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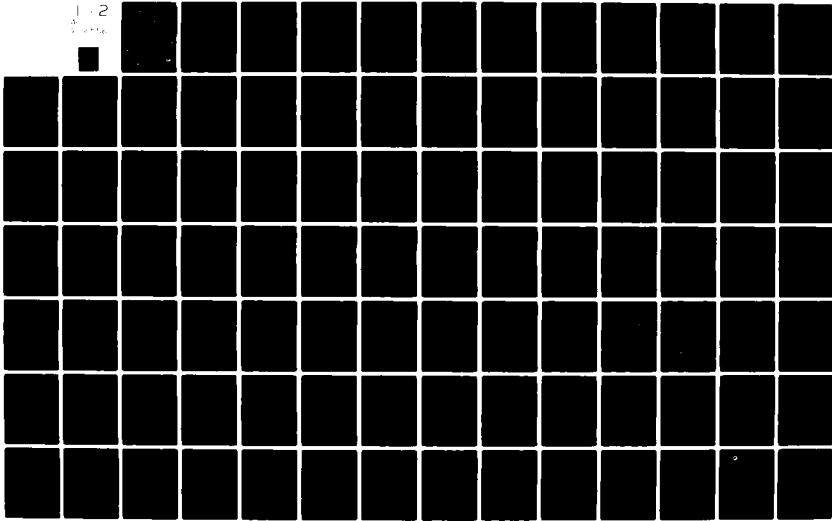
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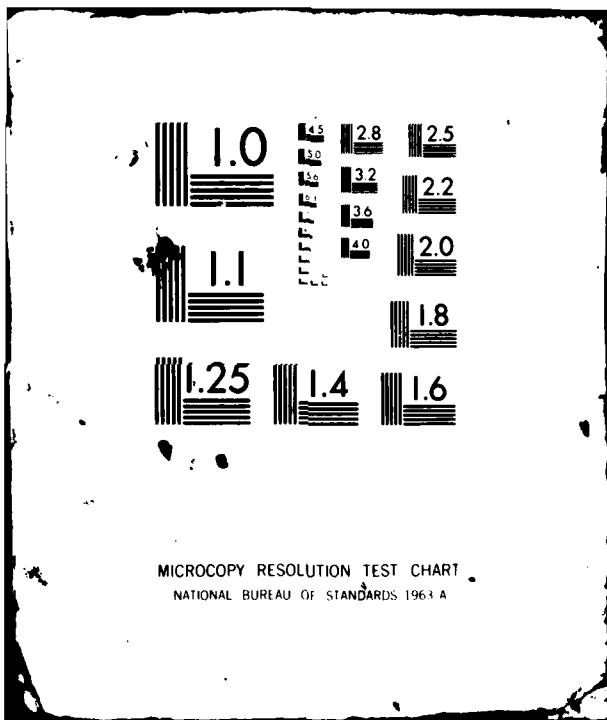
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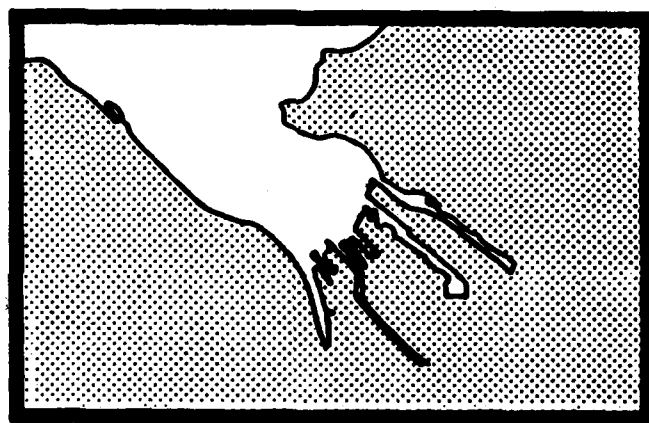




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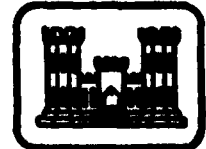
Water Quality



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<p>In the 20-month period ending December 1981, Dames & Moore (Seattle) assisted by four subcontractors completed a Phase I effort to collect baseline data and provide a detailed description of the natural and human systems of the Commencement Bay area in the southern Main Basin of Puget Sound in Washington State.</p>			

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COMMENCEMENT BAY STUDIES
TECHNICAL REPORT

VOLUME V

WATER QUALITY

for

U.S. Army Corps of Engineers
Seattle District

December 1981

Authors:

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1.0 INTRODUCTION

This report characterizes water quality of those bodies of marine and fresh water in the study area, including Commencement Bay, the industrial waterways, and the lower Puyallup River. The data and evaluations herein respond to the stated objectives of the water quality studies established by the U.S. Army Corps of Engineers (the Corps) in their Statement of Work (SOW Section 3.6) for the Commencement Bay Studies (COBS). These are:

- a. Determine existing conditions in terms of traditional water quality parameters.*
- b. Characterize vertical stratification in the study area.
- c. Identify and locate ongoing activities affecting water quality.
- d. Characterize seasonal variations in water quality throughout the study area.

Field investigations were completed in response to Task Objectives a, b, and d. Task Objective c was completed without fieldwork and involved review of available data obtained with the assistance of the Environmental Protection Agency (EPA) Region X and Washington Department of Ecology (DOE).

The remainder of the technical report is organized into three sections. Section 2.0 presents a description of the results of other water quality studies conducted in Commencement Bay as contained in published and unpublished reports. Section 3.0 presents a description of the procedures and methods employed on the COBS water quality study, and Section 4.0 presents a description of the COBS study results.

*Note that the term "traditional water quality parameters" as used in the SOW is not totally accurate since data on selected heavy metals and PCBs were requested.

This study has several limitations that require discussion. At the time the COBS SOW was being drafted and finalized, the water quality concerns in the area were considered to be relatively minor. Concurrent with and following drafting of the SOW, several studies were completed that indicated possible problems associated with sediment and water quality. As this study was being conducted and completed in response to the SOW, even more studies were initiated. The effect of these concurrent activities is twofold. First, as noted above, the COBS SOW directed studies at traditional water quality parameters with total PCBs and a few heavy metals as exceptions. Concurrent studies have focused more on additional heavy metals and many more exotic organic chemicals. This precludes data comparisons between the COBS and ongoing water quality studies in the COBS study area. Second, the manload negotiated to complete the SOW tasks for water quality did not include sufficient time to integrate the multitude of water quality related reports now in existence or in preparation. These studies were not anticipated by parties involved with the COBS scoping sessions conducted in early 1980.

In summary, we acknowledge that literally hundreds of organic chemicals have been identified in studies conducted within the COBS study area; however, the focus of the COBS water quality studies described herein are responsive solely to the COBS SOW and, for the most part, the limited water quality parameters therein. Section 2.0 has been expanded to list and provide brief descriptions of ongoing studies to permit the reader the opportunity of receiving a broader water quality data base than is presented in this report. Where reports are unpublished, non-traditional parameters are discussed in this report since they might otherwise be unavailable to the reader.

2.0 REVIEW OF PAST AND ONGOING STUDIES

2.1 GENERAL

Major available data sources considered during the initial scoping and design of the water quality study by the Corps included STORET data sets from EPA/DOE for water sampling stations in the study area and previously conducted oceanographic studies in south-central Puget Sound that included one or more stations in the study area. However, as discussed in Section 1.0, numerous other studies directed at defining the organic and heavy metal contamination of portions of the COBS study area have been initiated and, in some cases, completed. Several of these studies were funded through the NOAA/MESA Puget Sound Project Office and EPA Region X in Seattle. The most recent local government study was completed in 1979 for a City of Tacoma 301(h) waiver study in two locations in the COBS study area (City of Tacoma 1979a,b) and in City Waterway (City of Tacoma 1981). In addition, the COBS physical oceanography study entailed some water quality measurements (see the Physical Oceanography Technical Report).

The sections below summarize the major past and ongoing studies and present summaries of data available from these study results. The reader is advised that terms like "high" and "low," when linked with levels of certain identified pollutants, are only used in a relative sense (as compared to levels of the same pollutant in other areas both within and outside of the study area). These relative terms are not intended to reflect toxic or pristine conditions relative to the marine ecosystem or man. Selected water quality parameters are related to water quality criteria in Section 4.2.

2.2 UNIVERSITY OF WASHINGTON

2.2.1 General

Many sampling programs in Puget Sound, often including Commencement Bay, were undertaken between 1932 and 1975 by the University of Washington.

These programs were designed to characterize water quality parameters for Puget Sound. In addition, some past and present University of Washington oceanographers have completed studies in the area as Northwest Consultant Oceanographers (NCO).

2.2.2 Sampling Locations and Parameters

The University of Washington sampled a deep-water station west of Browns Point (47° 19.2'N, 122° 28.0'W) 85 times between 1932 and 1962 (Collias 1970) and 18 times from 1974 to 1975. The Browns Point data base resulting from this sampling is sufficient to characterize the source marine waters to Commencement Bay. Data from these studies are presented in Appendix A to this technical report. Alki Point and Point Pulley data are presented for comparison with Browns Point.

The water parameters measured at the Browns Point station during the 1932-1962 period included temperature, salinity, dissolved oxygen, and phosphate. Temperature, salinity, and depth information permitted computations of density which are always presented with the University's data as sigma-t units ($\sigma\text{-t} = [\text{density} - 1] 1,000$). The 1974-75 data included the same parameters as well as nitrate, nitrite, ammonia, and silicate.

Two stations located in Commencement Bay near the mouth of the Puyallup River were also sampled routinely during the 1974-75 study to assess nutrient inputs to Puget Sound from the Puyallup River. (The City of Tacoma discharges primary treated sewage to this river.) One station (47° 16.2'N, 122° 25.7'W) was in shallow water near the top of the delta of the river, while the other (47° 16.5'N, 122° 25.8'W) was in deeper water on the slope of the delta. Samples were taken at these stations a combined total of 18 times.

2.2.3 Results

The temperature, salinity, and density information are useful in tracing water masses in Puget Sound.* The greatest densities occur in

*These data are presented in the physical oceanography data in Appendix A.

the late summer and fall and are associated with upwelling of deeper oceanic water off the entrance to the Strait of Juan de Fuca (the ultimate source of salt water to Puget Sound) in the summer. Characteristics of upwelled water include lower dissolved oxygen (DO) (naturally occurring values as low as 4.8 mg/l [0.3 mg-at/l] were measured in Commencement Bay) and higher nutrient concentrations.

The Puyallup River plume forms a low density, low salinity surface layer that is most evident in the data collected near the river mouth. This layer is essentially confined to the upper 2 or 3 m. Density profiles for the 1974-75 data from the Puyallup River mouth stations in Commencement Bay were presented by NCO for the City of Tacoma's application for waiver 301(h) of secondary treatment to the EPA in 1979 (see Figure A-1 in Appendix A).

