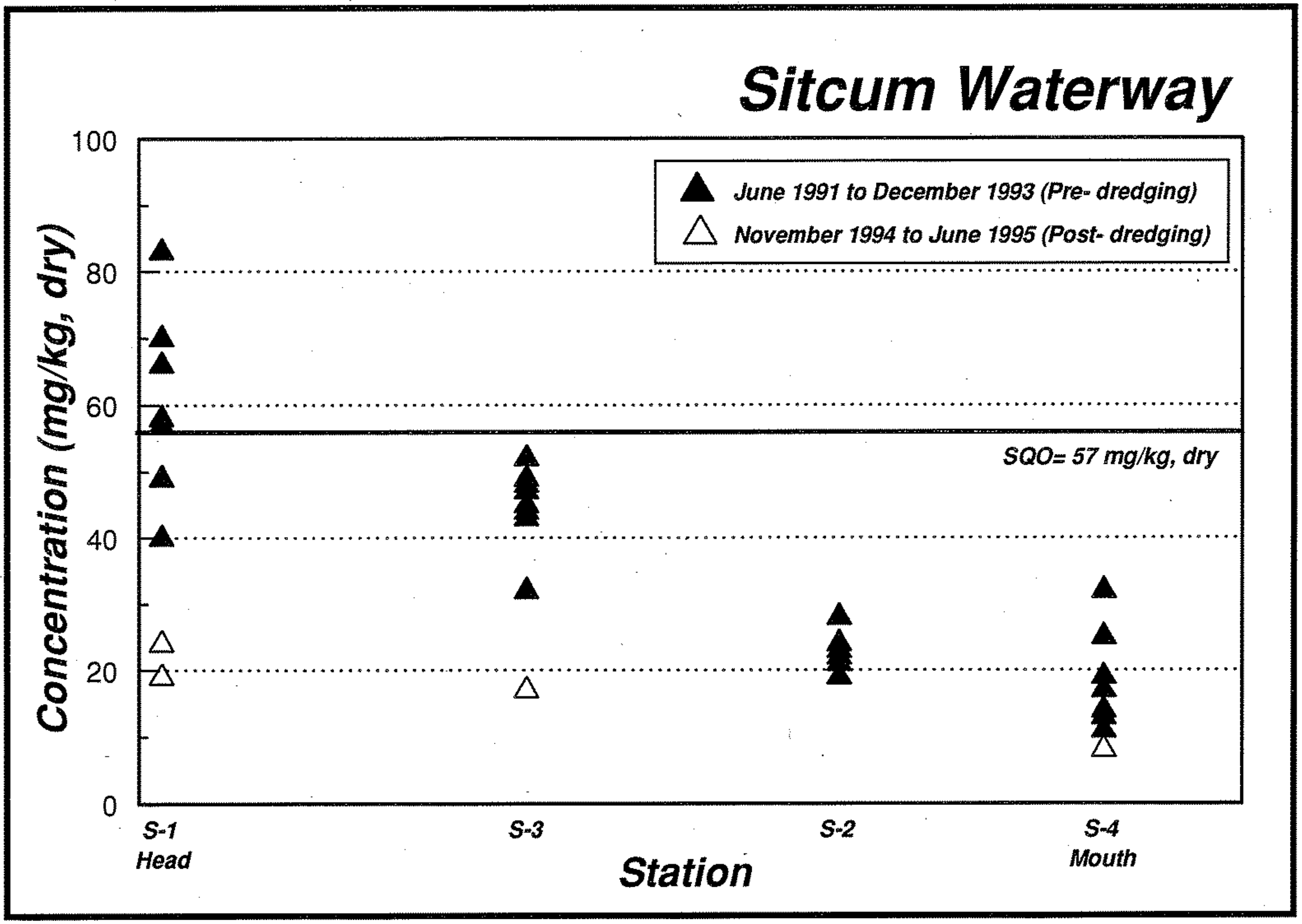


Figure 10: Arsenic concentrations in Sitcum Waterway settling particulate matter, June 1991 to June 1995.

Substantially lower metals concentrations were noted at all monitoring stations after dredging was completed in December 1993. A portion of the observed decrease in metals concentrations is undoubtedly the result of sediment cleanup activities in the waterway. Unfortunately, due to a change in analytical methods for metals (see sample analysis and quality assurance section), which occurred in December 1993, it is difficult to evaluate the actual decrease in metals concentrations in the waterway. Sample splits planned for XRF and ICP analysis during the next routine collection (December 1995) should help in evaluating the comparability of results from these two methods.

Thirty-two organic compounds, primarily PAHs were quantified in SPM. A complete list of semivolatile organics in Sitcum SPM is included in Appendix C, Table C7. Detected concentration (ug/kg) of selected organics in Sitcum SPM are shown below. For comparison pre- and post-dredging data have been separated.

June 1991 to December 1993 (Pre-dredging)

Compound	Range	Mean	C.V.	Detection Frequency	N
LPAH	480-5400	1900	76%	100%	19
HPAH	1800-12000	5400	56%	100%	19
Dibenzofuran	28-460	180	73%	100%	19
Bis(2EH)phthalate	34000-170000	110000	52%	16%	3
Benzoic Acid	1400-5500	3200	43%	32%	6

November 1994 to June 1995 (Post-dredging)

Compound	Range	Mean	C.V.	Detection Frequency	N
LPAH	77-2300	1300	71%	100%	3
HPAH	160-4100	2700	67%	100%	3
Dibenzofuran	120-240	180	33%	67%	2
Bis(2EH)phthalate	ND	-	-	-	-
Benzoic Acid	970	-	-	33%	1

C.V.= Coefficient of Variation (SD/Mean)
N= Number of Samples
ND= Not detected

Concentrations of most organics were more variable than metals in Sitcum SPM. PAHs were present in 100% of the samples analyzed from Sitcum Waterway. The distribution of LPAH and HPAH in Sitcum is shown in Figure 11. Based on means, LPAH concentrations were highest at Berth B along terminal 7, while maximum HPAH concentrations occurred near the north corner drain at the head of the waterway. For both LPAH and HPAH the lowest levels were present at the mouth of the waterway. Prior to dredging, Dibenzofuran was detected in 100% of the samples analyzed from Sitcum Waterway at concentrations ranging from 28-460 ug/kg (mean= 180 ug/kg). Chemically, dibenzofuran is closely related to the PAHs. Phthalate acid esters were

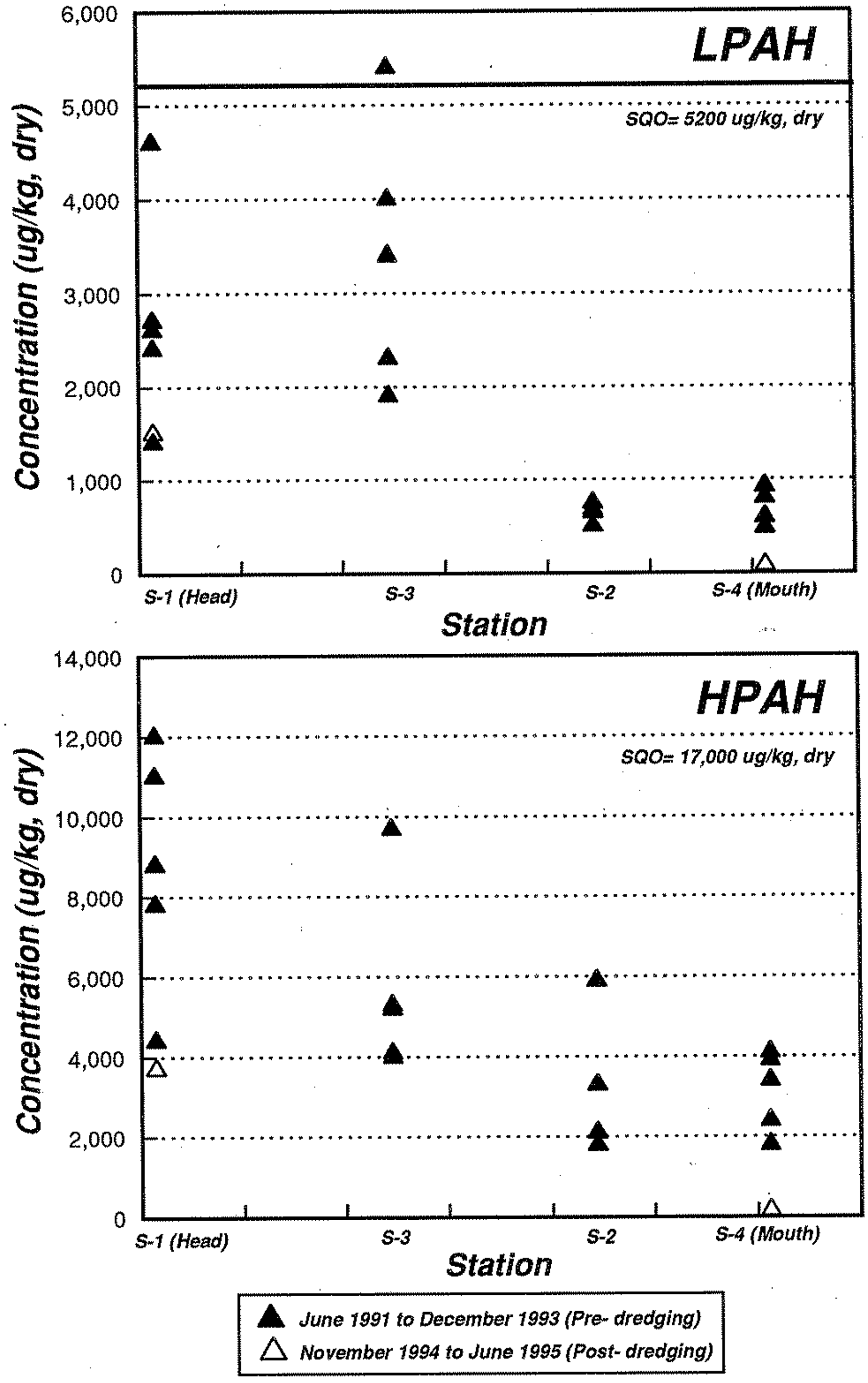


Figure 11: LPAH and HPAH Concentrations in Sitcum Settling Particulate Matter, June 1991 and June 1995.

primarily detected near the north corner drain. Retene was present at low levels (150-670 ug/kg) throughout the waterway.

Substantial reductions were noted for most organic compounds associated with SPM after dredging was completed in Sitcum. This was especially true at the mouth of the waterway.

Chemicals in Bottom Sediment

Results of conventionals and metals analysis of bottom sediments from Sitcum Waterway, collected in January 1991 and November 1994, are listed in Appendix D, Table D4. TOC values in bottom sediments were quite low and consistent at all stations in the waterway ranging from 1.1 to 2.0%. Grain size analysis indicated that the bottom sediments collected consisted primarily of silt and clay size particles.

Metals concentrations (mg/kg) in bottom sediments were as follows; arsenic= 7-28; copper= 55-160; lead= 19-290; and zinc= 69-470. The highest concentrations for lead and zinc were measured at Berth B, along Terminal 7. The lowest levels for all metals were consistently measured at the mouth of the waterway. As was noted earlier, due to a change in analytical methodologies for metals it is difficult to evaluate actual changes in metals concentrations resulting from dredging in the waterway.

Concentrations of semivolatile organics in Sitcum bottom sediments (Appendix D, Table D5) were <1000 ug/kg with the exception of PAHs. LPAH concentrations in the waterway ranged from 120-5,500 ug/kg. HPAH levels ranged from 950-10,000 ug/kg.

Reductions in contaminant levels were not as apparent in bottom sediments as those observed in SPM. Very little change was noted in contaminant levels at the head and mouth of the waterway between 1991 and 1994. A possible explanation for this finding could be that the areas sampled at the head and mouth of the waterway are just outside the limit of dredging. In contrast, a substantial decrease in PAH levels was noted at Berth B, along Terminal 7. Comparing pre- and post-dredge values, LPAH and HPAH concentrations were lower by 98% and 83%, respectively. In addition, dibenzofuran was not detected at this location in 1994. While this conclusion is based on a limited amount of data it does seem to strongly suggest that contaminant levels at Berth B, along Terminal 7, are lower then those measured prior to dredging. Post-dredging monitoring which is being conducted by the Port of Tacoma will be useful in evaluating changes in bottom sediment conditions.

Comparison to Commencement Bay SQOs

In Sitcum Waterway a total of 7 chemicals (1 metal and 6 organics) exceeded the SQOs in SPM (Table 5). The greatest number of exceedances (4) were measured at the head of the waterway near the north corner drain. Arsenic was above the SQO in 55% of the samples tested at this location. Benzoic acid was present above the SQOs at three of the four sites in Sitcum. After

Table 5: Summary of metals and organic compounds exceeding the Commencement Bay sediment quality objectives (SQO) in settling particulate matter and bottom sediments from Sitcum Waterway, June 1991 to June 1995.

Station	S-1	S-2	S-3	S-4
Location	Head near North corner Drain	North end Sealand Terminal	Terminal 7 @ Berth B	Terminal 7 @ Mouth
Metals				
Arsenic	55_{11}			
Zinc			bs	
Organics				
LPAH			20^{*}_{6}	
Dibenzofuran			bs	
Benzoic acid	50_{4}	33_{3}		25_{4}
Benzyl alcohol				100_{1}
Pentachlorophenol			33_{3}	
Dimethyl phthalate	50^{*}_{6}			
Bis(2-ethyl hexyl)phthalate	75_{4}		20_{5}	

Values shown are percent of total SPM samples collected that exceeded the sediment quality objectives

Subscript= Number of samples

*=SQO also exceeded in bottom sediment

bs= Chemical only exceeded SQO in bottom sediments completion of dredging in the waterway no chemicals were detected above the SQOs in SPM from Sitcum Waterway.

Four chemicals (zinc, LPAH, dibenzofuran, and dimethyl phthalate) were above the SQOs in Sitcum bottom sediments. Dimethyl phthalate near the north corner drain was the only chemical present above the SQO after dredging was completed in the waterway.

Gross Sedimentation Rates

Gross sedimentation rates for Sitcum Waterway are shown in Figure 12. Gross accumulation rates in the waterway were quite variable, ranging from 1.3 to 8.3 $g/cm^2/yr$. The mean rate for the waterway was 4.8 ± 1.8 $g/cm^2/yr$. The highest mean rate in the waterway (6.4 ± 2.2 $g/cm^2/yr$) was measured at Berth B, along Terminal 7. Mean rates at the remaining stations were similar, ranging from 4.1 ± 1.6 $g/cm^2/yr$ at the mouth to 4.5 ± 1.2 $g/cm^2/yr$ at the head of the waterway. Predicted accumulation rates for the waterway ranged from 1.3 to 13 cm/yr, with a mean of 5.1 ± 2.1 cm/yr.

Temporally, the lowest sedimentation rates in the waterway occurred during the late winter and spring months (February to May). The highest rates were typically measured between July and November. A complete list of sedimentation rates for Sitcum Waterway between June 1991 and June 1995 is included in Appendix C, Table C8.

Thea Foss Waterway

Chemicals in SPM

Between November 1992 and June 1995 44 sediment traps were deployed in Thea Foss Waterway. Of these traps, 41 were retrieved for a recovery rate of 93%. Monitoring results for conventionals and metals in Thea Foss SPM are included in Appendix C, Table C9.

Relatively high TOC concentrations were measured in Thea Foss Waterway, especially at the head. TOC values ranged from 3.8 to 12%. The mean value at the head (9.2%), was elevated by a factor of two compared to the mean value at the mouth (4.6%) of the waterway. TOC is listed as a problem chemical at the head of the waterway.

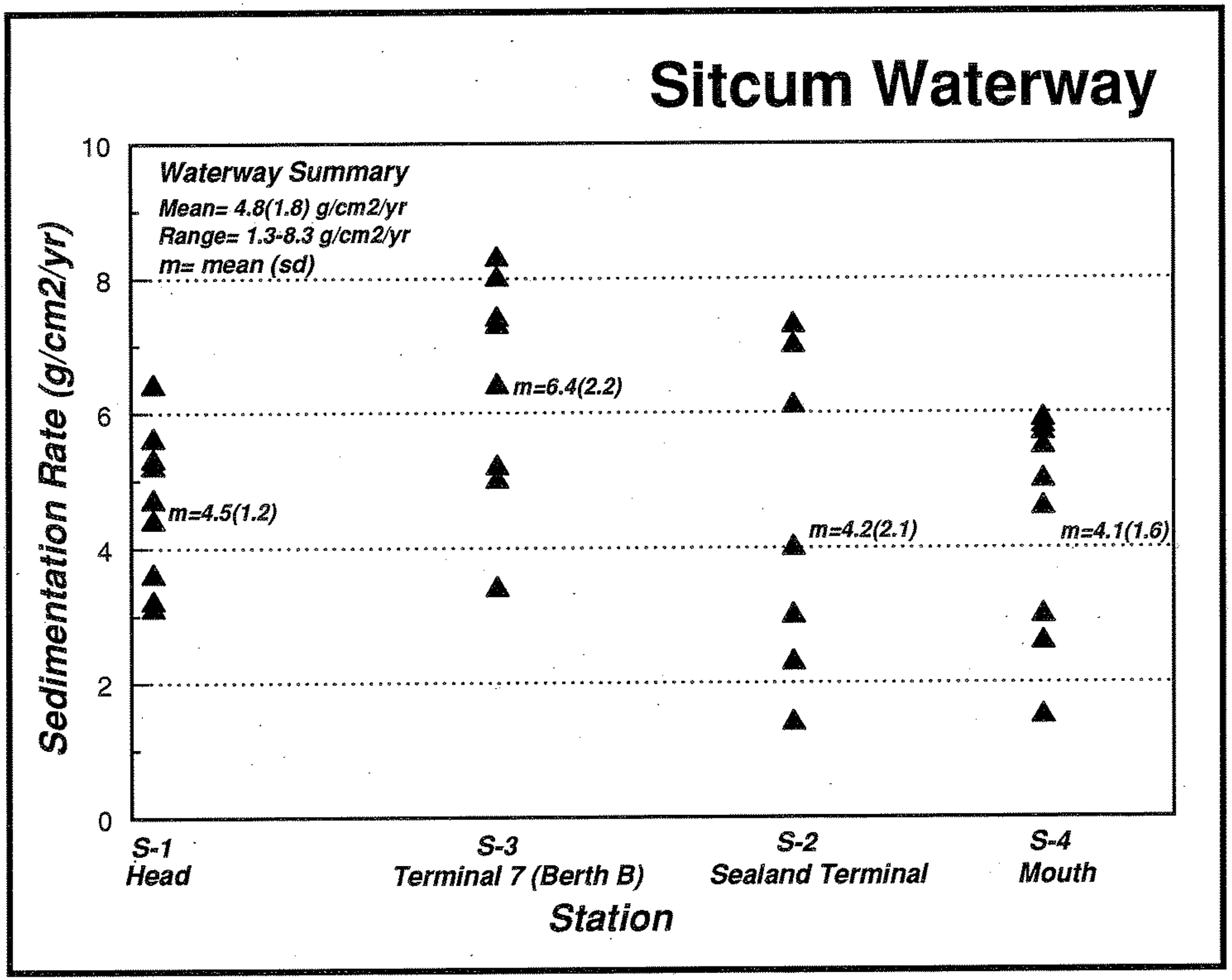


Figure 12: Gross sedimentation rates for Sitcum Waterway, June 1991 to June 1995.

Concentrations of selected metals (mg/kg) in Thea Foss SPM between November 1992 and June 1995 are:

Metal	Range	Mean	C.V.	Detection Frequency	N
Copper	97-310	180	24%	100%	41
Lead	90-420	250	36%	100%	41
Mercury	0.4-1.5	0.70	31%	100%	41
Zinc	120-510	300	35%	100%	41

C.V.= Coefficient of Variation (SD/Mean)
N= Number of Samples

The distribution of metals in Thea Foss Waterway during the current monitoring period is consistent with the results from previous monitoring (Norton, 1993). Peak concentrations of cadmium, lead, nickel, and zinc were measured at the head of the waterway near the twin 96" drains. The highest copper concentrations were present near the mouth of Wheeler-Osgood Waterway. On average, mercury levels were at a maximum in the central portion of the waterway near the 15th Street drain and the mouth of Wheeler-Osgood Waterway. The 15th Street drain, shoreline banks adjoining the Investco Site, and the inactive Surplus Steam Plant #1 have been identified as potential sources of mercury in this portion of the waterway (Smith, 1995). The lowest metals concentrations were consistently measured at the mouth of the waterway.

As illustrated in Figure 13, two longitudinal patterns were evident for metals concentrations in Thea Foss Waterway. Lead, nickel, and zinc decreased moving out the waterway, with the highest concentrations occurring at the head and the lowest at the mouth. The distribution of cadmium and nickel, which are not shown in Figure 13, also followed this pattern. In contrast, copper and mercury increased moving away from the head, peaking in the middle, and then decreasing to a minimum at the mouth of the waterway. Consistently higher (8/8) copper values were measured at station TF-3 (mouth of Wheeler-Osgood) compared to TF-2 (15th Street) which is located at the opposite side of the waterway. This result suggests a source of copper is located in or near the mouth of Wheeler-Osgood Waterway. Previous studies have documented high concentrations of copper in sediments at J.M. Martinac Shipbuilding (Norton and Johnson, 1984; Norton, 1995). Sources of copper at Martinac Shipbuilding include the use of granulated slag as sandblasting material, and removal of antifouling paints during vessel renovations (Tetra Tech, 1985).

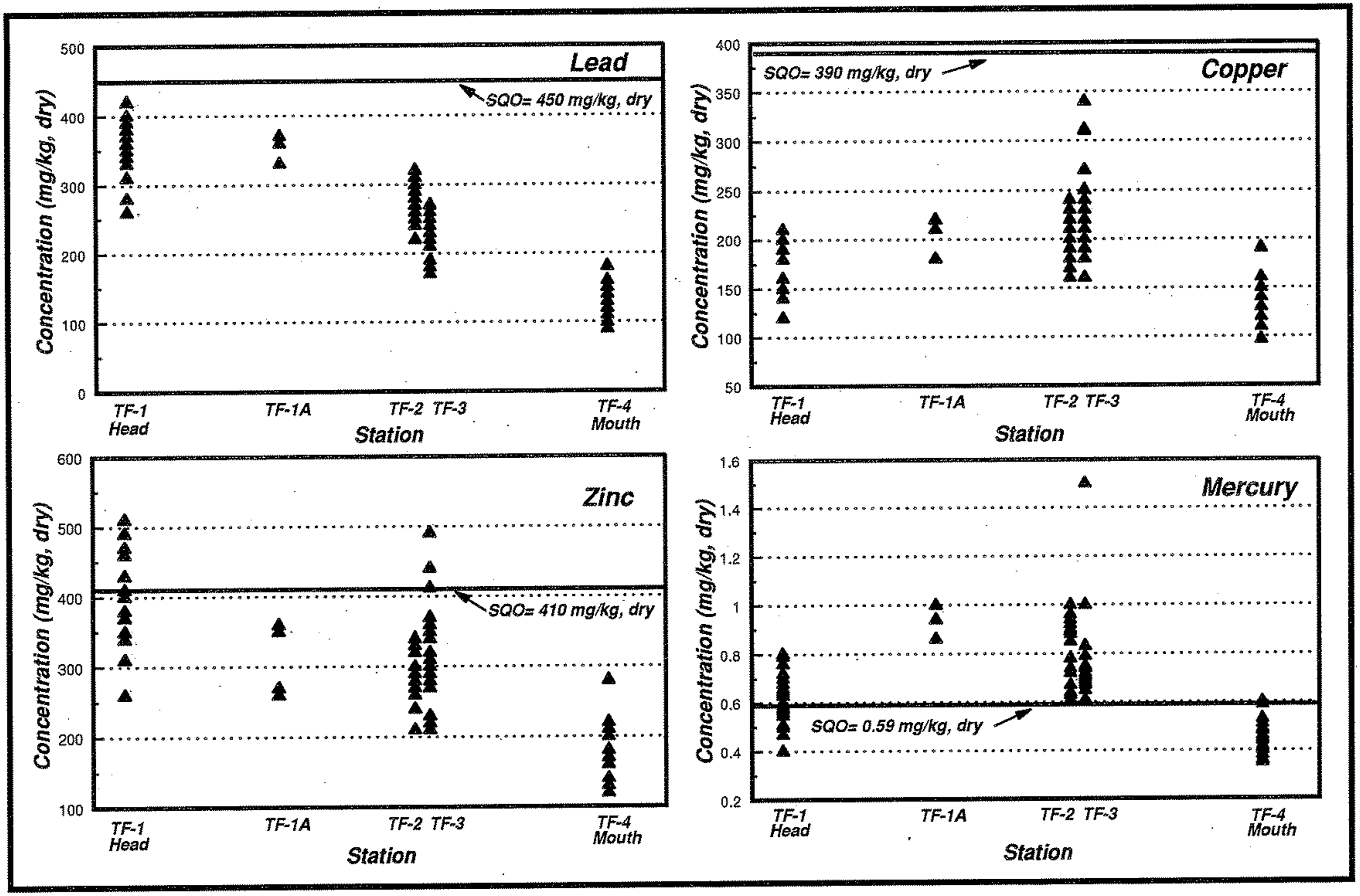


Figure 13: Selected Metals in Thea Foss Settling Particulate Matter, November 1992 to June 1995.

The results of semivolatile organics and butyltin analysis of Thea Foss Waterway SPM are listed in Appendix C, Table C10. Thirty-two target semivolatile compounds were detected in SPM. Detected concentrations of selected organics in Thea Foss SPM are:

Compound	Range	Mean	C.V.	Detection Frequency	N
LPAH	2100-17000	5300	66%	100%	22
HPAH	5200-84000	25000	81%	100%	22
Butyl benzyl phthalate	160-2500	890	75%	73%	16
Bis(2EH)phthalate	590-96000	28000	130%	46%	10
Benzoic Acid	1100-9600	4600	57%	55%	12
Tributyltin	30-790	470	44%	100%	20

C.V.= Coefficient of Variation (SD/Mean)
N= Number of Samples

On average, concentrations of most problem chemicals tended to be highest at the head of the waterway. In particular, HPAH concentrations, shown in Figure 14, were substantially higher at the head of the waterway. An exception to this pattern was Bis(2-ethyl hexyl)phthalate. The highest concentration of Bis(2-ethyl hexyl)phthalate (96,000 ug/kg) was measured north of the 15th Street drain. The lowest concentrations of most problem chemicals were typically measured at the mouth of the waterway.

In contrast to metals, few strong longitudinal gradients were evident for semivolatile organics in Thea Foss Waterway, with the exception of HPAH. HPAH concentrations were highest at the head and decreased moving toward the mouth of the waterway. Major PAH sources previously identified at the head of Thea Foss Waterway included discharge from storm drains -- primarily the twin 96" -- and operation of a historic coal gasification plant (Tetra Tech, 1985).

Temporally, intra-station concentrations of most "problem" chemicals tended to be somewhat variable. However, differences in quantitation limits between several of the monitoring periods hinder interpretations of temporal trends (see quality assurance section).

The distribution of TBT in Thea Foss SPM is displayed in Figure 15. TBT and its breakdown products were detected throughout the waterway. TBT concentrations ranged from 30-790 ug/kg with a mean of 470 ug/kg. The highest concentrations were measured in the upper portion of the waterway adjacent to the City Marina (station TF-1A). Recent sampling by inspectors at Ecology's Southwest Regional Office has identified high concentrations of TBT (up to 1,400,000 ug/kg) in sediments from catch basins which drain the Picks Cove Marina boat yard into this section of the waterway (Mercuri, 1995). Longitudinally, TBT levels tended to increase slightly moving away from the head, peaked approximately 0.4 miles from the head

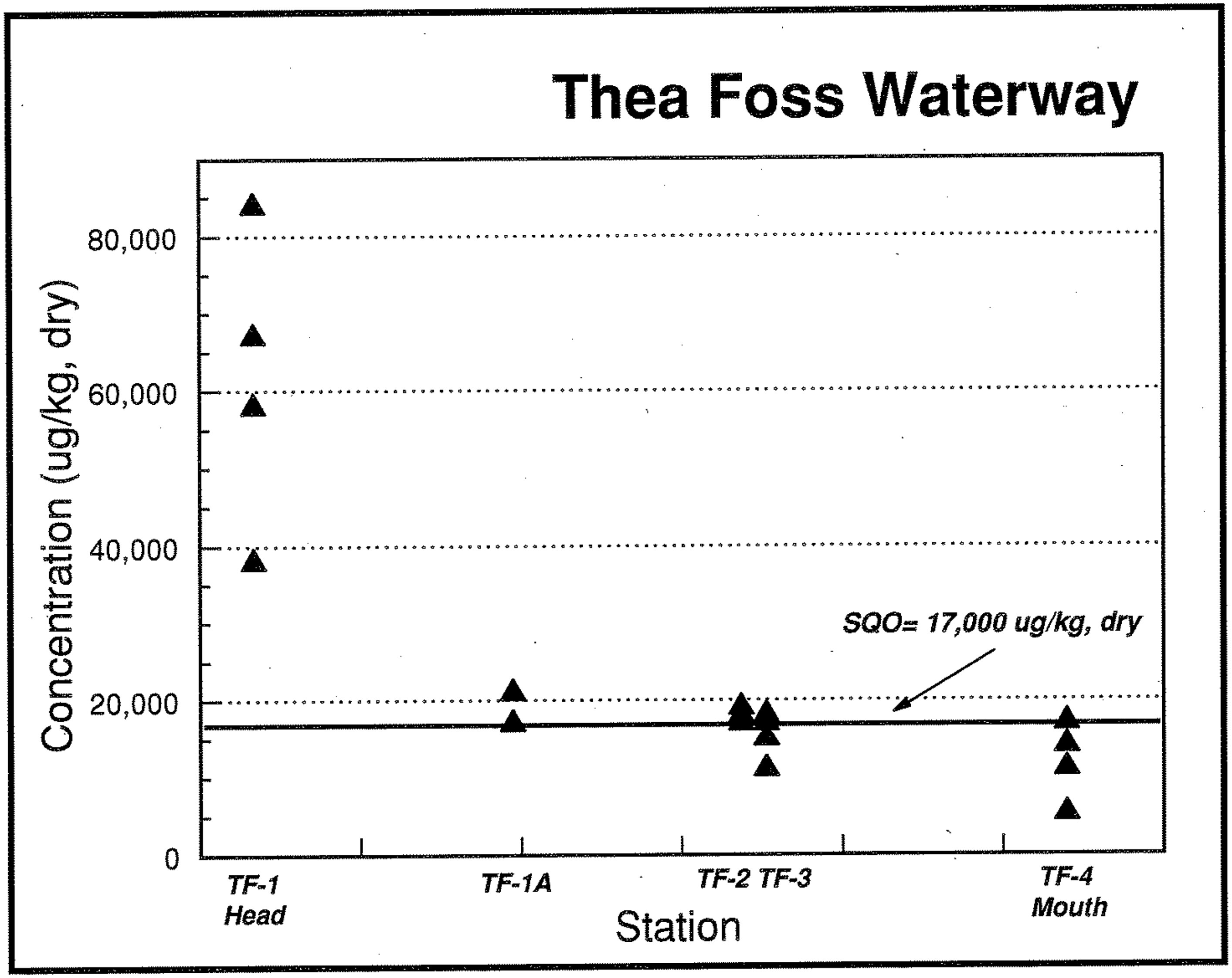


Figure 14: HPAH concentrations in Thea Foss Settling Particulate Matter, November 1992 and June 1995.

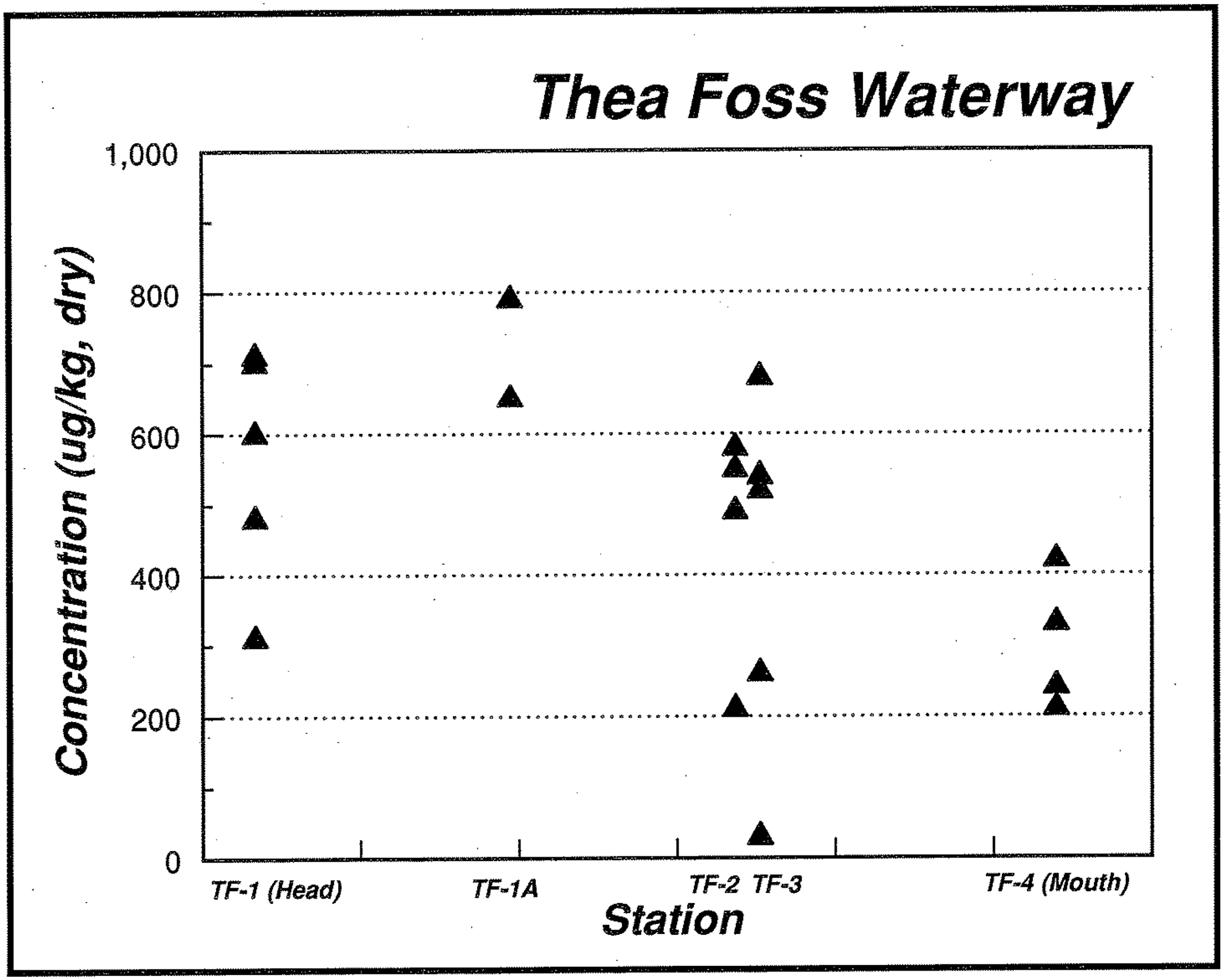


Figure 15: Distribution of Tributyltin in Thea Foss Settling Particulate Matter, November 1992 and June 1995.

(station TF-1A), and then decreased moving toward the mouth of the waterway. The lowest TBT levels were measured at the mouth of the waterway.

At the request of the City of Tacoma, PCBs were added as a target analyte in Thea Foss Waterway beginning with the November 1994 to June 1994 sample set. During this period PCBs were detected at all monitoring stations in the waterway (Appendix C, Table C11). Concentrations of total PCBs ranged from 280 to 610 ug/kg, with a mean of 500 ug/kg. The highest value was present north of the 15th Street drain (station TF-2). As was the case for most contaminants in the waterway the lowest PCB levels were measured at the mouth.

Chemicals in Bottom Sediment

The results of conventionals and metals analyses of bottom sediments collected from each of the sediment trap stations on three occasions -- December 1989, January 1991, and November 1994 -- are summarized in Appendix D, Table D6. TOC concentrations in the waterway ranged from 1.4 to 8.8% with a mean of 5.6%. TOC tended to be highest at the head and decreased moving toward the mouth of the waterway. Grain size analysis indicated that sediments collected from the head and near the mouth of Wheeler-Osgood consisted primarily of silt and clay size particles. Sediments from the area north of 15th Street drain and the mouth tended to have a higher percentage of sand size material.

Metals concentrations were somewhat variable in Thea Foss bottom sediments. The highest concentrations of nickel (190 mg/kg) and zinc (520 mg/kg) were present at the head. Lead was at a maximum north of the 15th Street drain. Peak concentrations for cadmium, copper, and mercury were measured near the mouth of Wheeler-Osgood Waterway. The lowest concentrations for all metals were present at the mouth of Thea Foss Waterway.

Compared to SPM, fewer semivolatile organics (Appendix D, Table D7) were detected in bottom sediments. LPAH and HPAH concentrations tended to be highest at the head of the waterway and decreased moving towards the mouth. At all stations, the sum of HPAH exceeded the sum of LPAH. As previously mentioned the apparent enrichment of HPAHs relative to LPAHs would suggest that historical sources of PAHs have played an important role in the pattern of PAH contamination observed in bottom sediments.

Peak concentrations for the majority of phthalate esters were present north of the 15th Street drain. The lowest concentrations for all organics were measured at the mouth of the waterway.

TBT and its breakdown products MBT and DBT were detected throughout Thea Foss Waterway. Butyltin concentrations in bottom sediments (Appendix D, Table D8) were quite variable, ranging from 10 to 410 ug/kg with a mean of 150 ug/kg. In general, bottom sediment TBT concentrations were typically lower than those measured in SPM. Based on means the highest TBT levels were present near the mouth of Wheeler-Osgood Waterway. As was the case for many of the contaminants in the waterway the lowest TBT levels were present at the mouth of Thea Foss Waterway.