The sewage input to the Puyallup River is detectable within the plume in Commencement Bay mainly in the form of increased concentrations of ammonia, with values up to 5 $\mu\text{g-at/l}$ detected. While these ammonia values are associated with the sewage discharge of Tacoma, they do not constitute a water quality problem of any concern. Ammonia also occurs naturally in marine environments, a product of decay of marine plants and animals and excretion by zooplankton and other marine animals. The State of California has established a water quality standard for ammonia in marine waters as 0.6 mg/l (43 $\mu\text{g-at/l}$) for the 6-month median value, 2.4 mg/l (171 $\mu\text{g-at/l}$) for the 24-hour median value, and 6.0 mg/l (430 $\mu\text{g-at/l}$ ammonia-nitrogen) as an instantaneous maximum not to be exceeded in marine waters. The State of Washington has no standard for ammonia, so the California standard is offered for a basis of comparison with the levels detected in the plume of the Puyallup River.

The Puyallup River plume also increases levels of silica in the bay. The plume of the river contributes to increased turbidity in the bay, as measured in the University data by use of a secchi disc hung over the side of the boat. Secchi disc observations at Browns Point sometimes exceeded 10 m of water depth during the winter, while at the mouth of the Puyallup River, the suspended sediment load reduced the secchi disc observation to a few tenths of a meter.

A common concern of sewage discharge is that the organic wastes impose a biological oxygen demand (BOD) that can lower the dissolved oxygen (DO) in the water. It must be recognized that this demand occurs over the period of time that these wastes are broken down by bacteria; that is, such demand is not instantaneous. A common measurement of BOD is the 5-day biological oxygen demand (BOD5). Such a measurement of the Puyallup River water would be meaningless because the receiving water (the Puyallup River near its mouth) is dispersed rapidly into Commencement Bay and Puget Sound. Depression of DO from the treated sewage discharge is not evident in the data.*

Additional information contained within the data set from the University of Washington includes weather (temperature, barometric pressure, wind speed and direction, tide height and tide stage (rising, high, falling, low) for the time of observation. These considerations are important in interpreting data from stations near the mouth of the river. The rising tide acts to inhibit the flow of the Puyallup while the falling tide "enhances" its flow into the bay. The river water (and its waste loads and turbidity) collects in the lower reaches on the rising tide and is released as a pulse on the falling tide. Therefore, the characteristics of the surface waters of the bay vary considerably with the tide stage as well as with the river flow and season.

Oceanographic data for stations at Browns Point and the Puyallup River mouth are appended (Appendix A) for the 1932-62 and 1974-75 sampling periods. Figures A-2 through A-11 in Appendix A present the changes in temperature, salinity, density, dissolved oxygen, dissolved oxygen saturation, phosphate, nitrate, nitrite, ammonia, and silicate throughout the water column occurring during the 1974-75 sampling period, based on data obtained approximately every 3 weeks. These figures are extracted from a published report by Collias and Lincoln (1977) that provided

*The City of Tacoma is considering relocating their outfall from the river site to a subtidal location off the delta of the Puyallup. While such a relocation would eliminate sewage-related water quality impacts to the river, it would result in discharge into slow moving, naturally low DO water where the effluent would disperse slowly and where its inherent oxygen demand may become an important factor.

interpretation of the 1974-75 data to assess nutrient inputs in Puget Sound. Temperature ranged from 7 to 14°C, surface salinity from 27 to almost 30 parts per thousand (ppt), and DO saturation from less than 60 percent in the deeper water in the fall of both 1974 and 1975 to greater than 130 percent at the surface during the periods of high phytoplankton productivity. The nutrients phosphate, silicate, and nitrate showed decreases at the surface during the periods of high biological productivity (spring and summer) while ammonia showed increased levels during the same time frame that the other nutrients decreased. Patterns in the distribution of nitrite over time are not easily defined from the data (see Appendix A).

2.3 CITY OF TACOMA

Some water quality data for treated sewage effluent discharged to Commencement Bay were collected by the City of Tacoma in conjunction with Section 301(h) waiver applications for each of two wastewater treatment plants (Tables 1 and 2).

The effluent of the Tacoma Central Wastewater Treatment Plant (S.T.P. No. 1) is discharged from a 48-inch (1.2-m) pipe to the Puyallup River about 1.5 miles (2.4 km) upstream of the river's mouth. The effluent from the North End Wastewater Treatment Plant (S.T.P. No. 3) is discharged from a 36-inch (0.92-m) pipe without diffuser into 90 feet (27.3 m) of water just offshore of the Ruston Way shoreline (47° 17'16"N, 122° 30'56"W).

The effluent streams of both treatment plants are monitored under requirements of National Pollution Discharge Evaluation System (NPDES) permits; however, the Section 301(h) waiver applications afford the only known data for concentrations of metals, fibers, and organics considered as priority toxic chemicals (see Tables 1 and 2). These analyses were completed during two periods in 1979.

Most recently the City of Tacoma (1981) has reported selected water quality measurements in City Waterway (see Appendix B). Interpretations of their data is provided in the transmittal letter. This report updates

TABLE 1
DETECTABLE PRIORITY TOXIC CHEMICALS IN THE WASTEWATER EFFLUENT
DURING PERIODS OF WET AND DRY WEATHER FLOWS
FOR TACOMA CENTRAL WASTEWATER TREATMENT PLANT (S.T.P. NO. 1)(a)

Constituent	Lower Detection Limit (µg/l)	Sample Concentration	
		Dry Weather Flow (µg/l)	Wet Weather Flow (µg/l)
Metals			
Arsenic	2.50	6.00	31.00
Cadmium	0.09	0.48	0.63
Chromium	2.00	11.25	8.65
Copper	0.55	22.20	39.80
Lead	0.05	0.83	0.59
Mercury	2.30	ND ^(b)	4.10
Zinc	5.50	110.00	305.00
Fibers			
Asbestos (Chrysotile)	1.4x10 ⁶ fibers/l	7.2x10 ⁶ fibers/l	
Organic Residues			
Anthracene		0.95	0.38
Azobenzene (from Diphenylhydrazine)		0.04	0.45
BIS (2-Chloroethoxy) methane		0.02	ND
BIS (2-Chloroisopropyl) ether		0.06	2.73
BIS (2-Ethylhexyl) Phthalate		0.92	ND
Chrysene		ND	3.47
Cresol		ND	5.73
Dibenzo (A,H) Anthracene		ND	0.29
1,2-Dichlorobenzene		2.95	14.24
1,3-Dichlorobenzene		0.02	0.44
1,4-Dichlorobenzene		0.74	ND
DI-N-Butylphthalate		1.54	ND
Fluorene		ND	6.88
Hexachlorobenzene		ND	6.95
Hexamethylbenzene		ND	18.40
Napthalene		0.21	ND
N-Nitrosodimethylamine		ND	10.50
N-Nitroso-DI-N-Propylamine		0.05	0.11
Pentachlorophenol		7.30	17.30
Phenanthrene		1.01	1.04
Phenol		ND	4.18
Pyrene		ND	11.81
Percent of Priority I toxic pollutants and pesticides detectable in effluent samples		28	34

(a) Data from: City of Tacoma (1979a).

Note--These values are prior to dilution in the Puyallup River.
Present EPA criteria for some of these constituents are discussed in
Section 4.2.

(b) ND = Not detectable.

TABLE 2

DETECTABLE PRIORITY TOXIC CHEMICALS IN THE WASTEWATER EFFLUENT
DURING PERIODS OF WET AND DRY WEATHER FLOWS
FOR NORTH END WASTEWATER TREATMENT PLANT (S.T.P. NO. 3)(a)

Constituent	Lower Detection Limit (µg/l)	Sample Concentration	
		Dry Weather Flow (µg/l)	Wet Weather Flow (µg/l)
<u>Metals</u>			
Arsenic	2.50	6.00	20.00
Cadmium	0.09	0.87	0.98
Chromium	2.00	3.75	6.80
Copper	0.55	32.30	61.90
Lead	0.05	1.40	1.66
Mercury	2.30	ND(b)	3.50
Selenium	1.00	1.40	ND
Zinc	5.50	33.00	180.00
<u>Fibers</u>			
Asbestos (Chrysotile)	1.4x10 ⁶ fibers/l	11.54x10 ⁶ fibers/l	
<u>Organic Residues</u>			
Acenaphthene		2.13	ND
Anthracene		ND	0.47
Azobenzene (from Diphenylhydrazine)		0.30	0.75
Benzo (B) Fluoranthene		2.46	ND
Benzo (K) Fluoranthene		5.12	ND
BHC-Alpha + Beta		9.14	ND
BHC-Gamma		8.61	ND
BIS (2-Chloroisopropyl) ether		ND	4.16
Chrysene		1.00	8.19
Cresol		ND	4.29
Dibenzo (A,H) Anthracene		ND	0.80
1,2-Dichlorobenzene		ND	16.15
1,3-Dichlorobenzene		ND	0.88
2,6-Dinitrotoluene		0.21	ND
Fluoranthene		ND	2.97
Fluorene		ND	12.80
Hexachlorobenzene		ND	18.26
Hexachlorobutadiene		5.50	ND
Hexamethylbenzene		ND	32.50
Napthalene		ND	0.22
N-Nitrosodimethylamine		ND	3.41
Pentachlorophenol		ND	15.61
Phenanthrene		ND	1.21
Phenol		ND	2.37
Pyrene		5.97	ND
Percent of Priority I toxic pollutants and pesticides detectable in effluent samples		25	32

(a) Data from: City of Tacoma (1979a).

Note--These values are prior to dilution in the bay.

Present EPA criteria for some of these constituents are discussed in Section 4.2.

(b) ND = Not detectable.

an earlier evaluation (City of Tacoma 1974) of City Waterway which found DO levels of 4.9 to 8.0 mg/l, pH levels of 5.57 to 7.58, and total coliform levels of 400 to 49,000 MPS/100 ml. These 1974 studies also noted that: (1) a small thermocline exists at about 4 feet and (2) storm outfalls at the head of this waterway probably influenced the total coliform bacteria count at this location.

2.4 U.S. ARMY CORPS OF ENGINEERS SEATTLE DISTRICT: BLAIR-SITCUM STUDIES

Table 3 presents water quality data collected as part of a bulk sediment and elutriate analysis completed in August 1979 by Parametrix, Inc. for the Corps.

A request from several agencies (including the Corps) that the Port of Tacoma provide sediment analyses with water quality implications associated with Blair-Sitcum main channel dredging. These studies are in review by the Corps and others and are not presently available.

2.5 STORET DATA

A total of 26 STORET long-term data stations (noted CMB-Number) have been established in Commencement Bay. These represent locations, expressed in latitude and longitude, for which a variety of data (water quality, sediment quality, etc.) have been collected during several historic studies conducted in the study area. These data have in turn been entered into the STORET program maintained and updated by the Washington Department of Ecology, permitting instantaneous recall of location-specific environmental data.

These long-term Commencement Bay STORET stations report only traditional water quality parameters; the same parameters were not measured at all stations. No heavy metal or organic chemical data are reported for these 26 stations. Note that more recent data have been added to STORET in 1981 which is generally summarized in other reports presented here. These new locations (not designated CMB) do include heavy metal and organic chemical data.

TABLE 3

COMPOSITE WATER ANALYSIS: BLAIR AND SITCUM WATERWAYS,
 COMMENCEMENT BAY, WASHINGTON, AUGUST 23, 1979(a)
 (all units in ppm or mg/l)

Station	COD	Oil and Grease	Cu	Zn	Pb	As	Cr	Cd	PCB	Sulfide(S)
DNR Disposal Site	40	<5	0.057	0.007	0.003	0.005	<0.005	<0.027	<0.005	<0.5
Blair Waterway Slip 2	40	<5	0.011	0.009	0.009	0.043	<0.005	<0.002	<0.005	<0.5
Vicinity of Lincoln Avenue	40	<5	<0.002	0.004	<0.005	<0.005	<0.005	<0.002	<0.005	<0.5
Sitcum Waterway, Mid-Channel	40	<5	0.020	0.026	0.032	0.005	<0.005	<0.026	<0.005	<0.5
Milwaukee Waterway, Mid-Channel	<20	<5	0.026	0.029	<0.005	<0.005	<0.005	<0.071	<0.005	<0.5

(a) Data from: Parametrix (1979).

STORET stations are either close to or coincident with COBS stations as follows (see Section 3.1 for COBS station locations).

<u>STORET STATION NO.</u>	<u>COBS STATION NO.</u>
CMB-004	26
005	24
006	23
008	20
011	16
604	22

The summary data for these CMB stations are presented in Appendix C.

2.6 NOAA/MESA PUGET SOUND PROJECT

2.6.1 General

The Marine Ecosystem Analysis (MESA) and Office of Marine Pollution Assessment (OMPA) component of the National Oceanic and Atmospheric Administration (NOAA) is currently conducting a multi-year study of the waters of four industrial areas of Puget Sound (using an additional area as a control) to: (1) assess the effects of critical environmental problems in Puget Sound waters, (2) determine the effects of critical environmental stress within associated ecological systems, and (3) identify and characterize the major marine components and processes of Puget Sound ecosystems that are involved in critical environmental problems (Riley 1980). The NOAA/MESA Puget Sound Project is specifically intended to: (1) provide preliminary information regarding significant pollution levels in areas of Puget Sound, and (2) provide a chemical base for aiding in the design of future research directed toward meeting the above goals. Amplifying data as indicated below on the NOAA/MESA Puget Sound Project are presented in Appendix D.

Note that studies underway and completed may not be included if the reports have not been received or reviewed by NOAA/MESA. The following list provided by the NOAA/MESA Puget Sound Project Office (Long 1981) provides a description of project activities with both direct and indirect relationships to water quality in Commencement Bay and other Puget Sound locations.

1. Summary of Knowledge of Puget Sound Related to Chemical Contaminants.
URS Company. A literature review of oceanography, sedimentation, biology, contaminants, and biological abnormalities in the sound with emphasis on Commencement and Elliott Bays and Budd and Sinclair Inlets. Publication: late 1981 or early 1982.

2. Organic Contaminants in Waterways Adjacent to Commencement Bay.
Battelle Northwest Laboratories. A study of organics in sediment cores from Hylebos and Blair Waterways (10 sites) and water column samples (one site each at the mouth of each waterway). Data include age-dating of cores, chemical analyses of core strata, geographic trends in PCBs, etc., and estimates of mass inputs for selected compounds. A Riley et al. (1981) version was made available and is referenced in Section 2.6.2.

3. Effects, Pathways, Processes, and Transformations of Puget Sound Contaminants of Concern. E.V.S. Consultants, Ltd. A literature review of what is known of the contaminants observed in the sound and a selection of those that are of environmental concern, based upon their persistence, distribution, and effects. Publication: early 1982.

4. Chemical Contaminants and Abnormalities in Fish and Invertebrates from Puget Sound. NMFS/NWAFPC. A summary of the biological and chemical work performed in 1979/80 for NOAA. No raw data tables. Data include: chemical analyses of biota and sediments, catch statistics, infauna statistics, histologic abnormalities, hematology data, and chemical/biological statistical correlations. Publication: early 1982.

5. Colonization Rates and Processes as an Index of Pollution Severity. University of Washington. Colonization of hard substrates by marine biota, dissolved oxygen, temperature, and salinity monitored for 12 months at five sites in the sound. Sites include Hylebos, Blair, Milwaukee, and Duwamish Waterways and Manchester. Study is underway. Publication: 1982.

6. Survey of Biological Effects of Toxicants upon Puget Sound Biota. E.V.S. Consultants, Ltd. A survey of 100 sites in the sound (37 in Commencement Bay). Bioassays of sediments with fish, crustacea, and worms; worm respiration test; fish cell anaphase aberration tests. This study is underway. Publication: 1982.
7. Circulation and Suspended Matter in Commencement Bay. NOAA/PMEL. A study of currents and suspended matter in the bay as they may affect transport of pollutants. Publication: 1982.
8. Deep Water Cores from Commencement Bay. NOAA/PMEL and Battelle. One meter cores taken at four sites in the bay, age dated, and analyzed for metals and organics. The study is underway. Publication: 1982.

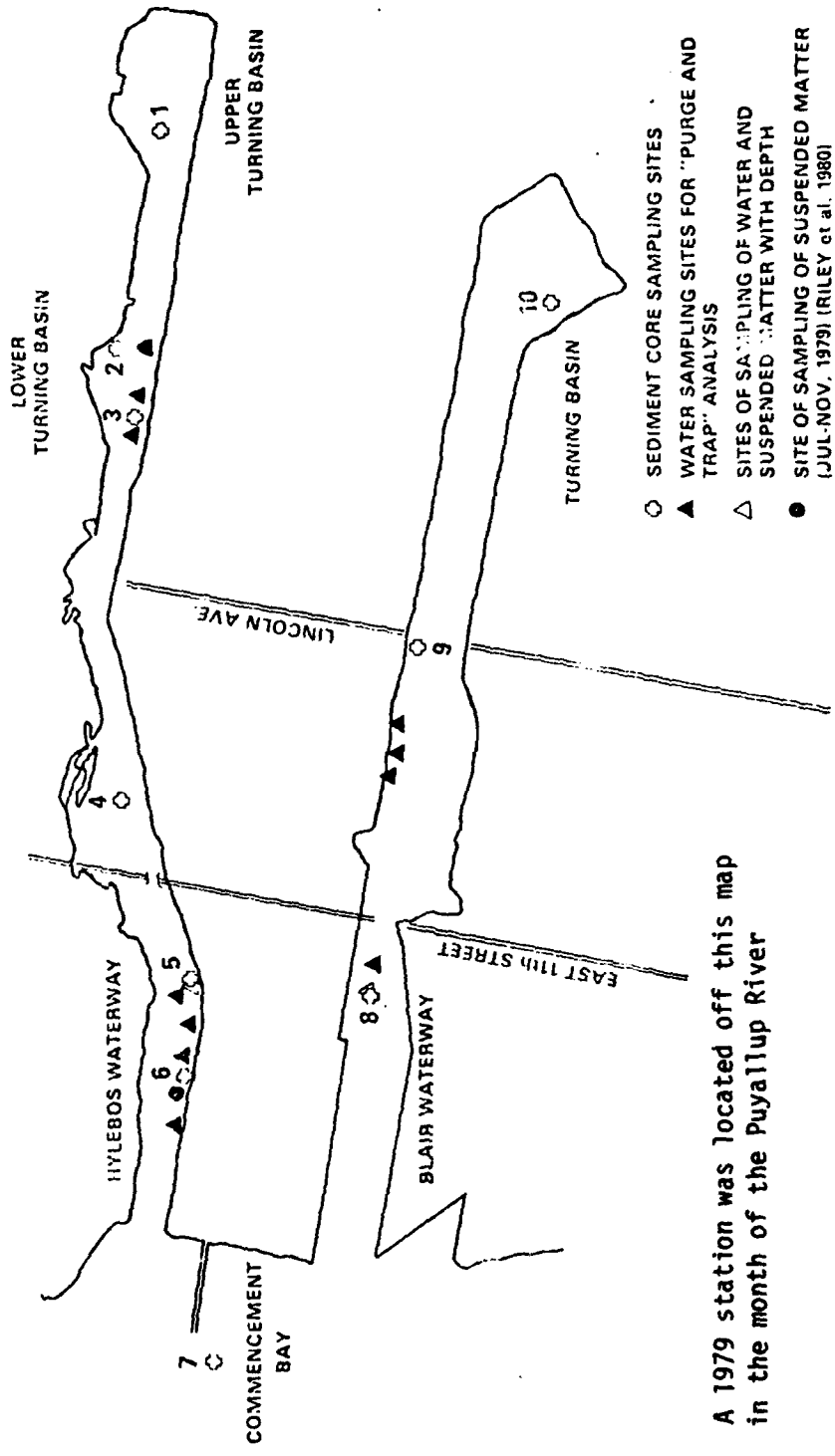
2.6.2 Sampling Locations

Industrial areas selected for sampling included Commencement Bay, Elliott Bay (Seattle), Sinclair Inlet (Bremerton) and Budd Inlet (Olympia). Port Madison, a non-industrial area, was used as a reference area for comparison. Within Commencement Bay, three sampling stations were selected in 1979. In 1980, 10 stations were established in Blair and Hylebos Waterways (see Figure 1).

2.6.3 Results

The results presented below represent a brief overview of water quality data compiled in conjunction with the NOAA/MESA Puget Sound Project to date. The project is ongoing, and future annual reports will be generated.

The waters of Commencement Bay (along with Elliott Bay) were found to have higher levels of five metals (arsenic [As], copper [Cu], lead [Pb], antimony [Sb], and zinc [Zn]) than the other Puget Sound water bodies sampled. All of these metals are on the EPA priority pollutant list (Riley 1980).