Mercury, TBT, and HPAH levels in bottom sediments collected between 1984 and 1994 are compared in Figure 16. At all locations except the mouth, mercury levels in bottom sediments at each of the sediment trap stations were higher than levels reported in 1984 as part of the CBRI (Tetra Tech, 1985). A similar pattern is evident for HPAH levels at the head of the waterway and near the mouth of Wheeler-Osgood Waterway. For TBT, 1994 levels at three of the four stations were the highest measured between 1989 and 1994. These data suggest that mercury, TBT, and HPAH levels in bottom sediments from much of the waterway have not decreased during the period of monitoring. It should be noted that factors such as spatial and analytical variability between surveys may be contributing to the apparent trends in contaminant levels.

Comparison to Commencement Bay SQOs

Chemicals exceeding the SQOs in Thea Foss SPM and bottom sediments are shown in Table 6. A total of 14 compounds in SPM (3 metals and 11 organics) are listed as exceeding the SQOs. The greatest exceedances (11) were present at the head of the waterway near the twin 96" drains. Four chemicals (mercury, HPAH, PCBs, and benzoic acid) were present at concentrations above the SQOs throughout the waterway. Bis(2-ethyl hexyl)phthalate was also measured at problem levels at all monitoring stations except the mouth. PCB levels at all stations except TF-1A were above the SQO for the protection of human health. The fewest number of exceedances (5) were measured in the center of the waterway adjacent to the City Marina.

Comparing TBT levels in Thea Foss SPM to the PSDDA ISL of 30 ug/kg indicates that 100% of the samples (20/20) tested during the monitoring period were above the ISL. Biological testing planned as part of the Thea Foss Pre-Remedial Design Evaluation being conducted by the City of Tacoma should help evaluate the toxicity associated with the observed TBT levels in the waterway.

Thirteen individual chemicals (4 metals and 9 organics) were present above the SQOs in bottom sediments. As was the case for SPM, the greatest number of exceedances (10) were measured at the head of the waterway near the twin 96" drains. The fewest exceedances (3) were present at the mouth of the waterway. Phthalate esters were the predominant group of organic chemicals exceeding the SQOs.

Lower TBT concentrations were present in Thea Foss bottom sediments compared to levels in SPM. However, the majority of bottom sediments still contained TBT levels above the PSDDA ISL.

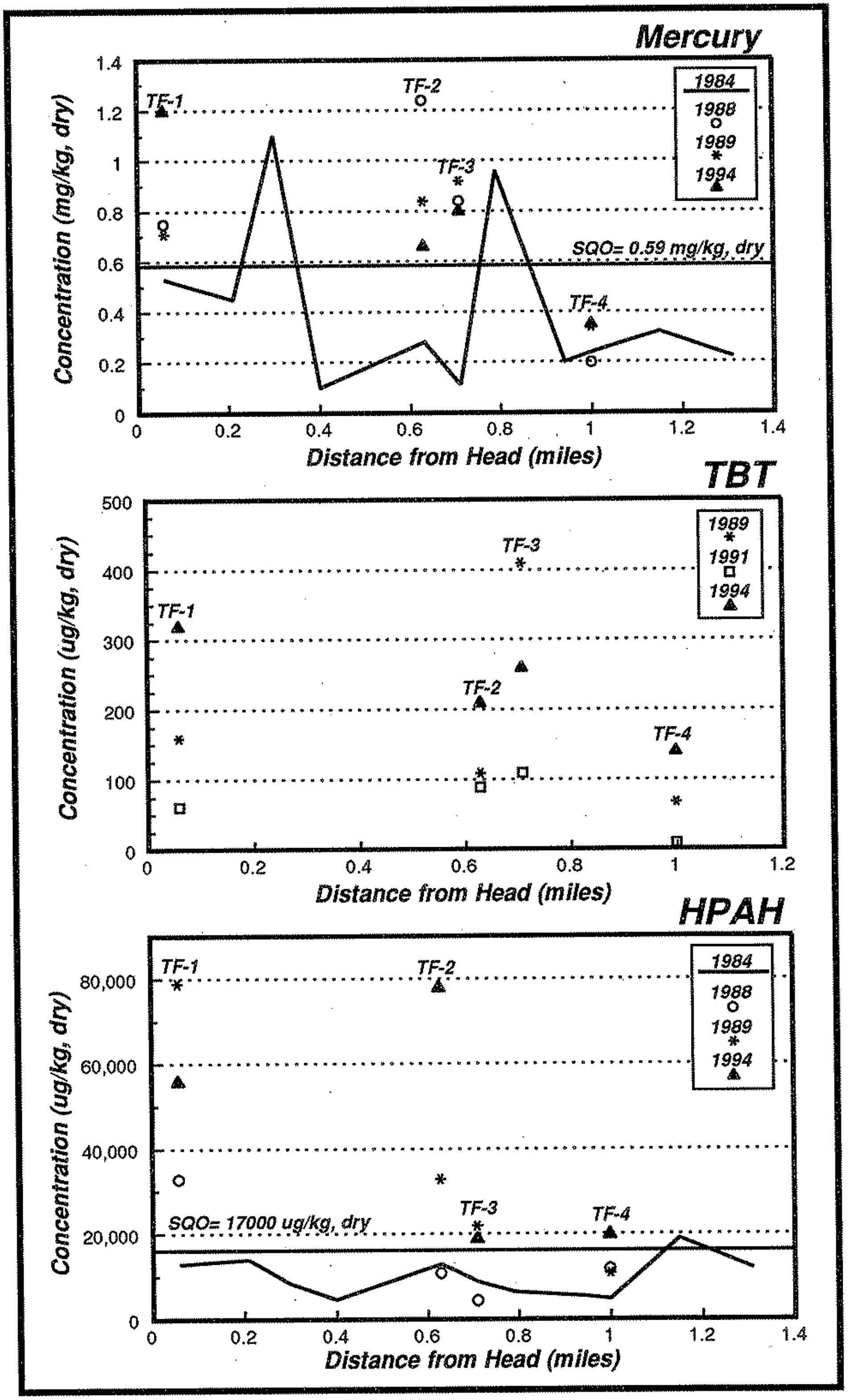


Figure 16: Comparison of Mercury, TBT, and HPAH levels in Thea Foss Waterway Bottom Sediments from Multiple Years.

Table 6: Summary of metals and organic compounds exceeding the Commencement Bay sediment quality objectives (SQO) in settling particulate matter and bottom sediments from Thea Foss Waterway, November 1992 to June 1995.

Station	TF-1	TF-1A	TF-2	TF-3	TF-4
Location	Head near Twin 96" Drains	Mid-Channel near City Marina	North of 15th Street Drain	Near Mouth of Wheeler-Osgood	Mouth
Metals					
Lead	bs		bs		
Mercury	70*$_{10}$	100 $_{4}$	100 $_{8}$	100*$_{9}$	10 $_{10}$
Nickel	bs	50 $_{2}$		bs	
Zinc	60*$_{10}$			11 $_{9}$	
Organics					
LPAH	100*$_{5}$		bs	20 $_{5}$	bs
HPAH	100*$_{5}$	100 $_{2}$	100*$_{5}$	40*$_{5}$	20*$_{5}$
2-Methyl napthalene	20 $_{5}$				
1,4-Dichlorobenzene			bs		
Benzoic acid	100 $_{3}$	100 $_{1}$	67 $_{3}$	75 $_{4}$	100 $_{3}$
Benzyl alcohol	bs		100*$_{1}$	100 $_{1}$	
Diethyl phthalate			bs		
Dimethyl phthalate	bs		40 $_{5}$		
Di-n-butyl phthalate	25 $_{4}$		20*$_{5}$		20 $_{5}$
Di-n-octyl phthalate	25 $_{4}$				
Butyl benzyl phthalate	100*$_{4}$		bs		20 $_{4}$
Bis(2-ethyl hexyl)phthalate	100 $_{2}$	100 $_{2}$	100*$_{4}$	50*$_{2}$	bs
PCBs+	100 $_{1}$		100 $_{1}$	100 $_{2}$	100 $_{1}$

Values shown are percent of total SPM samples collected that exceeded the sediment quality objectives

Subscript= Number of samples

*=SQO also exceeded in bottom sediment

bs= Chemical only exceeded SQO in bottom sediments

+= SQO for PCBs based on protection of human health

Gross Sedimentation Rates

Gross sedimentation rates for Thea Foss Waterway are listed in Appendix C, Table C12. Compared to rates measured in the other waterways, mass accumulation rates for Thea Foss Waterway, shown in Figure 17, were fairly low and consistent, ranging from 0.5-4.4 g/cm^2/yr, with a mean of 1.5±0.9 g/cm^2/yr. Significantly higher accumulation rates (ANOVA, $P<0.01$) were measured approximately 0.4 miles from the head (TF-1A). Sedimentation rates at the remaining stations were not significantly different.

During the March to June 1995 collection period a three-fold increase in sedimentation was noted at the head of the waterway. The observed increase in this area is probably related to higher bottom sediment resuspension rates caused from bridge construction activities. In March 1995 pile driving was started for the new SR-509 bridge which crosses Thea Foss Waterway at the head (Coleman, 1995). Increased bottom sediment resuspension resulting from this type of in-water construction activity has the potential to redistribute contaminants in the waterway. Redistribution of contaminants is a real concern in a heavily contaminated area like the head of Thea Foss Waterway.

In general, the data collected indicate that sedimentation in most of the waterway tends to be highest during the summer and lowest during winter months. Factors such as seasonal variations in plankton populations, increases in vessel traffic during the summer months which could resuspend bottom material, and variations in runoff from the Puyallup River could all be contributing to the seasonal patterns observed. Seasonal analysis of ^{210}Pb levels in SPM and adjacent bottom sediments could help identify the relative importance of the various factors contributing to resuspension of bottom sediments. This work would involve analyzing ^{210}Pb levels in SPM on a quarterly basis. ^{210}Pb activities in SPM could then be compared to levels in adjacent bottom sediments (top 2cm). Predicted accumulation rates on the bottom during the monitoring period ranged from 0.5-8.7 cm/yr with a mean of 2.5±1.8 cm/yr.

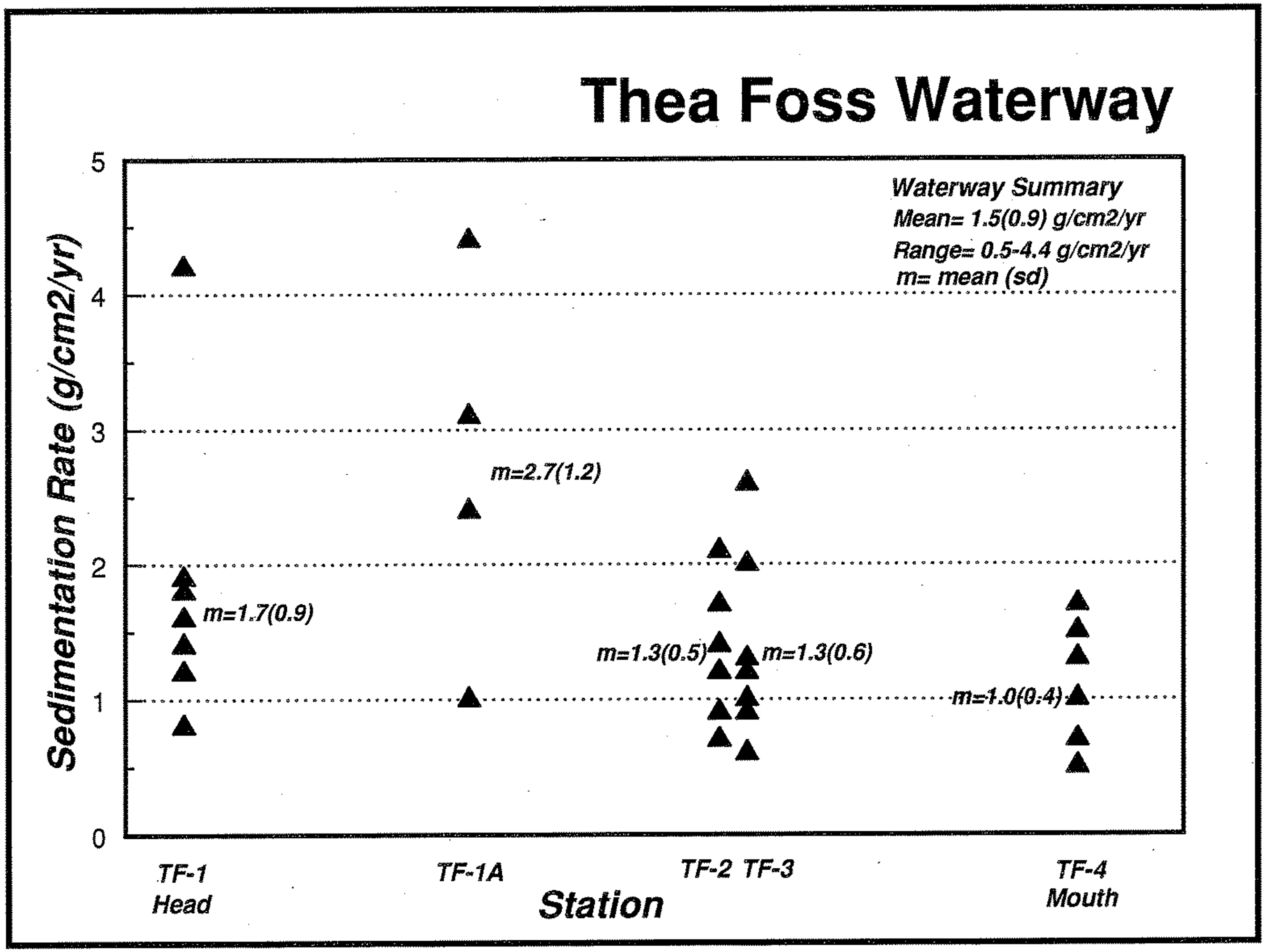


Figure 17: Gross sedimentation rates for Thea Foss Waterway, November 1992 to June 1995.

Discussion

Contaminant Trends Over Time

Simple linear regression was used to determine whether changes in contaminant levels associated with SPM have occurred over time. All SPM data collected during the monitoring program were used in this evaluation to provide the longest time-series record possible for each waterway. An exception was metals data collected after May 1994 for all parameters except mercury which was not used in the analysis of temporal trends. The reason for this omission is that metals data collected after 1994 were generated using different analytical methods then were employed prior to May 1994 (see sample analysis and quality assurance section).

In comparison to metals (c.v.= 23-57%), organics concentrations in SPM tended to have a higher degree of temporal variability (c.v.= 33-400%) in SPM. This fact, combined with differences in quantitation limits between monitoring periods, hinders a detailed statistical analysis of trends for organics. Consequently, most of the statistically significant trends noted were for metals.

In most instances little change was evident in contaminant levels associated with SPM in Hylebos and Thea Foss Waterways during the monitoring period. Several exceptions to this general statement are discussed below.

Arsenic in Hylebos Waterway SPM between July 1990 and May 1994 is shown in Figure 18. A significant reduction (r^2= 0.45, P<0.01) in arsenic levels was noted at the mouth of the waterway. The reason for the apparent reduction in arsenic at this location is not clear.

In contrast to Hylebos and Thea Foss Waterways, substantial reductions for most metals and organics levels were seen in Sitcum Waterway SPM. Arsenic, lead, and zinc concentrations in Sitcum Waterway SPM are shown in Figure 19. Significant decreases in lead and zinc levels were noted between July 1990 and December 1993 at the following locations:

Lead	Head at north corner (r^2= 0.83, P<0.001)
	Terminal 7 at Berth B (r^2= 0.49, P<0.02)
Zinc	Head at north corner drain (r^2= 0.53, P<0.005)

This finding is consistent with the fact that, as of July 1991, off-loading and handling of black ore (lead and zinc) ceased at Terminal 7 (Norton and Barnard, 1992).

In contrast to lead and zinc, a significant increase (r^2=0.83, P<0.001) in arsenic levels was measured near the north corner drain between July 1990 and December 1993. The north corner drain (SI-172) has been documented as a major source of contaminants in past studies

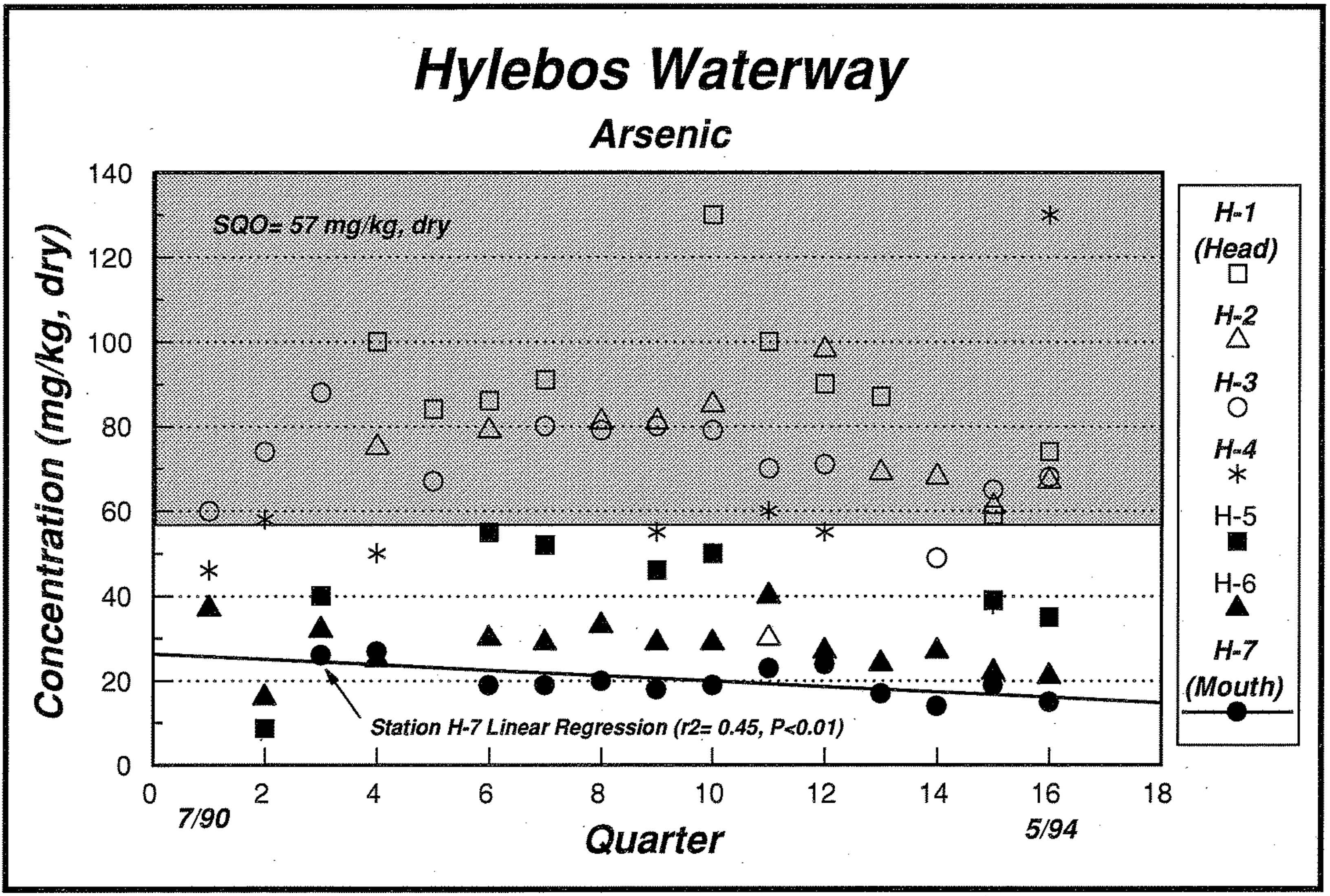


Figure 18: Arsenic Trends in Hylebos Waterway Settling Particulate Matter, July 1990 and May 1994.

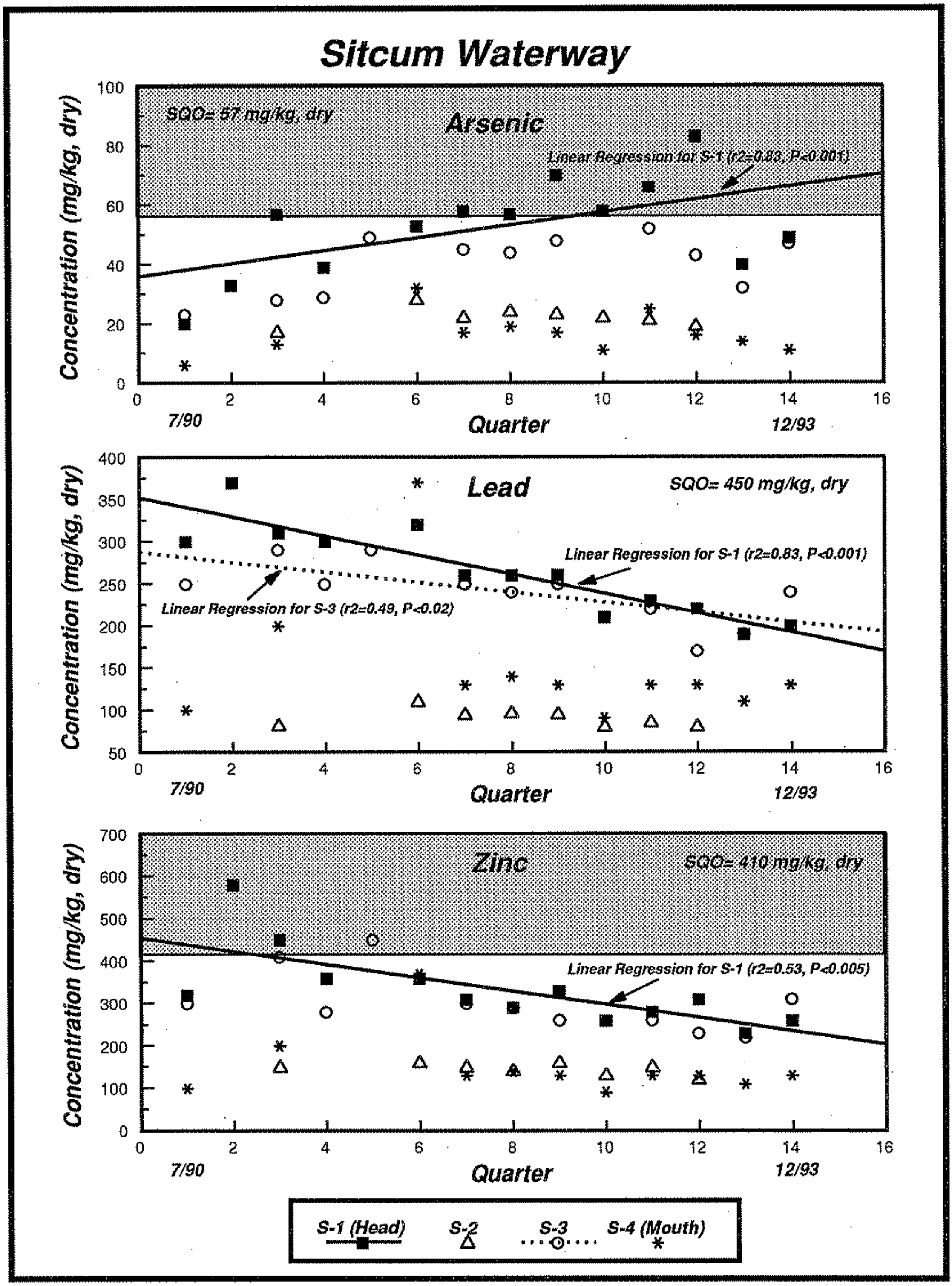


Figure 19: Arsenic, Lead and Zinc Trends in Sitcum Waterway Settling Particulate Matter, July 1990 to December 1993.

(EPA, 1992). Recent work conducted by the City of Tacoma in the summer of 1995 to clean this drain may have already reduced arsenic loadings to the waterway (Mercuri, 1995). The results of this work would not have been evident in the monitoring data shown in Figure 18. Ongoing monitoring in the waterway should prove to be useful in evaluating arsenic trends in this portion of the waterway.

The statement that substantial reductions have occurred for most organic compounds in Sitcum Waterway is primarily based on the fact that, prior to dredging, concentrations of seven individual compounds exceeded the SQOs in SPM. After completion of dredging in the waterway **no** chemicals were detected above the SQOs in SPM.

Monitoring data collected in Thea Foss Waterway between November 1988 and November 1992 indicated a significant increase in mercury levels was occurring at the head of the waterway and north of the 15th Street drain (Norton, 1993). The lack of a significant regression at these locations when the most recent data set is included might suggest that mercury concentrations are stabilizing in these areas of the waterway.

Comparison of Problem Chemicals in SPM Between Waterways

A comparison of selected metals and organics concentrations between November 1988 and June 1995 in Hylebos, Sitcum and Thea Foss SPM is presented in Table 7. Based on means, the highest concentrations of TOC, mercury, lead, zinc, LPAH, and HPAH were present in Thea Foss Waterway. Mean arsenic levels in Hylebos Waterway were approximately twice as high as those measured in Thea Foss Waterway. In addition, mean PCB levels in Hylebos were approximate five times higher than levels in Thea Foss Waterway. The highest bis(2-ethyl hexyl)phthalate concentrations were typically present in Sitcum Waterway. Similar concentrations of copper were measured in all three waterways. TBT concentrations in Hylebos and Thea Foss Waterways are also similar.

Comparison of Gross and Net Sedimentation Rates

Sedimentation rate data for Hylebos, Sitcum, and Thea Foss Waterways are summarized in Table 8. Two types of rates are listed. The first is gross sedimentation (net + resuspension) which was determined from sediment trap data collected between September 1991 and June 1995. Also shown are net accumulation rates which have been estimated from several ^{210}Pb dated cores collected during the remedial investigation in 1984 (EPA, 1992), and a subsequent study in Sitcum Waterway (Hart Crowser, 1992).

Gross accumulation rates reported for the three waterways agreed within a factor of 2. The highest mean rates were measured in Sitcum Waterway (4.8±1.8 g/cm^2/yr), followed by Hylebos (2.4±1.0 g/cm^2/yr), and then Thea Foss Waterway (1.5±0.9 g/cm^2/yr).

Table 7: Comparison of Selected Metals* and Organics Associated with Settling Particulate Matter from Hylebos, Sitcum, and Thea Foss Waterways, November 1988 to June 1995.

Location	Hylebos	Sitcum	Thea Foss
Collection Period	7/90–6/95	7/90–6/95	11/88–6/95
Number of Samples	7–97	26–47	5–92
Total Organic Carbon (%)	3.9 (1.7–8.5)	2.0 (1.2–3.7)	6.1 (1.9–12)
Metals* (mg/kg, dry)			
Arsenic	53 (8.7–130)	34 (6–83)	22 (21–30)
Copper	140 (71–410)	120 (64–190)	190 (120–340)
Lead	9386 (41–250)	180 (44–370)	260 (120–460)
Mercury	0.38 (0.16–0.93)	–	0.65 (0.35–1.5)
Zinc	210 (110–520)	240 (91–580)	320 (160–570)
Organics (ug/kg, dry)			
LPAH	3400j (190j–75000j)	2200j (77–8600j)	6000j (250j–32000j)
HPAH	10000j (4100j–49000j)	5800j (160–21000j)	26000j (980j–120000j)
Bis(2EH)phthalate	5100j (730–44000)	41000j (110u–170000)	18000j (590–96000)
Total PCBs	2400j (130–73000)	–	500 (280–610)
Tributyltin	460 (210j–660)	–	360 (11–790)

Mean of detected values (range of all values)

u= Not detected at detection limit shown

j= Estimated concentration

–= No data

*= Metals data collected after May 1994 was not included due to different method of analysis

Table 8: Comparison of Sediment Accumulation Rates for Commencement Bay Waterways Obtained from Sediment Trap and Bottom Core Data.

	Collection		No.	Sedimentation Rate(1)	
Location	Period	Method	Samples	(g/cm2/yr)	(cm/yr)
GROSS SEDIMENTATION					
HYLEBOS WATERWAY					
Head	12/91-6/95	Sediment Trap	20	1.6±0.5	2.7±0.9
Mouth	"	"	23	3.1±1.2	3.0±1.2
Overall	"	"	145	2.4±1.0	3.4±1.3
SITCUM WATERWAY					
Head	9/91-6/95	Sediment Trap	19	4.5±1.2	5.0±1.3
Mouth	"	"	19	4.1±1.6	4.6±1.9
Overall	"	"	70	4.8±1.8	5.1±2.1
THEA FOSS WATERWAY					
Head	11/92-6/95	Sediment Trap	20	1.7±0.9	3.4±1.7
Mouth	"	"	19	1.0±0.4	0.9±0.4
Overall	"	"	81	1.5±0.9	2.5±2.0
NET SEDIMENTATION(2)					
HYLEBOS WATERWAY					
Head	5/84	Pb-210 cores (3)	-	0.33	0.77
Mouth	"	"	-	1.1	1.8
SITCUM WATERWAY					
Head	1991	Pb-210 cores (4)	-	0.6±0.3	0.6±0.3
THEA FOSS WATERWAY					
Head	5/84	Pb-210 cores (3)	-	0.3	0.45
Mouth	"	"	-	0.45	0.67

(1)=Mean±sd
(2)= EPA, 1992
(3)=Estimated values
(4)= Hart Crowser, 1992
-=No information

Net accumulation rates for the three waterways ranged from 0.3 to 1.1 g/cm^2/yr. The uncertainty associated with these measurements was not reported.

Resuspension

Comparison of sedimentation rates from sediment traps (gross sedimentation) and rates from ^{210}Pb dated cores (net sedimentation) have been used in other investigations to estimate bottom sediment resuspension rates (Baker et.al., 1991). Gross and net sedimentation rates for Hylebos, Sitcum, and Thea Foss Waterways are compared in Table 9 below.

Table 9: Summary of Estimated Resuspension Rates for Hylebos, Sitcum, and Thea Foss Waterways Based on Sediment Trap and Bottom Core Data (g/cm^2/yr).

Location	Gross	Net[1,2]	Resuspension	Percent
Hylebos				
Head	1.6±0.5	0.33	1.3±0.5	81%
Mouth	3.0±1.2	1.1	1.9±1.2	63%
Sitcum				
Head	4.5±1.2	0.6±0.3	3.9±1.2	71%
Mouth	4.1±1.6	0.6±0.3	3.5±1.6	85%
Thea Foss				
Head	1.7±0.9	0.3	1.4±0.9	82%
Mouth	1.0±0.4	0.45	0.6±0.4	60%

Values shown are Mean"S.D.
Resuspension= (gross sedimentation - net sedimentation)
Percent= (resuspension/gross sedimentation) * 100
[1]= EPA, 1992
[2]= Net rates for Sitcum reported in Hart Crowser, 1992

Resuspension estimates for the three waterways ranged from 60% at the mouth of Thea Foss Waterway to 85% at the mouth of Sitcum Waterway. The highest resuspension rates were estimated for Sitcum Waterway, followed by Hylebos, and Thea Foss Waterways. The reason that the highest resuspension rates were observed in Sitcum Waterway is probably related to the fact that Sitcum receives the heaviest amount of large ship traffic of the three waterways monitored. While the exact proportion of "new" versus "old" material collected by the traps cannot be reliably determined with the available data, it is fair to assume that the trapped material is representative of sediments which are mobile in the waterways.

Resuspension estimates for Hylebos, Sitcum, and Thea Foss Waterways fall within the range of values (0.4-3.6 g/cm^2/yr) reported by Patmont and Crecelius (1991) for other urban embayments in Puget Sound. In addition, the resuspension estimates for Sitcum Waterway, 71-85%, are similar to values reported along the central Seattle Waterfront (74-92%) in areas that receive a large amount of vessel traffic.

Conclusions

In general, the spatial distribution of contaminants measured in SPM in Hylebos, Sitcum, and Thea Foss Waterways was in relatively good agreement with previous monitoring results collected between November 1988 and November 1992. In all three waterways metals concentrations were typically higher at the head of the waterways and decreased moving toward the mouth. A similar pattern was also present for most of the organic compounds; however, concentrations tended to be more variable.

In Hylebos Waterway, lead, tetrachloroethene, hexachlorobenzene, hexachlorobutadiene, and 1,2,4-trichlorobenzene were elevated in the outer portion of the waterway adjacent to Occidental Chemical. Occidental Chemical was identified as a source of hexachlorobenzene and hexachlorobutadiene during the Commencement Bay Nearshore/Tideflats Remedial Investigation (Tetra Tech, 1985). In addition, between 1947 and 1973 tetrachloroethene was produced in commercial quantities at Occidental's solvent plant (Tetra Tech, 1986b). Tributyltin (TBT) which has been used extensively in the past as an active ingredient in antifouling paints was present at relatively high levels throughout Hylebos.

Mercury and copper concentrations in Thea Foss Waterway tended to peak in the central portion of the waterway near the mouth of Wheeler-Osgood Waterway (copper) and north of the 15th Street drain (mercury). J.M. Martinac Shipbuilding located near the mouth of Wheeler-Osgood Waterway has been identified as a copper source in past studies (Norton and Johnson, 1984; Norton, 1995). The 15th Street drain, shoreline banks adjoining the Investco Site, and the inactive Surplus Steam Plant #1 have been identified as potential sources of mercury in this area of the waterway (Smith, 1995). As was the case for Hylebos Waterway, TBT was elevated throughout Foss Waterway.

Overall, the SPM data collected from Hylebos and Thea Foss Waterway suggest that concentrations of most problem chemicals have not decreased since sediment trap monitoring was started in July 1990 and November 1988, respectively. In both Hylebos and Thea Foss Waterways, 14 separate chemicals were above the Commencement Bay "Sediment Quality Objectives" (SQOs) in SPM. The greatest number of individual exceedances were present at the head of both waterways.

In contrast, dramatic reductions in contaminant levels have been observed in Sitcum Waterway comparing pre- and post-dredging conditions. Prior to dredging in Sitcum Waterway, seven individual chemicals exceeded the SQOs in SPM. After the completion of dredging **no** exceedances of the SQOs were observed for contaminant levels in SPM. In all waterways monitored, fewer chemicals exceeded the SQOs in bottom sediments compared to SPM.

The highest gross sedimentation rates (net + resuspension) were measured in Sitcum Waterway (4.8 ± 1.8 g/cm^2/yr) followed by Hylebos (2.4 ± 1.0 g/cm^2/yr), and Thea Foss (1.5 ± 0.9 g/cm^2/yr) Waterways. Bottom sediment resuspension estimates ranged from 60% at the mouth of Thea Foss Waterway to 85% at the mouth of Sitcum Waterway. The highest resuspension rates were estimated for Sitcum, followed by Hylebos and Thea Foss Waterway. While the exact proportion of "new" versus "old" material collected by the traps cannot be reliably determined with the available data, it is fair to assume that the trapped material is representative of sediments which are mobile in the waterways.

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Appendices

Appendix A

Station Location and Deployment Information

Table A1: Station Descriptions
Table A2: Sediment Trap Deployment Schedule

Table A1: Station descriptions for Commencement Bay Sediment Trap Monitoring Program.

Station No.	Position (deg/min/sec)		Water Depth (ft @ MLLW)	Station Description
	Latitude	Longitude		
HYLEBOS WATERWAY				
H-1	47 15 44	122 21 31	25	North east corner of Upper Turning Basin
H-2	47 16 8	122 22 11	32	North end of General Metals
H-3	47 16 11	122 22 26	24	@ Elf Atochem
H-4	47 16 26	122 22 43	22	Near Lincoln Street Drain
H-5	47 16 35	122 23 11	25	Near Cenex Plant
H-6	47 16 45	122 24 2	30	@ Occidental Chemical
H-7	47 16 59	122 24 22	31	@ Mouth
SITCUM WATERWAY				
S-1	47 15 59	122 24 39	31	Head at North Corner Drain
S-2	47 16 11	122 25 4	42	North end of Sealand Terminal
S-3	47 16 7	122 24 50	54	Terminal 7 @ Berth B
S-4	47 16 20	122 25 8	45	Mouth @ Terminal 7
THEA FOSS WATERWAY				
TF-1	47 14 35	122 25 52	18	Head near Twin 96" Drains
TF-1A	47 14 50	122 25 52	36	Mid-Channel adjacent to City Marina
TF-2	47 15 5	122 25 58	20	North of 15th Street Drain
TF-3	47 15 7	122 25 50	30	@ Mouth of Wheeler-Osgood Waterway
TF-4	47 15 26	122 25 59	25	@ Mouth near D-Street Tank Farms

Table A2: Deployment Schedule for Commencement Bay Sediment Traps, June 1991 to June 1995.