NOTE: A 1979 station was located off this map in the month of the Puyallup River

FIGURE 1

NOAA/MESA PUYALLUP RIVER, HYLEBOS WATERWAY AND BLAIR WATERWAY SAMPLING AREAS

Source: Riley et al. (in press)

Riley et al. (1981) should be further consulted for the wide array of organic pollutants beyond the data on chlorinated biphenyls (isomers of PCBs) that follow in the report. The complex organic chemicals covered in Riley et al. (1981) are beyond the scope of traditional water quality parameters covered in the COBS SOW (with the exception of PCBs).*

In Riley et al. (1981) total selected chlorinated biphenyls in filtered water of Hylebos and Blair Waterways ranged from 81 to 540 pptr in September 1980 and 22 to 387 pptr in December 1980. Riley et al. (1981) indicated the highest total selected chlorinated biphenyls were located in the mouth of Hylebos Waterway, and Stations 5 and 6 had the highest surface (2.0 meter depth) values in both sampling periods in 1980. Of further interest is the fact that these values decline with depth in the water column at Station 5 as indicated below.

TOTAL SELECTED CHLORINATED BIPHENYLS
(pptr)

<u>Depth (m)</u>	<u>September 1980</u>	<u>December 1980</u>
2.0	540	387
5.0	131	192
9.0	91	22

This pattern is reversed at Station 8 although all values at all depths sampled were relatively close to one another. The individual chlorinated biphenyls with highest concentrations were the mono- and dichlorinated biphenyls. This is due to their higher solubility (Riley et al. 1981). Riley et al. (1981) concluded that "Hylebos and Blair Waterways are currently receiving input of anthropogenic organic toxicants and have received significant historical input of these same organic toxicants."

*Note that the single COBS value is total PCBs while all of the Riley et al. data are a lesser value and include only total selected isomers of PCBs.

2.7 ENVIRONMENTAL PROTECTION AGENCY STUDIES

2.7.1 General

Three general types of water quality related studies by EPA in the Commencement Bay area are currently underway: source surveys (jointly completed with Washington Department of Ecology), screening surveys, and analyses of edible fish tissues (Hileman 1981).

The source surveys have focused on six major sources to date. The sources evaluated to date include Reichhold Chemical, U.S. Oil, Pennwalt Chemical, Sound Refining, St. Regis, and the Tacoma Central Sewage Treatment Plant.

The objectives of the source surveys are to determine: (1) the level of compliance with existing permit requirements, (2) the level of toxic materials, if any, and (3) the existence of any unpermitted discharges or other sources of chemical contamination. Surface discharges, as well as observable seeps and leachates, were analyzed for a wide variety of organic and inorganic chemicals.

The only reports completed to date evaluated Reichhold Chemical and U.S. Oil and Refining Company. This first survey report (Yake 1981a) indicates Reichhold has little or no direct discharge to inner Commencement Bay and that indirect impacts, including seepage and discharge to treated sewers will be investigated at a later date. Reichhold was found to be meeting all current permit limitations. The second survey report (Yake 1981b) stated "there was no indication that U.S. Oil's effluent had a significant impact on water quality in inner Commencement Bay. Priority pollutants were detected in the waters being discharged from the sewer to the Lincoln Avenue drain; however, the data strongly indicate that these pollutants were generated by sources other than U.S. Oil's treated effluent. The treatment facility at U.S. Oil appeared to be operating well and U.S. Oil was meeting all current permit limitations."

The screening surveys involved two sampling trips in 1980 (see Section 2.7.2 below) whose purpose was to identify "hot spots" of chemical contamination. All significant drains, pipe discharges, and bank seeps were checked. Based on these results, three additional screening surveys were conducted with samples taken from Sitcum, City, St. Paul, Wheeler Osgood, and Hylebos Waterways and additional samples from Hylebos Creek, Kaiser Ditch, Wapato Creek, and the Puyallup River.

In addition to chemical analyses, oyster bioassays were completed on samples taken during both source and screening surveys. EPA reports for the five remaining source surveys and the latter screening surveys should be available in the near future.

Analyses of edible fish tissue for 29 fish from four Commencement Bay stations are underway by EPA.

EPA Region X, in concert with many other organizations, is currently completing workshop evaluations of the Commencement Bay marine and ground water situation in anticipation of possible Superfund activity in this area. Once Superfund monies are allocated, a substantial number of new water quality and water-related investigations are likely in the study area.

2.7.2 Sampling Locations

Sampling stations for the June 3 and the September 23-24, 1980 study efforts are depicted on Figures 2 and 3 and Appendix D, respectively. All stations sampled in the June 3 effort were sampled at the surface, with some of the waterway stations sampled at 20 feet below the surface to determine if water quality parameters were influenced by depth (EPA 1980). Stations sampled in the September 23-24 effort were sampled at the water surface or from bank seepage, except for Station Number 38301 (in upper Hylebos; see Figure 4), which was bottom-sampled approximately 50 feet from shore (EPA 1980b).