Station	Deployed	Retrieved	# Days	Deployed	Retrieved	# Days	Deployed	Retrieved	# Days	Deployed	Retrieved	# Days
Hylebos Waterway												
H-1	6/20/91	9/17/91	89	9/26/91	11/21/91	56	11/21/91	2/20/92	91	2/20/92	NR	–
H-2	6/18/91	NR	–	9/26/91	11/21/91	56	11/21/91	NR	–	2/20/92	5/14/92	84
H-3	6/20/91	9/17/91	89	9/17/91	NR	–	11/21/91	2/20/92	91	2/20/92	5/12/92	82
H-4	6/18/91	NR	–	9/26/91	NR	–	11/21/91	NR	–	2/20/92	NR	–
H-5	6/20/91	NR	–	9/26/91	11/21/91	56	11/21/91	2/19/92	90	2/19/92	NR	–
H-6	6/18/91	NR	–	9/17/91	11/20/91	64	11/20/91	2/18/92	90	2/18/92	5/12/92	84
H-7	6/18/91	NR	–	9/26/91	11/20/91	55	11/20/91	2/18/92	90	2/18/92	5/12/92	84
Sitcum Waterway												
S-1	6/19/91	NR	–	9/18/91	11/20/91	63	11/20/91	2/18/92	90	2/18/92	5/11/92	83
S-2	6/20/91	NR	–	9/16/91	11/18/91	63	11/18/91	2/18/92	92	2/18/92	5/11/92	83
S-3	6/18/91	9/18/91	92	9/18/91	NR	–	11/20/91	2/18/92	90	2/18/92	5/11/92	83
S-4	6/20/91	NR	–	9/16/91	11/18/91	63	11/18/91	2/18/92	92	2/18/92	5/11/92	83
Thea Foss Waterway												
TF-1	6/17/91	NR	–	9/18/91	11/18/91	61	11/18/91	2/19/92	93	2/19/92	5/12/92	83
TF-1A	ND	–	–	ND	–	–	ND	–	–	ND	–	–
TF-2	6/17/91	9/16/91	91	9/17/91	11/18/91	62	11/18/91	2/19/92	93	2/19/92	5/12/92	83
TF-3	6/17/91	9/16/91	91	9/16/91	11/18/91	63	11/18/91	2/19/92	93	2/19/92	5/12/92	83
TF-4	6/17/91	9/16/91	91	9/17/91	11/18/91	62	11/18/91	2/19/92	93	2/19/92	5/12/92	83

Station	Deployed	Retrieved	# Days	Deployed	Retrieved	# Days	Deployed	Retrieved	# Days	Deployed	Retrieved	# Days
Hylebos Waterway												
H-1	5/14/92	NR	–	8/12/92	11/18/92	98	11/18/92	2/23/93	97	2/23/93	5/18/93	84
H-2	5/14/92	8/12/92	90	8/12/92	11/18/92	98	11/18/92	2/23/93	97	2/23/93	5/18/93	84
H-3	5/12/92	8/12/92	92	8/12/92	11/18/92	98	11/18/92	2/23/93	97	2/23/93	5/18/93	84
H-4	5/14/92	8/11/92	89	8/11/92	11/18/92	99	11/18/92	2/22/93	96	2/22/93	5/18/93	85
H-5	5/14/92	8/11/92	89	8/11/92	11/18/92	99	11/18/92	NR	–	2/22/93	NR	–
H-6	5/12/92	8/11/92	91	8/11/92	11/18/92	99	11/18/92	2/22/93	96	2/22/93	5/18/93	85
H-7	5/12/92	8/11/92	91	8/11/92	11/17/92	98	11/17/92	2/22/93	97	2/22/93	5/18/93	85
Sitcum Waterway												
S-1	5/11/92	8/10/92	91	8/10/92	11/16/92	98	11/16/92	2/22/93	98	2/22/93	5/17/93	84
S-2	5/11/92	8/10/92	91	8/10/92	11/16/92	98	11/16/92	2/22/93	98	2/22/93	5/17/93	84
S-3	5/11/92	8/10/92	91	8/10/92	NR	–	11/17/92	2/22/93	97	2/22/93	5/17/93	84
S-4	5/11/92	8/10/92	91	8/10/92	11/16/92	98	11/16/92	2/22/93	98	2/22/93	5/17/93	84
Thea Foss Waterway												
TF-1	5/12/92	8/11/92	91	8/11/92	11/17/92	98	11/17/92	2/24/93	99	2/24/93	5/17/93	82
TF-1A	ND	–	–	ND	–	–	ND	–	–	ND	–	–
TF-2	5/12/92	8/10/92	90	8/10/92	11/17/92	99	11/17/92	2/24/93	99	2/24/93	5/17/93	82
TF-3	5/12/92	NR	–	8/11/92	11/17/92	98	11/17/92	2/24/93	99	2/24/93	5/17/93	82
TF-4	5/12/92	8/10/92	90	8/10/92	11/17/92	99	11/17/92	2/24/93	99	2/24/93	5/17/93	82

NR= Not recovered

ND= Not deployed

Table A2(cont): Deployment Schedule for Commencement Bay Sediment Traps, June 1991 to June 1995.

Station	Deployed	Retrieved	# Days	Deployed	Retrieved	# Days	Deployed	Retrieved	# Days	Deployed	Retrieved	# Days
Hylebos Waterway												
H-1	7/20/93	9/28/93	70	9/28/93	NR	–	12/7/93	3/28/94	111	3/28/94	5/24/94	57
H-2	7/20/93	9/28/93	70	9/28/93	12/7/93	70	12/7/93	3/28/94	111	3/28/94	5/24/94	57
H-3	7/20/93	NR	–	9/28/93	12/7/93	70	12/7/93	3/28/94	111	3/28/94	5/24/94	57
H-4	ND	–	–	ND	–	–	12/7/93	3/28/94	111	3/28/94	5/24/94	57
H-5	ND	–	–	ND	–	–	12/7/93	3/28/94	111	3/28/94	5/24/94	57
H-6	7/20/93	9/28/93	70	9/28/93	12/7/93	70	12/7/93	3/28/94	111	3/28/94	5/24/94	57
H-7	7/20/93	9/28/93	70	9/28/93	12/7/93	70	12/7/93	3/28/94	111	3/28/94	5/23/94	56
Sitcum Waterway												
S-1	7/19/93	9/27/93	70	9/27/93	11/9/93	43	ND	–	–	ND	–	–
S-2	ND	–	–	ND	–	–	ND	–	–	ND	–	–
S-3	7/19/93	10/01/93	74	10/01/93	11/9/93	39	ND	–	–	ND	–	–
S-4	7/19/93	9/27/93	70	9/27/93	11/9/93	43	ND	–	–	ND	–	–
Thea Foss Waterway												
TF-1	7/19/93	9/27/93	70	9/27/93	12/13/93	77	12/13/93	3/29/94	106	3/29/94	5/23/94	55
TF-1A	ND	–	–	ND	–	–	12/13/93	3/29/94	106	3/29/94	5/23/94	55
TF-2	7/19/93	9/27/93	70	9/27/93	12/13/93	77	12/13/93	3/29/94	106	3/29/94	5/23/94	55
TF-3	7/19/93	9/27/93	70	9/27/93	12/13/93	77	12/13/93	3/29/94	106	3/29/94	5/23/94	55
TF-4	7/20/93	9/27/93	69	9/27/93	12/13/93	77	12/13/93	3/29/94	106	3/29/94	5/23/94	55

Station	Deployed	Retrieved	# Days	Deployed	Retrieved	# Days	Deployed	Retrieved	# Days	Deployed	Retrieved	# Days
Hylebos Waterway												
H-1	5/24/94	8/22/94	90	8/22/94	11/30/94	100	11/30/94	3/7/95	97	3/7/95	6/13/95	98
H-2	5/24/94	8/22/94	90	8/22/94	11/30/94	100	11/30/94	3/7/95	97	3/7/95	6/13/95	98
H-3	5/24/94	8/22/94	90	8/22/94	11/30/94	100	11/30/94	3/7/95	97	3/7/95	6/13/95	98
H-4	5/24/94	8/22/94	90	8/22/94	11/30/94	100	ND	–	–	ND	–	–
H-5	5/24/94	8/23/94	91	8/23/94	11/30/94	99	ND	–	–	ND	–	–
H-6	5/24/94	8/23/94	91	8/23/94	11/29/94	98	11/29/94	NR	–	3/7/95	NR	–
H-7	5/24/94	8/24/94	92	8/24/94	11/29/94	97	11/29/94	3/7/95	98	3/7/95	NR	–
Sitcum Waterway												
S-1	ND	–	–	ND	–	–	11/30/94	3/6/95	96	3/6/95	6/12/95	98
S-2	ND	–	–	ND	–	–	ND	–	–	ND	–	–
S-3	ND	–	–	ND	–	–	11/30/94	3/6/95	96	3/6/95	NR	–
S-4	ND	–	–	ND	–	–	11/30/94	NR	–	3/6/95	6/12/95	98
Thea Foss Waterway												
TF-1	5/23/94	8/23/94	92	8/23/94	11/29/94	98	11/29/94	3/6/95	97	3/6/95	6/12/95	98
TF-1A	5/23/94	8/23/94	92	8/23/94	11/29/94	98	ND	ND	–	ND		–
TF-2	5/23/94	NR	–	8/23/94	11/29/94	98	11/29/94	3/6/95	97	3/6/95	NR	–
TF-3	5/23/94	8/23/94	92	8/23/94	NR	–	11/29/94	3/6/95	97	3/6/95	6/12/95	98
TF-4	5/23/94	8/23/94	92	8/23/94	11/29/94	98	11/29/94	3/6/95	97	3/6/95	6/12/95	98

NR= Not recovered

ND=Not Deployed

Appendix B

Quality Assurance Information

Table B1: Summary of Quality Assurance Samples
Case Narratives for Data Packages

Table B1: Summary of Quality Assurance Samples and Frequency of Analysis for th
Commencement Bay Sediment Trap Monitoring Program.

Analyte	Internal Standards	Surrogate Spikes	Method Blank	Matrix Spike*	Reference Materials*	Field Duplicate*
Percent Solids	–	–	–	–	–	1/Batch
Grain Size	–	–	–	–	–	1/Batch
TOC	–	–	1/Batch	–	–	1/Batch
Metals						
Antimony	–	–	1/Batch	–	1/Batch	1/Batch
Arsenic	–	–	1/Batch	–	1/Batch	1/Batch
Cadmium	–	–	1/Batch	–	1/Batch	1/Batch
Copper	–	–	1/Batch	–	1/Batch	1/Batch
Lead	–	–	1/Batch	–	1/Batch	1/Batch
Mercury	–	–	1/Batch	–	1/Batch	1/Batch
Nickel	–	–	1/Batch	–	1/Batch	1/Batch
Zinc	–	–	1/Batch	–	1/Batch	1/Batch
Organics						
Volatiles	1/sample	1/sample	1/Batch	1/Batch	–	1/Batch
Semivolatiles	1/sample	1/sample	1/Batch	1/Batch	(1/Batch)	1/Batch
PCBs	1/sample	1/sample	1/Batch	1/Batch	1/Batch	1/Batch
Butyltins	1/sample	1/sample	1/Batch	1/Batch	–	1/Batch

*= Samples analyzed in duplicate

( )= PAH only

Certified Reference Materials

Metals– NIST #1646 (Estuarine Sediment)
PAH– NRCC #HS–6 (Harbour Marine)
PCBs– NRCC #HS–2 (Harbour Marine)

Case Narratives

Conventionals Analysis

June 1991 to June 1995

6/91 - 12/91

WASHINGTON STATE DEPARTMENT OF ECOLOGY
ENVIRONMENTAL INVESTIGATIONS AND LABORATORY SERVICES
MANCHESTER ENVIRONMENTAL LABORATORY

January 21, 1991

TO: Dale Norton

FROM: Craig Smith

SUBJECT: Sediment Traps - Commencement Bay amended report

SAMPLE RECEIPT
The samples were received by the Manchester Laboratory on 12/19/91, in good condition.

HOLDING TIMES:
All analyses were performed within the suggested holding time for TOC and % Solids(6 months-frozen).

INSTRUMENT CALIBRATION:
Instrument calibration was performed before the run, and checked by initial calibration verification standards and blanks. Continuing calibration standards were analyzed at the frequency of 10% during the run. All initial and continuing verification standards were within the control limits of +/-10%.

PROCEDURAL BLANKS:
The blank values were within the acceptable range and showed no analytically significant levels.

PRECISION DATA
The results of the duplicate samples were used to evaluate analytical precision related to the sample set. The RPD's were within a 5% window of acceptance for duplicate analysis, except sample 518509, 518543, and 518568. Triplicate analysis were run on these samples.

STANDARD REFERENCE MATERIAL:
The analysis of the external verification standards gave no unusual results, and were within the acceptable established criteria.

SUMMARY
The data generated by the analysis of the samples above may be used noting any stated qualifications.

For TOC analysis, the samples were dried to constant weight at 71 degrees C.

If you have any questions concerning the results, please feel free to call me at SCAN 744-4737.

12/91 - 5/92

WASHINGTON STATE DEPARTMENT OF ECOLOGY
ENVIRONMENTAL INVESTIGATIONS AND LABORATORY SERVICES
MANCHESTER LABORATORY

August 20, 1992

TO: Project Officer

FROM: David A. Thomson DAT

SUBJECT: Commencement Bay Sediment TOC Results

SAMPLE RECEIPT:

The samples from Commencement Bay were received by the Manchester Laboratory on 6/25/92 in good condition.

The Total Organic Oxygen analyses were performed by Analytical Resources Incorporated using Puget Sound Estuary Protocol (PSEP) for TOC.

PROCEDURAL BLANKS:

All blanks are within the method guideline.

PRECISION DATA:

The % RSD for all the replicate analyses were all less than 5%.

STANDARD REFERENCE MATERIAL:

Standard reference material (KHP) and external verification standards were all within 10% of the stated value.

SUMMARY:

The data generated by the analysis of the Commencement Bay samples can be used without qualification.

If you have any questions about the results or the methods used to obtain these results please call me at (206) 871-8823.

5/92 - 11/92

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (206) 895-4737 • SCAN 744-4737

February 9, 1993

TO: Project Officer

FROM: David A Thomson

SUBJECT: Quality Assurance memo for the Commencement Bay Sediment Traps TOC Results

SAMPLE RECEIPT

The samples from the Commencement Bay Sediment Traps were received by the Manchester Laboratory on December 9, 1992 in good condition. The analyses for these samples were subsequently contracted to Laucks Testing Laboratories. The samples were run using the Puget Sound Estuary Program (PSEP1986) for TOC.

HOLDING TIMES

All analyses were performed within 30 days of sample collection.

PROCEDURAL BLANKS

The procedural blanks associated with these samples showed no analytically significant levels of analytes.

PRECISION DATA

Five samples were run in duplicate to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes was within the +/- 10% window for duplicate analysis.

LABORATORY CONTROL SAMPLE (LCS) ANALYSES

LCS analyses were within the windows established for TOC.

SUMMARY

The data generated by the analysis of these samples can be used without qualifications.

Please call David A Thomson at SCAN 744-4737 to further discuss this project.

1889

11/92 - 5/93

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (206) 871-8860 • SCAN 871-8860

July 7, 1993

TO: Project Officer

FROM: David A Thomson

SUBJECT: Quality Assurance memo for the Commencement Bay ~~Bremerton/Bellingham Storm Drains~~ TOC Results

SAMPLE RECEIPT
The samples from the Commencement Bay ~~Bremerton/Bellingham Storm Drains~~ were received by the Manchester Laboratory on May 28, 1993 in good condition. The analyses for these samples were subsequently contracted to Analytical Resources Inc. The samples were run using the Puget Sound Estuary Program (PSEP1986) for TOC.

HOLDING TIMES
All analyses were performed within 30 days of sample collection.

PROCEDURAL BLANKS
The procedural blanks associated with these samples showed no analytically significant levels of analytes.

PRECISION DATA
Two samples were run in duplicate to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes was within the +/- 10% window for duplicate analysis.

SPIKED SAMPLE ANALYSIS
Spike and duplicate spike analysis were performed on two samples. All spike recoveries were within limits of 100 +/- 30%.

LABORATORY CONTROL SAMPLE (LCS) ANALYSES
LCS analyses were within the windows established for TOC.

SUMMARY
The data generated by the analysis of these samples can be used noting the data qualifications discussed in this memo.
Please call David A Thomson at SCAN 871-8822 to further discuss this project.

TOC 6/93 - 12/93

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

February 16, 1994

Project: **Commencement Bay Sediment Traps**

Samples: 028502 through 028582

Laboratory: Weyerhaeuser Analytical and Testing Services 13807

By: Karin Feddersen KF

These samples were received at the Manchester Laboratory on January 10, 1994, and were sent to Weyerhaeuser Analytical and Testing Services on January 12, 1994 for TOC analysis using PSEP.

HOLDING TIMES

The holding time for frozen sediments is six (6) months. There have been no studies performed to indicate the effect of holding time after the samples have been thawed for analysis. Therefore an evaluation of the results with regard to holding time is not feasible. All samples were stored in the proper containers at 4 degrees C after being thawed. All analyses were performed within twenty-nine (29) days of thawing.

PROCEDURAL BLANKS

The procedural blanks associated with these samples demonstrated that the processes were free from contamination.

INITIAL CALIBRATION

The % Relative Standard Deviation (%RSD) was within QC limits of ≤20%.

CHECK STANDARDS

All Check Standard recoveries are reasonable, acceptable, and within QC limits of 90% to 100%.

DUPLICATES

The Relative Percent Difference (RPD) of the duplicate analyses to the original analyses are within QC limits of ≤10%.

SUMMARY

This data is acceptable for use as amended.

TOC 12/93-5/94

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366
June 22, 1994

Project:	**Commencement Bay**
Samples:	228503, 228504, 228507, 228510, 228513, 228516, 228519, 228522, 228525, 228528, 228531, 228540, 228544, 228545 ,228548, 228551, 228554, 228557, 228560, 228563, 228566, 228569, 228572, 228575, 228578, 228581
Laboratory:	Sound Analytical Services, Inc. 40700
By:	Karin Feddersen KF

These samples were received at the Manchester Laboratory on May 31, 1994, and were sent to Sound Analytical Services, Inc. on June 1, 1994 for TOC analysis using the following method: Puget Sound Estuary Program

DATA QUALIFIER DEFINITIONS

U - The analyte was not detected at or above the reported result.

HOLDING TIMES

All analyses were performed within the method holding times of six (6) months from the date of collection.

PROCEDURAL BLANKS

The procedural blanks associated with these samples have demonstrated that the process is free from contamination.

CHECK STANDARDS

All recoveries were within QC limits of +/- 20%.

TRIPLICATE

Samples 228503 and 228560 were run in triplicate. The triplicate analyses are in acceptable agreement with the original analyses. The Relative Percent Differences (RPD) were within the +/- 20% window for triplicate analyses.

SUMMARY

For consistency with Manchester Environmental Laboratory reporting requirements, all non-detect values have been qualified with a "U". This data is acceptable for use as amended.

Particulates
5/94 - 11/94

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366
February 3, 1995

Project:	**Commencement Bay**
Samples:	518132, 35, 40, 43, 47, 50, 53, 56, 60, 63, 68, 69, 72, 76, 79, 84, 87, 91, 94, 98, 518201, 518206, 518207
Laboratory:	Sound Analytical Services, Inc. 45364
By:	Karin Feddersen KF

These samples were received at the Manchester Environmental Laboratory (MEL) on December 23, 1994, and were sent to Sound Analytical Services, Inc. on December 23, 1994 for TOC analysis using the following method: Puget Sound Estuary Program.

HOLDING TIMES

The PSEP TOC holding time for frozen sediments is six (6) months. It is unknown how holding time affects samples that have not been stored frozen prior to analysis. No studies to my knowledge have been performed to indicate whether there is any effect. Therefore, an evaluation of the results with regard to holding time is not feasible. The samples were stored in the proper containers at 4 degrees C until analysis.

PROCEDURAL BLANKS

The procedural blanks associated with these samples have demonstrated that the process is free from contamination.

CHECK STANDARDS

All recoveries were within QC limits of +/- 20% of the expected values.

TRIPLICATE

Samples 518132 and 518187 were analyzed in triplicate. The Relative Standard Deviation (RSD) was within 20% for all samples.

SUMMARY

The result for sample 518135 exceeded the concentration of the highest standard analyzed with these samples. The result for this sample has therefore been qualified with a "J" (the reported result is an estimated quantity).

For consistency with MEL reporting protocol, all non-detect values have been qualified with a "U" (the analyte was not detected at or above the reported result). This data is acceptable for use as amended.

Bottom Sediments
11/94
Grain Size

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

December 28, 1994

Project: Commencement Bay

Samples: 49-8180-81,84-88, 90-98

Laboratory: Soil Technology

By: Pam Covey

Case Summary

The Commencement Bay samples required sixteen (16) Grain Size analyses on sediment using Puget Sound Esturary Program Portocol with wet preparation.

These samples were received at the Manchester Environmental Laboratory on December 5, 1994 and transported to Soil Technology on December 8, 1994 for Grain Size analyses. These analyses were reviewed for qualitative and quantitative accuracy, validity and usefullness.

The results are acceptable for use as reported.

Bottom Sediment
11/94

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366
January 11, 1995

Project: **Commencement Bay**

Samples: 498180, 498181, 498184 through 498188, and 498190 through 498198

Laboratory: Sound Analytical Services, Inc. 45009

By: Karin Feddersen KF

These samples were received at the Manchester Laboratory on December 5, 1994, and were sent to Sound Analytical Services, Inc. on December 8, 1994 for TOC analysis using the following method: Puget Sound Estuary Program

DATA QUALIFIER DEFINITIONS

U - The analyte was not detected at or above the reported result.

HOLDING TIMES

The PSEP TOC holding time for frozen sediments is six (6) months. No studies to my knowledge have been performed to indicate the effect of holding time on samples that have not been stored frozen prior to analysis. Therefore an evaluation of the results with regard to holding time is not feasible. The samples were stored in the proper containers at 4 degrees C until analysis.

PROCEDURAL BLANKS

The procedural blanks associated with these samples have demonstrated that the process is free from contamination.

CHECK STANDARDS

All recoveries were within QC limits of +/- 20% of the expected values.

TRIPLICATE

Sample 498180 was run in triplicate. The triplicate analyses are in acceptable agreement with the original analysis. The Relative Standard Deviation (RSD) was within 20%.

SUMMARY

For consistency with Manchester Environmental Laboratory reporting requirements, all non-detect values have been qualified with a "U". This data is acceptable for use as amended.

11/94 - 6/95

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366
August 8, 1995

Project:	**Commencement Bay**
Samples:	248702 through 2478086
Laboratory:	Sound Analytical Services, Inc. 49648
By:	Karin Feddersen KF

These samples were received at the Manchester Environmental Laboratory (MEL) on June 16, 1995, and were sent to Sound Analytical Services, Inc. on June 22, 1995, for TOC analysis using the following: Puget Sound Estuary Program.

HOLDING TIMES

These samples were analyzed within the specified PSEP TOC holding time for frozen sediments of six (6) months.

PROCEDURAL BLANKS

The procedural blanks associated with these samples have demonstrated that the process is free from contamination.

CHECK STANDARDS

All recoveries were within QC limits of +/- 20% of the expected values.

TRIPLICATE

Sample 248702 was analyzed in triplicate. The Relative Standard Deviation (RSD) was within 20%.

SUMMARY

For consistency with MEL reporting protocol, all non-detect values have been qualified with a "U" (the analyte was not detected at or above the reported result). This data is acceptable for use as amended.

Case Narratives

Metals Analysis

June 1991 to June 1995

Particulates
June - Dec, 1991

WASHINGTON STATE DEPARTMENT OF ECOLOGY
ENVIRONMENTAL INVESTIGATIONS AND LABORATORY SERVICES
MANCHESTER ENVIRONMENTAL LABORATORY

January 28, 1992

TO: Dale Norton

FROM: Craig Smith

SUBJECT: Commencement Bay - Sediment Traps

SAMPLE RECEIPT

The samples were received by the Manchester Laboratory on 12/19/91, in good condition.

HOLDING TIMES

All analyses were performed within the specified holding time for Metals analysis (28 days for Hg, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before the run, and checked by initial calibration verification standards and blanks. Continuing calibration standards were analyzed at the frequency of 10% during the run, and again at the end of the analytical run.

PROCEDURAL BLANKS

The blank values were within the acceptable range and showed no analytically significant levels except for Sb. The blank value for Sb is significant, and a "B" qualifier will be attached to the data.

PRECISION DATA

The results of the duplicate samples were used to evaluate analytical precision related to the sample set. The RPD's for all parameters were within the +/-20% window of acceptance for duplicate analysis.

STANDARD REFERENCE MATERIAL

The analysis of the external verification standards for GFAA gave no unusual results, and were within the acceptable established criteria. The external reference materials for XRF analyses were within acceptable limits.

SUMMARY

During the XRF run, an additional external verification standard was run, USGSAGV-1. All of the values obtained were within acceptable limits except for Ni. This is the only reported SRM which bracketed the analytical run. PACS-1 and 1646 apparently were not analyzed at the beginning of the run. All of the PACS-1 and 1646 values were within acceptable limits. Caution might be called for with the Ni data.

The data generated by the analysis of the samples above may be used noting any stated qualifications.

If you have any questions concerning the results, please feel free to call me at SCAN 744-4737.

12/91 - 5/92

WASHINGTON STATE DEPARTMENT OF ECOLOGY
ENVIRONMENTAL INVESTIGATIONS AND LABORATORY SERVICES
MANCHESTER ENVIRONMENTAL LABORATORY

August 27, 1992

TO: Dale Norton

FROM: Bill Kammin, Environmental_Lab_Director

SUBJECT: June 1992 Commencement Bay Metals Results

SAMPLE RECEIPT

The samples from the June 1992 Commencement Bay Metals project were received by the Manchester Laboratory on 6/25/92 in good condition. The analytical work was subsequently contracted to Battelle/Sequim. Analytical methods were specified by the project officer and included: X-ray fluorescence for arsenic, copper, nickel, lead, and zinc; mercury by cold vapor generation, and cadmium and antimony by graphite furnace atomic absorption.

HOLDING TIMES

All analyses were performed within the specified holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency approximately 10% during atomic absorption analytical runs. AA calibration gave correlation coefficients greater than the criteria of 0.995. A correlation coefficient of 0.995 or higher means that the calibration is acceptable.

PROCEDURAL BLANKS

The procedural blanks associated with these samples showed detectable levels of mercury and antimony. Reporting limits were adjusted up in these instances, and for mercury the levels in the blanks were less than 10% of sample values, so no blank qualifiers were required. For antimony, six samples were between the adjusted reporting limit and the estimated reliable quantitation limit. These results were flagged P, B -- denoting possible blank influence on results, and results in an area of less-certain quantitation. Results from atomic absorption analyses were not background corrected.

5/92 - 11/92

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (206) 895-4737 • SCAN 744-4737

March 22, 1993

TO: Dale Norton

FROM: Bill Kammin, Environmental_Lab_Director

SUBJECT: December 1992 Commencement Bay Metals Results

SAMPLE RECEIPT

The samples from the December 1992 Commencement Bay Metals project were received by the Manchester Laboratory on 12/4/92 in good condition. The analytical work was subsequently contracted to Battelle/Sequim. Analytical methods were specified by the project officer and included: X-ray fluorescence for arsenic, copper, nickel, lead, and zinc; mercury by cold vapor generation, and cadmium and antimony by graphite furnace atomic absorption. The review of this data consisted of evaluation of QA/QC/reference material results, spot checks of calculations, and examination of data and final reports for transcription errors.

HOLDING TIMES

All analyses were performed within the specified holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency approximately 10% during atomic absorption analytical runs. AA calibration gave correlation coefficients greater than the criteria of 0.995. A correlation coefficient of 0.995 or higher means that the calibration is acceptable. With regard to XRF analyses for copper, please find as an attachment information from Battelle Richland on problems with the XRF instrument. Because copper results in the reference materials were over 20% high, copper data is qualified as estimated (J).

PROCEDURAL BLANKS

The procedural blanks associated with these samples showed no analytically significant blank levels. Results from atomic absorption analyses were not background corrected.

REFERENCE SAMPLE ANALYSIS

Results from the analysis of two different reference samples were used to evaluate the accuracy of the results submitted by the contract lab. The reference materials used were NIST 1646, Estuarine Sediment, and the Canadian material, PACS-1. For all anlytes except copper and mercury, the mean results for the analysis of all reference materials were within the +/- 20% of the certified analyte value given by the reference material manufacturers. For copper and mercury, the mean results from the analysis of the above mentioned reference materials were at or outside the +/- 20% limit. For this reason, all mercury and cadmium results are qualified with J, indicating estimated values.

With the exception of cadmium results under 1 mg/kg, all results are reported to 3 significant figures. When using these numbers in a final report (particularly for mercury), it may be more appropriate to round to two significant figures.

SUMMARY

The data generated by the analysis of the above referenced samples can be used with the above-mentioned qualifications.

If you have any questions about the results or the methods used to obtain these results, please call me at SCAN 744-4737.

11/92 - 5/93

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (206) 895-4737 • SCAN 744-4737

July 28, 1993

TO: Dale Norton

FROM: Bill Kammin, Environmental_Lab_Director

SUBJECT: May 1993 Commencement Bay Metals Results

SAMPLE RECEIPT

The samples from the May 1993 Commencement Bay Metals project were received by the Manchester Laboratory on 05/28/93 in good condition. The analytical work was subsequently contracted to Battelle/Sequim. Analytical methods were specified by the project officer and included: X-ray fluorescence for arsenic, copper, nickel, lead, and zinc; mercury by cold vapor generation, and cadmium and antimony by graphite furnace atomic absorption. The review of this data consisted of evaluation of QA/QC/reference material results, spot checks of calculations, and examination of data and final reports for transcription errors.

HOLDING TIMES

All analyses were performed within the specified holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency approximately 10% during atomic absorption analytical runs. AA calibration gave correlation coefficients greater than the criteria of 0.995. A correlation coefficient of 0.995 or higher means that the calibration is acceptable.

PROCEDURAL BLANKS

The procedural blanks associated with these samples showed no analytically significant blank levels. Results from atomic absorption analyses were not blank corrected.

REFERENCE SAMPLE ANALYSIS

Results from the analysis of two different reference samples were used to evaluate the accuracy of the results submitted by the contract lab. The reference materials used were NIST 1646, Estuarine Sediment, and the Canadian material, PACS-1. Generally, results for these reference materials indicated acceptable data quality.

With the exception of cadmium results under 1 mg/kg, all results are reported to 3 significant figures. When using these numbers in a final report (particularly for mercury), it may be more appropriate to round to two significant figures.

SUMMARY

The data generated by the analysis of the above referenced samples can be used with the above-mentioned qualifications.

If you have any questions about the results or the methods used to obtain these results, please call me at SCAN 744-4737.

Particulates
7/93 - 12/93

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (206) 871-8860 • SCAN 871-8860

April 13, 1994

TO: Dale Norton

FROM: Bill Kammin, Environmental Lab Director

SUBJECT: January 1994 Commencement Bay Metals Results

SAMPLE RECEIPT

The samples from the January 1994 Commencement Bay Metals project were received by the Manchester Laboratory on 1/10/94 in good condition. The analytical work was subsequently contracted to Battelle/Sequim. Analytical methods were specified by the project officer and included: X-ray fluorescence (XRF) for arsenic, copper, nickel, lead, and zinc; mercury by cold vapor generation followed by atomic fluorescence (CVAF), and cadmium and antimony by graphite furnace atomic absorption (GFAA). The review of this data consisted of evaluation of QA/QC/reference material results, spot checks of calculations, and examination of data and final reports for transcription errors.

HOLDING TIMES

All analyses were performed within the specified holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

XRF calibration was evaluated by the analysis of the following reference materials:

1. PACS-1
2. NIST 1646
3. MESS-1

All XRF recoveries for these reference materials were within +/- 20% of the certified values, with the following exception: arsenic in PACS-1. These results ranged from 22% to 28% high. No qualification of the XRF data was necessary.

The GFAA data was of typical interest. The calibration regime used by Battelle is highly unusual. It consists of the following steps:

- Analysis of NIST 1646 by the Method of Standard Additions (MSA).
- Then, samples are analyzed and analyte response is equated to the analyte response for 1646 on the MSA curve.

This technique might be acceptable if 1646 was very similar to the sediment trap samples. However, NIST reference material 1646 is a highly processed, very homogeneous material with very low organic content. The sediment trap samples generally have very high organic content. In the absence of any spike recovery data for the sediment trap samples, it is impossible to know how well analytes are being recovered by Battelle's method. The recoveries of these analytes do seem reasonable, but how accurate these GFAA results are is really unknown.

These GFAA calibration techniques do not appear in any USEPA methodology, and carry no regulatory approval.

Continuing calibration standards and blanks were analyzed at a frequency approximately 10% during atomic absorption analytical runs. GFAA reference material results were within +/-20% of the certified values.

For mercury, reference material recoveries were within +/- 20% of the certified values. A sample independent calibration was performed.

PROCEDURAL BLANKS

The procedural blanks associated with these samples showed no analytically significant blank levels. Results from atomic absorption analyses were not blank corrected.

SUMMARY

The data generated by the analysis of the above referenced samples can be used with the above-mentioned qualifications.

If you have any questions about the results or the methods used to obtain these results, please call me at SCAN 744-4737.

12/93 - 5/94
particulates

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (206) 871-8860 • SCAN 871-8860

August 29, 1994

TO: Dale Norton

FROM: Bill Kammin, Environmental_Lab_Director

SUBJECT: June 1994 Commencement Bay Metals Results

SAMPLE RECEIPT

The samples from the June 1994 Commencement Bay Metals project were received by the Manchester Laboratory on 1/10/94 in good condition. The analytical work was subsequently contracted to Battelle/Sequim. Analytical methods were specified by the project officer and included: X-ray fluorescence for arsenic, copper, nickel, lead, and zinc, and mercury by cold vapor generation. The review of this data consisted of evaluation of QA/QC/reference material results, spot checks of calculations, and examination of data and final reports for transcription errors.

HOLDING TIMES

All analyses were performed within the specified holding times for metals analysis (28 days for mercury, 180 days for all other metals), with the following exception: mercury. Mercury was analyzed 29 days after the requested analysis date of 6/20/94. Mercury data is qualified with J, denoting estimated values.

INSTRUMENT CALIBRATION

Atomic fluorescence calibration gave correlation coefficients greater than the criteria of 0.995. A correlation coefficient of 0.995 or higher means that the calibration is acceptable. Continuing calibration standards and blanks were analyzed at a frequency approximately 10% during atomic fluorescence analytical runs. Results for the analysis of these standards were acceptable.

PROCEDURAL BLANKS

The procedural blanks associated with these samples showed no analytically significant blank levels. Results from atomic fluorescence analyses were not blank corrected.

REFERENCE SAMPLE ANALYSIS

Results from the analysis of two different reference samples were used to evaluate the accuracy of the results submitted by the contract lab. The reference materials used were NIST 1646, Estuarine Sediment, and the Canadian material, PACS-1. Generally, results for these reference materials indicated acceptable data quality. For mercury, the analysis of 1646 showed high recoveries (135% and 143%). However, analysis of PACS-1 and BEST-1 showed acceptable recoveries

SUMMARY

The data generated by the analysis of the above referenced samples can be used with the above-mentioned qualifications.

If you have any questions about the results or the methods used to obtain these results, please call me at SCAN 744-4737.

Particulates
5/94 - 12/94
Hg/kbos

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (206) 871-8860 • SCAN 871-8860

March 17, 1995

TO: Dale Norton, Project Officer

FROM: Myrna McIntosh, Metals Chemist

SUBJECT: Metals Quality Assurance memo for the Commencement Bay Project

QUALITY ASSURANCE SUMMARY

Data quality for this project is good. No significant quality assurance issues are noted for mercury analysis, ICP analysis, or graphite furnace (GFAA) analysis.

SAMPLE INFORMATION

The samples from the Week 51 Commencement Bay Sediment project were received by the Manchester Laboratory on 12/23/94 in good condition.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks associated with these samples show no analytically significant levels of analytes.

SPIKED SAMPLE ANALYSES

Spiked and duplicate spiked sample analyses were performed on this data set. All spike recoveries are within the CLP acceptance limits of +/- 25%.

PRECISION DATA

The results of the spiked and duplicate spiked samples are used to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes is within the 20% CLP acceptance window for duplicate analysis.

LABORATORY CONTROL SAMPLE (LCS) ANALYSES

LCS analyses are within the windows established for each parameter. Our normal LCS is a sediment from ERA (Environmental Resource Associates) and this was run with the samples and recovered well. NIST 1646 was analyzed in duplicate for GFAA and ICP and in triplicate for mercury. It gave approximately 45% recovery of arsenic. Because our normal LCS gave good recovery, the sample results are not qualified.

Please call Bill Kammin at SCAN 206-871-8801 to further discuss this project.

MMM:mmm

Metals

Bottom Sediment
Sitcum + Hylebos
12/94

Washington State Department of Ecology
Manchester Environment Laboratory

February 24, 1995

TO: Dale Norton

FROM: Bill Kammin, Environmental_Lab_Director

SUBJECT: Metals Quality Assurance memo for the Week 49 Commencement Bay Project

QUALITY ASSURANCE SUMMARY

Both the contract data and the in-house data showed few quality assurance issues. The contract mercury data showed high recoveries for SRM 1646, and this data may be biased high. Split sample results showed generally good agreement, with the following exception: nickel. Nickel results were significantly higher (150 mg/Kg vs. 40 mg/Kg) by digestion and analysis by ICP compared to X Ray Fluorescence (XRF). However, quality assurance results for both techniques were in specification. It is possible that this sample has an interference affecting one of the analytical techniques.

SAMPLE INFORMATION

These samples from the Week 49 Commencement Bay project were received by the Manchester Laboratory on 12/5/94 in good condition. All ICP and arsenic results are reported on a dry weight basis. Mercury results are reported on a wet weight basis.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks associated with these samples showed no analytically significant levels of analytes. These samples were digested by our normal sediment digestion technique with one modification: 200 microliters of hydrofluoric acid was added to the digestion mix to help solubilize mineralized analytes.

SPIKED SAMPLE ANALYSES

Manchester Results

Spike and duplicate spike sample analyses were performed on this data set. All spike recoveries were within the CLP acceptance limits of +/- 25%.

Battelle Results

No spikes were performed for XRF, mercury or cadmium analyses. It is not possible to assess matrix interference for this data.

PRECISION DATA

Manchester Results

The results of the spike and duplicate spike samples were used to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes was within the 20% CLP acceptance window for duplicate analysis.

Battelle Results

Based on recoveries of Standard Reference Materials, precision met CLP specification for all results except mercury. Mercury precision results did not meet CLP criteria. Battelle mercury results are qualified J, denoting estimated values.

LABORATORY CONTROL SAMPLE (LCS) AND STANDARD REFERENCE MATERIAL (SRM) ANALYSES

Manchester Results

LCS (Environmental Resource Associates soil sample) analyses were within the windows established for each parameter. NIST SRM 1646 was analyzed for ICP and arsenic. For ICP, NIST 1646 recoveries ranged from 72-99%. For arsenic, NIST 1646 recoveries were both 78%.For mercury, recoveries for multiple analyses of NIST 2704 ranged from 93-95%. Precision for all LCS and SRM analyses was within CLP acceptance criteria.

Battelle Results

Analyses of all SRM's was acceptable, with one exception: mercury. NIST 1646 showed very high recoveries and poor precision. Battelle mercury results are qualified J, denoting estimates.

Please call Bill Kammin at SCAN 206-871-8801 to further discuss this project.

WRK:wrk

Particulates 11/94 - 6/95
%S, metals

Mussel Tissue 3-5/95
metals

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (360) 871-8860 • FAX (360) 871-8850

July 31, 1995

TO: Dale Norton, Project Officer

FROM: Myrna McIntosh, Metals Chemist

SUBJECT: Metals Quality Assurance memo for the Commencement Bay Project
Sediment Sample Numbers: 95248730 - 95248786
Tissue Sample Numbers: 95248788 - 95248791

QUALITY ASSURANCE SUMMARY

Data quality for this project is generally good. None of the sediment samples have any QA issues. There is a small amount of copper in the tissue digestion blank. Because the amount of copper was low in the samples it was necessary to qualify these results as estimates, "J".

The arsenic recoveries for the tissue spikes and LCS were low and so these arsenic results are qualified with "J" as estimates.

SAMPLE INFORMATION

The samples from the Commencement Bay project were received by the Manchester Laboratory on 6/16/95 in good condition.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks from the tissue digestion show a trace of copper contamination. The copper level of the samples is low (within ten times the detection limit) so the copper results are qualified with "J" as estimates.

SPIKED SAMPLE ANALYSES

Spiked and duplicate spiked sample analyses were performed on this data set. All spike recoveries from the sediment digestion are within the CLP acceptance limits of +/- 25%. Arsenic recovery in the tissue samples is low at approximately 35%.

PRECISION DATA

The results of the spiked and duplicate spiked samples are used to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes is within the 20% CLP acceptance window for duplicate analysis.

LABORATORY CONTROL SAMPLE (LCS) ANALYSES

LCS analyses are within the windows established for each parameter, with the exception of arsenic in the tissue LCS. The tissue arsenic results are qualified "J", as estimates. The certified value for lead in the tissue LCS is too low to be useful as a control.

Please call Bill Kammin at SCAN 360-871-8801 to further discuss this project.

MMM:mmm

Case Narratives

Organics Analysis

June 1991 to June 1995

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 <u>estimate</u>.

UJ - The analyte was not detected at or above the reported estimated result.

REJ - The data are <u>unusable</u> 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 X 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

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 X 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 <u>estimate</u>.
UJ	-	The analyte was not detected at or above the reported estimated result.
REJ	-	The data are <u>unusable</u> 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 X 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.)

Particulates
12/91 - 5/92
8

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

CASE NARRATIVE

September 23, 1992

Subject:	Commencement Bay Sediment Traps
Samples:	92 - 268433, -268444, -268465 to -268467
Case No.	DOE-370Y
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

VOLATILE ORGANIC ANALYSIS

ANALYTICAL METHODS:

Volatile organic compounds were analyzed using Manchester modification of the EPA SW 846 Method 8240 purge-trap procedure with capillary GC/MS analysis. Normal 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 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:

Surrogate recoveries were within acceptable limits for the soil samples.

HOLDING TIMES:

The soil samples were analyzed within the recommended 14 day holding time.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Soil matrix spikes were within acceptable QC limits for both percent recovery and Relative Percent Difference (RPD) for most compounds. Four compounds, trans-1,3-dichloropropene, cis-1,3-dichloropropene, 4-methyl-2-pentanone and 1,2,3-trichlorobenzene had spike recoveries outside acceptable limits and the results for these compounds in sample 268465 were qualified with the "J" flag.

SPECIAL ANALYTICAL PROBLEMS:

No analytical problems were encountered in the analysis. 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 X 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

October 8, 1992

Subject: Commencement Bay Sediment Traps

Samples: 92 - 268426 to -268430, -268433, -268436, -268444, -268452, -268463 to 268467, -268494 to -268498.

Case No. DOE-370Y

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 SW 846 8270 procedure with capillary GC/MS analysis of the sample extracts. Normal QA/QC procedures were performed with the analyses.

HOLDING TIMES:

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

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 surrogates compounds were added to the sample prior to extraction. Only three surrogate spike recoveries were outside acceptable QC limits all of the others were acceptable. Four samples, blanks BS2189 and BS2189D along with samples 92-268396 and -268397 (Canadian reference material HR-6), under went the silica gel polynuclear aromatic hydrocarbon (PAH) clean-up procedure. Consequently only surrogate recoveries for 2-fluorobiphenyl, d10-pyrene and d14-terphenyl are valid.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spike recoveries and Relative Percent Differences (RPD) were acceptable for most of the Contract Laboratory Program (CLP) check compounds except for phenanthrene and pyrene. Both of these compounds were found in the sample at relatively high levels and correction of the matrix spikes could not be made. Spike recoveries for most of the remaining non-CLP compounds were also affected by the high native concentrations and could not be calculated.

SPECIAL ANALYTICAL PROBLEMS:

No special analytical problems were encountered in the semivolatile analyses. The HR-6 reference material samples, -268396 and -97 were mistakenly given the silica gel clean-up procedure. Since HR-6 is primarily certified for the PAH compounds this should not be a major problem and the results should still be valid.

A smaller sample size than normal, five to 10 grams, was used in the extraction. The small sample size was compensated for by concentrating to a lower volume for injection. This resulted in similar sample quantitation limits compared to previous analyses. Analysis and review at these low levels was complicated by the large amounts of interfering biogenic material which affected the chromatography.

In all samples except, 268427, 268433, 268463 and 268465, results for benzo(b)fluoranthene and benzo(k)fluoranthene could not resolved. Consequently the results were reported as benzo(b) fluoranthene but includes benzo(k)fluoranthene as well and the results for benzo(k)fluoranthene were flagged as not detected, "U".

Due to interferences in the samples several internal standard area counts were outside the acceptable limits. Those samples and compounds affected by this were qualified by adding the "J" qualifier.

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 X 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

September 22, 1992

Subject:	Commencement Bay Sediment Traps
Samples:	92 - 268433, -268436, -268444, -268452, -268463 to -268465, -268467.
Case No.	DOE-370Y
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

POLYCHLORINATED BIPHENYLS

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:

All sample extraction and analysis holding times were met.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

All surrogate spike recoveries were within acceptable QC limits. Surrogates ranged from 60% to 99% recovery.
Surrogate recovery for 4,4-Dibromooctafluorobiphenyl (DBOB) is not reported in the matrix spikes due to interference from the spiking compounds.

MATRIX SPIKE AND MATRIX SPIKE :

The matrix spikes recoveries ranged from 84% to 89%. The Relative Percent Differences (RPD) ranged from 2.3% to 5.8%. All recoveries and RPD were within acceptable QC limits.

SPECIAL ANALYTICAL PROBLEMS:

There were no significant problems with the Pesticide/PCB analysis. Several PCB's were detected in the samples. These included PCB-1242, PCB-1254 and PCB-1260. The station identification for one sample, -268433, was entered incorrectly. The correct station description is PUY-1C not DUY-1C.

Samples 92-268398 and -268399, labeled PCBREF and PCBREFD (duplicate), were EPA PCB in soil reference materials. The sample was a natural sediment characterized for two aroclors by the National Institute of Standards and Technology (NIST) and obtained from EPA-Cincinnati.

Table1. Comparison of PCB concentrations in NIST sediment sample with results from EPA Region X inter- laboratory study and results from sediment trap analyses. All results are reported as ug/Kg.

Aroclor	NIST	EPA - Interlab *	92 -268398	92-268399
1242	8160 +/- 280	11,300 +/- 368	8000	7500
1260	6810 +/- 140	14,000 +/- 705 **	15,000	15,000

* +/- one standard deviation
** data from 33 laboratories.

The PCB-1242 sediment trap results were comparable to the NIST value and lower than the EPA-Interlab results. Results for PCB-1260 in the inter laboratory study were 2 to 2.5 times higher than the NIST value but were comparable to the inter-laboratory results. A conversation between Bob Rieck, EPA Manchester, Laboratory and Jim Longbottom, EPA, Cincinnati confirmed the disparity with the NIST reference values.

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 X 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.)

Particulates
5/92 - 11/92

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

May 24, 1993

Subject: Commencement Bay Sediment Traps

Samples: 92 - 498276 to -498279

Case No. DOE-555Y

Officer: Dale Norton

By: Dickey D. Huntamer
Organics Analysis Unit

VOLATILE ORGANIC ANALYSIS

ANALYTICAL METHODS:

Volatile organic compounds were analyzed using Manchester modification of the EPA SW 846 Method 8240 purge-trap procedure with capillary GC/MS analysis. Normal 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 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:

All surrogate recoveries were within acceptable limits for soil samples.

HOLDING TIMES:

The soil samples were stored frozen following Puget Sound Estuarine Protocols and were analyzed within the recommended 14 day holding time after thawing out..

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spike recoveries and Relative Percent Differences (RPD) were within acceptable limits.

SPECIAL ANALYTICAL PROBLEMS:

There were no analytical problems with these analyses. 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 X 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 31, 1993

Subject:	Commencement Bay
Samples:	92 - 498272 to -498277, -498279, -498288 -498303 to -498305, -498307, -498331 to -498335
Case No.	DOE-555Y
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 SW 846 8270 procedure with capillary GC/MS analysis of the sample extracts. The sample extracts were cleaned up prior to analysis using silica gel. By eluting with various mixtures of solvents the semivolatile target compounds could be recovered. Normal QA/QC procedures were performed with the analyses. A pair of Canadian reference materials (HS-6) were also analyzed with the samples.

HOLDING TIMES:

The samples were stored frozen until sample preparation following Puget Sound Estuary Program guidelines. All sample and extraction holding times were within the recommended limits.

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 surrogates compounds were added to the sample prior to extraction. All surrogate spike recoveries were within acceptable QC limits.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spike recoveries for the EPA Contract Laboratory Program (CLP) compounds were within acceptable limits. Eight other non-CLP compounds had less than 50% recovery and the results for those compounds in the matrix sample, 92-498303 were qualified by adding "J". The base compounds were not part of the spiking mixture and therefore are reported as no analyte found (NAF). One compound, Hexachloroethane had low recoveries < 4%, and also was reported as NAF.

SPECIAL ANALYTICAL PROBLEMS:

No special analytical problems were encountered in the semivolatile analyses. The silica gel clean-up for semivolatiles worked well, eliminating much of the interferences caused by the presence of fats and lipids. This allowed the samples to be analyzed at a smaller volume and improved chromatography which resulted in better quantitation limits.

The Canadian reference material (HS-6) results are reported as sample 93498335 SRM1 and SRM2.

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.

bold - 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

April 2, 1993

Subject:	Commencement Bay Sediment Traps
Samples:	92 - 498272 to -498277 and -498279
Case No.	DOE-555Y
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

POLYCHLORINATED BIPHENYLS

ANALYTICAL METHODS:

The sediment 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). Interferences were removed by acid treatment.

HOLDING TIMES:

The samples were stored frozen following Puget Sound Estuary Program guidelines until time for extraction. The extracts were analyzed within the recommended holding times.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

Surrogates ranged from 77% to 129% recovery for most of the samples. Decachlorobiphenyl had 187% recovery in sample -498277. This could be due to chromatographic interference since the other surrogate recovery was acceptable. The "J" data qualifier was added to all results for sample -498277 because of the high surrogate recovery. Surrogate recoveries for the first blank were low, less than 15%, however the duplicate blank recoveries were acceptable. Surrogate recovery for Dibutylchlorendate (DBC) was not reported in some of the samples because it was removed by the acid treatment.

MATRIX SPIKE AND MATRIX SPIKE :

The matrix spikes recoveries for PCB-1242 ranged from 125% to 130%. The Relative Percent Differences (RPD) was 3.9%. All recoveries and RPD were within acceptable QC limits.

ANALYTICAL COMMENTS:

There were no significant problems with the Pesticide/PCB analysis. PCB-1254 was detected in all of the samples.

A Canadian PCB reference material was analyzed in duplicate with the samples. These samples are identified in the report as 93-498279 SRM1 and 93-498279 SRM2. Significant interferences from sulfur were encountered in the analysis. One Arochlor PCB-1260 was quantitated and reported, a smaller amount of PCB-1254 also appears to be present, however it could not be quantitated separately due to the interferences and was incorporated into the PCB-1260 value.

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 X 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.)

Particulates
11/92-5/93

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

August 4, 1993

Subject: Commencement Bay Sediment Traps

Samples: 93 - 228219, -228249 and -228250

Case No. DOE-761Y

Officer: Dale Norton

By: Dickey D. Huntamer
Organics Analysis Unit

VOLATILE ORGANIC ANALYSIS

ANALYTICAL METHODS:

Volatile organic compounds were analyzed using Manchester modification of the EPA SW 846 Method 8240 purge-trap procedure with capillary GC/MS analysis. Normal 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 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:

Surrogate recoveries were within acceptable limits for soil samples.

HOLDING TIMES:

The samples were analyzed twelve days past the recommended holding time of fourteen days due to instrument problems. All of the sample results were qualified with "J to indicate the increased uncertainty in their quantitation.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Soil matrix spikes were within acceptable QC limits for both percent recovery and Relative Percent Differences (RPD) for all but seven compounds. These were chloromethane, chloroform, trans-1,3-dichloropropene, p-isopropyltoluene, butylbenzene, naphthalene and hexachlorobutadiene. All of the results for these compounds in the matrix spike sample were given the "J" qualifier. Acetone was also outside the limits but that was due to the high background in the sample matrix and the "REJ" qualifier was applied to the acetone results.

ANALYTICAL COMMENTS:

Other than the holding time no analytical problems were encountered in the analysis. The data is acceptable for use as qualified. A number of chlorinated butadienes were detected in the 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.)

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

August 30, 1993

Subject: Commencement Bay

Samples: 93 - 228219, -228243 to -228247,-228250, -228277 to -228281, -228308 to -238312

Case No. DOE-761Y

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 SW 846 8270 procedure with capillary GC/MS analysis of the sample extracts. The sample extracts were cleaned up prior to analysis using silica gel. By eluting with various mixtures of solvents the semivolatile target compounds could be recovered. Normal QA/QC procedures were performed with the analyses. A pair of Canadian reference materials (HS-6) sample numbers 93-228400 and -228401, were also analyzed with the samples.

HOLDING TIMES:

The samples were stored frozen until sample preparation following Puget Sound Estuary Program guidelines. All sample and extraction holding times were within the recommended limits.

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 surrogates compounds were added to the sample prior to extraction. All surrogate spike recoveries were within acceptable QC limits except for pyrene-d10 in sample 93-228312 which was 6.6%. Since the other surrogates and terphenyl-d14 had acceptable recoveries no additional qualifiers were added.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spike recoveries for eight of the EPA Contract Laboratory Program (CLP) compounds were within acceptable limits. Three compounds were outside the CLP limits. Thirteen other non-CLP compounds had less than 50% recovery and the results for those compounds, along with the three CLP compounds, were qualified by adding "J" to the results for the matrix sample, 93-228280 . The base compounds were not part of the spiking mixture and therefore are reported as no analyte found (NAF).

SPECIAL ANALYTICAL PROBLEMS:

No special analytical problems were encountered in the semivolatile analyses. The silica gel clean-up as with the previous set of semivolatiles samples worked well, eliminating much of the interferences caused by the presence of fats and lipids. This allowed the samples to be analyzed at a smaller volume and improved chromatography which resulted in better quantitation limits.

The Canadian reference material (HS-6) results are reported as sample 93-228400 SRM1 and 93-228401 SRM2.

The samples reported as LDP1 are dilutions to bring the sample into the quantitation range, not sample duplicates.

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 X 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

August 24, 1993

Subject: Commencement Bay Sediment Trap

Samples: 93 - 228219, -228243 to -228247 and -228247

Case No. DOE-761Y

Officer: Dale Norton

By: Dickey D. Huntamer
Organics Analysis Unit

POLYCHLORINATED BIPHENYLS

ANALYTICAL METHODS:

The soil sample was 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 samples were stored frozen until extraction. The samples were analyzed within forty days of extraction.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

All surrogate spike recoveries were within acceptable QC limits. Surrogates ranged from 50% to 142% recovery.

MATRIX SPIKE AND MATRIX SPIKE :

The matrix spikes recoveries ranged from 91% to 106%. The Relative Percent Differences (RPD) ranged from 10% to 11%. All recoveries and RPD were within acceptable QC limits.

SPECIAL ANALYTICAL PROBLEMS:

There were no significant problems with the Pesticide/PCB analysis. Two reference samples were analyzed with the sample set. These are identified as 93-228314 and -228315. Canadian reference material PACS-1 was used in the analysis. Both PCB-1254 and PCB-1260 were detected in the reference samples. The RPD was 27% for PCB-1254 and 42% for PCB-1260.

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 X 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

August 5, 1993

Subject: Commencement Bay Sediment Traps

Samples: 93 - 228308, -228309 and 238311

Case No. DOE-761Y

Officer: Dale Norton

By: Dickey D. Huntamer
Organics Analysis Unit

TRIBUTYL TINS

ANALYTICAL METHODS:

The samples were extracted following the methods given in Puget Sound Estuary Program (PSEP) "Recommended Guidelines for Measuring Organic Compounds in Puget Sound Sediment and Tissue Samples" Recommended Methods for Organotin Compounds. The samples were Soxhlet extracted using acetone and tropolone, 0.2% by weight, solvent exchanged to hexane and dried using sodium sulfate. The organotin compounds were hexylated using the Grignard reaction given in Krone et al (1989) including the silica gel/alumina cleanup. Analysis was done by capillary Gas Chromatography using a Ion Trap Detector (FPD). All results are on a dry weight basis.

HOLDING TIMES:

The samples were stored frozen following PSEP Guidelines until extraction. After extraction all samples were analyzed within the recommended 40 day extract time.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

The surrogate, Tripropyltin had consistently poor recoveries for all of the analyses. Recoveries ranged from not found to 5.2%. The reason for the poor recoveries is not readily apparent. The possibility that the surrogates were not added is unlikely since all of the samples were the same and a second set of tin analyses prepared and extracted at a different time also showed a similar problem. This would suggest a possible problem with the spiking solution but it was used in a previous sample set and recoveries were acceptable. Another potential problem area is the derivitization reagent, but it appeared to behave normally. If it was not working properly then no tributyltin (TBT) would be detected and TBT was detected in all samples except the laboratory blanks. A possible scenario is that the Tripropyltin surrogate failed to elute off the silica gel/alumina column used to clean-up the extracts. Unfortunately the real reason can not be determined at this time. All of the sample data was qualified with the "J" flag because of the low surrogate recoveries.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

One of the matrix spike samples went dry during the Soxhlet extraction. No tin compounds were recovered in that sample. The other matrix spike had 79.5% recovery of tributyltin and 117% recovery of dibutyltin. The tetrabutyl and mono butyl tin spikes were not detected. No recovery or RPD limits have been established for this method.

ANALYTICAL COMMENTS:

Sample -228309 also went dry during the Soxhlet process although apparently not as long as the one matrix spike because tributyltin was detected in that sample. All of sample -228309 was used up in the initial extractions and re-extractions could not be done.

The "J" data qualifier was added to all of the results due to the low surrogate recoveries and is used to indicate that the quantitation values and quantitation limits are estimates. The reason for the low surrogate recovery is not apparent at this time and additional testing will be required to ascertain the problem. Tributyltin was detected in all three samples and in the Sequim Bay reference material sample, -228313 at 54.1 ug/Kg dry or 31.2 ug/Kg wet weight.

The Sequim Bay Reference Sediment is presumably spiked with 100 ng/gm (100 ug/Kg) wet weight of tributyltin. No value for tributyltin has been established for the Sequim Bay Reference Sediment so the accuracy of the analysis cannot be determined.

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 X 10^6.
NAF	-	No analyte found.
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.)

Particulates
7/93 - 12/93

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

February 17, 1994

Subject:	Commencement Bay Sediment Traps
Samples:	94 - 028587 to -028589
Case No.	DOE-957Y
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

VOLATILE ORGANIC ANALYSIS

ANALYTICAL METHODS:

Volatile organic compounds were analyzed using Manchester modification of the EPA SW 846 Method 8260 purge-trap procedure with capillary GC/MS analysis. Normal 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 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:

Surrogate recoveries were within acceptable limits for the soil samples except for 1,2-dichloroethane-d4 in matrix spike samples -028588 LMX1 and LMX2 which were close to 400% recovery. This appears to be interference from the matrix spiking since the recovery in the source sample -028588 itself was acceptable.

HOLDING TIMES:

The soil samples were analyzed within the recommended 14 day holding time.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Soil matrix spikes were within acceptable QC limits for both percent recovery and Relative Percent Differences (RPD) for most of the compounds. The "J" qualifiers were added to results in the matrix source sample -028588 for acetone, 2-butanone, p-isopropyl toluene and naphthalene the "R" reject qualifier was added to results for 4-methyl-2-pentanone, 2-hexanone.

ANALYTICAL COMMENTS:

No analytical problems were encountered in the analysis. 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 X 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.)

All Data reported
on Dry Wt Basis

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

CASE NARRATIVE

April 10, 1994

Subject: Commencement Bay Sediment Traps

Samples: 94 - 028526 to -028530, -028533, -028584 to -028587, -028589 to -028595

Case No. DOE-957Y

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 SW 846 8270 procedure with capillary GC/MS analysis of the sample extracts. The sample extracts were cleaned up using silica gel prior to analysis. Normal QA/QC procedures were performed with the analyses.

HOLDING TIMES:

The samples were composites from two collections and were stored frozen following Puget Sound Estuary Program guidelines until analysis. Upon release of the samples from the project officer to the laboratory all sample and extraction holding times were kept within the recommended limits of fourteen days for extraction and forty days for analyses.

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 surrogates compounds were added to the sample prior to extraction. All surrogate spike recoveries were within acceptable QC limits.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spike recoveries were acceptable for most of the compounds however the Relative Percent Differences (RPD) for the majority of the earlier eluting compounds were low and consequently the "J" qualifier was added to the results for those compounds in sample -028592. An additional problem was the high native concentrations in the source sample, -028592. This interfered with the recovery calculations and resulted in some of the RPD's being outside of the 25% limit.

ANALYTICAL COMMENTS:

During the extraction two samples were labeled as -028528 and no sample -028526. Both extracts were shot as -028528a and -028528b with the rest of the samples. Since there was no way to distinguish which sample was which both were re-extracted, but after the holding time, and analyzed. The results of the second analysis are reported for these samples. Normally all results would be qualified with "J" as estimates since holding times were exceeded. This action was not felt to be necessary since a compound by compound comparison of the re-analyses with the original analyses showed that the results in the second analysis were higher and no loss of analytes due to holding times is apparent.

Other than those items discussed above no special analytical problems were encountered in the semivolatile analyses and 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 <u>estimate</u>.
UJ	-	The analyte was not detected at or above the reported estimated result.
REJ	-	The data are <u>unusable</u> 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 X 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

February 11, 1994

Subject: Commencement Bay Sediment Trap

Samples: 94 - 028533, -028584 to -028587, -028589, -028596 and -028597

Case No. DOE-957Y

Officer: Dale Norton

By: Dickey D. Huntamer
Organics Analysis Unit

POLYCHLORINATED BIPHENYLS

ANALYTICAL METHODS:

The soil sample was 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 samples were stored frozen until extraction. The samples were analyzed within forty days of extraction.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

Four surrogate compounds were analyzed with the PCB's. Surrogates ranged from 47% to 206% recovery. Surrogate spike recoveries were within the acceptable QC limits of 50% to 150% for most of the samples. In the few cases where surrogate recoveries exceeded the limits only one of the four surrogates was outside the range. Since the remaining surrogates were acceptable no data was qualified because of surrogate recoveries.

MATRIX SPIKE AND MATRIX SPIKE :

The matrix spikes recoveries ranged from 90% to 111%. The Relative Percent Differences (RPD) ranged from 5.1% to 10.4%. All recoveries and RPD were within acceptable QC limits.

SPECIAL ANALYTICAL PROBLEMS:

There were no significant problems with the Pesticide/PCB analysis. Two reference samples were analyzed with the sample set. These are identified as 94-028596 and -028597. Canadian reference material HS-2 was used in the analysis. Both PCB-1254 and PCB-1260 were detected in the reference samples. The RPD was 1.6% for PCB-1254 and 2.0% for PCB-1260.

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 <u>estimate</u>.

UJ - The analyte was not detected at or above the reported estimated result.

REJ - The data are <u>unusable</u> 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 X 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

July 8, 1994

Subject:	Commencement Bay Sediment Traps
Samples:	94 - 028526, -028528 to -028530
Case No.	DOE-957Y
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

ORGANO TINS

ANALYTICAL METHODS:

The samples were extracted following the methods given in Puget Sound Estuary Program (PSEP) "Recommended Guidelines for Measuring Organic Compounds in Puget Sound Sediment and Tissue Samples" Recommended Methods for Organotin Compounds. The samples were Soxhlet extracted using acetone and tropolone, 0.2% by weight, solvent exchanged to hexane and dried using sodium sulfate. The organotin compounds were hexylated using the Grignard reaction given in Krone et al (1989) including the silica gel/alumina cleanup. Analysis was done by capillary Gas Chromatography/Mass Spectrometry using the selected ion monitoring (SIM) mode to decrease quantitation limits. Percent solids were available so all results are on a dry weight basis.

HOLDING TIMES:

The samples were stored frozen following PSEP Guidelines until extraction. After extraction all samples were analyzed within the recommended 40 day extract time.

BLANKS:

No organotin compounds were detected in the laboratory blanks.

SURROGATES:

The surrogate, tripropyltin chloride was inadvertently spiked in a a concentration ten times higher than planned due to a dilution error. Recovery of the surrogate spike, Tripropyltin, ranged from 46% to 106%. No limits have been established for this method.

MATRIX SPIKE AND MATRIX SPIKE :

The matrix spikes were also added at a concentration ten times higher than desired and were outside the linear calibration range. The spiked samples were diluted, reanalyzed and the results from the dilution are reported. Spike recoveries ranged from 41.6% to 160.6%. The Relative Percent Differences (RPD) were high, greater than 50%, for all except dibutyltin chloride, at 26%. The recoveries for the tributyltin chloride were compromised by the high tributyltin found in the matrix spike source sample.

ANALYTICAL COMMENTS:

Despite the use of SIM mode GC/MS analysis their were still chromatographic interferences which contributed interfering ions. This resulted in some hits for the other non-tributyl tin species being marked as undetected due to poor spectra. The tributyltin had relatively high concentrations and presented minimal problems. Tetrabutyl tin was not detected in any of the samples.

Two additional samples were analyzed with the sediment samples. This was a Sequim Bay Reference Sediment which presumably was spiked with 100 ng/gm (100 ug/Kg) wet weight of tributyltin. No value for tributyltin has been established for the Sequim Bay Reference Sediment so the accuracy of the analysis cannot be determined.

SQ4139	110	ng/Kg (wet weight)	Tributyltin
	33.3	" " "	Monobutyltin
SQ4139D	83.3	" " "	Tributyltin
	12.3	" " "	Dibutyltin

ANALYTICAL COMMENTS:

No analytical problems were encountered in the analysis. 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 X 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.)

Particulates
12/93 - 5/94

Manchester Environmental Laboratory

7411 Beach Dr E, Port Orchard Washington 98366
July 20, 1994

Project:	**Commencement Bay**
Samples:	94228587, 94228588, 94228589, 94228590
Project Officer:	Dale Norton
By:	Karin Feddersen KF

These samples were analyzed by EPA Method 624 for Volatile Organic Compounds.

Holding Times:

The samples were analyzed within method holding times.

Method Blanks:

Low levels of several analytes were detected in both method blanks. When these analytes are detected in the samples at a concentration greater than five (5) times that detected in the corresponding method blank, the contribution to the results due to laboratory contamination is considered negligible. No qualification of the results is necessary.
When these analytes are detected in the samples at a concentration less than five (5) times that detected in the corresponding method blank, they are most likely present due to laboratory contamination and not native to the samples. Results for these analytes in the corresponding samples have been changed (qualifier "U") to indicate that these analytes were not detected at a level above the suspected contamination.

GC/MS Tuning and Calibration:

Calibration against Bromofluorobenzene (BFB) is acceptable for the initial calibration, continuing calibration and all associated sample analyses.

Initial Calibration:

The initial calibration met the minimum response criteria for the average relative responses. The % Relative Standard Deviations were within the maximum of 30% with the exception of Acetone. All results for Acetone have been qualified with a "J".

Continuing Calibration:

The average relative response factors for all target analytes were above the minimums, and the percent deviations between the initial and continuing calibration standards were within the maximum of 25% with several exceptions. In the corresponding samples: positive results for these analytes have been qualified with a "J"; non-detect results for these analytes have been qualified with a "UJ".

Surrogates:

All surrogate recoveries for these samples, the matrix spikes, and the associated method blanks are reasonable, acceptable, and within QC limits.

Matrix Spikes (MS/MSD):

Matrix spike recovery and precision data are reasonable, acceptable, and within advisory QC limits of 50% to 150% with several exceptions. The matrix spike duplicate recovery for Isopropyltoluene, and both matrix spike recoveries for Acetone, 2-Butanone, and Napthalene are outside QC limits. Due to the high concentration of these analytes present in the original sample compared to the amount spiked, the matrix spike recovery data is unreliable. Also, all surrogates for these samples are within QC limits. Therefore, sample results have not been qualified on the basis of the spike data. All affected spike recoveries for these analytes have been qualified with "NAR". Isopropylbenzene co-eluted with an unknown compound which resulted in artificiallly elevated recoveries for this analyte. The spike recoveries for Isopropylbenzene have been qualified with "NAR". Matrix spike recoveries for 1,2,4-Trichlorobenzene, Hexachlorobutadiene, and 1,2,3-Trichlorobenzene are slightly below QC limits. All positive results for these analytes have been qualified with a "J"; the instrument sensitivity is sufficient that the non-detect results are unaffected.

Sample Results:

This data is acceptable for use as amended.

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.
NAR -	No viable analytical result obtained for this analyte.
* -	The analyte was present in the sample. (Visual Aid to locate detected analyte on report sheet.)

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

August 3, 1994

Subject:	Commencement Bay
Samples:	94 - 228582 to -228588 and -228590 to -228592
Case No.	DOE-118X
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

POLYCHLORINATED BIPHENYLS

ANALYTICAL METHODS:

The soil sample was 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:

All extraction and analysis holding times were met.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

Surrogates recoveries for the samples ranged from 25% to 117%. In several samples, surrogate recovery for Dibutylchlorendate (DBC) is low, the other surrogates are okay, consequently no qualifiers were added to the results. Surrogate recoveries in the blanks tended to be lower than in the samples and possibly reflects losses during sample concentration.

MATRIX SPIKE AND MATRIX SPIKE :

The matrix spike compounds were apparently not added to the samples. Since the sample, (-228582), used for the matrix spikes contained some native PCB's, the native amount was also calculated in the two "spiked" samples to provide a triplicate analysis.

ANALYTICAL COMMENTS:

There were no significant problems with the PCB analysis other than the problem with the matrix spikes. Samples -228591 and -228592 are duplicates of Canadian Reference Material HS-2.

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

August 30, 1994

Subject:	Commencement Bay
Samples:	94 - 228585 Matrix Spikes
Case No.	DOE-118X
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

POLYCHLORINATED BIPHENYLS

ANALYTICAL METHODS:

The soil 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:

These samples were extracted after the recommended 14 day holding time. However given the persistence and stability of Arochlor (PCB) mixtures, exceeding the holding times will have no detrimental effect on the concentrations.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

Surrogates recoveries for the samples ranged from 61% to 99%.

MATRIX SPIKE AND MATRIX SPIKE :

Matrix spike recoveries ranged from 71% to 104% and the Relative Percent Differences (RPD) ranged from 2.0% to 4.1%.

ANALYTICAL COMMENTS:

There were no significant problems with the PCB analysis. Sample -228585 was used since it had the most material remaining after the earlier 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 X 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.)

12/93 - 5/94
Particulates

Manchester Environmental Laboratory
7411 Beach Dr E, Port Orchard Washington 98366

CASE NARRATIVE

September 23, 1994

Subject: Commencement Bay

Samples: 942285582 - 228588

Case No. DOE-118X

Officer: Dale Norton

By: Greg Perez
Organics Analysis Unit

SEMIVOLATILE ANALYSIS

ANALYTICAL METHODS:

The semivolatile water samples were extracted with methylene chloride following the Manchester Laboratory modification of the EPA CLP and SW 88846 8270 procedure with capillary GC/MS analysis of the sample extracts. Normal QA/QC procedures were performed with the analyses.

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:

Surrogate recoveries were within acceptable limits for the soil samples. Surrogate recoveries for both the blanks were unusually low and below the recommended limits. Why this occurred has not been fully determined. The problem seems to have been restricted to the blanks, as the recoveries for the samples were reasonable. No samples were qualified because of the problems with the blanks.

HOLDING TIMES:

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

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Spiked compounds which were recovered but had recoveries below the recommended limits were given a J qualifier in the native sample only. Several compound were not recovered at all in either of the matrix spikes. This an effect of column degradation or injection port contamination which often occurs with sediment samples. Data for these compounds was rejected (qualifier REJ) in all samples

ANALYTICAL COMMENTS:

This 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.)

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

October 24, 1994

Subject:	Commencement Bay
Samples:	94 - 228532 to -228537
Case No.	DOE-118X
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

TRIBUTYL TINS

ANALYTICAL METHODS:

The samples were extracted following the methods given in Puget Sound Estuary Program (PSEP) "Recommended Guidelines for Measuring Organic Compounds in Puget Sound Sediment and Tissue Samples" Recommended Methods for Organotin Compounds. The samples were Soxhlet extracted using acetone and tropolone, 0.2% by weight, solvent exchanged to hexane and dried using sodium sulfate. The organotin compounds were hexylated using the Grignard reaction given in Krone et al (1989) including the silica gel/alumina cleanup. Analysis was done by capillary Gas Chromatography using Single Ion Monitoring (SIM) mode GC/MS. All samples are reported on a dry weight basis.

HOLDING TIMES:

The samples were stored frozen following PSEP Guidelines until extraction. After extraction all samples were analyzed within the recommended 40 day extract time.

BLANKS:

No target analytes were detected in the laboratory blanks.

SURROGATES:

Recovery of the surrogate spike, Tripropyltin, ranged from 28% to 156% except for sample -228534 LMX2 which was 235%. Most of the recoveries were greater than 100% due to chromatographic interference with the quantitation ion. The "J" qualifier was added to sample results in those samples where the surrogate recovery was over 150%. No surrogate recovery QC limits have been established for this method.

MATRIX SPIKE AND MATRIX SPIKE :

Both the matrix spike and spike duplicate had significant chromatographic interference. Consequently recoveries for only tetrabutyltin and monobutyltin are reported. Recoveries of the other analytes in the matrix spikes could not be determined due to chromatographic interference which gave high (>200%) recoveries. No spike recovery QC limits have been established for Organotins at this time. The Relative Percent Differences (RPD) for tetrabutyltin was 1.1% and monobutyltin, 9.4%.

ANALYTICAL COMMENTS:

The samples were analyzed at a higher concentration, which is reflected in the lower quantitation limits. Consequently most of the samples had to be diluted and reanalyzed to bring the organotin concentrations within the linear calibration range. The results for the diluted samples were generally within about 10% of the result from the undiluted sample. One sample -228536 was not diluted and consequently an "E" flag was added to indicate that it was outside the calibration curve. Based on the dilution results from the other samples it is probably still within 10% of the diluted "true" value.

The principle analytical problems encountered were directly related to the chromatographic interferences in some of the samples. This was a problem with tributyltin and dibutyltin in the matrix spikes. Analysis of diluted sample extracts also had interference problems.

Two additional samples were analyzed with the sediment samples. This was a Sequim Bay Reference Sediment which presumably was spiked with 100 ng/gm (100ug/Kg) wet weight of tributyltin. No value for tributyltin has been established for the Sequim Bay Reference Sediment so the accuracy of the analysis cannot be determined. These samples are identified as -228598 (SRM) and -228599 (SRM2).

SRM	85.8	ug/Kg (wet weight)	Tributyltin
SRM2	120	ug/Kg (wet weight)	Tributyltin

Note that the data sheets report these values as dry weight. The percent solids is 58% for 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.)

Hylebos Volatils

Particulates
5-11/94

Manchester Environmental Laboratory

7411 Beach Dr E, Port Orchard Washington 98366

CASE NARRATIVE

March 6, 1995

Subject:	Commencement Bay sediments-51
Samples:	94518195 - 518209
Case No.	170494
Officer:	Dale Norton
By:	Greg Perez Organics Analysis Unit

VOLATILE ORGANIC ANALYSIS

SUMMARY:

Carryover from a previous sample affected the results for sample 518203. The sample was reanalyzed. Both results have been reported, however the duplicate more accurately represents the character of the sample.

ANALYTICAL METHODS:

Volatile organic compounds were analyzed using Manchester modification of the EPA SW 846 Method 8260 purge-trap procedure with capillary GC/MS analysis. Normal 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. If the concentrations of the compounds in the sample are greater than or equal to five times the concentrations of the compounds in the associated method blank, they are considered native to the sample.

SURROGATES:

Surrogate recoveries were within acceptable limits for the sediment samples.

HOLDING TIMES:

The sediment samples were analyzed within the recommended 14 day holding time.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Sediment matrix spikes were within acceptable QC limits for both percent recovery and Relative Percent Differences (RPD).

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.

bold - 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 24, 1995

Subject:	Commencement Bay Sediment Traps - 51
Samples:	94 - 518136, -518137, -518144, -518147, -518150, -518157, -518164, -518173, -518180, -518188, -518195, -518202 and -518209.
Case No.	1704 - 94
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

SEMIVOLATILE ORGANICS

ANALYTICAL METHODS:

The semivolatile soil samples were extracted with acetone following the Manchester modification of the EPA CLP and SW 846 8270 procedure. The sample extracts were cleaned up with Gel Permeation Chromatography followed by silica gel chromatography. Analysis was by capillary GC/MS. Normal QA/QC procedures were performed with the analyses.

HOLDING TIMES:

All sample and extraction holding times were within the recommended limits except for sample -518202. No surrogates were added in the original extraction of sample -518202 and the sample was re-extracted after the recommended fourteen day holding time. All results for sample -518202 were given the "J" qualifier.