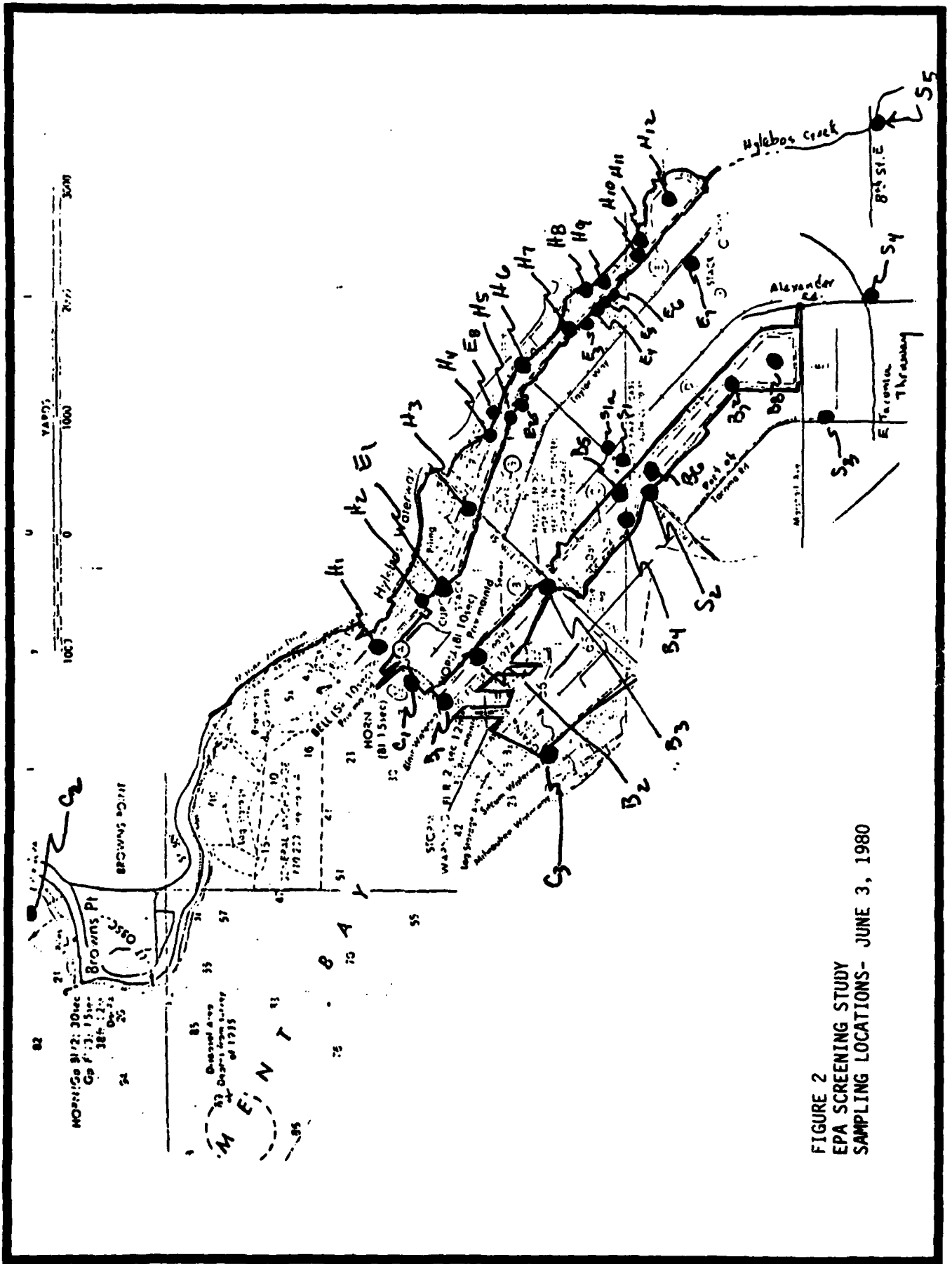


FIGURE 2
 EPA SCREENING STUDY
 SAMPLING LOCATIONS- JUNE 3, 1980

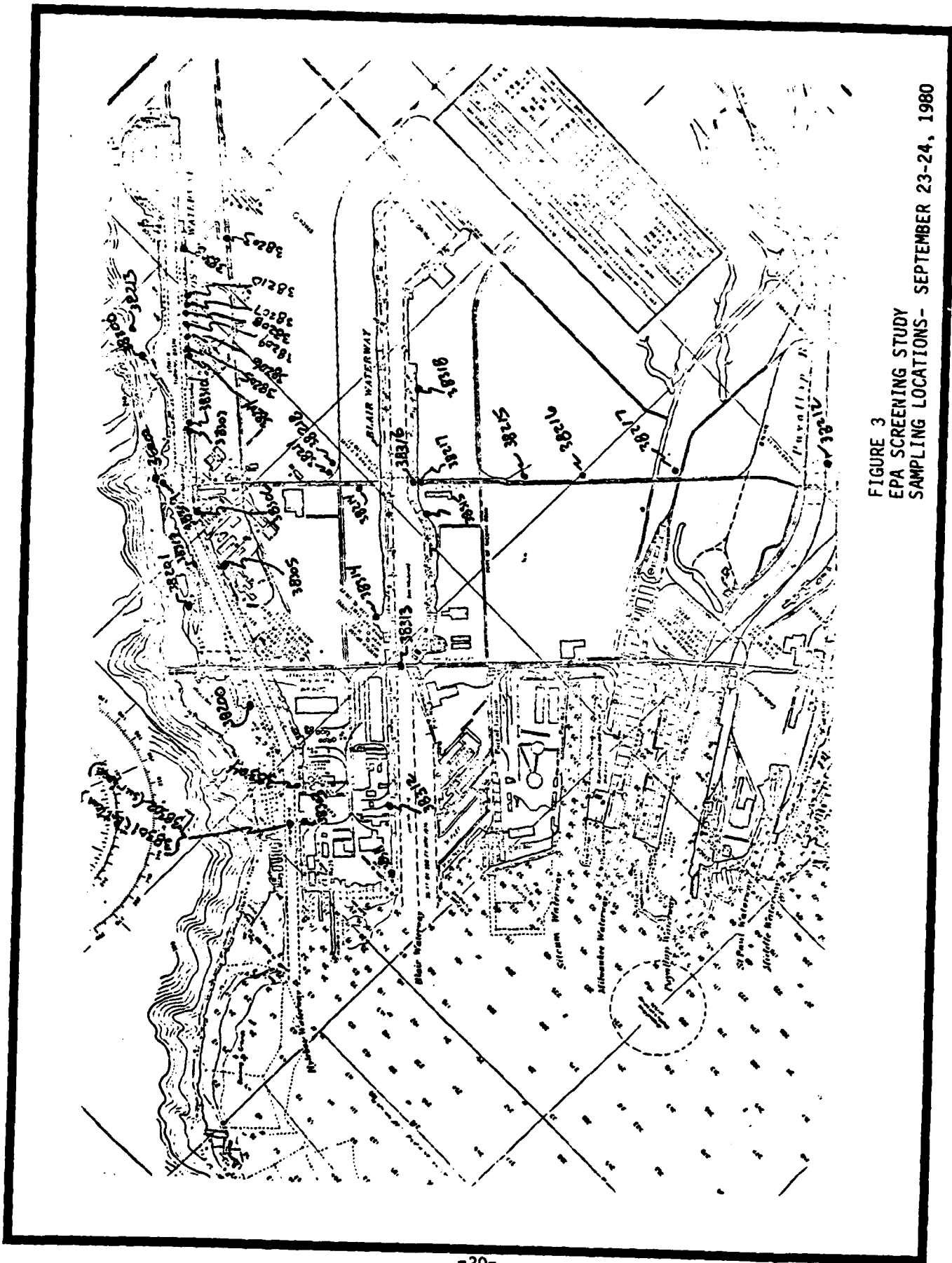


FIGURE 3
 EPA SCREENING STUDY
 SAMPLING LOCATIONS - SEPTEMBER 23-24, 1980

2.7.3 Results

In the interest of brevity, the summaries of results for both study efforts as presented in EPA 1980a and 1980b are reproduced below. The reader is referred to Appendix D and the actual reports available from EPA or the Corps (Seattle District) for supplemental data.

2.7.3.1 June 3, 1980 Study Summary

"On June 3, 1980, samples were collected at 37 locations, including a control station, in the Commencement Bay area. The screening analytical procedure used was designed to look for 38 chemicals. This process showed that most of the chemicals were present in one or more stations but only 6 in concentrations which would be of concern if they were found in the waterways, based on recommended aquatic life criteria. "High" concentrations were found at eight shoreside stations and one waterway station.* Additional field studies are being planned by EPA as a continuing effort to locate and confirm areas of concentration and/or sources of toxic chemicals entering the aquatic environment of Commencement Bay and its waterways" (EPA 1980a).

2.7.3.2 September 23-24, 1980 Study Summary

"On September 23-24, 1980 samples were collected at 39 locations in the Commencement Bay area. The screening analytical procedures used were designed to look for 40 chemicals. Many of the chemicals were found at one or more stations in at least trace amounts. However, five locations are worthy of special consideration due to the number of chemicals and/or concentrations found. These locations are represented by (S)tation (N)umbers 38202 (bank seepage on the north bank of the Hylebos, across from Lincoln Avenue--Metals); 38204 through 38210 (Pennwalt waterfront area--Metals and organic toxicants); 38303 (bank seepage at Hooker--organic toxicants); 38310 (bank seepage at U.S. Gypsum--Metals); and 38318 (storm drain at Pan Pacific property on the Blair Waterway--Metals). More intensive

*The eight shore stations where "high" concentrations of chemicals were identified included a storm drain discharging to Blair (benzene), Sound Refinery effluent (benzene), a bank seepage and storm drain on the property of the Pennwalt Chemical Company (tetrachloroethene and chloroform), the shoreline station at Buffelen Woodworking on Hylebos (unidentified chlorinated hydrocarbons), and three adjacent stations on the Pennwalt Chemical Company property (various chemicals, including pesticides). Copper, selenium, and arsenic were high in most portions of the study area.

through 38210 (Pennwalt waterfront area--Metals and organic toxicants); 38303 (bank seepage at Hooker--organic toxicants); 38310 (bank seepage at U.S. Gypsum--Metals); and 38318 (storm drain at Pan Pacific property on the Blair Waterway--Metals). More intensive NOAA as well as other Federal, State, and local efforts to assess the quality and health of these waters" (EPA 1980b).

2.8 NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM DATA

Point source discharges from recognized industries (as differentiated from storm sewers which collect runoff from multiple sources) and public waste discharges (two sewage treatment plants) in the COBS study area usually undergo some degree of water quality monitoring as required in the discharger's NPDES permit (EPA permit administered by Washington Department of Ecology). With a few exceptions (e.g., ASARCO), most monitoring requirements placed upon the dischargers are directed at identifying both standard water quality measurements (e.g., temperature, pH, flow) as well as other specific parameters for which some limitations exist due to federal or state water quality criteria.

The large volume of historic data available only through interviews (in most cases) for the NPDES monitored points sources in the COBS study area could not be summarized within the COBS scope of work. In many cases, little if any monitoring data exist for pollutants of interest. For example, the City of Tacoma Central Wastewater Treatment Plant (S.T.P. No. 1) receives waste water from industrial facilities in addition to stormwater containing possible heavy metal and organic chemical effluents. The 301(h) waiver data presented in Section 2.3 above indicate a need for NPDES monitoring to identify and quantify some of the heavy metals (copper, zinc, arsenic) and organic chemicals shown in the 1979 301(h) study.

NPDES-monitored and unmonitored point sources are discussed and mapped in Section 4.3 of this technical report.

2.9 WASHINGTON DEPARTMENT OF ECOLOGY

The DOE in concert with EPA has completed studies (see Section 2.7.1), and plans to conduct additional studies designed to identify critical conditions in the COBS study area.

In the spring of 1981, the DOE completed inspections at several log sort yards after an EPA screening study (EPA 1980b) showed high levels of pollutants (including arsenic) in the stormwater drainage from one of these yards. The data from these preliminary surveys are of interest since the major local source of arsenic is the ASARCO smelter. Slag from the smelter has been used historically as fill and for road surfaces in the three log yards surveyed. While slag was formerly believed to be unleachable, evidence gathered in these studies suggests otherwise. DOE study data indicate that stormwater runoff from these log sort yards contain arsenic compounds, likely attributable in part to the presence of small nonsoluble arsenic in this stormwater runoff, with leachate accounting for the remainder.

3.0 METHODS

In this section, methods employed to obtain water quality data as part of the COBS study effort are presented. The negotiated level of effort for water quality studies and the COBS statement of work (SOW) was a major influence on the scope of services undertaken and the methodology employed to achieve the four objectives presented in Section 1.0. Based upon this input, a study plan and a sampling location map were submitted for Corps review. Comments received resulted in modifications to the plan and station locations.

3.1 STATION LOCATIONS

A total of 33 water quality sampling stations were selected for the COBS study. Figure 4 presents the station locations and indicates those stations that are close to or co-existent with established STORET stations (see Section 2.5). In addition, several other stations are close to or co-existent with: (1) water quality sampling stations established in conjunction with other studies, or (2) COBS sediment and fish studies station locations (see the corresponding COBS technical reports). Table 4 provides the longitude and latitude locations of the 33 water quality sampling stations.

As indicated in Figure 4, at least one station was located in each of the industrial waterways and multiple stations were located in several waterways. Nearshore stations in the bay were located to cover most shoreline segments although more stations were located along the more developable Ruston Way (south shore) segment than the Browns Point (north shore) segment.

Three transect lines of five stations each were established in the area to provide a means of collecting data designed to meet the vertical stratification objective (b) in the SOW. These transect lines extended from Hylebos and Blair Waterways and the Puyallup River into the bay as follows:

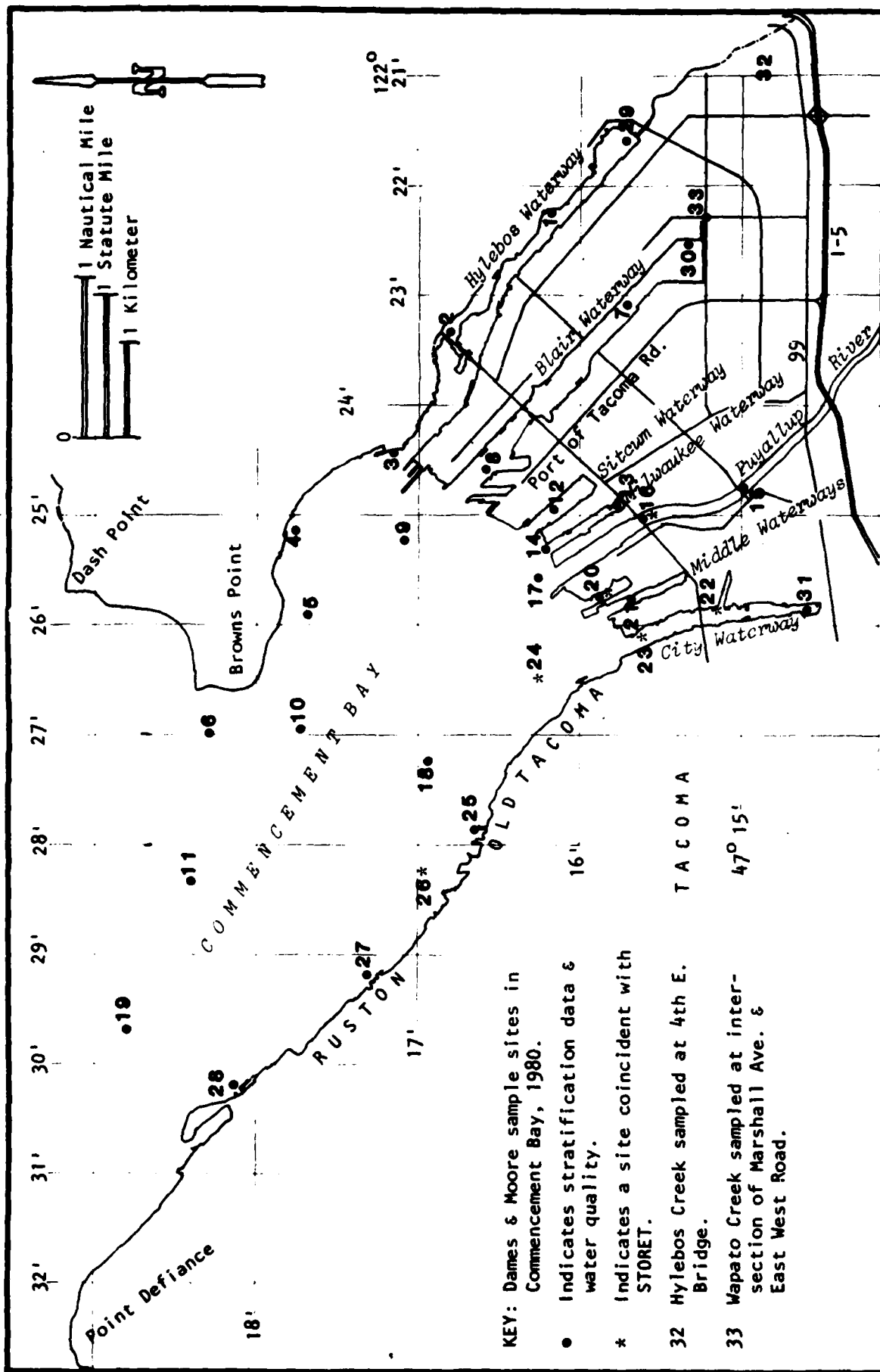


FIGURE 4
WATER QUALITY SAMPLING STATIONS

TABLE 4

LONGITUDE AND LATITUDE LOCATIONS FOR COBS WATER QUALITY STATIONS, 1980

Station Number	General Location	Latitude (N)	Longitude (W)
1	Hylebos Waterway Lower Turning Basin	47°16'07"	122°22'16"
2	Hylebos Waterway, East 11th Street	47°16'38"	122°23'30"
3	Hylebos Waterway, Entrance	47°17'06"	122°24'31"
4	North Shore, Tyee Marina	47°17'42"	122°25'12"
5	Browns Point, Inner	47°17'39"	122°26'04"
6	Browns Point, Outer	47°18'16"	122°27'10"
7	Blair Waterway, Middle	47°15'47"	122°23'12"
8	Blair Waterway, Near Entrance	47°16'35"	122°24'30"
9	Commencement Bay, Inner-mid	47°17'05"	122°25'27"
10	Commencement Bay, Center-mid	47°17'38"	122°27'20"
11	Commencement Bay, Outer-mid	47°18'24"	122°28'21"
12	Sitcum Waterway	47°16'13"	122°25'02"
13	Milwaukee Waterway, Inner	47°15'50"	122°24'58"
14	Milwaukee Waterway, Entrance	47°16'13"	122°25'24"
15	Puyallup River, Lincoln Street	47°14'59"	122°24'46"
16	Puyallup River, East 11th Street	47°15'37"	122°25'02"
17	Puyallup River, Mouth	47°16'15"	122°25'10"
18	Commencement Bay, S.W.-mid	47°16'58"	122°27'27"
29	Commencement Bay, S.W.-outer	47°18'40"	122°29'57"
20	St. Paul Waterway	47°15'54"	122°25'13"
21	Middle Waterway	47°15'45"	122°25'50"
22	City Waterway, at Wheeler Osgood	47°15'07"	122°25'52"
23	City Waterway, Entrance	47°15'40"	122°26'11"
24	Ruston Way, Stadium High	47°16'09"	122°26'46"
25	Ruston Way, Commencement Park	47°16'37"	122°27'40"
26	Ruston Way, Puget Gulch	47°16'57"	122°28'32"
27	Ruston Way, North End Treatment Plant	47°17'19"	122°29'10"
28	Ruston Way, off ASARCO Smelter	47°18'04"	122°20'06"
29	Hylebos Waterway, Upper Turning Basin	47°16'07"	122°22'16"
30	Blair Waterway, Turning Basin	47°15'19"	122°22'42"
31	City Waterway, Upper End	47°14'35"	122°25'51"
32	Hylebos Creek, 4th E. Road Bridge	47°15'14"	122°20'59"
33	Wapato Creek, East-West Road	47°15'10"	122°22'17"

- a) Transect 1 (Hylebos) - Stations 29, 1, 2, 3, 5, and 6
- b) Transect 2 (Blair) - Stations 30, 7, 8, 9, 10, and 11
- c) Transect 3 (Puyallup River) - Stations 15, 16, 17, 18, and 19

In addition to the required bay and waterway stations, one station each was added to accessible locations in Wapato Creek (Station No. 33) and Hylebos Creek (Station No. 32).

3.2 SAMPLING PERIODS

Sampling periods were selected with an orientation to low- and high-flow periods on the Puyallup River in calendar year 1980. The timing of authorizations-to-proceed and budgetary constraints required all fieldwork to be completed in calendar year 1980 and precluded sampling at the historical low- and high-flow periods. Calendar year 1980 was an atypical rainfall year, with low rainfall totals making periods of low and high river flows difficult to forecast. However, the periods that were selected--October 1-3, 1980 and December 16 and 17, 1980--had moderately low and high river flows, respectively, for the year. Table 5 presents United States Geological Survey (USGS) Puyallup River flow data preceding and during those selected sampling periods.

The low 1980 flows indicated in Table 5 are typical of low flows reported in water year 1979; the high 1980 flows do not completely represent the sporadic flows in water year 1979 when the Puyallup River reached a daily average of over 9,000 cubic feet/second (cfs) on 1 day each in February and March 1979 (USGS 1980). On the other hand, the flows of December 15 to 17, 1980 are similar to the average high flows occurring in water year 1979 which include flows of 4,000 to 6,000 cfs (USGS 1980).

Predicted tidal conditions during the two COBS water quality sampling periods are graphed in Figure 5. Commencement Bay has a mean tide range of 8.1 feet (2.5 m), a diurnal range of 11.8 feet (3.5 m), and a mean tide level of 6.8 feet (2.1 m) (NOAA-National Oceanic Survey 1979).

TABLE 5

PUYALLUP RIVER FLOWS, 1980
PUYALLUP STATION (12101500), RIVER MILE 6.6

<u>Date(a)</u>		<u>Daily Average (cfs)</u>
<u>1980</u>		
September	24	1,310
	25	1,460
	26	1,370
	27	1,350
	28	1,480
	29	1,220
	30	2,070
October	1	1,960
	2	1,400
	3	1,410
December	9	2,700
	10	3,320
	11	5,590
	12	6,500
	13	5,640
	14	4,980
	15	7,880
	16	6,880
	17	5,990

(a) Data from: USGS (1980).

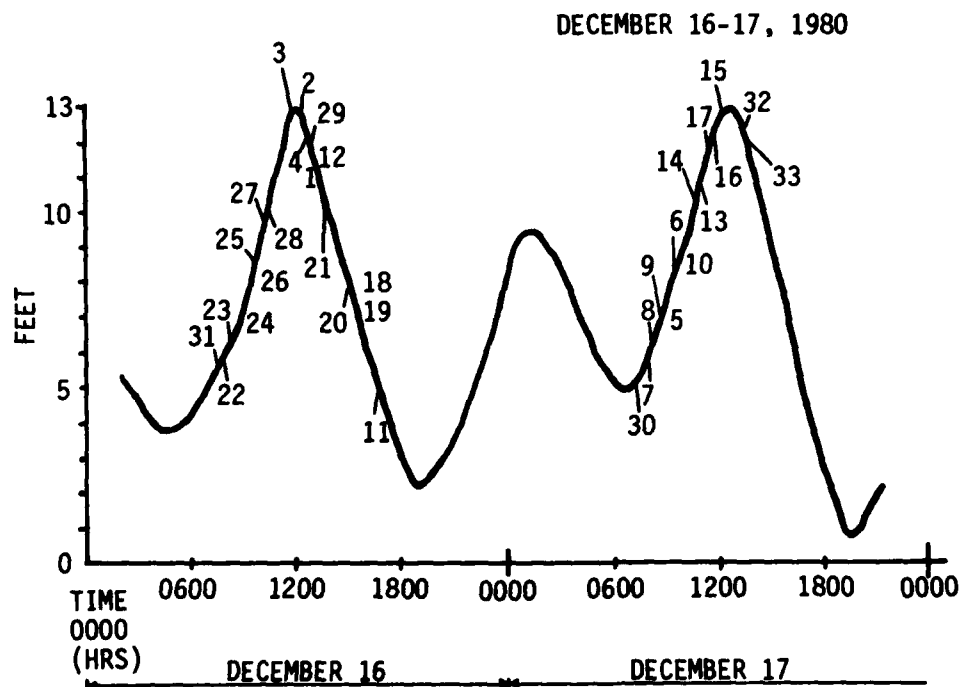
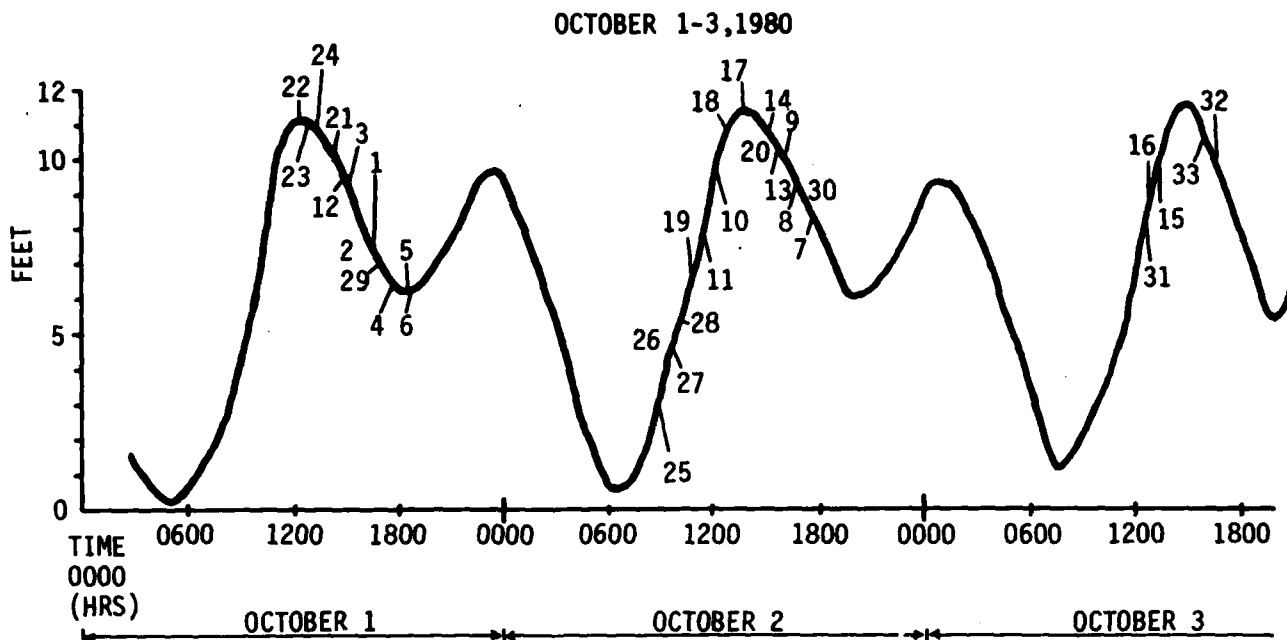


FIGURE 5
 PREDICTED TIDES FOR COMMENCEMENT BAY AND
 SAMPLING STATION NUMBERS AS TAKEN IN EACH SAMPLING DAY

3.3 SAMPLING STRATEGY

As defined in the COBS SOW, the sampling strategy called for sampling three depths (surface, middle, and bottom) at each station, as permitted by water depths at each station. Only surface or surface and bottom samples were taken at some shallow waterway stations; only a surface sample was taken at the two creek stations.