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 Manchester Laboratory surrogates were added to the sample prior to extraction. All surrogate recoveries were within acceptable limits except for blank, BLNK5652 (BS5039) associated with the re-extraction of sample -518202. BLNK5652 apparently was not spiked with surrogates. No recoveries are available and the "J" data qualifier was added to all results for this sample.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spike recoveries were low for hexchloroethane, 1,3 and 1,2-dichlorobenzene, 2,4-dinitrophenol, 4-nitroaniline 4,6-dinitro-2-methylphenol. The "J" qualifier was added to the results for sample -518188 these compounds. The following compounds, hexachlorocylcopentadiene, 3 and, 4-chloroaniline, and 4-nitrophenol had zero percent recovery in the matrix spikes and were qualified as rejected, "REJ" in the matrix spike source sample, -518188.

ANALYTICAL COMMENTS:

No other analytical problems were encountered in the semivolatile analyses. 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 X 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.

bold - 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

January 28, 1995

Subject:	Commencement Bay Sediments -51
Samples:	94 - 518164, -518173, -518180, -518181, -518188, -518195, and -518202
Case No:	1704-94
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

POLYCHLORINATED BIPHENYLS

ANALYTICAL METHODS:

The soil 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:

All extraction and analysis holding times were met.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

Surrogates recoveries for the samples ranged from 57% to 145% and were within the acceptable limits.

MATRIX SPIKE AND MATRIX SPIKE :

Matrix spike recoveries ranged from 11% to 121%. The Relative Percent Differences (RPD) for the PCB-1242 was 3.4%. Recovery of PCB-1260 was good, 86% in one sample (LMX1) but only 11% in the other sample (LMX2). This could be due to the high native PCB-1260 present in the sample interfering. No qualifiers were added because of matrix spike recoveries.

ANALYTICAL COMMENTS:

There were no significant problems with the PCB analysis and the data is acceptable as qualified. samples labeled HS-24828 and HS-24829 are Canadian Reference Material 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 X 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

April 6, 1995

Subject:	Commencement Bay Sediments Traps - 51
Samples:	94 - 518136 , -518137, -518144, -518147, -518150, -518157, -518164, -518173, -518180, -518188, -518195, -518202, and -518209.
Case No.	1704 - 94
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

TRIBUTYL TINS

ANALYTICAL METHODS:

The samples were extracted following the methods given in Puget Sound Estuary Program (PSEP) "Recommended Guidelines for Measuring Organic Compounds in Puget Sound Sediment and Tissue Samples" Recommended Methods for Organotin Compounds. The samples were Soxhlet extracted using acetone and tropolone, 0.2% by weight, solvent exchanged to hexane and dried using sodium sulfate. The organotin compounds were hexylated using the Grignard reaction given in Krone et al (1989) including the silica gel/alumina cleanup. Analysis was done by capillary Gas Chromatography using Single Ion Monitoring (SIM) mode GC/MS. All samples are reported on a dry weight basis.

HOLDING TIMES:

The samples were extracted within the recommended fourteen day holding time. After extraction all samples were analyzed within the recommended 40 day extract holding time.

BLANKS:

No tributyltin was detected in the laboratory blanks.

SURROGATES:

Recovery of the surrogate spike, Tripropyltin, ranged from 55% to 166% except for two samples, -518209 and SQ5012 which had 259% and 199% respectively. Data for both these samples was "J" qualified due to the high surrogate recoveries. No surrogate recovery QC limits have been established for this method.

MATRIX SPIKE AND MATRIX SPIKE :

Both the matrix spike and spike duplicate had significant native compound interference. Recoveries ranged from 81% to 156% except for a high recovery, 310%, of dibutyltin chloride in LMX1. The compound interferences for tributyltin chloride in LMX2 resulted in very high recoveries and consequently there is No Analytical Result (NAR) reported for this sample. The Relative Percent Differences (RPD) ranged from 13.7% to 31.7% for tetrabutyl and monobutyltin. No percent recovery or RPD limits have been established for this method.

ANALYTICAL COMMENTS:

The samples were analyzed at a higher concentration, which is reflected in the lower quantitation limits. Consequently most of the samples had to be diluted and reanalyzed to bring the organotin concentrations within the linear calibration range. The "E" flag was given to tributyltin in two samples. -518150 and -518180, since even after dilution the concentration was just above the calibration curve.

The principle analytical problems encountered were directly related to the chromatographic interference's in some of the samples. This was a problem with tributyltin and dibutyltin in the matrix spikes

Two additional samples were analyzed with the sediment samples. These were Sequim Bay Reference Sediments which presumably were spiked with 100 ng/gm (100 ug/Kg) wet weight of tributyltin. No value for tributyltin has been established for the Sequim Bay Reference Sediment so the accuracy of the analysis cannot be determined. These samples are identified as SQ5012 and SQ5012D

SQ5012	108	ug/Kg (wet weight)	Tributyltin
SQ5012D	95.4	ug/Kg (wet weight)	Tributyltin

Note that the data sheets report these values as dry weight. The percent solids is 60.4% for 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 X 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.

bold - The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

CN_CBAY9.DOC

Hylebos Bottom Sediments 12/94

Manchester Environmental Laboratory

7411 Beach Dr E, Port Orchard Washington 98366

CASE NARRATIVE

February 15, 1995

Subject:	Commencement Bay sediments-49
Samples:	94498187 - 190
Case No.	160894
Officer:	Dale Norton
By:	Greg Perez Organics Analysis Unit

VOLATILE ORGANIC ANALYSIS

SUMMARY:

No difficulties were encountered in the analysis of these samples. The data is usable as qualified.

ANALYTICAL METHODS:

Volatile organic compounds were analyzed using Manchester modification of the EPA SW 846 Method 8260 purge-trap procedure with capillary GC/MS analysis. Normal 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. If the concentrations of the compounds in the sample are greater than or equal to five times the concentrations of the compounds in the associated method blank, they are considered native to the sample.

SURROGATES:

Surrogate recoveries were within acceptable limits for the sediment samples.

HOLDING TIMES:

The sediment samples were analyzed within the recommended 14 day holding time.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Sediment matrix spikes were within acceptable QC limits for both percent recovery and Relative Percent Differences (RPD).

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 X 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.

bold - The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

Bottom Sediment
11/94

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

January 27, 1995

Subject:	Commencement Bay Sediments
Samples:	94 - 498180, -498181, -498184 to -498188, and -498191 to-498198
Case No.	1608-94
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 SW 846 8270 procedure with capillary GC/MS analysis of the sample extracts. Normal QA/QC procedures were performed with the analyses.

HOLDING TIMES:

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

BLANKS:

A number of 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.

The target compounds detected in the lab blanks may be due to carryover in the automated Gel Permeation Chromatography (GPC) unit. Procedures have been implemented to reduce this problem in the future.

SURROGATES:

The normal surrogates compounds were added to the sample prior to extraction. All surrogate recoveries were within acceptable limits, except for the two laboratory blanks which had double the expected recovery. This probably due to these samples being double spiked with surrogate compounds. No qualifiers were added due to the high recoveries.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spikes were extracted with these samples Recoveries were acceptable with the exception of the following compounds 1,3-dichlorobenzene, hexachloroethane, 4-chloroaniline, hexachlorocyclopentadiene, 3 and 4-nitroaniline, and di-n-butylphthalate. The "J" qualifier was added to the results for these compounds in the matrix spike source sample, -498192.

ANALYTICAL COMMENTS:

There were no other problems with the analysis and 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 X 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.

bold - The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

H-11 Semi Vol

Bottom Sediment
12/94

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

March 3, 1995

Subject:	Commencement Bay Sediments
Samples:	94 -498190
Case No.	1608-94
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

SEMIVOLATILE ORGANICS

ANALYTICAL METHODS:

This sample was inadvertently left off the request for analysis. Consequently it was not analyzed with the other semivolatile samples. The project officer requested that it be analyzed if possible, despite the fact that the fourteen day holding time was exceeded. The semivolatile soil samples were Soxhlet extracted with acetone following the Manchester modification of the EPA SW 846 8270 procedure with capillary GC/MS analysis of the sample extracts. Normal QA/QC procedures were performed with the analyses except for matrix spikes.

HOLDING TIMES:

The sample was extracted after the recommended fourteen day holding time. All sample results were qualified by adding "J". Extract holding times were within recommended limits.

BLANKS:

One blank was analyzed with the sample. Several target compounds were detected in the laboratory blank. 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 surrogates compounds were added to the sample prior to extraction. All surrogate recoveries were within acceptable limits.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

No matrix spikes were extracted with these samples.

ANALYTICAL COMMENTS:

There were no problems other than the holding time which resulted in all of the data being "J" 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 X 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.

bold - The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

Bottom Sediment
12/94

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

January 28, 1995

Subject:	Commencement Bay Sediments -49
Samples:	94 - 498180, -498181, -498184 to -498188, and -498190
Case No:	1608-94
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

POLYCHLORINATED BIPHENYLS

ANALYTICAL METHODS:

The soil 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:

All extraction and analysis holding times were met.

BLANKS:

No target compounds were detected in the laboratory blanks.

SURROGATES:

Surrogates recoveries for the samples ranged from 59% to 151% and were within the acceptable limits.

MATRIX SPIKE AND MATRIX SPIKE :

Matrix spike recoveries ranged from 67% to 82% and were within acceptable limits. The Relative Percent Differences (RPD) ranged from 7.7% to 20%.

ANALYTICAL COMMENTS:

ANALYTICAL COMMENTS:

There were no significant problems with the PCB analysis and the data is acceptable as qualified. No Canadian sediment reference materials were analyzed with this sample set.

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 X 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 31, 1995

Subject: Commencement Bay Sediments - 49

Samples: 94 - 498180, -498181, -498184 to -498188, -498190, -498194 to -498198

Case No. 1608-94

Officer: Dale Norton

By: Dickey D. Huntamer
Organics Analysis Unit

TRIBUTYL TINS

ANALYTICAL METHODS:

The samples were extracted following the methods given in Puget Sound Estuary Program (PSEP) "Recommended Guidelines for Measuring Organic Compounds in Puget Sound Sediment and Tissue Samples" Recommended Methods for Organotin Compounds. The samples were Soxhlet extracted using acetone and tropolone, 0.2% by weight, solvent exchanged to hexane and dried using sodium sulfate. The organotin compounds were hexylated using the Grignard reaction given in Krone et al (1989) including the silica gel/alumina cleanup. Analysis was done by capillary Gas Chromatography using Single Ion Monitoring (SIM) mode GC/MS. All samples are reported on a dry weight basis.

HOLDING TIMES:

The samples were extracted within the recommended fourteen day holding time. After extraction all samples were analyzed within the recommended 40 day extract holding time.

BLANKS:

A small amount of tributyltin was detected in the duplicate laboratory blank, BLNK5608. No tributyltin was detected in the first blank, BLNK5607. 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:

Recovery of the surrogate spike, Tripropyltin, ranged from 30% to 106%. The "J" qualifier was added to the results for samples -498184, -498197 and SQ4348 because the surrogate recoveries were less than 50%. No surrogate recovery QC limits have been established for this method.

MATRIX SPIKE AND MATRIX SPIKE :

Both the matrix spike and spike duplicate had significant native compound interference. Recoveries ranged from 20% to 109%. The Relative Percent Differences (RPD) ranged from 5.4% to 95%. No percent recovery or RPD limits have been established for this method.

ANALYTICAL COMMENTS:

The samples were analyzed at a higher concentration which is reflected in the lower quantitation limits. Consequently most of the samples had to be diluted and reanalyzed to bring the organotin concentrations within the linear calibration range.

The principle analytical problems encountered were directly related to the chromatographic interference's in some of the samples. This was a problem with tributyltin and dibutyltin in the matrix spikes

Two additional samples were analyzed with the sediment samples. These were Sequim Bay Reference Sediments which presumably were spiked with 100 ng/gm (100 ug/Kg) wet weight of tributyltin. No value for tributyltin has been established for the Sequim Bay Reference Sediment so the accuracy of the analysis cannot be determined. These samples are identified as SQ4348 and SQ4348D

SQ4348	75.3	ug/Kg (wet weight)	Tributyltin
SQ4348D	61.9	ug/Kg (wet weight)	Tributyltin

Note that the data sheets report these values as dry weight. The percent solids is 58.4% for 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 X 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.

bold - The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

Particulate,
11/94 - 6/95

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

August 28, 1995

Subject: Commencement Bay

Samples: 95 - 248762

Case No. 1942 - 95

Officer: Dale Norton

By: Dickey D. Huntamer
Organics Analysis Unit

VOLATILE ORGANIC ANALYSIS

ANALYTICAL METHODS:

Volatile organic compounds were analyzed using Manchester modification of the EPA SW 846 Method 8260 purge-trap procedure with capillary GC/MS analysis. Normal 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 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:

Surrogate recoveries were within acceptable limits for sediment samples.

HOLDING TIMES:

The samples were analyzed within the recommended 14 day holding time.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spikes were within acceptable QC limits for both percent recovery and RPD except for acetone, 2-butanone, bromodichloromethane, cis and trans-1,3-dichloropropene, dibromochloromethane, bromoform, and 1,2,4--trichlorobenzene. The "J" qualifier was added to the sample results for these compounds. Hexachlorobutadiene, naphthalene p-isopropyltoluene and 1,2,3-trichlorobenzene were outside acceptable limits due to high native amounts interfering. No qualifiers were added to these compound results.

ANALYTICAL COMMENTS:

There were problems with the blanks due to carry over. A continuing check standard was analyzed just prior to the laboratory blank, KBS5178. Numerous compounds were detected in the blank. Normally two blanks are run after a standard and the first one is discarded. Due to holding times and the length of the sample analyses run the second blank was not analyzed. A follow-up blank was done after the samples and it also showed considerable contamination. The EPA five times rule was applied to the sample data in those situations where target compounds were detected in both the sample and blank. This resulted in higher than normal quantitation limits for some compounds and the possibility of not detecting some compounds which may have been present.

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 <u>estimate</u>.
UJ	-	The analyte was not detected at or above the reported estimated result.
REJ	-	The data are <u>unusable</u> 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 X 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.
bold	-	The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

CN_CBY10.DOC

Particulates
11/94 - 6/95

Manchester Environmental Laboratory

7411 Beach Dr E,
Port Orchard Washington 98366
October 2, 1995

Project: **Commencement Bay**

Samples: 95248706, 248707, 248710, 248717, 248727, 248734, 248743, 248750, 248762, 248773, 248774, 248786

By: Karin Feddersen KF

These samples were analyzed for Semivolatiles (BNA's) by Puget Sound Estuary Program (PSEP) protocols.

Holding Times:

The samples were extracted and analyzed within PSEP holding times.

Method Blanks:

Many target analytes were detected in the method blanks. When these analytes were also detected in the samples at less than five (5) times the on-column amount detected in the method blanks, the results were qualified with a "U". In these instances, these analytes are most likely present due to laboratory contamination and not native to the sample.

When these analytes were detected in the samples at greater than 5 times the method blank, no corrective action was required. The amount of laboratory contamination contributing to the results is not significant.

GC/MS Tuning and Calibration:

Calibration against Decafluorotriphenylphosphine (DFTPP) is acceptable for the initial calibration, continuing calibrations and all associated sample analyses.

Initial Calibration:

The initial calibration met the minimum response criteria for the average relative responses. The % Relative Standard Deviations were within the maximum of 30% with two exceptions which do not affect the results.

Continuing Calibration:

The average relative response factors for all target analytes were above the minimums, and the percent deviations between the initial and continuing calibration standards were within the maximum of 25% with two notable exceptions on September 7, Benzidine and 3,3-Dichorobenzidine. These analytes were not detected in any of the samples. All results for these two analytes have been qualified with a "UJ" in the corresponding samples.

Matrix Spikes (MS/MSD):

Matrix spike recovery and precision data are reasonable, acceptable, and within QC limits with several exceptions. Results for these analytes in the samples may be biased low. This condition is typical due to the extensive cleanup procedures performed on these samples. The most volatile compounds exhibited 0% recovery.

Therefore, analytes with recoveries below 50%, when detected, have been qualified with a "J", and non-detected analytes been qualified with a "UJ". Analytes with both spike recoveries below 20% have been qualified "REJ" when not detected in the samples.

Surrogates:

All surrogate recoveries were within QC limits with two exceptions. Recovery of 2-Fluorophenol was slightly below the QC limit of 25% in sample HS65213 (19.2%) and HS65213D (24.5%). Some analytes may have been affected in the same manner as the surrogates. However, the detection limits for these analytes are low enough that they would still be visible to the detector. No qualification of the results is necessary for this condition.

Sample Results:

This data is acceptable for use as amended.

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.

Particulates
11/94 - 6/95

Manchester Environmental Laboratory

7411 Beach Dr E
Port Orchard Washington 98366
September 25, 1995

Project: **Commencement Bay**

Samples: 248734, 248743, 248750, 248751, 248762

By: Karin Feddersen KF

These samples were analyzed by EPA Method 8080 for Polychlorinated Biphenyls (PCBs) employing the dual column confirmation technique.

Holding Times:

These samples were extracted six days past the method holding time of fourteen days. PCBs are extremely stable. Therefore, extraction beyond the holding time should not affect the results. The samples were analyzed within the method holding time of forty days from extraction.

Method Blanks:

No analytes of interest were detected in the method blanks.

Initial Calibration:

The % Relative Standard Deviations were within the maximum of 30% for all target analytes.

Continuing Calibration:

The Percent Differences between the initial and continuing calibrations were within the maximum of 25% for all target analytes.

Surrogates:

Four surrogates were added to each sample. The recommended range for surrogate recovery is between 60% and 150%. Dibutylchlorendate (DBC) recoveries were low in most of the samples. An acid cleanup was performed on these samples. DBC is very susceptible to degradation by acid. Since PCBs are not susceptible to acid degradation, and because the other surrogates demonstrated acceptable recoveries, qualification of the results is not required.

4,4-Dibrooctafluorobiphenyl was low in sample 95248750. Decachlorobiphenyl and Tetrachloro-m-xylene recoveries were acceptable. No qualification of the data was warranted.

Matrix Spikes (MS/MSD):

All matrix spike recoveries were between 75% and 110%. These recoveries are reasonable and acceptable.

Sample Results:

When the RPD between the two columns was greater than 30% for an analyte, the result was qualified with a "J".

This data is acceptable for use with the qualifications mentioned.

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.

NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.

NAF - Not analyzed for.

REJ - The data are unusable for all purposes.

Particulates
11/94 - 6/95

Manchester Environmental Laboratory

7411 Beach Dr. E
Port Orchard Washington 98366
October 11, 1995

Project: **Commencement Bay**

Samples: 248706, 248710, 248717, 248720, 248727

By: Karin Feddersen KF

These samples were analyzed according to Puget Sound Estuary Program (PSEP) protocol for Polychlorinated Biphenyls (PCBs) employing the dual column confirmation technique.

Holding Times:

These samples were extracted within the PSEP holding time. The samples were analyzed twenty-one days past the method holding time of forty days from extraction. PCBs are extremely stable. Therefore, analysis beyond the holding time should not affect the results.

Method Blanks:

No analytes of interest were detected in the method blank.

Initial Calibration:

The % Relative Standard Deviations were within the maximum of 30% for all target analytes.

Continuing Calibration:

The Percent Differences between the initial and continuing calibrations were within the maximum of 25% for all target analytes.

Surrogates:

There was insufficient sample to perform a separate extraction for PCBs on these samples. Therefore, the BNA extracts were analyzed for PCBs, and only the surrogates normally added for BNA analysis are present in these extracts. The results for the surrogates normally added to extracts for PCB analysis have been qualified "NAF".

One BNA surrogate, 2-Fluorobiphenyl (FBP), is chemically similar to PCBs, and its recovery was therefore evaluated for each sample. The EPA method 8270 (BNA) QC limits for FBP recovery are 30% to 115%. No limits have been established for this surrogate's use in the PCB method. FBP recoveries for these samples ranged from 41% to 53%. These recoveries are acceptable, although lower than those reported for the BNA analyses of these samples. The differences in surrogate recovery can be most likely explained by differences in the two methods used, and are not due to loss of sample material in any way.

These recoveries are acceptable and within expected parameters, and no qualification of the results is necessary.

Sample Results:

This data is acceptable for use as reported.

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.

NJ - There is evidence that the analyte is present. The associated numerical result is an estimate.

NAF - Not analyzed for.

REJ - The data are unusable for all purposes.

Particulates
11/94 - 6/95

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

November 3, 1995

Subject:	Commencement Bay
Samples:	95 - 248706, -248707, -248710, -248717, -248720, -248727, -248734, -248743, -248750 and -248762
Case No.	1942 -95
Officer:	Dale Norton
By:	Dickey D. Huntamer Organics Analysis Unit

TRIBUTYL TINS

ANALYTICAL METHODS:

The samples were extracted following the methods given in Puget Sound Estuary Program (PSEP) "Recommended Guidelines for Measuring Organic Compounds in Puget Sound Sediment and Tissue Samples" Recommended Methods for Organotin Compounds. The samples were Soxhlet extracted with acetone and tropolone, 0.2% by weight, solvent exchanged to hexane and dried using sodium sulfate. The organotin compounds were hexylated using the Grignard reaction given in Krone et al (1989) including the silica gel/alumina cleanup. Analysis was done by capillary Gas Chromatography using Single Ion Monitoring (SIM) mode GC/MS. Verification screening to check for interference's was done using Atomic Emission Spectroscopy. All samples are reported on a dry weight basis.

HOLDING TIMES:

The samples were stored frozen following PSEP Guidelines until extraction. After extraction all samples were analyzed within the recommended 40 day extract time.

BLANKS:

No target compounds were detected in the laboratory blank.

SURROGATES:

Recovery of the surrogate spike, Tripropyltin, ranged from 54% to 150%. Some of the recoveries were greater than 100% due to chromatographic interference with the quantitation ion. No surrogate recovery QC limits have been established for this method.

MATRIX SPIKE AND MATRIX SPIKE :

The matrix caused some interference problems with determining the organotin recoveries. A quick screen was made using the atomic emission detector (AED) and organotin recoveries reported were based on the analyses.

ANALYTICAL COMMENTS:

Some samples had chromatographic interference's with the organotin peaks, particularly monobutyl tin. The samples were screened on the AED to confirm whether organotins were present.

Internal standard area counts fell below the +/-50% limits for several samples. The "J" qualifier was added to the data results for those samples. Generally results from the samples with low area counts was comparable to the results from the dilution analyses indicating that there was little effect on the quantitation.

Two additional samples were analyzed with the sediment samples. This was a Sequim Bay Reference Sediment which presumably was spiked with 100 ng/gm (100 ug/Kg) wet weight of tributyltin. No value for tributyltin has been established for the Sequim Bay Reference Sediment so the accuracy of the analysis cannot be determined. These samples are identified as SBR53598 and SBR53599.

SBR53598	67	ug/Kg (wet weight)	Tributyltin
SBR53599	57	ug/Kg (wet weight)	Tributyltin

Note that the data sheets report these values as dry weight. The percent solids is 61.2% for 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 <u>estimate</u>.
UJ	-	The analyte was not detected at or above the reported estimated result.
REJ	-	The data are <u>unusable</u> 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 X 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.
bold	-	The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

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Appendix C

Physical/Chemical Analysis of Settling Particulate Matter (Dry Weight)

June 1991 to June 1995

Hylebos Waterway

Table C1: Conventionals and Metals Analysis
Table C2: Volatiles Analysis
Table C3: Semivolatiles and PCB Analysis
Table C4: Butyltins Analysis
Table C5: Sediment Accumulation Rates

Sitcum Waterway

Table C6: Conventionals and Metals Analysis
Table C7: Semivolatiles Analysis
Table C8: Sediment Accumulation Rates

Thea Foss Waterway

Table C9: Conventionals and Metals Analysis
Table C10: Semivolatiles and Butyltins Analysis
Table C11: PCB Analysis
Table C12: Sediment Accumulation Rates

Hylebos Waterway

Table C1: Results of Conventionals and Metals Analysis of Settling Particulate Matter from Hylebos Waterway, December 1991 to June 1995 (mg/kg, dry weight).

Location	Upper Turning Basin													
Station No.	H-1													
Collection Period	12/91–2/92	2/92–5/92	5/92–8/92	8/92–11/92	11/92–2/93	2/93–5/93	7/93–9/93	9/93–12/93	12/93–3/94	3/94–5/94	5/94–8/94	8/94–11/94	11/94–3/95	3/95–6/95
Solids (%)	43	–	–	30	46	40	39	–	42	30	34	37	45	28
TOC (%)	6.0	–	–	–	8.5	7.5	7.1	–	5.1	7.1	6.3	5.2	4.4	5.6
Metals														
Antimony	16	–	–	14	35	11	11	–	na	na	na	na	na	na
Arsenic	91	–	–	130	100	90	87	–	59	74	54	45	34	44
Cadmium	0.9j	–	–	1.3	0.88	0.93	1.7	–	na	na	na	na	na	na
Copper	120	–	–	170 j	130	130	170	–	140	160	130	130	80	130
Mercury	0.61 j	–	–	0.28 j	0.29	0.37	0.38	–	na	na	0.43	0.36	0.32	0.39
Lead	75	–	–	87	80	70	78	–	66	69	55	50	35	49
Nickel	40	–	–	48	45	51	39	–	49	38	na	na	na	na
Zinc	220	–	–	520	270	280	310	–	250	310	250	260	150	220

Location	@ General Metals													
Station No.	H-2													
Collection Period	12/91–2/92	2/92–5/92	5/92–8/92	8/92–11/92	11/92–2/93	2/93–5/93	7/93–9/93	9/93 12/93	12/93–3/94	3/94–5/94	5/94–8/94	8/94–11/94	11/94–3/95	3/95–6/95
Solids (%)	–	42	41	45	68	45	41	44	43	34	37	37	37	33
TOC (%)	–	4.6	5.5	5.5	2.8	4.2	5.0	4.6	4.5	5.1	4.8	5.0	4.7	4.9
Metals														
Antimony	–	11	11	12	7.4	30	7.1	11	na	na	na	na	na	na
Arsenic	–	81	81	85	30	98	69	68	61	67	42	41	43	45
Cadmium	–	1.3	1.6	1.6	0.51	1.2	1.4	1.5	na	na	na	na	na	na
Copper	–	160 j	170 j	180 j	71	160	170	170	160	170	130	140	130	120
Mercury	–	0.6 j	0.54 j	0.54 j	0.27	0.7	0.48	0.5	na	na	0.53	0.55	0.50	0.48
Lead	–	110	100	110	49	100	100	100	93	91	73	71	75	68
Nickel	–	47	46	45	42	52	41	45	47	46	na	na	na	na
Zinc	–	300	300	300	190	310	270	290	270	300	240	240	230	210

j=Estimated concentration
na=Not analyzed
–=No sample

Table C1(cont): Results of Conventionals and Metals Analysis of Settling Particulate Matter from Hylebos Waterway, December, 1991 to June, 1995 (mg/kg, dry weight).

Location	@ Elf Atochem													
Station No.	H-3													
Collection Period	12/91–2/92	2/92–5/92	5/92–8/92	8/92 11/92	11/92–2/93	2/93–5/93	7/93–9/93	9/93–12/93	12/93–3/94	3/94–5/94	5/94–8/94	8/94–11/94	11/94–3/95	3/95–6/95
Solids (%)	49	44	47	49	51	48	–	50	46	38	36	40	42	37
TOC (%)	3.5	4.3	5.3	4.8	4.0	3.6	–	4.2	4.4	5.2	5.0	4.2	4.6	5.4
Metals														
Antimony	15	12	12	11	17	18	–	10	na	na	na	na	na	na
Arsenic	80	79	80	79	70	71	–	49	65	68	45	40	46	47
Cadmium	1.1 j	0.97	1.3	1.2	0.95	0.93	–	1.2	na	na	na	na	na	na
Copper	160	160	160 j	170 j	150	130	–	160	150	150	130	130	130	120
Mercury	0.79 j	0.59 j	0.58 j	0.61 j	0.55	0.93	–	0.48	na	na	na	na	0.64	0.47
Lead	110	110	110	110	100	93	–	95	94	88	72	68	71	67
Nickel	46	48	45	47	53	50	–	45	45	36	na	na	na	na
Zinc	230	230	260	250	220	230	–	230	220	230	190	180	170	170

Location	Near Lincoln Drain													
Station No.	H-4													
Collection Period	12/91–2/92	2/92–5/92	5/92–8/92	8/92–11/92	11/92–2/93	2/93–5/93	7/93–9/93	9/93–12/93	12/93–3/94	3/94–5/94	5/94–8/94	8/94–11/94	11/94–3/95	3/95–6/95
Solids (%)	–	–	48	51	44	47	na	na	51	40	39	43	na	na
TOC (%)	–	–	4.5	4.3	4.0	3.6	na	na	3.7	3.7	4.0	3.6	na	na
Metals														
Antimony	–	–	8.4	8.2	9.5	9.7	na	na	na	na	na	na	na	na
Arsenic	–	–	55	50	60	55	na	na	38	130	30	27	na	na
Cadmium	–	–	1.1	0.99	0.8	0.72	na	na	na	na	na	na	na	na
Copper	–	–	160 j	150 j	150	150	na	na	150	130	120	120	na	na
Mercury	–	–	0.43 j	0.41 j	0.46	0.49	na	na	na	na	na	na	na	na
Lead	–	–	95	93	96	88	na	na	76	71	61	58	na	na
Nickel	–	–	40	40	48	44	na	na	34	33	na	na	na	na
Zinc	–	–	230	200	200	200	na	na	170	180	150	130	na	na

j=Estimated concentration

–=No sample

na=Not analyzed

Table C1(cont): Results of Conventionals and Metals Analysis of Settling Particulate Matter from Hylebos Waterway, December, 1991 to June, 1995 (mg/kg, dry weight).

Location	Near Cenex													
Station No.	H–5													
Collection Period	12/91–2/92	2/92–5/92	5/92–8/92	8/92–11/92	11/92–2/93	2/93–5/93	7/93–9/93	9/93–12/93	12/93–3/94	3/94–5/94	5/94–8/94	8/94–11/94	11/94–3/95	3/95–6/95
Solids (%)	50	–	50	53	–	–	na	na	49	41	42	43	na	na
TOC (%)	3.4	–	4.5	4.5	–	–	na	na	4.4	4.0	3.9	4.2	na	na
Metals														
Antimony	11	–	10	8.8	–	–	na	na	na	na	na	na	na	na
Arsenic	52	–	46	50	–	–	na	na	39	35	26	26	na	na
Cadmium	0.7 j	–	0.95	1.0	–	–	na	na	na	na	na	na	na	na
Copper	140	–	150 j	150 j	–	–	na	na	140	120	110	110	na	na
Mercury	0.51 j	–	0.38 j	0.41 j	–	–	na	na	na	na	na	na	na	na
Lead	92	–	97	100	–	–	na	na	81	74	61	60	na	na
Nickel	39	–	40	38	–	–	na	na	34	31	na	na	na	na
Zinc	170	–	200	200	–	–	na	na	170	160	120	120	na	na

Location	@ Occidental Chemical													
Station No.	H–6													
Collection Period	12/91–2/92	2/92–5/92	5/92–8/92	8/92–11/92	11/92–2/93	2/93–5/93	7/93–9/93	9/93–12/93	12/93–3/94	3/94–5/94	5/94–8/94	8/94–11/94	11/94–3/95	3/95–6/95
Solids (%)	49	49	48	52	52	39	49	48	52	38	41	45	–	–
TOC (%)	2.5	2.7	3.6	3.3	2.9	–	3.0	3.2	2.3	3.2	2.6	3.0	–	–
Metals														
Antimony	43	5.1	3.2	3.5	4.8	3.5	2.7	4.0	na	na	na	na	na	na
Arsenic	29	33	29	29	40	27	24	27	22	21	16	16	–	–
Cadmium	0.6 j	0.66	0.77	0.67	0.55	0.38	0.72	0.5	na	na	na	na	na	na
Copper	110	120	130 j	120 j	130	120	110	120	120	110	90	93	–	–
Mercury	0.27 j	0.35 j	0.35 j	0.3 j	0.36	0.41	0.26	0.26	na	na	0.23	0.24	–	–
Lead	130	120	170	110	250	100	93	110	110	82	100	64	–	–
Nickel	34	38	38	34	47	36	28	31	31	30	na	na	na	na
Zinc	140	150	170	150	160	140	150	170	140	140	100	93	–	–

j=Estimated concentration

–=No sample

na=Not analyzed

Table C1(cont): Results of Conventionals and Metals Analysis of Settling Particulate Matter from Hylebos Waterway, December, 1991 to June, 1995 (mg/kg, dry weight).

Location	Mouth													
Station No.	H-7													
Collection Period	12/91–2/92	2/92–5/92	5/92–8/92	8/92–11/92	11/92–2/93	2/93–5/93	7/93–9/93	9/93–12/93	12/93–3/94	3/94–5/94	5/94–8/94	8/94–11/94	11/94–3/95	3/95–6/95
Solids (%)	55	53	56	60	60	53	54	55	58	41	53	56	53	–
TOC (%)	2.0	2.3	2.7	2.5	2.2	2.4	2.2	2.4	2.1	2.3	2.2	1.9	2.0	–
Metals														
Antimony	3.2	3.3	3.5	2	2.8	2.9	11	2.5	na	na	na	na	na	na
Arsenic	19	20	18	19	23	24	17	14	19	15	9.6	10	11	–
Cadmium	0.4 j	0.41	0.64	1.8	0.38	0.38	0.41	0.38	na	na	na	na	na	na
Copper	86	82	93 j	95 j	100	95	92	94	82	87	76	70	62	–
Mercury	0.27 j	0.24 j	0.31 j	0.24 j	0.21	0.25	0.18	0.2	na	na	0.22	0.19	0.16	–
Lead	51	48	47	44	52	52	48	52	42	41	36	31	28	–
Nickel	29	28	26	28	35	38	30	27	30	24	na	na	na	na
Zinc	110	110	130	160	120	140	120	120	110	120	88	71	66	–

j=Estimated concentration

na= Not analzyed

–=No sample

Table C2: Summary of Volatile Organic Compounds Detected in Settling Particulate Matter from Hylebos Waterway, December 1991 to June 1995 (ug/kg, dry weight).

Location	Near Cenex							@ Occidental Chemical						
Station No.	H-5							H-6						
Collection	12/91–	5/92	11/92–	7/93–	12/93–	5/94–	11/94–	12/91–	5/92	11/92–	7/93–	12/93–	5/94–	11/94–
Period	5/92	11/92	5/93	12/93	5/94	11/94	6/95	5/92	11/92	5/93	12/93	5/94	11/94	6/95
TOC (%)	3.4	4.5	–	na	4.2	4.1	na	2.6	3.5	2.9	3.1	2.8	2.8	–
Chloromethane	3 j	8 u	–	na	4.1 j	6.8 u	na	2 j	8 u	12 j	12	5.2 j	27 uj	–
Trichlorofluoromethane	0.9 j	8 u	–	na	1.6 j	0.53 j	na	5 uj	8 u	2 j	3.8 uj	0.78 j	2.9 u	–
Acetone	140 uj	420 j	–	na	290 j	69 uj	na	110 uj	290 j	–	200 uj	400	63 uj	–
Vinyl Chloride	5 u	8 u	–	na	4.5 u	3.4 u	na	5 u	8 u	8 uj	3.8 u	0.42 j	1.34 uj	–
Carbon Disulfide	1 j	8 u	–	na	4.5 u	7.4	na	0.8 j	8 u	9 uj	15 uj	4.1 u	9.2 uj	–
Cis 1,2–Dichloroethene	2 j	1 j	–	na	2 j	1.6 j	na	6 j	4 j	11 j	6	8.4 j	2.7 j	–
Trans 1,2–Dichloroethene	5 u	8 u	–	na	4.5 u	3.4 u	na	0.2 j	8 u	1 j	0.6 j	1.9 j	2 uj	–
Trichloroethene	1 j	8 u	–	na	1.3 j	1.1 j	na	3 j	3 j	6 j	3.6 uj	11	1.1 j	–
Tetrachloroethene	1 j	8 u	–	na	2.5 j	1.6 j	na	16	7 j	35 j	5.3	12	3.4	–
Chloroform	1 j	8 u	–	na	4 j	2 j	na	15	7 j	57 j	4	22	3.2 uj	–
2–Hexanone	5 u	8 u	–	na	4.5 u	17 uj	na	5 u	8 u	8 uj	37 uj	3.5 j	20 uj	–
2–Butanone	55 u	100 j	–	na	170	22 j	na	66	71 j	120 uj	130 j	230	30 uj	–
4–Methyl–2–Pentanone	5 u	8 u	–	na	4.2 j	3.4 u	na	5 uj	8 u	8 uj	74 u	4.6	2.7 u	–
Toluene	5 j	8 u	–	na	1 j	1.8 j	na	1 j	8 u	3 uj	1.3 j	1.3 j	2.7 uj	–
Isopropyltoluene	140	230	–	na	170	300 j	na	14	43	38 j	74 j	170	71	–
Ethylbenzene	0.85 j	8 u	–	na	4.5 u	0.69 j	na	0.4 j	8 u	2 j	0.79 j	0.45 j	0.64 j	–
1,2,4–Trimethylbenzene	5 u	8 u	–	na	7.5 j	4.2	na	6	8 u	16 j	14	4.7	4.9	–
1,3,5–Trimethylbenzene	5 u	8 u	–	na	4.5 u	2.8 j	na	3 j	8 u	10 j	6.6	2.5 j	3.5 j	–
Total Xylenes	5 j	8 u	–	na	2.9 j	3.6 j	na	3 j	8 u	16 j	9.2 uj	3.2 j	3.4 j	–
Isopropylbenzene	5 u	8 u	–	na	4.5 u	3.4 u	na	5 u	8 u	8 uj	11	4.1 u	2.9 u	–
1,1,1–Trichloroethane	2 j	8 u	–	na	4.5 u	3.4 u	na	5 u	8 u	8 uj	3.8 u	0.8 j	2.9 u	–
Styrene	0.4 j	8 u	–	na	4.5 u	0.59 j	na	5 u	8 u	8 uj	1.4 j	0.4 uj	0.32 j	–
Carbon Tetrachloride	5 u	8 u	–	na	4.5 u	3.4 u	na	5 u	8 u	5 j	4 u	0.25 j	2.9 u	–
Methylene Chloride	5 u	8 u	–	na	4.5 u	3.2 j	na	5 u	8 u	8 uj	4 u	19	2.9 uj	–
1,4 Dichlorobenzene	5 u	8 u	–	na	4.5 u	0.53 j	na	5 u	8 u	8 uj	4 u	4.1 u	3.7 u	–
1,1,2,2–Tetrachloroethane	5 u	8 u	–	na	4.5 u	3.4 u	na	5 u	8 u	8 uj	4 u	4.1 u	2.9 u	–
1,1 Dichloroethane	5 u	8 u	–	na	4.5 u	3.4 u	na	5 u	8 u	8 uj	4 u	4.1 u	2.9 u	–
4–Chlorotoluene	5 u	8 u	–	na	4.5 u	1.4 j	na	5 u	8 u	8 uj	4 u	4.1 u	2.9 u	–
Benzene	5 u	8 u	–	na	4.5 u	0.77 j	na	5 u	8 u	8 uj	4 u	4.1 u	1.2 j	–
Chlorobenzene	5 u	8 u	–	na	4.5 u	3.4 u	na	5 u	8 u	4 j	4 u	4.1 u	2.9 u	–

–=No sample
na=Not analyzed
u=Not detected at detection limit shown

j=Estimated concentration
uj=Estimated detection limit

Table C2(cont): Summary of Volatile Organic Compounds Detected in Settling Particulate Matter from Hylebos Waterway, December 1991 to June 1995 (ug/kg, dry weight).

Location	Mouth of Waterway						
Station No.	H-7						
Collection Period	12/91– 5/92	5/92 11/92	11/92– 5/93	7/93– 12/93	12/93– 5/94	5/94– 11/94	11/94– 6/95
TOC (%)	2.2	2.6	2.3	2.3	2.2	2.1	2.0
Chloromethane	1 j	7 u	12 j	3.3 u	2.8 j	40 uj	1.8 u
Trichlorofluoromethane	4 u	7 u	16 uj	3.3 u	0.66 j	3.9 u	1.8 u
Acetone	83 uj	250 j	550 uj	200 uj	320 j	150 j	30 uj
Vinyl Chloride	4 u	7 u	20 uj	3.3 u	3.3 u	3.9 u	1.8 u
Carbon Disulfide	1 j	7 u	30 uj	17 uj	3.3 u	18	3.8 uj
Cis 1,2-Dichloroethene	1 j	1 j	15 j	1.1 j	2.4 j	1.4 j	0.41 j
Trans 1,2-Dichloroethene	4 u	7 u	96 j	0.31 j	1 j	3.9 u	1.8 j
Trichloroethene	0.8 j	7 u	23 j	3.3 uj	1.4 j	0.89 j	1.8 u
Tetrachloroethene	1 j	0.9 j	33 j	0.93 j	1.8 j	0.88 j	0.53 j
Chloroform	2 j	7 u	10 j	0.86 j	2.4 j	3.9 u	1.8 uj
2-Hexanone	4 u	7 u	20 uj	33 uj	4.7 j	20 uj	3.6 uj
2-Butanone	38 u	51 j	290 uj	67	170	47 j	10 uj
4-methyl-2-Pentanone	4 u	7 u	20 uj	67 u	3.6	3.9 u	1.8 uj
Toluene	0.6 j	7 u	15 uj	3.3 u	1.3 j	1.8 j	1.8 uj
Isopropyltoluene	45	7 u	44 j	4.9	57	53	110
Ethylbenzene	4 u	7 u	10 uj	3.3 u	0.5 j	0.47 j	1.8 uj
1,2,4-Trimethylbenzene	4 u	7 u	25 j	3.3 uj	3.1 j	2.4 j	1.9
1,3,5-Trimethylbenzene	1 j	7 u	15 j	3.3 uj	3.3 u	1.1 j	1.8 j
Total Xylenes	1.2 j	7 u	16 j	10 u	3.9 j	2.4 j	5.4 uj
Isopropylbenzene	4 u	7 u	19 uj	3.3 u	3.3 u	3.9 u	1.8 uj
1,1,1-Trichloroethane	4 u	7 u	19 uj	3.3 u	3.3 u	3.9 u	1.8 u
Styrene	4 u	7 u	19 uj	3.3 u	0.08 j	0.33 j	1.8 u
Carbon Tetrachloride	4 u	7 u	19 uj	3.3 u	3.3 u	3.9 u	1.8 u
Methylene Chloride	4 u	7 u	320 uj	3.3 u	3.3 u	3.9 uj	1.8 uj
1,4-Dichlorobenzene	0.5 j	7 u	19 uj	3.3 u	3.3 u	0.57 j	1.8 u
1,1,2,2-Tetrachloroethane	4 u	3 j	21 uj	3.3 u	3.3 u	3.9 u	1.8 u
1,1-Dichloroethane	4 u	7 u	95 uj	3.3 u	7.9	3.9 u	1.8 u
4-Chlorotoluene	4 u	7 u	19 uj	3.3 u	3.3 u	3.9 u	1.8 u
Benzene	4 u	7 u	19 uj	3.3 u	3.3 u	2.2 j	1.8 u
Chlorobenzene	4 u	7 u	19 uj	3.3 u	3.3 u	3.9 u	1.8 u

–=No sample
na=Not analyzed
u=Not detected at detection limit shown

j=Estimated concentration
uj=Estimated detection limit

Table C3: Summary of Semivolatile Organics and Polychlorinated Biphenyls Detected in Settling Particulate Matter from Hylebos Waterway, December 1991 to June 1995 (ug/kg, dry weight).

Location	Head @ Upper Turning Basin							@ General Metals							@ Elf Atochem						
Station No.	H-1							H-2							H-3						
Collection Period	12/91–5/92	5/92–11/92	1/92–5/93	7/93–12/93	12/93–5/94	5/94–11/94	11/94–6/95	12/91–5/92	5/92–11/92	11/92–5/93	7/93–12/93	12/93–5/94	5/94–11/94	11/94–6/95	12/91–5/92	5/92–11/92	11/92–5/93	7/93–12/93	12/93–5/94	5/94–11/94	11/94–6/95
TOC (%)	6.0	–	8.0	7.1	6.1	5.8	5.0	4.6	5.5	3.5	4.8	4.8	4.9	4.8	3.9	5.1	3.8	4.2	4.8	4.6	5.0
Acenaphthene	190 j	–	170	140 j	110	220 j	88 j	48 j	100 j	110	120 j	160	82 j	110 j	320 j	340	80 j	40 j	230	360	380
Acenaphthylene	230 u	–	57 j	73 j	56 j	96 j	59 j	410 u	62 j	48 uj	68 j	76 j	54 j	66 j	110 j	94 j	63 j	29 j	66	140 j	120 j
Naphthalene	53 j	–	49 j	170 u	68	160 j	190 u	85 j	130 u	84	150 j	94 j	100 j	230 u	130 j	190	100 u	140 u	120	150 j	230 u
Fluorene	240	–	290	160 j	170	220 j	110 j	410 u	120 j	120	150	220	110 j	170 j	420	350	120	77 j	270	390	710
Anthracene	280	–	540	360	310	420	240 u	380 j	380	270	390	490	330	430 u	650	720	370	240	530	710	2500
Phenanthrene	1200	–	1300	840	770	1200	670 u	750	720	670	840	1800	640	990 u	2300	1800	580	430	1500	2300	3000
Sum LPAH	2000 j	–	2400 j	1600 j	1500 j	2300 j	260 j	1300 j	1400 j	1300	1700 j	2800 j	1300 j	350 j	3900 j	3500 j	1200 j	820 j	2700 j	4100 j	6700 j
Fluoranthene	4700	–	2000	2200	1400	3200	1800	2200	1970	2000	2600	3500	1500	2300	3800	3700	2200	1900	3700	4500	4400
Benzo(a)anthracene	4000 u	–	600	880	500	1100	650 u	3700 u	810	750	1100	1400	670	910 u	1650	1400	920	640	1300	1600	1600 u
Chrysene	4600 j	–	1400	2000	110	2700	1800	4200	2600	1500	3200	3300	2000	2600	1600	3400	2100	1700	3100	3900	3500
Pyrene	2400 j	–	1100	1600	910	2600	1400	1800	1940	1800	3000	3400	1600	1900	4100	3600	2100	2200	4000	3900	3800
Benzofluoranthenes	5800 uj	–	1400	3100	1600	3800	1000 u	2900	3000	1800	4000	4000	2600	2700	940	3900	2800	2100	3300	4400	4100
Benzo(a)pyrene	1500 j	–	240	870	64 u	1000	570 u	460	800	400	1200	1200	740	990	790	1200	640	620	1000	1400	240
Dibenzo(a,h)anthracene	570 u	–	110 u	170	220	200 j	190 u	1000 u	190	100	250	260	160	240 u	300 uj	390	180	100 j	99 j	280	240
Indeno(1,2,3-cd)pyrene	230 u	–	210	600	250	700	400 u	410 u	630	300	850	870	530	690 u	460	800	440	370	690	870	830 u
Benzo(g,h,i)perylene	230 u	–	130	580	120	680	380 u	410 u	410	77 u	950	600	570	680 u	150 u	510	370	440	620	800	820
Sum HPAH	19000 j	–	7100	12000	5100	16000 j	3400	12000	12000	8700	17000	19000	10000	10000	14000	19000	12000	10000	18000	22000	17000
Total PAH	21000 j	–	9500 j	14000 j	6600 j	18000 j	3700 j	13000 j	13000 j	10000 j	19000 j	22000 j	11000 j	10000 j	18000 j	23000 j	13000 j	11000 j	21000 j	26000 j	24000 j
1-Methylnapthalene	50 j	–	93 j	na	na	–	–	410 u	57 j	40 j	na	na	–	–	96 j	150	40 j	na	na	–	–
2-Methylnaphthalene	51 j	–	90 j	170 u	120	130 j	190 u	44 j	58 j	36 j	180	80 j	79 j	280 u	92 j	160	41 j	140 u	120	170 j	290 u
Dibenzofuran	140 j	–	160	110 j	110	160 j	190 u	71 j	110 j	170 j	110 j	150	85 j	230 u	240	270	82 j	48 j	190	280	330 u
Carbazole	1200 uj	–	170	170 u	100	240 u	190 u	2100 uj	110 j	110 j	160 u	200	150 u	230 u	1100 uj	180	120	50 j	120	150 j	750
Isophrone	230 uj	–	110 u	170 u	64 u	86 j	190 u	410 u	130 u	76 u	160 u	120 u	25 j	230 u	200 u	110 u	100 u	140 u	66 u	52 j	230 u
Retene	230 u	–	190	na	240	–	190 j	410 u	290	130	na	330	–	240	180 u	310	210	na	250	–	330
Coprostanol	na	–	na	na	na	na	7600 u	na	na	na	na	na	na	9300 u	na	na	na	na	na	na	9000 u
Phenol	370 u	–	110 u	170 u	64 u	150 j	190 u	410 u	130 u	77 u	330	52 j	210	230 u	270	390	100 u	140 u	66 u	240 u	230 u
Pentachlorophenol	–	–	55 uj	1700 u	640 u	2400 u	950 u	–	130 u	38 uj	1600 u	1200 u	1500 u	1200 u	–	110 u	500 uj	1400 u	660 u	2400 u	1100 u
4-Methylphenol	230 u	–	110 u	170 u	64 u	1500	190 u	410 u	420	77 u	570	49 j	830	230 u	180 u	770	100 u	140 u	390	500	230 u
Benzoic Acid	3000 uj	–	900 uj	5400 j	1700 j	3500 uj	380 uj	5300 uj	1500	1100	2500 uj	1400 j	2500 uj	470 uj	2600 uj	770 u	320 uj	900 uj	1400 j	2600 uj	450 uj
Hexachloroethane	230 u	–	110 uj	170 u	–	–	–	410 u	130 u	76 u	160 u	120 u	–	–	200 u	110 u	100 uj	140 u	–	–	–
Hexachlorobenzene	230 u	–	110 u	170 u	64 u	–	190 u	410 u	130 u	76 u	160 u	120 u	–	230 u	200 u	110 u	100 u	140 u	66 u	45 j	230 u
1,2,4-Trichlorobenzene	230 u	–	110 u	170 u	64 u	–	190 u	410 u	130 u	76 u	160 u	120 u	11 j	230 u	200 u	110 u	100 u	140 u	66 u	–	230 u
Hexachlorobutadiene	570 u	–	110 u	170 u	64 u	–	190 u	1000 u	26	76 u	160 u	120 u	–	230 uj	59 j	41 j	100 u	140 u	66 u	–	230 u
Dimethylphthalate	230 u	–	110 u	120 j	64 u	210 j	110 j	410 u	130 u	77 u	160 u	120 u	150 u	230 u	180 u	110 u	100	140 u	66 u	240 u	230 u
Butylbenzylphthalate	570 uj	–	110 u	860 u	320 u	230 j	190 u	1000 u	130 u	100	200 uj	580 u	150 j	400	450 u	210	100 u	140 uj	330 u	120 j	230 u
Di-n-Butylphthalate	230 u	–	110 u	170 u	170 uj	270	330 u	410 u	130 u	60 uj	120 j	2400	220	340 u	700 u	110 u	100 u	140 u	71 uj	240 uj	340 u
Bis(2EH)phthalate	4000 uj	–	4000 uj	2500 uj	3200 uj	2300	1800 u	2400 u	2500	12000 uj	2200 uj	3300 uj	2500 uj	2700 u	2200 u	2000 u	1600 uj	6300 uj	1600 uj	1800 uj	1500 u
PCBs																					
1242	46 u	–	110 u	86 u	80 u	120 u	95 u	73000	130 u	80 u	160 u	140 u	100 u	310	200 u	110 u	100 u	140 u	83 u	120	81 u
1254	160 u	–	230	390	240	330	230	4200 u	1100	510	850	970	610	820	2000	1300	1800	700	1400	1100	960
1260	250	–	110 u	190	120	190	130 j	1300 u	130 u	190	460	360	410	500	870	110 u	730	300	490	690	530
Total PCB'S	250	–	230	580	360	520	460 j	73000	1100	700	1300	1300	1000	1600	2900	1300	2500	1000	1900	1900	1500

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

–=No sample
na=Not analyzed

Table C3(cont.): Summary of Semivolatile Organics and Polychlorinated Biphenyls Detected in Settling Particulate Matter from Hylebos Waterway December 1991 to June 1995 (ug/kg, dry weight).

Location	Near Lincoln Drain							Near Cenex							@ Occidental Chemical						
Station No.	H-4							H-5							H-6						
Collection Period	12/91–5/92	5/92–11/92	11/92–5/93	7/93–12/93	2/93–5/94	5/94–11/94	11/94–6/95	12/91–5/92	5/92–11/92–	11/92–5/93	7/93–12/93	2/93–5/94	5/94–11/94	11/94–6/95	12/91–5/92	5/92–11/92–	11/92–5/93	7/93–12/93	12/93–5/94	5/94–11/94	11/94–6/95
TOC (%)	–	4.4	3.8	na	3.7	3.8	na	3.4	4.5	–	na	4.2	4.1	na	2.6	3.5	2.9	3.1	2.8	2.8	–
Acenaphthene	–	75 j	68 j	na	98	70 j	na	55 j	120 j	–	na	230	210	na	90 j	320	141	580	940	310 j	–
Acenaphthylene	–	69 j	70 j	na	51	57 j	na	28 j	44 j	–	na	76	95 j	na	37 j	84 j	66 j	93 j	130	91 j	–
Naphthalene	–	130	97 j	na	120	130 j	na	86 j	146 u	–	na	310	380	na	110 j	250	130	370	500	240 j	–
Fluorene	–	97 j	85 j	na	130	88 j	na	200 j	146 j	–	na	320	290	na	180 j	400	181	640	770	370 j	–
Anthracene	–	270	250	na	250	190 j	na	200 j	240	–	na	370	400	na	300	470	410	790	730	520 j	–
Phenanthrene	–	570	450	na	610	490	na	1200	680	–	na	1200	1200	na	920	1700	980	2800	2700	1700 j	–
Sum LPAH	–	1200 j	1000 j	na	1300	1000 j	na	1800	1200 j	–	na	2500	2600 j	na	1600 j	3200 j	1900 j	5300 j	5800	3200	–
Fluoranthene	–	1200	1100	na	1100	1000	na	3200	1000	–	na	1500	1800	na	1400	2200	1600	3600	2900	2100 j	–
Benzo(a)anthracene	–	550	460	na	480	420	na	2000 j	390	–	na	550	620	na	1300	800	620	1200	900	770 j	–
Chrysene	–	590	1200	na	1200	1000	na	1600 j	870	–	na	1100	1400	na	1300	860	1200	1800	1600	1200 j	–
Pyrene	–	1300	580	na	1200	1000	na	2100 j	1000	–	na	1100	1600	na	1100	1800	970	2600	2100	1600 j	–
Benzofluoranthenes	–	1900	1600	na	1700	4800	na	5400 uj	1200	–	na	1400	1900	na	2100	1800	1400	2500	1400	1500 j	–
Benzo(a)pyrene	–	540	100 u	na	490	480	na	670 j	120 j	–	na	380	620	na	520	600	340	950	580	610 j	–
Dibenzo(a,h)anthracene	–	110 j	97 j	na	100	230 uj	na	590 u	73 j	–	na	96	380 uj	na	590 u	110 j	89 j	160	110	97 j	–
Indeno(1,2,3–cd)pyrene	–	430	170	na	370	360	na	230 u	230 j	–	na	280	420	na	320	390	230	570	370	380 j	–
Benzo(g,h,i)perylene	–	170	100 u	na	390	330	na	230 u	150 j	–	na	180	400	na	290	210	160	520	140	360 j	–
Sum HPAH	–	6800 j	5200 j	na	7000	9600	na	16000 j	5000 j	–	na	6600	9100	na	8900	8800 j	6600 j	14000	10000	8600 j	–
Total PAH	–	8000 j	6200 j	na	8300	11000 j	na	18000 j	6200 j	–	na	9100	12000 j	na	11000 j	12000 j	8500 j	19000 j	16000	12000 j	–
1–Methylnapthalene	–	62 j	50 j	na	na	–	na	43 j	59 j	–	na	na	–	na	62 j	160	70 j	na	na	–	–
2–Methylnaphthalene	–	58 j	47 j	na	72	68 j	na	30 j	58 j	–	na	200	210	na	51 j	160	76 j	420	440	230 j	–
Dibenzofuran	–	93 j	67 j	na	100	77 j	na	130 j	120 j	–	na	250	220	na	99 j	290	130	460	700	270 j	–
Carbazole	–	77 j	74 j	na	66	230 u	na	1200 uj	56 j	–	na	86	110	na	280 j	100 j	87 j	220	190	80 uj	–
Isophrone	–	120 u	100 u	na	44 u	230 u	na	230 uj	150 u	–	na	67 u	–	na	280 u	130 u	94 u	140 u	71 u	–	–
Retene	–	400	230	na	390	–	na	700 j	250	–	na	370	–	na	620	400	300	na	410	–	–
Coprostanol	–	na	na	na	na	na	na	na	na	–	na	na	na	na	na	na	na	na	nas	na	–
Phenol	–	151	100 u	na	44 u	230 u	na	230 u	36 u	–	na	37 j	190 u	na	240 u	130 u	94 u	140 u	71 u	80 uj	–
Pentachlorophenol	–	120 u	500 uj	na	440 u	2300 u	na	–	146 u	–	na	670 u	1900 u	na	–	130 u	470 uj	1400 uj	710 u	800 uj	–
4–Methylphenol	–	3800	100 u	na	44 u	770	na	230 u	1400	–	na	67 u	2600	na	240 u	2500	94 u	140 u	71 u	11000 j	–
Benzoic Acid	–	1200 u	3200	na	540 uj	2600 uj	na	3000 uj	500 u	–	na	1000 u	2000 uj	na	1700 j	990 u	2400 j	4100 uj	1400 uj	1400 uj	–
Hexachloroethane	–	120 u	100 uj	na	–	–	na	230 u	150 u	–	na	–	–	na	280 u	130 u	94 uj	140 u	–	–	–
Hexachlorobenzene	–	120 u	100 u	na	44 u	–	na	230 u	150 u	–	na	67 u	–	na	280 u	130 j	91 j	75 j	71 u	98 j	–
1,2,4–Trichlorobenzene	–	120 u	100 u	na	44 u	230 u	na	230 u	150 u	–	na	67 u	–	na	280 u	26 j	94 u	19 j	71 u	21 j	–
Hexachlorobutadiene	–	30 j	100 u	na	44 u	–	na	590 u	18 j	–	na	67 u	21 j	na	110 j	97 j	190	84 j	200	120 j	–
Dimethylphthalate	–	120 u	100 u	na	44 u	230 u	na	230 u	150 u	–	na	67 u	190 u	na	240 u	130 j	94 u	140 u	71 u	27 j	–
Butylbenzylphthalate	–	120 u	100 u	na	220 u	150 j	na	590 uj	150 u	–	na	330 u	950 uj	na	590 u	230	94 u	690 u	360 u	400 uj	–
Di–n–Butylphthalate	–	300 u	43 uj	na	91 uj	1200 uj	na	570 u	400 u	–	na	84 uj	1300	na	380 u	130 u	94 u	210 uj	71 uj	80 uj	–
Bis(2EH)phthalate	–	2100 u	1800 uj	na	1300 uj	1400 uj	na	2700 uj	870 u	–	na	44000	810	na	4500 uj	1200 u	1800 uj	5400 uj	1200 uj	940 j	–
PCBs																					
1242	–	120 u	100 u	na	59 u	120 u	na	160 u	150 u	–	na	83 u	95 u	na	160 u	130 uj	470 u	140 u	100 u	600	–
1254	–	820	760	na	420	450	na	650	830	–	na	330	320	na	350	1800 j	670	270	240	640 j	–
1260	–	120 u	410	na	320	590	na	940	150 u	–	na	480	640	na	380	130 uj	430 j	450	250	1600	–
Total PCB'S	–	820	1200	na	740	1000	na	1600	830	–	na	810	960	na	730	1900 uj	1100 j	720	490	2800	–

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

–=No sample
na=Not analyzed

Table C3(cont.): Summary of Semivolatile Organics and Polychlorinated Biphenyls Detected in Settling Particulate Matter from Hylebos Waterway, December 1991 to June 1995 (ug/kg, dry weight).

Location	Mouth of Waterway						
Station No.	H-7						
Collection Period	12/91–5/92	5/92–11/92	11/92–5/93	7/93–12/93	12/93–5/94	5/94–11/94	11/94–6/95
TOC (%)	2.2	2.6	2.3	2.3	2.2	2.1	2.0
Acenaphthene	49 j	92 j	91	290	170	64 j	71 j
Acenaphthylene	38 j	49 j	50 j	59 j	52 j	61 j	58 j
Naphthalene	120 j	110	120	170	130	150	170 u
Fluorene	120 j	110	140	350	320	100 j	100 j
Anthracene	260	190	250	390	560	220	230 u
Phenanthrene	540	560	770	1500	1100	450	550 u
Sum LPAH	1100 j	1100 j	1400 j	2800 j	2300 j	1000 j	230 j
Fluoranthene	710	850	1200	1700	1300	970	950 u
Benzo(a)anthracene	1300 u	340	530	530	480	400	170 u
Chrysene	1400	620	810	810	820	690	830
Pyrene	630	840	820	1400	1100	830	840 u
Benzofluoranthenes	2100 uj	840	1200	1100	1100	970	470 u
Benzo(a)pyrene	270	280	330	410	350	370	360 u
Dibenzo(a,h)anthracene	480	57 j	69 j	76 j	56 j	280	170 u
Indeno(1,2,3-cd)pyrene	190 u	180 j	230	260	210	220	230 u
Benzo(g,h,i)perylene	190 u	85 j	150	280	140	220	230 u
Sum HPAH	7300	4100 j	5300 j	6600 j	5600 j	5000	830
Total PAH	8400 j	5200 j	5700 j	9400 j	7900 j	6000 j	1100 j
1-Methylnapthalene	52 j	54 j	90 u	na	na	-	-
2-Methylnaphthalene	47 j	52 j	51 j	180	130	81 j	170 u
Dibenzofuran	77 j	99	100	260	190	89 j	170 u
Carbazole	350 j	41 j	70 j	180	150	140 u	170 u
Isophrone	190 u	97 u	90 u	130 u	68 u	-	170 u
Retene	350	360	290	na	350	-	400
Coprostanol	na	na	na	na	na	na	5100 J
Phenol	190 u	97 u	90 u	130 u	59 j	140 j	170 u
Pentachlorophenol	-	97 u	450 uj	1300 uj	680 u	1400 u	840 u
4-Methylphenol	190 u	580	90 u	140	68 u	140 u	170 u
Benzoic Acid	1500 j	170 uj	2000 j	820 uj	780 j	1500 uj	340 uj
Hexachloroethane	190 u	97 u	90 uj	130 u	-	-	-
Hexachlorobenzene	40 j	54 j	90 u	40 j	68 u	-	170 u
1,2,4-Trichlorobenzene	190 u	12 j	90 u	130 uj	68 u	-	170 u
Hexachlorobutadiene	39 j	51 j	110	56 j	68 u	43 j	54 j
Dimethylphthalate	190 u	97 u	90 u	130 u	68 u	140 u	170 u
Butylbenzylphthalate	480 u	120	90 u	130 uj	340 u	1300 uj	170 u
Di-n-Butylphthalate	440 u	110 u	180 uj	130 uj	140 uj	170	170 u
Bis(2EH)phthalate	7000	790 u	1000 uj	700 uj	750 uj	1300	49000 uj
PCBs							
1242	100 u	97 u	90 u	180 u	110 u	71 u	84 u
1254	330	320	230	180	100 j	120	110 j
1260	100 u	790	190	290	170	270	170 j
Total PCB'S	330	1100	420	470	270 j	390	280 j

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

-=No sample
na=Not analyzed

Table C4: Results of Butyltin* Analysis of Settling Particulate Matter from Hylebos Waterway, May 1994 to June 1995 (ug/kg, dry weight).

Location	Upper Turning Basin		@ General Metals		@ Elf Atochem		Near Lincoln Drain		Near Cenex		@ Occidental Chemical		Mouth	
Station	H-1		H-2		H-3		H-4		H-5		H-6		H-7	
Collection Date	5/94–11/94	11/94–6/95	5/94–11/94	11/94–6/95	5/94–11/94	11/94–6/95	5/94–11/94	11/94–6/95	5/94–11/94	11/94–6/95	5/94–11/94	11/94–6/95	5/94–11/94	11/94–6/95
Monobutyltin	13 u	24 u	50	20 uj	140	24 uj	58	na	76	na	55	–	32 u	20 uj
Dibutyltin	230	110	210	7.3 j	37	28	210	na	150	na	64	–	16 u	9.4 u
Tributyltin	620	280	450	160	530 j	1300	660	na	480	na	240	–	210 j	55
Tetrabutyltin	13 u	12 u	13 u	10 u	13 u	12 u	10 j	na	11 u	na	12 u	–	8.3 u	9.8 u

*=Reported as chloride

u=Not detected at detection limit shown

j=Estimated concentration

uj=Estimated detection limit

–=No sample

na= Not analyzed

Table C5: Sediment Accumulation Rates for Hylebos Waterway from Sediment Trap Data, December 1991 to June 1995.

Station	Deployment Period	Number Days Deployed	Collection Area cm2	SPM Wet g Collected	SPM Percent Solids	BS Percent Solids	SPM Dry g Collected	Dry Density* g/cm3	Gross Accumulation g/cm2/year	Accumulation Rate cm/year
H-1A	12/91-2/92	91	78.5	65.1	43	43	28	0.58	1.4	2.4
-1B	"	91	78.5	68.9	42	43	29	0.58	1.5	2.5
-1A	11/92-2/93	97	78.5	79.0	45	43	36	0.58	1.7	2.9
-1B	"	97	78.5	77.3	46	43	36	0.58	1.7	2.9
-1A	2-5/93	84	78.5	56.5	39	43	22	0.58	1.2	2.1
-1B	"	84	78.5	55.0	41	43	23	0.58	1.2	2.1
-1A	7-9/93	70	78.5	82.2	39	43	32	0.58	2.1	3.6
-1B	"	70	78.5	83.6	39	43	33	0.58	2.2	3.7
-1A	12/93-3/94	111	78.5	74.3	43	43	32	0.58	1.3	2.3
-1B	"	111	78.5	73.9	42	43	31	0.58	1.3	2.2
-1A	3-5/94	57	78.5	35.7	29	43	10	0.58	0.8	1.4
-1B	"	57	78.5	36.6	30	43	11	0.58	0.9	1.5
-1A	5-8/94	90	78.5	92.0	33	43	30	0.58	1.6	2.7
-1B	"	90	78.5	90.0	34	43	31	0.58	1.6	2.7
-1A	8-11/94	100	78.5	78.0	36	43	28	0.58	1.3	2.2
-1B	"	100	78.5	79.0	37	43	29	0.58	1.4	2.3
-1A	11/94-3/95	97	78.5	133.0	45	43	60	0.58	2.9	4.9
-1B	"	97	78.5	135.0	45	43	61	0.58	2.9	5.0
-1A	3/95-6/95	98	78.5	123.0	28	43	34	0.58	1.6	2.8
-1B	"	98	78.5	102.0	28	43	29	0.58	1.4	2.3
								mean=	1.6	2.7
H-2A	2-5/92	84	78.5	54.1	41	43	22	0.58	1.2	2.1
-2B	"	84	78.5	54.1	42	43	23	0.58	1.3	2.2
-2A	5-8/92	90	78.5	109.5	43	43	47	0.58	2.4	4.2
-2B	"	90	78.5	109.4	42	43	46	0.58	2.4	4.1
-2A	8-11/92	98	78.5	114.3	45	43	51	0.58	2.4	4.2
-2B	"	98	78.5	116.2	45	43	52	0.58	2.5	4.2
-2A	2-5/93	84	78.5	74.9	44	43	33	0.58	1.8	3.1
-2B	"	84	78.5	76.4	46	43	35	0.58	1.9	3.3
-2A	7-9/93	70	78.5	86.4	41	43	35	0.58	2.4	4.0
-2B	"	70	78.5	85.6	42	43	36	0.58	2.4	4.1
-2A	9-12/93	70	78.5	69.4	44	43	31	0.58	2.0	3.5
-2B	"	70	78.5	77.7	43	43	33	0.58	2.2	3.8
-2A	12/93-3/94	111	78.5	74.7	44	43	33	0.58	1.4	2.4
-2B	"	111	78.5	73.9	43	43	32	0.58	1.3	2.3
-2A	3-5/94	57	78.5	43.9	34	43	15	0.58	1.2	2.1
-2B	"	57	78.5	43.0	34	43	15	0.58	1.2	2.0
-2A	5-8/94	90	78.5	108.0	37	43	40	0.58	2.1	3.5
-2B	"	90	78.5	103.0	38	43	39	0.58	2.0	3.5
-2A	8-11/94	100	78.5	103.0	38	43	39	0.58	1.8	3.1
-2B	"	100	78.5	102.0	37	43	38	0.58	1.8	3.0
-2A	11/94-3/95	97	78.5	77.0	37	43	28	0.58	1.4	2.3
-2B	"	97	78.5	78.0	37	43	29	0.58	1.4	2.4
-2A	3/95-6/95	98	78.5	106.0	33	43	35	0.58	1.7	2.8
-2B	"	98	78.5	105.0	33	43	35	0.58	1.6	2.8
								mean=	1.8	3.1

SPM= Settling Particulate Matter

BS= Bottom Sediment

=Estimated from Puget Sound Sediment Density Model (Crecelius, 1989) using % solids data from in-situ bottom sediments. (dry density=wet density(BS% solids/100)

Table C5(cont): Sediment Accumulation Rates for Hylebos Waterway from Sediment Trap Data, December 1991 to June 1995.

Station	Deployment Period	Number Days Deployed	Collection Area cm2	SPM Wet g Collected	SPM Percent Solids	BS Percent Solids	SPM Dry g Collected	Dry Density* g/cm3	Gross Accumulation g/cm2/year	Accumulation Rate cm/year
H-3A	12/91-2/92	91	78.5	134.6	49	41	66	0.55	3.4	6.2
-3B	"	91	78.5	132.2	49	41	65	0.55	3.3	6.1
-3A	2-5/92	82	78.5	82.0	44	41	36	0.55	2.0	3.7
-3A	5-8/92	92	78.5	152.5	47	41	72	0.55	3.6	6.6
-3B	"	92	78.5	155.4	46	41	71	0.55	3.6	6.6
-3A	8-11/92	98	78.5	162.8	49	41	80	0.55	3.8	6.9
-3B	"	98	78.5	161.6	48	41	78	0.55	3.7	6.7
-3A	11/92-2/93	97	78.5	99.1	51	41	51	0.55	2.4	4.4
-3B	"	97	78.5	93.3	50	41	47	0.55	2.2	4.1
-3A	2-5/93	84	78.5	74.9	48	41	36	0.55	2.0	3.6
-3B	"	84	78.5	75.5	48	41	36	0.55	2.0	3.7
-3A	9-12/93	70	78.5	88.5	46	41	41	0.55	2.7	4.9
-3A	12/93-3/94	111	78.5	125.2	46	41	58	0.55	2.4	4.4
-3B	"	111	78.5	122.3	45	41	55	0.55	2.3	4.2
-3A	3-5/94	57	78.5	68.8	39	41	27	0.55	2.2	4.0
-3B	"	57	78.5	71.9	38	41	27	0.55	2.2	4.1
-3A	5-8/94	90	78.5	136.0	37	41	50	0.55	2.6	4.8
-3B	"	90	78.5	139.0	36	41	50	0.55	2.6	4.7
-3A	8-11/94	100	78.5	149.0	40	41	60	0.55	2.8	5.1
-3B	"	100	78.5	148.0	40	41	59	0.55	2.8	5.0
-3A	11/94-3/95	97	78.5	98.0	42	41	41	0.55	2.0	3.6
-3B	"	97	78.5	96.0	43	41	41	0.55	2.0	3.6
-3A	3/95-6/95	98	78.5	138.0	38	41	52	0.55	2.5	4.6
-3B	"	98	78.5	134.0	36	41	48	0.55	2.3	4.2
								mean=	2.6	4.8
H-4A	5-8/92	89	78.5	139.8	48	51	67	0.75	3.5	4.7
-4B	"	89	78.5	141.5	48	51	68	0.75	3.5	4.7
-4A	8-11/92	99	78.5	160.1	51	51	82	0.75	3.8	5.1
-4B	"	99	78.5	161.4	51	51	82	0.75	3.9	5.2
-4A	11/92-2/93	96	78.5	90.0	40	51	36	0.75	1.7	2.3
-4B	"	96	78.5	90.4	52	51	47	0.75	2.3	3.0
-4A	2-5/93	85	78.5	94.4	46	51	43	0.75	2.4	3.2
-4B	"	85	78.5	91.6	49	51	45	0.75	2.5	3.3
-4A	12/93-3/94	111	78.5	101.1	51	51	52	0.75	2.2	2.9
-4B	"	111	78.5	105.7	50	51	53	0.75	2.2	3.0
-4A	3-5/94	57	78.5	58.4	40	51	23	0.75	1.9	2.5
-4B	"	57	78.5	54.6	40	51	22	0.75	1.8	2.4
-4A	5-8/94	90	78.5	126.0	39	51	49	0.75	2.5	3.4
-4B	"	90	78.5	132.0	38	51	50	0.75	2.6	3.5
-4A	8-11/94	100	78.5	81.0	43	51	35	0.75	1.6	2.2
-4B	"	100	78.5	79.0	43	51	34	0.75	1.6	2.1
								mean=	2.5	3.3
H-5A	12/91-2/92	90	78.5	111.9	50	51	56	0.75	2.9	3.9
-5B	"	90	78.5	109.0	50	51	55	0.75	2.8	3.8
-5A	5-8/92	89	78.5	185.8	50	51	93	0.75	4.9	6.5
-5B	"	89	78.5	190.5	50	51	95	0.75	5.0	6.7
-5A	8-11/92	99	78.5	218.6	54	51	118	0.75	5.5	7.4
-5B	"	99	78.5	220.8	52	51	115	0.75	5.4	7.2
-5A	12/93-3/94	111	78.5	106.6	49	51	52	0.75	2.2	2.9
-5B	"	111	78.5	107.3	48	51	52	0.75	2.2	2.9
-5A	3-5/94	57	78.5	56.0	39	51	22	0.75	1.8	2.4
-5B	"	57	78.5	57.3	43	51	25	0.75	2.0	2.7
-5A	5-8/94	91	78.5	135.0	41	51	55	0.75	2.8	3.8
-5B	"	91	78.5	142.0	42	51	60	0.75	3.0	4.1
-5A	8-11/94	99	78.5	162.0	43	51	70	0.75	3.3	4.4
-5B	"	99	78.5	169.0	42	51	71	0.75	3.3	4.5
								mean=	3.4	4.5

SPM= Settling Particulate Matter

BS= Bottom Sediment

*=Estimated from Puget Sound Sediment Density Model (Crecelius, 1989)
using % solids data from in-situ bottom sediments. (dry density=wet density*(BS% solids/100)

Table C5(cont): Sediment Accumulation Rates for Hylebos Waterway from Sediment Trap Data, December 1991 to June 1995.