Station locations were verified during sampling by taking compass bearing and/or sextant angles on objects of known location depicted on NOAA Chart 18453.

Water quality sampling was performed from an outboard-powered boat. A gasoline-powered winch with 3/8-inch (1 cm) stainless cable was mounted onboard. A meter wheel was employed to determine sampling depth. An 8-pound (3.6 kg) lead ball was used to deploy the sampling equipment. Two 5-liter messenger-triggered Scott-Richards bottles (of PVC with rubber tube trigger mechanisms) were deployed at the selected middle and bottom depths on the winch cable and activated by weighted messenger. Surface samples were always taken with another 5-liter Scott-Richards bottle (of the same design) that was hand-triggered. This bottle was held parallel to the water's surface and sampled the water layer from about 0.1 to 0.2 m (4 to 8 inches). This sampling method was chosen as it permitted sampling of surface water with a sampler of the same design used for the middle and bottom depths. Vertical (as opposed to horizontal) orientation of the water sampler, which is over 1 m (3.3 ft) long, would have resulted in collection of water from a depth of 1 m (3.3 ft) instead of the 0.1 to 0.2 m achieved.

In addition to water sampling, a STD-PH-DO profile was completed using a Hydrolab Probe with 60 m (200 ft) of cable. Due to the length limitation of the probe cable, some stations with bottom depths of over 60 m could not be profiled. At other stations, a 50- or -m middle depth was selected so that the probe could be used even though the total depth exceeded 100 or 120 m (approximately 330 to 400 ft); that is, the probe cable length determined the middle depth sampled. At most stations,

the profile was completed to the water sampler depths (if possible) and usually at 1-m (3.3 ft) intervals from 5 m (16.5 ft) depth to the surface. In some cases, additional depths or half-meter (1.6-ft) intervals were sampled with profiling to 10 m (33 ft).

3.4 FIELD SAMPLE PROCESSING

Data entered on field data forms at the time of collection included: (1) date, (2) time, (3) station number, (4) depth (m), and (5) the probe values for temperature (°C), dissolved oxygen (ppm), pH, and conductivity (mmho/cm). For station depths with associated water sampling, the number for the Scott-Richards sampler, DO bottle, and salinity bottle were recorded as required.

In addition to DO samples placed in standard DO bottles and salinity samples placed in standard bottles, the following samples were taken and placed in new or chemically rinsed containers supplied by the contracted analytical laboratory (AM TEST, Inc):

250-ml (8.5 oz) poly bottle with preservative	- sulfide sample
1-l (1.1 qt) cubitainer	- heavy metals sample
1-l (1.1 qt) cubitainer	- TSS and turbidity sample
1-gallon (3.79 l) glass bottle	- PCB sample
1-qt (0.94 l) brown glass bottle	- chlorophyll-a (unfiltered) sample

The water samples taken in October for heavy metal and PCB analyses were comprised of an equal-volume composite from all depths sampled at all stations. The December samples for heavy metal and PCB water analyses were taken at discrete depths, but only at selected stations (1, 2, 3, 8, 10, 15, 22, 23, 27, 28, 29, 31, 33) (see Figure 4 for station locations). This sampling procedure was adopted after analysis of October results to better define the water strata in which contaminants exist (see Section 3.6 below).

All samples were labeled with the corresponding station number and depth code (S-surface, M-middle, B-bottom, C-composite) and stored. The

chlorophyll-a (unfiltered) samples received special handling; each sample was placed out of direct light in an ice chest until delivered to the laboratory.

For each sample, an oxygen tube was used to transfer the first water subsample from the Scott-Richards sampler to a standard DO bottle. The DO bottle contents were then fixed by the Winkler method as modified by Thompson and Robinson (1939). After the series of five subsamples described above were separated, one final subsample was taken for salinity determination. This latter sample was placed in a standard salinity bottle.

As feasible during sample collection, two deliveries were made each day from the study area to AM TEST, Inc. in Seattle for those water quality samples to be analyzed for sulfide, heavy metals, TSS, turbidity, PCBs, and chlorophyll-a. DO and salinity samples were held until the end of a sampling period and then delivered to the University of Washington Department of Oceanography for analyses.

3.5 LABORATORY PROCESSING AND ANALYSES

The samples delivered to AM TEST, Inc. were placed in a dark, refrigerated room until analyzed. These samples were analyzed using procedures described in APHA, AWWA, WPLF (1976) and EPA (1979). The limit of detection for selected analyses by AM TEST, Inc. was as follows:

chlorophyll-a	0.10 mg/m ³
sulfide	0.10 mg/l
PCBs	0.2 ppb (October), 0.1 ppb (December)
arsenic	0.02 mg/l
copper	0.002 mg/l (October), 0.003 mg/l (December)
cadmium	0.001 mg/l
chromium	0.008 mg/l (October), 0.005 mg/l (December)
lead	0.01 mg/l (October), 0.02 mg/l (December)
zinc	0.002 mg/l
TSS	Not applicable

The DO and salinity samples delivered to the University of Washington Department of Oceanography were held in standard carrying boxes until processed. DO samples were analyzed to complete the modified Winkler Method (Thompson and Robinson 1939). Salinity samples were analyzed on the salt bridge by procedures described in Paquette (1958).

3.6 DIVERGENCE/LIMITATIONS IN OCTOBER AND DECEMBER SAMPLING

The evaluation of results encountered in both sampling periods was made more complex due to the lack of time standardization in sampling. Time of day can have great influence on some parameters measured. For example, DO levels at a single station can vary dramatically between early morning and midafternoon due to lower early-morning DO values attributable to the effects of all-night respiration. The sampling strategy employed called for screening a wide area in as short a period of time as possible. The amount of time necessary to complete water quality sampling at all stations varied significantly between the October and December sampling periods. This variance was attributable to several factors. In October, two 16-foot (4.9-m) boats were used. In addition to being relatively slow, these boats were small, requiring multiple trips to the staging area to offload samples. As a result, the October sampling period lasted 3 days. In December, one 21-foot (6.4-m) boat was used. This boat was faster and had much more storage space for samples. December sampling was completed in 2 long working days. The relatively short sampling periods resulted in the collection of samples during various tide conditions (see Figure 5).

Another limitation in the program was the failure of the Hydrolab 8002 probe to obtain meaningful conductivity values for October and December trips. This influenced the availability of corrected DO values and salinity values based upon the conductivity reading. The October problem was due to the wrong cell attached to the probe; the December problem was one of calibration which produced higher than observed salinity values. Since the malfunctioning probe was diagnosed in the field in October, a salinity sample was taken as a backup to probe readings at the surface, middle, and bottom water sampling positions

at each station using standard water sample bottles were used. Unfortunately, only a relatively few (21) DO bottles were available for use. As a result, few samples were taken and fixed; thus, DO data for the October sampling period are limited.

In December, enough salinity and DO bottles were obtained to accommodate every depth at every station sampled. This permitted collection of samples for laboratory analysis as a precaution against a report of probe problems. Abnormally high calculated salinity values based upon temperature and conductivity produced by the Hydrolab probe resulted. The conclusion drawn was that although the conductivity values appeared high, they appeared relatively consistent. Therefore, values obtained were used to develop conductivity profiles, which indicate the stratification present at sampled stations. Salinity and density profiles could not be constructed from the probe data.

In any case, the three depths sampled at most stations for temperature (via probe) and salinity (via water sample analysis) provided enough data to infer stratification at each station. This inference is naturally simpler at shallower stations (where the majority of sampling occurred) than at deeper stations.

As stated in Section 3.5 above, the December sampling for heavy metals and PCBs was modified based upon the October results. The October sampling included an equal volume composite from all depths sampled at all stations (usually surface, middle, and bottom). The results from October analyses indicated that samples should be taken from discrete depths at selected stations (to achieve the same number of total samples as negotiated for analyses) to determine if any heavy metals or the PCBs identified were associated with specific water masses in the water column at a station. As a result, discrete depth heavy metal analyses in December were performed for only 13 of 33 stations and discrete depth PCB analyses were performed on only 4 of the 33 stations.

Station locations were also approximated with compass bearings or sextant angles of known objects on NOAA Chart 18453 during both sampling periods. A great degree of accuracy of station location and relocation could have been achieved for offshore sampling locations with electronic range-finding equipment; however, associated costs were prohibitive and not justifiable. Accurate repositioning on stations was best in nearshore and waterway stations. It should also be noted that a free-drifting boat was used at all stations, and therefore a pinpoint position was not maintained for all water sampling and profiling completed at a single station. The tendency of the boat to drift during sample collection at a specified sampling location was greatest at the open bay stations where wind had the greatest effect on the boat. While the wind drift was somewhat compensated by attempts to hold the boat on station, some movement was inevitable. In any case, such drift had minimum effect on: (1) the integrity of samples taken and (2) achievement of accurate on-station positioning for correlation between data collected during the October and December COBS sampling periods or samples taken as part of other water quality studies discussed in Section 2 of this technical report. This is due to the relatively high degree of horizontal mixing and water movement in open-water areas of the bay. It is likely that this mixing resulted in similar water quality characteristics over large areas of the open bay. In more confined waterways, drifting caused by winds was usually significantly less due to protection afforded by surrounding structures and embankments.

The ASARCO copper smelter, a major heavy metal contributor to air and water in the COBS study area, was not operating during the October 1980 sampling period but was in the process of resuming operation in December 1980.

3.7 NON-FIELD STUDIES

Meeting Task Objectives a, b, and d (see Section 1.0) involved available data searches to acquire information from prior water quality studies in the COBS study area to supplement COBS field studies. All of Task Objective c was accomplished with available data. All of the Task Objective c effort is based upon DOE NPDES permit details. Additional data sources include those others discussed in Section 2.0.