Station	Deployment Period	Number Days Deployed	Collection Area cm2	SPM Wet g Collected	SPM Percent Solids	BS Percent Solids	SPM Dry g Collected	Dry Density* g/cm3	Gross Accumulation g/cm2/year	Accumulation Rate cm/year
H-6A	12/91-2/92	90	78.5	66.1	49	51	32	0.75	1.7	2.2
-6B	"	90	78.5	65.9	49	51	32	0.75	1.7	2.2
-6A	2-5/92	84	78.5	56.7	49	51	28	0.75	1.5	2.1
-6B	"	84	78.5	56.1	48	51	27	0.75	1.5	2.0
-6A	5-8/92	91	78.5	119.7	48	51	57	0.75	2.9	3.9
-6B	"	91	78.5	122.5	48	51	59	0.75	3.0	4.0
-6A	8-11/92	99	78.5	120.4	52	51	63	0.75	2.9	3.9
-6B	"	99	78.5	120.5	52	51	63	0.75	2.9	3.9
-6A	11/92-2/93	96	78.5	61.9	52	51	32	0.75	1.6	2.1
-6B	"	96	78.5	61.8	51	51	32	0.75	1.5	2.0
-6A	2-5/93	85	78.5	22.5	39	51	9	0.75	0.5	0.6
-6B	"	85	78.5	21.5	39	51	8	0.75	0.5	0.6
-6A	7-9/93	70	78.5	102.0	48	51	49	0.75	3.3	4.3
-6B	"	70	78.5	102.3	49	51	50	0.75	3.3	4.5
-6A	9-12/93	70	78.5	74.4	47	51	35	0.75	2.3	3.1
-6B	"	70	78.5	72.8	48	51	35	0.75	2.3	3.1
-6A	12/93-3/94	111	78.5	87.7	53	51	46	0.75	1.9	2.6
-6B	"	111	78.5	89.1	52	51	46	0.75	1.9	2.6
-6A	3-5/94	57	78.5	46.7	37	51	17	0.75	1.4	1.9
-6B	"	57	78.5	45.8	39	51	18	0.75	1.5	1.9
-6A	5-8/94	92	78.5	109.0	42	51	46	0.75	2.3	3.1
-6B	"	92	78.5	109.0	40	51	44	0.75	2.2	2.9
-6A	8-11/94	97	78.5	138.0	45	51	62	0.75	3.0	4.0
-6B	"	97	78.5	129.0	45	51	58	0.75	2.8	3.7
								mean=	2.1	2.8
H-7A	12/91-2/92	90	78.5	81.7	55	62	45	1.01	2.3	2.3
-7B	"	90	78.5	80.1	55	62	44	1.01	2.3	2.2
-7A	2-5/92	84	78.5	75.0	54	62	41	1.01	2.2	2.2
-7B	"	84	78.5	73.7	52	62	38	1.01	2.1	2.1
-7A	5-8/92	91	78.5	177.0	56	62	99	1.01	5.1	5.0
-7B	"	91	78.5	183.9	56	62	103	1.01	5.3	5.2
-7A	8-11/92	98	78.5	177.7	59	62	105	1.01	5.0	4.9
-7B	"	98	78.5	179.4	60	62	108	1.01	5.1	5.0
-7A	11/92-2/93	97	78.5	103.7	62	62	64	1.01	3.1	3.0
-7B	"	97	78.5	104.4	59	62	62	1.01	3.0	2.9
-7A	2-5/93	85	78.5	73.8	56	62	41	1.01	2.3	2.2
-7B	"	85	78.5	75.5	50	62	38	1.01	2.1	2.0
-7A	7-9/93	70	78.5	110.9	54	62	60	1.01	4.0	3.9
-7A	9-12/93	70	78.5	90.0	55	62	50	1.01	3.3	3.2
-7B	"	70	78.5	98.5	55	62	54	1.01	3.6	3.6
-7A	12/93-3/94	111	78.5	89.4	58	62	52	1.01	2.2	2.1
-7B	"	111	78.5	90.9	57	62	52	1.01	2.2	2.1
-7A	3-5/94	56	78.5	52.9	41	62	22	1.01	1.8	1.8
-7B	"	56	78.5	52.5	40	62	21	1.01	1.7	1.7
-7B	5-8/94	92	78.5	123.0	53	62	65	1.01	3.3	3.3
-7A	8-11/94	97	78.5	185.0	56	62	104	1.01	5.0	4.9
-7A	11/94-3/95	98	78.5	81.0	53	62	43	1.01	2.0	2.0
-7B	"	98	78.5	83.0	52	62	43	1.01	2.0	2.0
								mean=	3.1	3.0

SPM= Settling Particulate Matter

BS= Bottom Sediment

*=Estimated from Puget Sound Sediment Density Model (Crecelius, 1989)
using % solids data from in-situ bottom sediments. (dry density=wet density*(BS% solids/100)

Sitcum Waterway

Table C6: Results of Conventionals and Metals Analysis of Settling Particulate Matter from Sitcum Waterway, June 1991 to June 1995 (mg/kg, dry weight).

Location	Terminal 7 @ North Corner Drain												
Station No.	S–1												
Collection Period	6/91– 9/91	9/91– 11/91	11/91– 2/92	2/92– 5/92	5/92– 8/92	8/92– 11/92	11/92– 2/93	2/93– 5/93	7/93– 9/93	9/93– 12/93	12/93– 11/94	11/94– 3/95	3/95– 6/95
Total Solids (%)	–	50	62	57	59	58	60	57	58	58	na	56	41
TOC %	–	2.1	1.9	2.3	2.8	2.6	2.1	2.3	2.4	2.3	na	2.0	2.4
Metals													
Arsenic	–	53	58	57	70	58	66	83	40	49	na	19	24
Copper	–	150	150	150	180 j	170 j	150	150	130	150	na	85	99
Lead	–	320	260	260	260	210	230	220	190	200	na	110	160
Zinc	–	360	310	290	330	260	280	310	230	260	na	140	190

Location	Sealand Terminal												
Station No.	S–2												
Collection Period	6/91– 9/91	9/91– 11/91	11/91– 2/92	2/92– 5/92	5/92– 8/92	8/92– 11/92	11/92– 2/93	2/93– 5/93	7/93– 9/93	9/93– 12/93	12/93– 11/94	11/94– 3/95	3/95– 6/95
Total Solids (%)	–	57	62	56	59	51	62	56	na	na	na	na	na
TOC %	–	2.0	1.2	1.7	2.6	1.7	1.4	1.7	na	na	na	na	na
Metals													
Arsenic	–	28	22	24	23	22	21	19	na	na	na	na	na
Copper	–	130	95	86	100 j	90 j	80	70	na	na	na	na	na
Lead	–	110	94	96	95	80	85	80	na	na	na	na	na
Zinc	–	160	150	140	160	130	150	120	na	na	na	na	na

–=No sample

na=Not analyzed

j=Estimated concentration

Table C6(cont.): Results of Conventionals and Metals Analysis of Settling Particulate Matter from Sitcum Waterway, June 1991 to June 1995 (mg/kg, dry).

Location	Terminal 7 @ Berth B												
Station No.	S-3												
Collection Date	6/91–9/91	9/91–11/91	11/91–2/92	2/92–5/92	5/92–8/92	8/92–11/92	11/92–2/93	2/93–5/93	7/93–9/93	9/93–12/93	12/93–11/94	11/94–3/95	3/95–6/95
Total Solids (%)	53	–	65	61	58	–	62	58	60	54	na	59	–
TOC %	2.2	–	1.5	1.6	2.6	–	1.6	2.1	1.9	2.0	na	1.3	–
Metals													
Arsenic	49	–	45	44	48	–	52	43	32	47	na	17	–
Copper	140	–	130	120	150 j	–	130	110	120	150	na	75	–
Lead	290	–	250	240	250	–	220	170	190	240	na	130	–
Zinc	450	–	300	290	260	–	260	230	220	310	na	110	–

Location	Mouth @ Terminal 7												
Station No.	S-4												
Collection Date	6/91–9/91	9/91–11/91	11/91–2/92	2/92–5/92	5/92–8/92	8/92–11/92	11/92–2/93	2/93–5/93	7/93–9/93	9/93–12/93	12/93–11/94	11/94–3/95	3/95–6/95
Total Solids (%)	–	56	56	52	57	62	60	55	56	56	na	–	52
TOC %	–	2.0	1.7	1.9	3.0	1.7	1.5	1.7	1.9	1.9	na	–	1.8
Metals													
Arsenic	–	32	17	19	17	11	25	16	14	11	na	–	8.1
Copper	–	110	76	76	99 j	66 j	73	64	70	71	na	–	41
Lead	–	250	99	100	85	44	82	72	63	70	na	–	21
Zinc	–	370	130	140	130	91	130	130	110	130	na	–	50

–=No sample

na=Not analyzed

j=Estimated concentration

Table C7: Summary of Semivolatile Organics Detected in Settling Particulate Matter from Sitcum Waterway, June 1991 to June 1995 (ug/kg, dry weight).

Location	Head @ North Corner Drain								Sealand Terminal							
Station No.	S-1								S-2							
Collection Date	6/91–11/91	11/91–5/92	5/92–11/92	11/92–5/93	7/93–12/93	12/93–5/94	5/94–11/94	11/94–6/95	6/91–11/91	11/91–5/92	5/92–11/92	11/92–5/93	7/93–12/93	12/93–5/94	5/94–11/94	11/94–6/95
TOC (%)	2.1	2.1	2.7	2.2	2.4	na	na	2.2	2.0	1.5	2.2	1.6	na	na	na	na
Acenaphthene	140	200	270	350 j	200	na	na	120	56 j	35 j	72	72 j	na	na	na	na
Acenaphthylene	19 j	50 j	63 j	81 j	66	na	na	33 j	21 j	18 j	20 j	24 j	na	na	na	na
Naphthalene	110	190	220	250	180 j	na	na	59 u	240	59 j	120	210	na	na	na	na
Fluorene	130	270	310	530 j	320	na	na	180	76 j	200 u	71 j	74 j	na	na	na	na
Anthracene	87 j	320	310	710	510	na	na	360	240 u	66 j	79	100	na	na	na	na
Phenanthrene	880	1400	1400	2700	1400	na	na	780	360	330	290	300	na	na	na	na
Sum LPAH	1400 j	2400 j	2600 j	4600 j	2700 j	na	na	1500 j	750 j	500 j	650 j	680 j	na	na	na	na
Fluoranthene	1400	2400	2000	3600	2200	na	na	1200	1800	670	470	530	na	na	na	na
Benzo(a)anthracene	700 j	1800	650	1100 j	800	na	na	350 u	380	360	160	220	na	na	na	na
Chrysene	430 j	2000	930	1400	1400	na	na	590	340	450	210	280	na	na	na	na
Pyrene	850 j	2100	1600	1800	1600	na	na	810	1400	630	380	340	na	na	na	na
Benzofluoranthenes	650 uj	2100	1300	1800	1400	na	na	580	610	630	320	450	na	na	na	na
Benzo(a)pyrene	360 j	510	570	380	560	na	na	320	260 u	310	120	130	na	na	na	na
Dibenzo(a,h)anthracene	270 u	440 u	74	120	100 j	na	na	59 u	600 u	500 u	21 j	99 u	na	na	na	na
Indeno(1,2,3–cd)pyrene	110 u	400	380	320	360	na	na	220 u	240 u	130 j	85 j	81 j	na	na	na	na
Benzo(g,h,i)perylene	110 u	490	290	180	360	na	na	210	240 u	110 j	50 j	60 j	na	na	na	na
Sum HPAH	4400 j	12000	7800	11000 j	8800 j	na	na	3700	5900	3300 j	1800 j	2100	na	na	na	na
Total PAH	5800 j	14000 j	10000 j	16000 j	12000 j	na	na	5200 j	6700 j	3800 j	2500 j	2900	na	na	na	na
Phenol	110 u	180 u	80 u	560 u	180 u	na	na	59 u	240 u	200 u	71 u	99 u	na	na	na	na
Pentachlorophenol	–	–	80 u	430 u	1400 uj	na	na	300 u	–	–	71 u	490 uj	na	na	na	na
4–Methylphenol	110 u	180 u	730	560 u	200	na	na	–	240 u	200 u	390	99 u	na	na	na	na
1–Methylnaphthalene	68 j	120 j	140	150	–	na	na	–	86 j	42 j	62 j	63 j	na	na	na	na
2–Methylnaphthalene	62 j	100 j	130 j	200	80 j	na	na	86 u	75 j	31 j	53 j	56 j	na	na	na	na
Carbazole	550 uj	440 j	96	260 j	100 j	na	na	59 u	100 j	1000 uj	25 j	46 j	na	na	na	na
Benzoic Acid	1400 j	3300 uj	310 u	4200	2500 uj	na	na	120 uj	3100uj	2200 j	600 u	420 uj	na	na	na	na
Benzyl Alcohol	550 u	–	80 u	85 uj	180 u	na	na	59 u	1200 u	–	71 u	99 u	na	na	na	na
Retene	210 j	460	390	440	–	na	na	250	660	670	370	450	na	na	na	na
Coprostanol	na	na	na	na	na	na	na	2600	na	na	na	na	na	na	na	na
Dibenzofuran	110	210	270	340 j	220	na	na	120	83 j	44 j	69 j	88 j	na	na	na	na
Diethylphthalate	110 u	180 u	80 u	85 u	180 uj	na	na	59 u	240 u	200 u	71 u	99 u	na	na	na	na
Dimethylphthalate	55 j	390	230	110	230	na	na	140	240 u	200 u	71 u	99 u	na	na	na	na
Butylbenzylphthalate	270 u	440 u	80 u	120	200 uj	na	na	59 u	600 u	500 u	71 u	99 u	na	na	na	na
Di–n–butylphthalate	110 u	1000 u	600	85 u	270 uj	na	na	340 u	240 u	570 u	71 u	22 uj	na	na	na	na
Di–n–octylphthalate	110 uj	180 uj	200 uj	85 u	540 u	na	na	59 u	240 uj	200 uj	180 uj	99 u	na	na	na	na
Bis(2EH)phthalate	110 u	120000	41000 uj	34000	170000	na	na	1400 u	1000 u	980 u	530 u	780 uj	na	na	na	na

–=No sample
u=Not detected at detection limit shown
uj=Estimated detection limit
j=Estimated concentration
na=Not analyzed

Table C7(cont.): Summary of Semivolatile Organics Detected in Settling Particulate Matter from Sitcum Waterway, June 1991 to June 1995 (ug/kg, dry weight).

Location	Terminal 7 @ Berth B								Mouth @ Terminal 7							
Station No.	S-3								S-4							
Collection Date	6/91–11/91	11/91–5/92	5/92–11/92	11/92–5/93	7/93–12/93	12/93–5/94	5/94–11/94	11/94–6/95	6/91–11/91	11/91–5/92	5/92–11/92	11/92–5/93	7/93–12/93	12/93–5/94	5/94–11/94	11/94–6/95
TOC (%)	2.2	1.6	2.6	1.9	2.0	na	na	1.3	2.0	1.8	2.4	1.6	1.9	na	na	1.8
Acenaphthene	250 j	390	290	500	200	na	na	350	36 j	47 j	74 j	75 j	86 j	na	na	27 j
Acenaphthylene	22 j	43 j	87 u	74 u	30 j	na	na	23 j	5 j	11 j	15 j	95 u	21 j	na	na	15 j
Naphthalene	130 j	190	200	300	150 j	na	na	96 u	45 j	59 j	63 j	86 j	130 j	na	na	70 u
Fluorene	250 j	780	350	620	500	na	na	340	31 j	64 j	67 j	100	87 j	na	na	35 j
Anthracene	71 j	1100	220	570	880	na	na	290	35 j	150	62 j	130	90 j	na	na	70 u
Phenanthrene	1100 j	2900	1200	2000	1600	na	na	1300	330	470	310	530	390	na	na	170 u
Sum LPAH	1900 j	5400 j	2300	4000	3400 j	na	na	2300 j	480 j	800 j	590 j	920 j	800 j	na	na	77 j
Fluoranthene	1400 j	2900	1400	1800	1480	na	na	1500	690	790	460	870	630	na	na	290 u
Benzo(a)anthracene	565 j	1400	430	570	430	na	na	350	670	480	140	330	190	na	na	70 u
Chrysene	250 j	1000	610	590	600	na	na	530	310	480	220	450	270	na	na	160
Pyrene	780 j	1900	1200	930 j	1200	na	na	1000	620	750	390	540	500	na	na	200 u
Benzofluoranthenes	490 j	1500	830	840	740	na	na	450	870	630	300	640	400 j	na	na	120 u
Benzo(a)pyrene	235 j	390	360	220 j	330	na	na	260	350	240	120	215	150 j	na	na	70 u
Dibenzo(a,h)anthracene	26 j	350 u	60 j	60 j	47 j	na	na	55 u	250 u	430 u	12 j	95 u	180 u	na	na	70 u
Indeno(1,2,3–cd)pyrene	130 j	160	220 j	148 j	190	na	na	160 u	260	110 j	81	170	110 j	na	na	70 u
Benzo(g,h,i)perylene	98 j	140 u	180	69 j	180	na	na	140 u	150	170	57 j	150	120 j	na	na	70 u
Sum HPAH	4000 j	9700	5300 j	5200	5200 j	na	na	4100	3900	4100 j	1800 j	3400	2400 j	na	na	160
Total PAH	5900 j	15000 j	7600 j	9200 j	8600 j	na	na	6400 j	4400 j	4900 j	2400 j	4300 j	3200 j	na	na	240 j
Phenol	420 j	140 u	87 u	74 uj	170 uj	na	na	63 u	97 u	170 u	1000	95 u	180 u	na	na	81 u
Pentachlorophenol	390 u	–	87 u	370	1700 uj	na	na	270 u	500 u	–	79	470 uj	1800 u	na	na	350 u
4–Methylphenol	530 j	230	390	74 u	230	na	na	55 u	97 u	170 u	3600	95 u	180	na	na	70 u
1–Methylnaphthalene	120 j	170	140	200	na	na	na	–	22 j	56 j	53 j	65 j	na	na	na	–
2–Methylnaphthalene	110 j	120 j	140	270	170 j	na	na	160 u	22 j	44 j	43 j	57 j	97 j	na	na	70 u
Carbazole	59 j	310 j	54 j	230	220	na	na	83	84 j	860 uj	22 j	81 j	180 u	na	na	70 u
Benzoic Acid	1100 u	1900 u	1200 u	980 uj	1100 uj	na	na	110 uj	360 uj	3300 j	5500	2500 j	2700 uj	na	na	970 j
Benzyl Alcohol	430 u	–	21 j	74 uj	170 uj	na	na	55 u	500 u	–	81	95 u	180 u	na	na	70 u
Retene	200 j	540	330	430	na	na	na	150	230	460	230	460	na	na	na	200
Coprostanol	na	na	na	na	na	na	na	2000	na	na	na	na	na	na	na	70 u
Dibenzofuran	200 j	420	270	460	270	na	na	240	28 j	62 j	64 j	72 j	73 j	na	na	70 u
Diethylphthalate	83 u	140 u	87 u	74 u	170 uj	na	na	55 u	97 u	170 u	79	95 u	180 uj	na	na	70 u
Dimethylphthalate	83 u	140 u	87 u	74 u	33 j	na	na	55 u	97 u	170 u	200 u	95 u	180 u	na	na	70 u
Butylbenzylphthalate	210 u	350 u	87 u	74 u	170 uj	na	na	55 u	250 u	430 u	79 u	95 u	180 uj	na	na	70 u
Di–n–butylphthalate	88 u	140 u	14000 j	74 u	170 u	na	na	82 u	97 u	1300 u	370 u	95 u	200	na	na	190 u
Di–n–octylphthalate	83 u	140 u	220 uj	74 u	840 u	na	na	55 u	97 uj	170 uj	190 uj	95 u	180 u	na	na	70 u
Bis(2EH)phthalate	440 u	1100 u	850 u	870 uj	470 uj	na	na	19000 uj	530 u	1200 u	640 u	860 uj	1000 uj	na	na	1200 u

–=No sample
u=Not detected at detection limit shown
uj=Estimated detection limit

j=Estimated concentration
na=Not analyzed

Table C8: Sediment Accumulation Rates for Sitcum Waterway from Sediment Trap Data, June 1991 to June 1995.

Station	Deployment Period	Number Days Deployed	Collection Area cm2	SPM Wet g	SPM Percent Solids	BS Percent Solids	SPM Dry g	Dry Density* g/cm3	Gross Accumulation g/cm2/year	Accumulation Rate cm/year
S-1A	9-11/91	63	78.5	142.8	44	57	63	0.89	4.6	5.2
-1B	"	63	78.5	144.9	56	57	81	0.89	6.0	6.7
-1A	11/91-2/92	90	78.5	176.1	63	57	111	0.89	5.7	6.4
-1B	"	90	78.5	177.6	60	57	107	0.89	5.5	6.2
-1A	2-5/92	83	78.5	114.9	56	57	64	0.89	3.6	4.1
-1B	"	83	78.5	108.5	57	57	62	0.89	3.5	3.9
-1A	5-8/92	91	78.5	210.6	59	57	124	0.89	6.3	7.1
-1B	"	91	78.5	209.7	60	57	126	0.89	6.4	7.2
-1A	8-11/92	98	78.5	182.4	59	57	108	0.89	5.1	5.7
-1B	"	98	78.5	178.0	62	57	110	0.89	5.2	5.9
-1A	11/92-2/93	98	78.5	111.7	60	57	67	0.89	3.2	3.6
-1B	"	98	78.5	111.4	58	57	65	0.89	3.1	3.4
-1A	2-5/93	84	78.5	96.6	56	57	54	0.89	3.0	3.4
-1B	"	84	78.5	96.5	58	57	56	0.89	3.1	3.5
-1A	7-9/93	70	78.5	112.4	59	57	66	0.89	4.4	5.0
-1B	"	70	78.5	130.5	57	57	74	0.89	4.9	5.6
-1B	9-12/93	43	78.5	70.8	58	57	41	0.89	4.4	5.0
-1A	11/94-3/95	96	78.5	181.0	47	62	85	1.01	4.1	4.1
-1B	"	96	78.5	175.0	36	62	63	1.01	3.1	3.0
								mean=	4.5	5.0
S-2A	9-11/91	62	78.5	170.0	57	62	97	1.01	7.3	7.2
-2A	11/91-2/92	92	78.5	126.3	61	62	77	1.01	3.9	3.8
-2B	"	92	78.5	131.7	62	62	82	1.01	4.1	4.1
-2A	2-5/92	83	78.5	93.8	55	62	52	1.01	2.9	2.9
-2B	"	83	78.5	97.8	57	62	56	1.01	3.1	3.1
-2A	5-8/92	91	78.5	207.1	59	62	122	1.01	6.2	6.2
-2B	"	91	78.5	200.5	59	62	118	1.01	6.0	6.0
-2A	8-11/92	98	78.5	226.6	65	62	147	1.01	7.0	6.9
-2B	"	98	78.5	235.2	63	62	148	1.01	7.0	6.9
-2A	11/92-2/93	98	78.5	47.0	60	62	28	1.01	1.3	1.3
-2B	"	98	78.5	49.7	63	62	31	1.01	1.5	1.5
-2A	2-5/93	84	78.5	75.1	56	62	42	1.01	2.3	2.3
-2B	"	84	78.5	74.9	56	62	42	1.01	2.3	2.3
								mean=	4.2	4.2

SPM= Settling Particulate Matter

BS= Bottom Sediment

=Estimated from Puget Sound Sediment Density Model (Crecelius, 1989) using % solids data from in-situ bottom sediments. (dry density=wet density(BS% solids/100)

Table C8(cont): Sediment Accumulation Rates for Sitcum Waterway from Sediment Trap Data, June 1991 to June 1995.

Station	Deployment Period	Number Days Deployed	Collection Area cm2	SPM Wet g	SPM Percent Solids	BS Percent Solids	SPM Dry g	Dry Density* g/cm3	Gross Accumulation g/cm2/year	Accumulation Rate cm/year
S-3A	6-9/91	92	78.5	270.4	56	62	151	1.01	7.7	7.6
-3B	"	92	78.5	326.3	50	62	163	1.01	8.2	8.1
-3A	11/91-2/92	90	78.5	215.4	65	62	140	1.01	7.2	7.1
-3B	"	90	78.5	218.6	65	62	142	1.01	7.3	7.2
-3A	2-5/92	83	78.5	146.4	61	62	89	1.01	5.0	4.9
-3B	"	83	78.5	147.6	61	62	90	1.01	5.0	5.0
-3A	5-8/92	91	78.5	213.6	59	62	126	1.01	6.4	6.4
-3B	"	91	78.5	211.5	58	62	123	1.01	6.3	6.2
-3A	11/92-2/93	97	78.5	173.7	61	62	106	1.01	5.1	5.0
-3B	"	97	78.5	175.4	63	62	111	1.01	5.3	5.2
-3A	2-5/93	84	78.5	102.5	58	62	59	1.01	3.3	3.2
-3B	"	84	78.5	103.4	59	62	61	1.01	3.4	3.3
-3A	7-9/93	74	78.5	197.4	60	62	118	1.01	7.4	7.3
-3B	"	74	78.5	195.9	60	62	118	1.01	7.4	7.3
-3A	9-12/93	39	78.5	107.1	60	62	64	1.01	7.7	7.6
-3B	"	39	78.5	110.3	54	62	60	1.01	7.1	7.0
-3A	11/94-3/95	96	78.5	289.0	59	46	171	0.64	8.3	12.8
								mean=	6.4	6.6
S-4A	9-11/91	63	78.5	133.2	55	60	73	0.96	5.4	5.6
-4B	"	63	78.5	138.7	58	60	80	0.96	5.9	6.2
-4A	11/91-2/92	92	78.5	55.9	52	60	29	0.96	1.5	1.5
-4B	"	92	78.5	55.7	52	60	29	0.96	1.5	1.5
-4A	2-5/92	83	78.5	80.9	56	60	45	0.96	2.5	2.6
-4B	"	83	78.5	79.7	58	60	46	0.96	2.6	2.7
-4B	5-8/92	91	78.5	186.1	58	60	108	0.96	5.5	5.7
-4A	8-11/92	98	78.5	201.6	62	60	125	0.96	5.9	6.2
-4B	"	98	78.5	200.9	62	60	125	0.96	5.9	6.1
-4A	11/92-2/93	98	78.5	105.1	60	60	63	0.96	3.0	3.1
-4B	"	98	78.5	106.3	60	60	64	0.96	3.0	3.1
-4A	2-5/93	84	78.5	87.5	54	60	47	0.96	2.6	2.7
-4B	"	84	78.5	85.0	54	60	46	0.96	2.5	2.6
-4A	7-9/93	70	78.5	156.0	57	60	89	0.96	5.9	6.1
-4B	"	70	78.5	159.0	54	60	86	0.96	5.7	5.9
-4A	9-12/93	43	78.5	82.9	55	60	46	0.96	4.9	5.1
-4B	"	43	78.5	84.7	56	60	47	0.96	5.1	5.3
-4A	3/95-6/95	98	78.5	183.0	52	44	95	0.60	4.5	7.5
-4B	"	98	78.5	194.0	51	44	99	0.60	4.7	7.8
								mean=	4.1	4.6

SPM= Settling Particulate Matter

BS= Bottom Sediment

=Estimated from Puget Sound Sediment Density Model (Crecelius, 1989) using % solids data from in-situ bottom sediments. (dry density=wet density(BS% solids/100)

Thea Foss Waterway

Table C9: Results of Conventionals and Metals Analysis of Settling Particulate Matter from Thea Foss Waterway, November 1992 to June 1995 (mg/kg, dry weight).

Location	Head near twin 96" Drains										Midchannel near City Marina			
Station No.	TF-1										TF-1A			
Collection	11/92–	2/93–	7/93–	9/93–	12/93–	3/94–	5/94–	8/94–	11/94–	3/95–	12/93–	3/94–	5/94–	8/94–
Period	2/93	5/93	9/93	12/93	3/94	5/94	8/94	11/94	3/95	6/95	3/94	5/94	8/94	11/94
Total Solids	43	42	38	43	43	33	37	35	42	27	41	41	40	38
TOC %	6.8	6.7	7.6	11	12	10	7.6	11	9.6	9.6	7.6	5.8	5.5	5.6
Metals														
Arsenic	na	na	na	na	22	22	na	na	na	na	30	27	21	na
Cadmium	2.4	2.5	3.5	3.5	na	na	na	na	na	na	na	na	na	na
Copper	160	160	180	180	160	190	160	160	140	150	210	220	180	180
Mercury	0.80	0.65	0.70	0.60	0.63	0.58	0.64	0.56	0.47	0.59	0.86	1.0	1.0	0.94
Nickel	62	60	53	65	60	48	na	na	na	na	41	41	na	na
Lead	370	380	380	420	360	360	310	310	280	260	340	390	310	300
Zinc	470	490	350	510	490	460	340	430	310	260	360	350	260	270

Location	North of 15th Street Drain									
Station No.	TF-2									
Collection	11/92–	2/93–	7/93–	9/93–	12/93–	3/94–	5/94–	8/94–	11/94–	3/95–
Period	2/93	5/93	9/93	12/93	3/94	5/94	8/94	11/94	3/95	6/95
Total Solids	43	38	44	40	38	35	–	36	40	–
TOC %	5.5	6.8	5.4	5.9	6.2	5.8	–	5.4	5.9	–
Metals										
Arsenic	na	na	na	na	27	24	na	na	na	na
Cadmium	2	1.9	2.9	3	na	na	na	na	na	na
Copper	190	210	180	190	180	200	–	170	140	–
Mercury	0.94	0.72	0.92	0.85	0.67	0.90	–	1.0	0.72	–
Nickel	45	41	38	39	39	37	na	na	na	na
Lead	290	270	320	300	250	310	–	280	220	–
Zinc	330	340	290	290	300	320	–	260	210	–

–=No sample
na=Not analyzed

Table C9(cont.): Results of Conventionals and Metals Analysis of Settling Particulate Matter from Thea Foss Waterway, November 1992 to June 1995 (mg/kg, dry weight).

Location	Mouth of Wheeler–Osgood Waterway									
Station No.	TF–3									
Collection Period	11/92– 2/93	2/93– 5/93	7/93– 9/93	9/93– 12/93	12/93– 3/94	3/94– 5/94	5/94– 8/94	8/94– 11/94	11/94– 3/95	3/95– 6/95
Total Solids	44	39	39	40	37	30	37	–	40	30
TOC %	5.1	6.5	5.4	6.3	6.4	5.5	5.0	–	5.3	6.1
Metals										
Arsenic	na	na	na	na	24	23	na	na	na	na
Cadmium	1.9	1.9	2.8	2.9	na	na	na	na	na	na
Copper	270	310	200	220	210	240	180	–	160	210
Mercury	1.5	0.65	0.7	0.71	0.69	0.83	0.74	–	0.65	0.75
Nickel	43	45	36	40	41	38	na	na	na	na
Lead	250	210	240	260	220	240	190	–	170	180
Zinc	370	490	270	310	360	310	220	–	210	230

Location	Mouth									
Station No.	TF–4									
Collection Period	11/92– 2/93	2/93– 5/93	7/93– 9/93	9/93– 12/93	12/93– 3/94	3/94– 5/94	5/94– 8/94	8/94– 11/94	11/94– 3/95	3/95– 6/95
Total Solids	43	39	39	42	37	30	31	33	38	19
TOC %	–	5.8	4.2	4.8	5.3	4.6	4.0	3.8	4.2	5.1
Metals										
Arsenic	na	na	na	na	22	22	na	na	na	na
Cadmium	0.9	0.9	1.4	1.3	na	na	na	na	na	na
Copper	140	120	140	150	150	150	120	120	97	110
Mercury	0.51	0.44	0.46	0.45	0.42	0.60	0.44	0.44	0.40	0.53
Nickel	39	40	27	31	35	29	na	na	na	na
Lead	140	130	140	160	140	140	110	100	90	110
Zinc	210	200	180	210	210	210	140	130	120	130

–=No sample
na=Not analyzed

Table C10: Summary of Semivolatile Organics and Butyltin* Analysis of Settling Particulate Matter from Thea Foss Waterway, November 1992 to June 1995 (ug/kg, dry weight).

Location	Head near Twin 96" Drains					Mid-Channel		North of 15th Street Drain				
Station No.	TF-1					TF-1A		TF-2				
Collection Period	11/92-	7/93-	12/93-	5/94-	11/94-	12/93-	5/94-	11/92-	7/93-	12/93-	5/94-	11/94-
Period	5/93	12/93	5/94	11/94	6/95	5/94	11/94	5/93	12/93	5/94	11/94	6/95
TOC (%)	6.8	9.3	11	11	9.6	5.8	5.6	6.2	5.7	6.0	5.4	5.9
Semivolatiles												
Acenaphthene	2000	400	390 j	270	380	220 j	220	260	270	200	220	190
Acenaphthylene	440 j	310 j	210 j	210	240	230 j	290	190	250	320	290	230
Naphthalene	1600 j	800	510 j	580	690	560 j	820	380	710	560	830	530 u
Fluorene	1300	600	610 u	370	430	280 j	290	290	330	340	370	310
Anthracene	2000	1300	1100	830	1000	640	700	320	700	870	860	780
Phenanthrene	9300	6600	7800	3700	4000	1900	1600	2300 j	1900	1700	1700	2300
Sum LPAH	17000 j	10000 j	11000 j	6000	6700	3800 j	3900	3700 j	4200	4000	4300	3800
Fluoranthene	15000	12000	13000	7500	7200	3100	2900	4400	3100	3400	3200	4200
Benzo(a)anthracene	6600	3700	5500	2500	2400	1500	1200	2500 j	1300	1500	1300	1500
Chrysene	6600	6400	7000	4400	4000	2300	2000	2400 j	2000	1900	2300	2500
Pyrene	9000	11000	9300	6900	6100	2300	4100	3000 j	4100	2300	4000	3900
Benzofluoranthenes	12000	11000	13000	7700	7100	4000	2000	3700 j	3800	3200	1900	4000
Benzo(a)pyrene	3400	4600	4100	3200	3000	2000	1800	850	1700	950	1800	1500
Dibenzo(a,h)anthracene	940 j	930	960	540	510	350	300	240	320	260	340	120 u
Indeno(1,2,3-cd)pyrene	29000	4100	13000	2800	2600	4200	1500	770	1300	3700	1500	1400
Benzo(g,h,i)perylene	1600 j	4000	1400	2800	2600	1700	1400	240	1400	180	1500	1300
Sum HPAH	84000 j	58000	67000	38000	36000	21000	17000	18000 j	19000	17000	18000	20000
Total PAH	100000 j	68000 j	77000 j	44000	42000	25000 j	21000	22000 j	23000	21000	22000	24000
Phenol	370 j	350 u	190 j	100 j	210 u	180	350	160 u	150 j	130	130 u	140 u
Pentachlorophenol	2600 u	2600 uj	230 j	720 uj	630 u	3500 u	1100 u	800 u	1100 u	1200 u	1300 u	610 u
4-Methylphenol	510 u	270 j	170	170	310	93	2700	160 u	670	85 j	270	120 u
1-Methylnaphthalene	1200 j	-	-	-	-	-	-	200	-	-	-	-
2-Methylnaphthalene	700 j	530	460 j	360	410 u	250 j	360	190	340	310	420	280 u
Carbazole	1700	1200	1300	640	670	280 j	190	320	170 j	210	180	350
Benzoic Acid	9600	4000 uj	1100 j	4800 uj	5100 j	1300 j	1800 uj	8000 j	2700 uj	3400 j	2200 uj	420 uj
Benzyl Alcohol	170 uj	350 u	450 u	130 u	130 u	350 u	110 u	160 j	350 u	120 u	130 u	120 u
Retene	1000 j	na	730 j	-	520	860	-	400	-	530	-	440
Dibenzofuran	430 j	390	370 j	290	260	190 j	260	250	290	220	270	210 u
Coprostanol	na	na	na	na	12000	na	na	na	na	na	na	120 u
Diethyl phthalate	510 u	260 uj	500 u	100	130 u	380 uj	110 uj	160 u	220 uj	120 uj	130 uj	53 j
Dimethyl phthalate	510 u	350 u	450 u	90 j	130 u	350 u	110 u	160 u	350	120 u	57 j	500
Butyl benzyl phthalate	2500	2100 uj	2000	1300 j	1100	650 j	560 j	790	590	490 j	650 j	1300 u
Di-n-butyl phthalate	490	630 uj	550 j	1600	710 u	230 uj	240 uj	380	350 uj	310	2900	360
Di-n-octyl phthalate	8200	1900 uj	450 u	1100	380 u	350 uj	560 u	390	220 uj	120 u	660 u	7000 u
Bis(2EH)phthalate	26000	21000 uj	2900 uj	16000	14000 u	94000	7400	96000	13000 uj	13000	13000	4800
Butyltins*												
Monobutyltin	470 uj	65 u	67 uj	50	29 u	360 uj	72	na	70 u	19 uj	80	22 u
Dibutyltin	240 uj	130 u	310 j	360	150	370	420	na	140 u	86	280	22 u
Tributyltin	710 j	600	480	700	310	650	790	na	580	490	550	210
Tetrabutyltin	240 uj	68 u	13 uj	13 u	30 u	92 u	13 u	na	73 u	140 u	14 u	23 u

na= Not analyzed

-= No sample

u= Not detected at detection limit shown

j= Estimated concentration

uj= Estimated detection limit

*= Reported as chloride

Table C10(cont.): Summary of Semivolatile Organics and Butyltin* Analysis of Settling Particulate Matter from Thea Foss Waterway collected November 1992 to June 1995 (ug/kg, dry weight).

Location	Mouth of Wheeler–Osgood Waterway					Mouth near D–Street Tank Farms				
Station No.	TF–3					TF–4				
Collection Period Period	11/92– 5/93	7/93– 12/93	12/93– 5/94	5/94– 11/94	11/94– 6/95	11/92– 5/93	7/93– 12/93	12/93– 5/94	5/94– 11/94	11/94– 6/95
TOC (%)	5.8	5.9	6.0	5.0	5.7	4.6	4.5	5.0	3.8	4.7
Semivolatiles										
Acenaphthene	210	280	460	310	160 j	150 j	220 j	270 j	150 j	270
Acenaphthylene	230	240 j	320	290	190 j	170 j	220 j	430	190	240
Naphthalene	410	550	570	710	390 u	200 j	460	730	440	450 u
Fluorene	320	320	820	380	230	190 j	300	450	210	340
Anthracene	750	670	2100	750	550 u	390	570	950	470	620
Phenanthrene	1800	1700	2900	1700	1500	1200	1500	2100	1100	1700
Sum LPAH	3700	3800 j	7200	4100	2100 j	2300 j	3300 j	4900 j	2600 j	3200
Fluoranthene	3100	3000	3600	2800	2700	2000	2500	3600	1900	2900
Benzo(a)anthracene	1200	1200	1300	1200	950 u	720	1000	1400 uj	790	1100 u
Chrysene	1800	1900	1900	1800	1700	1000	1700	2200	1300	1800
Pyrene	1300	3800	2500	3500	2600	200 u	2900	3100	2200	3100
Benzofluoranthenes	2900	2500	3100	1700	2700	1500	2900	3800	2300	3100
Benzo(a)pyrene	130 u	1600	900	1600	950 u	210 u	1300	1300	1100	1100 u
Dibenzo(a,h)anthracene	200	250 j	230	310	210 u	210 u	240 j	290 j	170	230
Indeno(1,2,3–cd)pyrene	300	1100	3800	1100	990	210 u	970	1100	800	1000
Benzo(g,h,i)perylene	130 u	1200	370	1200	940	210 u	950	540	770	990
Sum HPAH	11000	17000 j	18000	15000	12000	5200	14000 j	17000 j	11000	13000
Total PAH	15000	21000 j	25000	19000	14000 j	7600 j	17000 j	22000 j	14000 j	16000
Phenol	130 u	260 u	210	120 u	210 u	210 u	270 u	340 j	160 u	270 u
Pentachlorophenol	130 u	2600 u	1800 u	1200 u	1100 u	1000 u	2700 uj	3400 u	1600 u	600 u
4–Methylphenol	130 u	650	110 j	85 j	210 u	210 u	77	260 j	87 j	120 u
1–Methylnaphthalene	200	–	–	–	–	96 j	–	–	–	–
2–Methylnaphthalene	200	300	490	380	230 u	100 j	270 j	410	250	280 u
Carbazole	130 u	260 u	590	150	210 u	150 j	270 u	340 u	91 j	120 u
Benzoic Acid	6700	5300 uj	2000 j	5200 j	420 uj	5400	7000 uj	4300 j	2700 uj	3000 j
Benzyl Alcohol	130 uj	100 j	180 u	120 u	210 u	210 u	270 u	340 u	160 u	120 j
Retene	400	–	610	–	420	350	–	1100	–	400
Dibenzofuran	190	250	430	300	210 u	150 j	220 j	310 j	160	220 u
Coprostanol	na	na	na	na	8500 u	na	na	na	na	6500
Diethyl phthalate	130 u	260 uj	180 u	120 u	210 u	210 u	270 uj	560 uj	160 uj	120 u
Dimethyl phthalate	130 u	260 u	180 u	120 u	210 u	210 u	80 j	340 u	160 u	85 j
Butyl benzyl phthalate	450	520uj	890 u	590	380	250	340 uj	1700	160 j	120 u
Di–n–butyl phthalate	580	260 u	180 u	360 uj	780 u	210 u	270 uj	270000 j	450	730 u
Di–n–octyl phthalate	130 u	260 u	180 u	590	210 u	210 u	1400 u	340 u	790 u	120 u
Bis(2EH)phthalate	9400	5200 uj	7300 uj	590	4800 u	210 u	24000 uj	9100 uj	2300 uj	4600 u
Butyltins*										
Monobutyltin	550 uj	280	26 uj	13 u	33 u	na	70 u	44 uj	65	150 j
Dibutyltin	270 uj	130 u	52 u	200	89	na	140 u	190 j	54	100 j
Tributyltin	30 j	680	520 j	540 j	260	na	330	420 j	210	240 j
Tetrabutyltin	270 uj	67 u	27 u	14 u	17 u	na	70 u	49 u	16 u	62 j

na= Not analyzed

–= No sample

u= Not detected at detection limit shown

j= Estimated concentration

uj= Estimated detection limit

*= Reported as chloride

Table C11: Summary of PCB analysis of settling particulate matter from Thea Foss Waterway, November 1994 to June 1995 (ug/kg, dry weight).

Station Collection Period	TF-1 11/94-6/95	TF-2 11/94-6/95	TF-3 11/94-3/95	TF-3 3-6/95	TF-4 11/94-6/95
1242	130u	120u	210u	120u	180u
1254	320	310	220	310	120
1260	260	300	230	260	160
Total	580	610	450	570	280

u= Not detected at detection limit shown

Table C12: Sediment Accumulation Rates for Thea Foss Waterway from Sediment Trap Data, November 1992 to June 1995.

Station	Deployment Period	Number Days Deployed	Collection Area cm2	SPM Wet grms	SPM Percent Solids	BS Percent Solids	SPM Dry g	Dry Density* g/cm3	Gross Accumulation g/cm2/year	Accumulation Rate cm/year
TF-1A	11/92-2/93	99	78.5	40.6	43	39	17	0.51	0.8	1.6
-1B	"	99	78.5	41.2	43	39	18	0.51	0.8	1.6
-1A	2-5/93	82	78.5	80.2	42	39	34	0.51	1.9	3.7
-1B	"	82	78.5	73.7	42	39	31	0.51	1.8	3.5
-1A	7-9/93	70	78.5	45.5	38	39	17	0.51	1.1	2.3
-1B	"	70	78.5	47.6	38	39	18	0.51	1.2	2.4
-1A	9-12/93	77	78.5	46.7	42	39	20	0.51	1.2	2.3
-1B	"	77	78.5	44.2	43	39	19	0.51	1.1	2.2
-1A	12/93-3/94	106	78.5	83.7	43	39	36	0.51	1.6	3.1
-1B	"	106	78.5	85.3	43	39	37	0.51	1.6	3.1
-1A	3-5/94	55	78.5	50.4	32	39	16	0.51	1.3	2.6
-1B	"	55	78.5	50.4	34	39	17	0.51	1.4	2.8
-1A	5-8/94	92	78.5	100.0	37	39	37	0.51	1.8	3.6
-1B	"	92	78.5	99.0	37	39	37	0.51	1.8	3.6
-1A	8-11/94	98	78.5	75.0	34	39	26	0.51	1.2	2.4
-1B	"	98	78.5	76.0	35	39	26	0.51	1.2	2.4
-1A	11/94-3/95	97	78.5	95.0	42	39	40	0.51	1.9	3.7
-1B	"	97	78.5	96.0	42	39	41	0.51	1.9	3.8
-1A	3/95-6/95	98	78.5	294.0	28	39	81	0.51	3.9	7.6
-1B	"	98	78.5	345.0	27	39	93	0.51	4.4	8.7
								mean=	1.7	3.4
TF1A-1	12/93-3/94	106	78.5	55.6	41	41	23	0.55	1.0	1.8
-1B	"	106	78.5	54.2	41	41	22	0.55	1.0	1.8
-2A	3-5/94	55	78.5	88.6	41	41	37	0.55	3.1	5.7
-2B	"	55	78.5	91.4	40	41	36	0.55	3.1	5.6
-2A	5-8/94	92	78.5	209.0	41	41	86	0.55	4.4	8.0
-2B	"	92	78.5	207.0	41	41	85	0.55	4.3	7.8
-2A	8-11/94	98	78.5	131.0	39	41	51	0.55	2.4	4.4
-2B	"	98	78.5	135.0	38	41	51	0.55	2.4	4.4
								mean=	2.7	4.9
TF-2A	11/92-2/93	99	78.5	33.8	43	46	15	0.64	0.7	1.1
-2B	"	99	78.5	33.8	43	46	14	0.64	0.7	1.1
-2A	2-5/93	82	78.5	38.5	37	46	14	0.64	0.8	1.3
-2B	"	82	78.5	39.8	38	46	15	0.64	0.9	1.3
-2A	7-9/93	70	78.5	71.8	45	46	32	0.64	2.1	3.3
-2B	"	70	78.5	70.5	42	46	30	0.64	2.0	3.1
-2A	9-12/93	77	78.5	47.1	41	46	19	0.64	1.2	1.8
-2B	"	77	78.5	44.2	40	46	18	0.64	1.1	1.7
-2A	12/93-3/94	106	78.5	38.1	39	46	15	0.64	0.7	1.0
-2B	"	106	78.5	39.3	38	46	15	0.64	0.7	1.0
-2A	3-5/94	55	78.5	57.6	36	46	21	0.64	1.7	2.7
-2B	"	55	78.5	57.7	34	46	20	0.64	1.6	2.6
-2A	8-11/94	98	78.5	118.0	36	46	42	0.64	2.0	3.1
-2B	"	98	78.5	119.0	37	46	44	0.64	2.1	3.2
-2A	11/94-3/95	97	78.5	75.0	39	46	30	0.64	1.4	2.2
-2B	"	97	78.5	75.0	40	46	30	0.64	1.4	2.2
								mean=	1.3	2.0

SPM= Settling Particulate Matter

BS= Bottom Sediment

=Estimated from Puget Sound Sediment Density Model (Crecelius, 1989) using % solids data from in-situ bottom sediments. (dry density=wet density(BS% solids/100)

Table C12(cont.): Sediment Accumulation Rates for Thea Foss Waterway from Sediment trap data, November 1992 – June 1995.

Station	Deployment Period	Number Days Deployed	Collection Area cm2	SPM Wet grms	SPM Percent Solids	BS Percent Solids	SPM Dry g	Dry Density* g/cm3	Gross Accumulation g/cm2/year	Accumulation Rate (cm/year)
TF-3A	11/92-2/93	99	78.5	41.5	43	40	18	0.53	0.8	1.6
-3B	"	99	78.5	41.4	45	40	19	0.53	0.9	1.6
-3A	2-5/93	82	78.5	38.5	40	40	15	0.53	0.9	1.6
-3B	"	82	78.5	38.3	38	40	15	0.53	0.8	1.6
-3A	7-9/93	70	78.5	76.2	41	40	31	0.53	2.1	3.9
-3B	"	70	78.5	73.6	39	40	29	0.53	1.9	3.6
-3A	9-12/93	77	78.5	51.4	39	40	20	0.53	1.2	2.3
-3B	"	77	78.5	51.9	40	40	21	0.53	1.3	2.4
-3A	12/93-3/94	106	78.5	33.4	38	40	13	0.53	0.6	1.0
-3B	"	106	78.5	34.1	36	40	12	0.53	0.5	1.0
-3A	3-5/94	55	78.5	49.2	29	40	14	0.53	1.2	2.3
-3B	"	55	78.5	44.7	31	40	14	0.53	1.2	2.2
-3A	5-8/94	92	78.5	141.0	37	40	52	0.53	2.6	5.0
-3B	"	92	78.5	133.0	37	40	49	0.53	2.5	4.6
-3A	11/94-3/95	97	78.5	53.0	40	40	21	0.53	1.0	1.9
-3B	"	97	78.5	54.0	40	40	22	0.53	1.0	2.0
-3A	3/95-6/95	98	78.5	89.0	31	40	27	0.53	1.3	2.5
-3B	"	98	78.5	91.0	30	40	27	0.53	1.3	2.5
								mean=	1.3	2.4
TF-4A	11/92-2/93	99	78.5	23.7	43	64	10	1.07	0.5	0.5
-4B	"	99	78.5	26.5	42	64	11	1.07	0.5	0.5
-4A	2-5/93	82	78.5	30.5	39	64	12	1.07	0.7	0.6
-4B	"	82	78.5	29.7	38	64	11	1.07	0.6	0.6
-4A	7-9/93	69	78.5	57.9	38	64	22	1.07	1.5	1.4
-4B	"	69	78.5	56.9	39	64	22	1.07	1.5	1.4
-4A	9-12/93	77	78.5	39.5	41	64	16	1.07	1.0	0.9
-4B	"	77	78.5	39.3	42	64	17	1.07	1.0	0.9
-4A	12/93-3/94	106	78.5	28.8	38	64	11	1.07	0.5	0.5
-4B	"	106	78.5	31.3	37	64	11	1.07	0.5	0.5
-4A	3-5/94	55	78.5	37.9	30	64	11	1.07	1.0	0.9
-4B	"	55	78.5	39.9	30	64	12	1.07	1.0	0.9
-4A	5-8/94	92	78.5	108.0	30	64	32	1.07	1.6	1.5
-4B	"	92	78.5	106.0	32	64	34	1.07	1.7	1.6
-4A	8-11/94	98	78.5	81.0	34	64	27	1.07	1.3	1.2
-4B	"	98	78.5	79.0	31	64	25	1.07	1.2	1.1
-4A	11/94-3/95	97	78.5	40.0	38	64	15	1.07	0.7	0.7
-4A	3/95-6/95	98	78.5	75.0	16	64	12	1.07	0.6	0.5
-4B	"	98	78.5	68.0	23	64	15	1.07	0.7	0.7
								mean=	0.95	0.89

SPM= Settling Particulate Matter

BS= Bottom Sediment

=Estimated from Puget Sound Sediment Density Model (Crecelius, 1989) using % solids data from in-situ bottom sediments. (dry density=wet density(BS% solids/100)

Appendix D

Physical/Chemical Analysis of Bottom Sediments (Dry Weight)
December 1989, January 1991, and November 1994

Hylebos Waterway

Table D1: Results of Conventionals and Metals Analysis of Bottom Sediments from Hylebos Waterway, January 1991 and November 1994.

Location	Upper Turning Basin			@ General Metals		@ Elf Atochem		Near Lincoln Drain		Near Cenex		@ Occidental Chemical		Mouth	
Station No.	H-1			H-2		H-3		H-4		H-5		H-6		H-7	
Collection Date	1/91	(Rep)	11/94	1/91	11/94	1/91	11/94	1/91	11/94	1/91	11/94	1/91	11/94	1/91	11/94
Depth (ft) @ MLLW	25			32		24		22		25		30		31	
Total Solids (%)	47	45	37	41	44	41	41	46	56	49	53	52	50	64	59
TOC (%)	4.4	4.6	4.9	5.2	3.4	4.3	3.6	4.0	3.1	5.3	12	2.7	2.1	1.8	1.7
Grain Size (%)															
Gravel (>2mm)	2	0	2	0	4	0	1	2	1	16	31	0	0	0	1
Sand (2mm-62um)	26	19	10	28	27	22	23	45	61	38	25	32	21	50	42
Silt (62um-4um)	46	60	62	39	48	45	54	31	28	26	35	42	58	44	42
Clay (<4um)	27	21	27	33	21	33	22	22	10	20	9	26	21	16	15
Metals (mg/kg, dry)															
Antimony	9.0	10	na	42	na	14	na	17	na	9.0	na	3.9	na	2.2 u	na
Arsenic	62	56	38	86	30	49	35	52	20	37	16	18	14	15	11
Cadmium	0.7	0.9	0.89 j	1.5	0.7 j	0.8	1.0 j	0.7	0.4 j	0.6	0.3 u	0.4	na	0.3	0.3 u
Copper	93	120	140	220	120	150	130	150	98	120	93	120	100	98	72
Mercury	0.22	0.26	0.35	0.46	0.43	0.45	0.45	0.30	0.19	0.28	0.22	0.23	0.25	0.16	0.14
Lead	55	69	63	160	67	97	88	92	48	84	53	100	100	43	39
Nickel	44	47	160	53	69	49	96	42	110	36	130	40	160	26	90
Zinc	190	230	230	540	200	210	180	200	110	160	95	140	110	120	67

u=Not detected at detection limit shown

j=Estimated concentration

na=Not analyzed

(Rep)=Replicate sample

Table D2: Summary of Volatiles, Semivolatiles and PCBs Detected in Bottom Sediments from Hylebos Waterway, January 1991 and November 1994 (ug/kg, dry weight).

Location	Upper Turning Basin			@ General Metals		@ Elf Atochem			Lincoln Drain	
Station No.	H-1			H-2		H-3			H-4	
Collection Date	1/91	Rep	11/94	1/91	11/94	1/91	Rep	11/94	1/91	11/94
Depth @ MLLW (ft)	23			28		31			23	
TOC (%)	4.4	4.6	4.9	5.2	3.4	4.2	4.3	3.6	4.0	3.1
Volatiles										
Acetone	na	na	na	na	na	na	na	na	na	na
Carbon Disulfide	na	na	na	na	na	na	na	na	na	na
Cis 1,2-Dichloroethene	na	na	na	na	na	na	na	na	na	na
Trichloroethene	na	na	na	na	na	na	na	na	na	na
Tetrachloroethene	na	na	na	na	na	na	na	na	na	na
Chloroform	na	na	na	na	na	na	na	na	na	na
Isopropyltoluene	na	na	na	na	na	na	na	na	na	na
Semivolatiles			na							
Acenaphthene	32 j	80 u	35 j	94 u	70 j	29 j	na	140 j	31 j	32 j
Acenaphthylene	28 j	33 j	64 j	36 j	59 j	23 j	na	86 j	23 j	36 j
Naphthalene	80 u	80 u	63 j	94 u	140 j	50 j	na	140 j	42 j	110 j
Fluorene	46 j	27 j	250 uj	40 j	96 j	54	na	160 j	48	43 j
Anthracene	170	170	290 j	240	300	170	na	570	130	130 j
Phenanthrene	230	180	310	350	430	320	na	1200	330	210
Sum LPAH	510 j	410 j	1000 j	670 j	1100 j	650 j	na	2300 j	600 j	560 j
Fluoranthene	790	930	1500	1300	1600	1200	na	2300	750	600
Benzo(a)anthracene	340	400	660	660	770	580	na	1200	390	280
Chrysene	730	820	1700	1800	2000	1500	na	2700	810	690
Pyrene	550	740	1300	1400	1800	1400	na	3200	680	900
Benzofluoranthenes	870	1100	2800	2300	3000	2100	na	4000	1100	1100
Benzo(a)pyrene	170	210	780	400	900	390	na	1400	210	330
Dibenzo(a,h)anthracene	80 u	58	260 uj	130 j	320	140	na	370	79	150 uj
Indeno(1,2,3-cd)pyrene	120	190	810	300	900	310	na	1300	210	350
Benzo(g,h,i)perylene	61 u	80 u	730	47 j	880	59 j	na	1200	33	350
Sum HPAH	3600	4400	11000	8300 j	12000	7700 j	na	18000	4300	4800
Total PAH	4100 j	4800 j	12000 j	9000 j	13000 j	8400 j	na	20000 j	4900 j	9900 j
Phenol	170 j	120	68 j	190 u	300	44 j	na	200 u	33 j	150 u
Pentachlorophenol	300 u	400 u	2500 u	470 u	2000 u	230 u	na	2000 u	210 u	58 j
2-Methylnaphthalene	80 u	80 u	51 j	94 u	69 j	33 j	na	86 j	23 j	41 j
Carbazole	na	na	120	na	140 j	na	na	150 j	na	150 u
Hexachloroethane	120 u	160 u	250 u	190 u	200 u	48	na	200 u	80 u	150 u
Hexachlorobenzene	61 u	80 u	250 u	94 u	200 u	34 j	na	200 u	41 u	150 u
Hexachlorobutadiene	120 u	160 u	250 u	190 u	200 u	93 u	na	31 j	82 u	150 u
Benzoic Acid	610 u	800 u	1700	940 u	320 j	210 j	na	2000 uj	410 u	1500 uj
Retene	na	na	200 uj	na	280	na	na	280	na	220
Dibenzofuran	80 u	80 u	46 j	94 u	89 j	37 j	na	89 j	35 j	39 j
Diethylphthalate	41 u	–	250 j	94 u	200 uj	46 u	na	200 uj	41 u	150 u
Dimethylphthalate	27 j	80 u	140 uj	94 u	200 u	39 j	na	200 u	34 j	150 u
Butylbenzylphthalate	80 u	80 u	710 j	100	200 uj	46 u	na	200 uj	40 j	770 uj
Di-n-Butylphthalate	61 u	80 u	8100 uj	94 u	16000 uj	27 j	na	2200	34 j	290 uj
Di-n-Octylphthalate	41 u	80 u	1200 uj	94 u	1000 uj	46 u	na	980 uj	41 u	770 uj
Bis(2EH)phthalate	650	790	1400 uj	1200	1500	820	na	760 uj	630	640
Isophorone	41 u	80 u	350 uj	94 u	36 j	46 u	na	17 j	41 u	150 u
Coprostanol	na	na	2000 j	na	2300 j	na	na	2300 j	na	690 j
N-Nitrodiphenylamine	41 u	80 u	250 u	94 u	110 j	46 u	na	200 u	41 u	150 u
1,4-Dichlorobenzene	41 u	80 u	250 u	94 u	200 u	46 u	na	200 u	41 u	150 u
1,2,4-Trichlorobenzene	41 u	80 u	250 u	94 u	200 u	46 u	na	200 u	41 u	150 u
PCB										
1242	85 u	na	120 u	96 u	120 j	100 u	100 u	150 j	85 u	77 j
1254	220	na	300	790	680 j	1100	1700	2000 j	660	440 j
1260	83 u	na	220	96 u	560 j	460	1300	860 j	420	440 j
Total PCB'S	220	na	520	790	1400 j	1600	3000	3000 j	1100	960 j

u=Not detected at detection limit shown
–=No sample
(Rep)=Replicate sample

uj=Estimated detection limit
na=Not analyzed
j=Estimated concentration

Table D2(cont): Summary of Volatiles, Semivolatiles and PCBs Detected in Bottom Sediments from Hylebos Waterway, January 1991 and November 1994 (ug/kg, dry weight).

Location	Near Cenex		@ Occidental Chemical			Mouth	
Station No.	H-5		H-6			H-7	
Collection Date	1/91	11/94	1/91	Rep	11/94	1/91	11/94
Depth @ MLLW (ft)	19		31	–		31	
TOC (%)	5.3	12	2.6	2.8	2.1	1.8	1.7
Volatiles							
Acetone	90 j	39 uj	15 uj	2 uj	49 uj	17 uj	20 uj
Carbon Disulfide	1 j	3.8 uj	1 j	1 j	6	0.6 j	1.8 u
Cis 1,2-Dichloroethene	1 j	3.5 uj	2	2	3.1	1 u	0.57 j
Trichloroethene	1 j	0.87 j	2 j	2	1.6 j	1 u	1.8 uj
Tetrachloroethene	0.8 j	3.5 u	2 j	1 j	4.4 u	1 u	1.8 u
Chloroform	2 u	3.5 uj	2 j	0.8 j	5.1 uj	1 u	1.8 uj
Isopropyltoluene	2 u	58	2 u	2 u	4.4 uj	1 u	1.8 uj
Semivolatiles							
Acenaphthene	320	150 j	41 j	na	65 j	17 j	54 j
Acenaphthylene	47 j	110 j	26 j	na	77 j	20 j	50 j
Naphthalene	120	340	61	na	170	26 j	150 j
Fluorene	360	230	70	na	120 j	26 j	120 j
Anthracene	850	420	200	na	360	97	360 j
Phenanthrene	1900	1000	410	na	640	290	470 j
Sum LPAH	3600 j	2300 j	810 j	na	1400 j	480 j	1200 j
Fluoranthene	2300	2400	900	na	1100	430	810 j
Benzo(a)anthracene	1300	900	410	na	530	170	360 j
Chrysene	1800	1600	730	na	1100	300	540 j
Pyrene	1700	2000	640	na	950	220 j	770 j
Benzofluoranthenes	1700	1700	920	na	1200	380	830 j
Benzo(a)pyrene	430	570	240	na	460	100	330 j
Dibenzo(a,h)anthracene	160	190 uj	75	na	160 uj	53 j	57 j
Indeno(1,2,3-cd)pyrene	360	450	220	na	400	110	200 j
Benzo(g,h,i)perylene	68 j	400	41 j	na	300	30 u	210 j
Sum HPAH	9800 j	10000	4200 j	na	6200	1800 j	4100 j
Total PAH	13000 j	12000 j	5000 j	na	7600 j	2300 j	5300 j
Phenol	40 j	190 u	72 j	na	160 u	17 j	54 uj
Pentachlorophenol	180 u	1900 u	89 j	na	1600 u	150 u	540 uj
2-Methylnaphthalene	190	290	45	na	98 j	12 j	81 j
Carbazole	na	150 j	na	na	66 j	na	100 j
Hexachloroethane	73 u	190 u	62	na	160 u	61 u	54 uj
Hexachlorobenzene	37 u	190 u	87	na	94 j	30 u	39 j
Hexachlorobutadiene	73 u	32 j	46 j	na	83 j	61 u	32 j
Benzoic Acid	230 j	1900 uj	200 j	na	1600 uj	300 u	190 uj
Retene	na	8900	na	na	340	30 u	54 u
Dibenzofuran	180	300	59	na	93 j	23 j	87 j
Diethylphthalate	37 u	1900 uj	38 u	na	160 u	30 u	54 uj
Dimethylphthalate	29 j	190 u	36 j	na	160 u	30 u	54 uj
Butylbenzylphthalate	37 u	190 uj	38 u	na	810 uj	30 u	270 uj
Di-n-Butylphthalate	37 u	3000 uj	38 u	na	160 uj	30 u	54 uj
Di-n-Octylphthalate	37 u	940 uj	38 u	na	810 uj	30 u	270 uj
Bis(2EH)phthalate	360	360 uj	460	na	440 uj	300	220 uj
Isophorone	37 u	190 u	38 u	na	16 j	30 u	54 uj
Coprostanol	na	1500 j	na	na	2300 j	na	54 uj
N-Nitrodiphenylamine	37 u	190 u	38 u	na	160 u	30 u	54 uj
1,4-Dichlorobenzene	37 u	190 u	38 u	na	26 j	30 u	54 uj
1,2,4-Trichlorobenzene	37 u	190 u	38 u	na	36 j	30 u	54 uj
PCB							
1242	100 u	94 u	71 u	na	250 j	63 u	120 j
1254	270	180 j	310	na	610 j	63 u	150 j
1260	1100	550 j	280	na	720 j	150	240 j
Total PCB'S	1400	730	590	na	1600 j	150	510 j

u=Not detected at detection limit shown
–=No sample
(Rep)=Replicate sample

uj=Estimated detection limit
na=Not analyzed
j=Estimated concentration

Table D3: Results of Butyltin* Analysis of Bottom Sediments from Hylebos Waterway, November 1994 (ug/kg, dry weight).

Location	Upper Turning Basin	@ General Metals	@ Elf Atochem	Near Lincoln Drain	Near Cenex	@ Occidental Chemical	Mouth
Station	H-1	H-2	H-3	H-4	H-5	H-6	H-7
Monobutyltin	100	34 j	120	35	47	110	23
Dibutyltin	160 j	210 j	44 j	380 j	39 uj	26 uj	92 j
Tributyltin	370	280 j	360	820	180	290	150
Tetrabutyltin	8 j	4.3 j	2.6 j	30	0.6 j	14 u	2 j

*= Reported as chloride

u=Not detected at detection limit shown

j=Estimated concentration

Sitcum Waterway

Table D4: Results of Conventionals and Metals Analysis of Bottom Sediments from Sitcum Waterway, January 1991 and November 1994 (mg/kg, dry weight)

Location	Head @ North Corner Drain		Sealand Terminal		Terminal 7 @ Berth B			Mouth @ Terminal 7	
Station No.	S-1		S-2		S-3			S-4	
Collection Date	1/91	11/94	1/91	11/94	1/91	(Rep)	11/94	1/91	11/94
Depth @ MLLW (ft)	22		44	na	47			47	
Total Solids (%)	57	52	62	na	62	61	46	60	44
TOC (%)	1.5	1.7	1.5	na	1.3	2.0	1.1	1.9	1.1
Grain Size (%)									
Gravel (>2mm)	8	1	1	na	1	0	0	0	0
Sand (2mm-62um)	22	27	18	na	39	41	1	14	0
Silt (62um-4um)	50	54	61	na	43	42	77	67	77
Clay (<4um)	20	18	20	na	18	17	22	19	23
Metals									
Arsenic	25	11	28	na	20	24	12	7	16
Copper	160	130	120	na	150	160	55	64	59
Lead	290	230	160	na	370	370	19	73	21
Zinc	340	250	190	na	450	470	69	120	73

na=Not analyzed

(Rep)=Replicate sample

Table D5: Summary of Semivolatile Organics Detected in Bottom Sediments from Sitcum Waterway, January 1991 and November 1994 (ug/kg, dry weight).

Location	Head @ North Corner Drain		Sealand Terminal		Terminal 7 @ Berth B			Mouth @ Terminal 7	
Station No.	S-1		S-2		S-3			S-4	
Collection Date	1/91	11/94	1/91		1/91	(Rep)	11/94	1/91	11/94
Depth @ MLLW (ft)	22		44	na	47			47	
Naphthalene	54	190 j	48 j	na	64 j	280	190 u	36 j	32 j
Acenaphthene	56	110 j	21 j	na	250	540	190 u	17 j	200 u
Acenaphthylene	24 j	72 j	11 j	na	20 j	28 j	15 j	31 u	200 u
Fluorene	170	150 j	27 j	na	290	580	190 u	22 j	200 uj
Anthracene	280	390	66	na	440	620	29 j	50	200 uj
Phenanthrene	820	860	120	na	1300	3500	73 j	130	74 j
Sum LPAH	1400 j	1800	300 j	na	2400 j	5500 j	120	260 j	500 j
Fluoranthene	1400	2400	290	na	2000	3600	120 j	300	110 j
Benzo(a)anthracene	660	800	150	na	770	1100	190 u	120	200 u
Chrysene	950	1300	300	na	950	1300	100 j	190	120 j
Pyrene	1100	2000	290	na	1300	2300	140 j	280	140 j
Benzofluoranthenes	1400	1500	330	na	1000	1200	330 uj	230	190 j
Benzo(a)pyrene	360	680	130	na	300	350	190 uj	89	63 j
Dibenzo(a,h)anthracene	120	190 uj	82	na	110	78	190 uj	56 j	200 uj
Indeno(1,2,3-cd)pyrene	360	420	150	na	260	250	190 uj	93	71 j
Benzo(g,h,i)perylene	32 j	360	67 j	na	47 j	30 j	190 uj	58 j	55 j
Sum HPAH	6400 j	9700	1800 j	na	6700 j	10000 j	1500	1400 j	950 j
Total PAH	7800 j	12000	2100 j	na	9100 j	16000 j	1600	1700 j	1500 j
Phenol	34 j	190 u	94 j	na	100 u	71 j	190 u	240	200 u
2-Methylnaphthalene	48	91 j	25 j	na	87	310	17 j	37	24 j
Carbazole	na	150 j	na	na	na	na	190 u	na	200 u
Coprostanol	na	810 j	na	na	na	na	na	na	
Benzoic Acid	160 j	1900 uj	320 u	na	300 u	86 j	1900 uj	81 j	2000 uj
Retene	na	310	na	na	na	na	120 j	na	110 j
Dibenzofuran	88	140 j	28 j	na	230	690	190 uj	28 j	200 uj
Dimethylphthalate	320	290	21 j	na	33	38	190 u	12	200 u
Butylbenzylphthalate	32 u	950 uj	32 u	na	30 j	30 u	190 uj	30 u	200 uj
Di-n-butylphthalate	32 u	11000 uj	32 u	na	31 u	30 u	3700 uj	30 j	7100 uj
Bis(2EH)phthalate	730	1100 uj	180	na	290	300	200 uj	160	270 uj

-=No sample

u=Not detected at detection limit shown

j=Estimated concentration

uj=Estimated detection limit

(Rep)=Replicate sample

na=Not analyzed

Thea Foss Waterway

Table D6: Results of Conventionals and Metals Analysis of Bottom Sediments from Thea Foss Waterway, December 1989, January 1991 and November 1994 (mg/kg, dry weight).

Location	Head near Twin 96" Drains					North of 15th Street Drain		
Station No.	TF-1					TF-2		
Collection Date	12/89	1/91	(Rep)	11/94	(Rep)	12/89	1/91	11/94
Total Solids (%)	37	40	41	38	38	48	44	46
TOC (%)	7.2	8.9	6.7	8.5	8.8	6.3	5.4	6.8
Grain Size (%)								
Gravel (>2mm)	0	0	1	1	0	6	0	1
Sand (2mm-62um)	25	30	43	21	21	53	13	55
Silt (62um-4um)	59	49	37	55	57	31	66	37
Clay (<4um)	16	22	19	23	22	10	21	17
Metals (mg/kg, dry)								
Cadmium	3.1	na	na	3.0	3.1	2.0	na	2.2
Copper	170	na	na	190	190	140	na	130
Mercury	0.71	na	na	1.8	0.6	0.84	na	0.66
Nickel	86	na	na	190	44	44	na	28
Lead	470	na	na	340	310	500	na	370
Zinc	520	na	na	400	430	400	na	310

Location	Mouth of Wheeler-Osgood Waterway			Mouth			
Station No.	TF-3			TF-4			
Collection Date	12/89	1/91	11/94	12/89	(Rep)	1/91	11/94
Total Solids (%)	38	42	40	49	75	73	59
TOC (%)	5.7	4.5	5.5	3.9	1.4	2.3	2.5
Grain Size (%)							
Gravel (>2mm)	0	0	0	0	5	5	3
Sand (2mm-62um)	10	22	12	28	86	79	52
Silt (62um-4um)	64	53	58	52	6	11	35
Clay (<4um)	26	25	30	20	3	5	10
Metals (mg/kg, dry)							
Cadmium	3.6	na	2.2 j	1.4	0.4	na	0.4 j
Copper	250	na	270	140	89	na	98
Mercury	0.92	na	0.8	0.58	0.09	na	0.35
Nickel	46	na	160	42	34	na	110
Lead	300	na	220	170	140	na	67
Zinc	360	na	300	190	200	na	100

na=Not analyzed

j=Estimated concentration

(Rep)=Replicate sample

Table D7: Summary of Semivolatile Organics Detected in Bottom Sediments from Thea Foss Waterway, December 1989 and November 1994 (ug/kg, dry weight).

Location	Head near Twin 96" Drains		North of 15th Street Drain		Mouth of Wheeler-Osgood		Mouth near D-Street Tank Farms	
Station No.	TF-1		TF-2		TF-3		TF-4	
Collection Date	12/89	11/94	12/89	11/94	12/89	11/94	12/89	11/94
Depth @ MLLW (ft)	14		15		18		30	
Acenaphthene	500	250 j	300 j	550	200 j	220	56 j	300
Acenaphthylene	310 j	260 j	190 j	290	280 j	330	170 j	340
Naphthalene	600	590	260 j	960	260 j	870	160 j	640
Fluorene	910	440	540	670	270 j	340	140 j	430
Anthracene	1900	1400	1100	1800	880	850	560	990
Phenanthrene	8000	4800	4200	6900	1400	1500	950	2500
Sum LPAH	12000 j	7700 j	6600 j	11000	3300 j	4100	2000 j	5200
Fluoranthene	19000	11000	7400	8900	3300	2700	1800	3400
Benzo(a)anthracene	7200	4000	2900	3800	2000	1200	930	1600
Chrysene	8600	6700	3600	5000	2600	2000	1100	2300
Pyrene	16000	9700	6800	9500	4500	4100	2200	4200
Benzofluoranthenes	15000	11000	5800	7300	4600	3600	2000	3300
Benzo(a)pyrene	5200	4600	2600	38000	2200	1700	1000	2100
Dibenzo(a,h)anthracene	1900	950	730	560	580	400 uj	360	400
Indeno(1,2,3-cd)pyrene	3100	4700	1800	2700	980	1500	640	1300
Benzo(g,h,i)perylene	3300	4000	1600	2400	1200	1400	810	1200
Sum HPAH	79000	56000	33000	78000	22000	19000	11000	20000
Total PAH	91000 j	64000 j	40000 j	89000	25000 j	23000	13000 j	25000
Phenol	na	220 j	na	160 j	na	270	na	150
Pentachlorophenol	na	250 j	na	100 j	na	2100 u	na	1500 u
4-Methylphenol	na	240 j	na	300	na	160 j	na	120 j
2-Methylnaphthalene	210	300 j	110 j	480	100 j	400	58 j	300
Carbazole	2200	960	1200	830	240 j	210 j	110 j	270
Benzoic Acid	na	2200 uj	na	590 j	na	2100 uj	na	1500 u
Benzyl Alcohol	na	170 j	na	90 j	na	210 u	na	150 u
Retene	na	480	na	480	na	460	na	370
Dibenzofuran	300	300	230 j	370	120 j	240	57 j	250
Diethyl phthalate	160 u	280 u	260	210 u	120 j	210 u	110 u	150 u
Dimethyl phthalate	220 j	110 j	130 j	210 u	130 j	210 u	110 u	150 u
Butyl benzyl phthalate	2100	1400 j	11000	1800 j	340	330 j	130 j	740 u
Di-n-Butyl phthalate	450	460 uj	250000	310 uj	150 u	210 u	110 u	150 u
Di-n-Octyl phthalate	1800	1400 uj	540	1000 uj	150 u	1000 uj	110 u	740 u
Bis(2-ethylhexyl)phthalate	21000	17000 uj	31000	12000 uj	6100	43000 uj	2600	1300 u
1,4-Dichlorobenzene	na	89 j	na	270	na	210 u	na	150 u
Coprostanol	na	6700	na	4200 u	na	3000 j	na	1000 j

u=Not detected at detection limit shown

j=Estimated concentration

na= not analyzed

Table D8: Results of Butyltin* Analysis of Bottom Sediments from Thea Foss Waterway, December 1989, January 1991, and November 1994 (ug/kg, dry weight).

Location	Head near Twin 96" Drains				North of 15th Street Drain		
Station	TF-1				TF-2		
Collection Date	12/89	1/91	(Rep)	11/94	12/89	1/91	11/94
Monobutyltin	16 u	21	15	66	14 u	25	82
Dibutyltin	160	33	25	160 j	94	46	120 j
Tributyltin	160	65	59	320	110	90	210
Tetrabutyltin	19 u	5.9 j	5.5 u	12 u	17 u	5.3 u	12 u

Location	Mouth of Wheeler-Osgood Waterway			Mouth near D-Street Tank Farms			
Station	TF-3			TF-4			
Collection Date	12/89	1/91	11/94	12/89	(Rep)	1/91	11/94
Monobutyltin	400	65	78 j	13 u	9.0 u	9.3	20
Dibutyltin	220	40	260 j	82	12	1.4 u	100 j
Tributyltin	410	110	260 j	120	15	10	140
Tetrabutyltin	20 u	5.4 u	23 uj	16 u	11 u	3.5 u	17 u

*= Reported as chloride

u=Not detected at detection limit shown

j=Estimated concentration

(Rep)=Replicate sample

uj=Estimated detection limit