4.0 RESULTS AND DISCUSSION

4.1 EXISTING WATER CONDITIONS

Tables 6 and 7 present the combined probe and laboratory results for the October 1-3, 1980 and December 16 and 17, 1980 water sampling periods for the 33 stations completed in this COBS screening study. Appendix E presents water quality probe profiles for selected stations.

Again, as stated in Section 2.1, the terms "high" and "low" used with regard to chemical contamination levels are only intended as relative values. Section 4.2 relates the values seen to present EPA water quality criteria.

4.1.1 Temperature/Salinity

As expected, significant declines in overall water temperature and surface salinities occurred between October and December 1980 as climatic changes and increased freshwater flows occurred in the study area. Salinities did not change much at most middle (M) and bottom (B) stations between the sampling periods in contrast to changes at the surface (S). The Puyallup River influence primarily affects the upper layer (3 m to surface) of marine waters in the COBS study area.

In October 1980 temperatures ranged from 11.7°C (52.1°F) (Station 5 B--50 m) to 16.6°C (61.9°F) (Station 33 S--Wapato Creek). In December, temperatures ranged from 5.3°C (41.5°F) (Station 15 S and B--Puyallup River) to 10.8°C (51.4°F) (Station 1 M).

In October 1980, salinities ranged from <0.500 parts per thousand (ppt) (Stations 15 and 16 S--Puyallup River) to 30.742 ppt (Station 11 B--160 m). In December, the salinity ranged from <0.500 ppt (Stations 15 S and B and 16 S--Puyallup River) to 30.513 ppt (Station 11 B--160 m).

In October, relatively higher temperatures are associated with lower salinity surface waters, whereas in December relatively lower temperatures are associated with the lower salinity surface waters. These patterns are not totally influenced by Puyallup River temperatures because several October stations had higher surface temperatures than the Puyallup.

TABLE 6

COBS WATER QUALITY SUMMARY - OCTOBER 1980 (a)

Sheet 1 of 3

Station Number	Day/ Time	Depth (m)	Temp (°C)	Temp (b)	Salinity (ppt)	pH (b)	D.O. (mg/l)	TSS (mg/l)	Turb. (JTU)	Chlor a (mg/m ³)	Sulfide (mg/l)	PCBs (ppb)	Composite Water Samples (equal volumes from depths sampled)					
													Arsenic (c)	Copper (c)	Calcium (c)	Chromium (c)	Lead (c)	Zinc (c)
1S	1/1622	0.1	14.8	25.912	8.05	1	1.9	9.03	ND	ND	ND	ND	ND	ND	ND	ND	0.016	
M	1/1622	4.5	13.3	28.600	7.86	<1	0.88	1.64	ND	ND	ND	ND	ND	ND	ND	ND	0.013	
B	1/1622	9	12.5	29.884	7.90	2	0.89	0.40	ND	ND	ND	ND	ND	ND	ND	ND	0.013	
2S	1/1548	0.1	14.2	25.807	7.96	<1	1.6	3.42	ND	ND	ND	ND	ND	ND	ND	ND	0.013	
M	1/1548	4.5	13.0	28.393	7.89	3	1.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.013	
B	1/1548	9	12.5	29.924	7.90	3	0.71	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.013	
3S	1/1523	0.1	13.5	29.716	7.96	2	1.3	1.07	ND	ND	ND	ND	ND	ND	ND	ND	0.013	
M	1/1523	5	12.4	29.948	7.95	2	0.65	0.41	ND	ND	ND	ND	ND	ND	ND	ND	0.009	
B	1/1523	10	12.3	30.176	7.95	3	0.79	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.009	
4S	1/1739	0.1	12.7	29.799	8.00	2	0.69	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.009	
M	1/1739	10	12.2	30.347	7.99	<1	0.54	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.009	
B	1/1739	20	12.2	30.416	7.98	<1	0.61	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.009	
5S	1/1810	0.1	12.7	29.737	8.02	<1	0.53	0.57	ND	ND	ND	ND	ND	ND	ND	ND	0.009	
M	1/1810	25	12.1	30.572	7.98	1	0.77	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.009	
B	1/1810	50	11.7	30.729	7.95	6	1.5	0.39	ND	ND	ND	ND	ND	ND	ND	ND	0.009	
6S	1/1840	0.1	12.6	30.043	8.02	<1	0.37	1.46	ND	ND	ND	ND	ND	ND	ND	ND	0.004	
M	1/1840	50	12.0	30.461	7.95	<1	0.46	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.004	
B	1/1840	135	Mo Trip														0.004	
7S	2/1717	0.1	14.7	23.471	8.17	4	1.1	2.85	ND	ND	ND	ND	ND	ND	ND	ND	0.006	
M	2/1717	5	12.8	29.339	8.00	4	0.79	0.57	ND	ND	ND	ND	ND	ND	ND	ND	0.006	
B	2/1717	11	12.5	30.032	7.96	2	1.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.006	
8S	2/1637	0.1	14.7	24.918	8.00	3	3.3	0.54	ND	ND	ND	ND	ND	ND	ND	ND	0.010	
M	2/1637	4.5	12.6	29.219	8.00	6	6.5	0.89	ND	ND	ND	ND	ND	ND	ND	ND	0.010	
B	2/1637	9	12.5	30.096	7.97	1	0.71	0.66	ND	ND	ND	ND	ND	ND	ND	ND	0.010	
9S	2/1603	0.1	14.4	25.843	8.05	3	2.6	1.38	ND	ND	ND	ND	ND	ND	ND	ND	0.008	
M	2/1603	30	12.1	30.384	7.99	2	0.45	0.43	ND	ND	ND	ND	ND	ND	ND	ND	0.008	
B	2/1603	60	11.8	30.645	7.96	3	0.89	0.43	ND	ND	ND	ND	ND	ND	ND	ND	0.008	
10S	2/1215	0.1	13.2	25.843	8.05	<1	2.3	1.79	ND	ND	ND	ND	ND	ND	ND	ND	0.012	
M	2/1215	50	12.2	30.442	8.00	<1	0.29	0.54	ND	ND	ND	ND	ND	ND	ND	ND	0.012	
B	2/1215	150		30.726	8.00	7.5	0.88	0.32	ND	ND	ND	ND	ND	ND	ND	ND	0.012	
11S	2/1132	0.1	13.0	28.935	8.04	4	0.55	1.40	ND	ND	ND	ND	ND	ND	ND	ND	0.013	
M	2/1132	50	12.1	30.479	7.96	<1	0.31	0.64	ND	ND	ND	ND	ND	ND	ND	ND	0.013	
B	2/1132	160		30.742	7.94	2	0.49	0.53	ND	ND	ND	ND	ND	ND	ND	ND	0.013	

(a) Laboratory analysis by AM TEST Inc. using methods described in Standard Methods (1976), EPA (1979a), and EPA (1979b).

(b) Values from field probe--Hydrolab model 8002. All other values are from laboratory analyses of water samples.

(c) Detection level.

(d) Not detected.

(e) Arachlor No. 1016.

TABLE 6

Station Number	Day/Time	Depth (m)	Temp (°C)	Salinity (ppt)	D.O. (mg/L)	TSS (mg/L)	Turb. (JTU)	Composite Water Samples (equal volumes from depths sampled)																	
								Chlor a (mg/m ³)	Sulfide (mg/l)	PCBs (ppb)	Heavy Metals (mg/l)				Lead (0.01)(c)	Zinc (0.002)(c)									
											(0.10)(c)	(0.10)(c)	(0.2)(c)	Arsenic (0.02)(c)			Copper (0.002)(c)	Cadmium (0.001)(c)	Chromium (0.008)(c)						
128	1/1458	0.1	14.4	13.760	8.04	19.5	19	6.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010	
M	1/1458	3	12.6	28.102	7.94	7	3.5	0.17	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
B	1/1458	6	12.4	30.093	7.93	1	0.61	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
135	2/1535	0.1	15.0	18.136	8.01	5	3.4	1.21	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.031
M	2/1535	4	12.7	29.046	7.96	2	1.1	0.56	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.031
B	2/1535	12	12.5	30.153	7.77	4	1.1	0.33	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.031
145	2/1515	0.1	14.2	21.868	7.95	8	3.85	5.26	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
M	2/1515	4	12.7	29.615	8.02	3	0.65	1.23	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
B	2/1515	8	12.6	30.109	7.98	4	0.64	0.64	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
155	3/1345	0.1	12.6	<0.500	7.89			0.14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.013
B	No boat access for water sampler																								
165	3/1325	0.1	12.7	<0.500	8.04	18	23	0.87	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.009
B	3/1325	2	13.2	26.817	7.89	14	2.9	3.62	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.009
175	2/1342	0.1	13.8	17.296	7.95	13	14	1.10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.013
M	2/1342	2	12.6	28.650	8.02	<1	0.64	0.92	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.013
B	2/1342	15	12.5	30.262	8.02	12	1.1	0.43	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.013
185	2/1254	0.1	13.8	25.422	8.00	3	2.2	2.65	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.023
M	2/1254	50	12.2	30.439	7.98	<1	0.36	0.29	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.023
B	2/1254	135	12.5	30.685	7.98	3	1.6	0.37	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.023
195	2/1046	0.1	12.6	28.591	8.05	6	0.41	1.23	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.004
M	2/1046	50	12.2	30.426	7.95	8	0.36	1.13	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.004
B	2/1046	125	12.2	30.696	8.01	7	0.45	0.69	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.004
205	2/1457	0.1	14.7	21.989	7.70	4	4.1	1.27	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.008
M	2/1457	4	12.8	28.103	8.06	2	1.2	1.71	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.008
B	2/1457	8	12.9	30.286	8.07	3	0.62	1.04	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.008
215	1/1422	0.1	14.1	19.208	7.79	10	11	6.33	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.009
M	1/1422	3	12.8	24.413	7.93	4	2.3	0.65	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.009
B	1/1422	6	12.6	30.286	7.97	<1	0.59	0.38	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.009
225	1/1209	0.1	13.2	20.625	7.69	3	7.3	3.42	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.025
M	1/1209	4	12.8	21.952	7.83	17	4.8	0.60	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.025
B	1/1209	8	12.8	29.478	7.72	5	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.025
235	1/1254	0.1	13.0	19.595	7.77	11	9.2	5.40	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
M	1/1254	5.5	12.4	29.624	7.93	4	0.80	1.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010
B	1/1254	11	12.4	30.319	7.89	3	0.58	0.19	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.010

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TABLE 6

Station Number	Day/ Time	Depth (m)	Temp (°C)	Salinity (ppt)	pH (b)	D.O. (mg/l)	TSS (mg/l)	Turb. (JTU)	Chlor a (µg/l)	Sulfide (mg/l)	PCBs (ppb)	Composite Water Samples (equal volumes from depths sampled)						
												Arsenic (c)	Copper (c)	Cadmium (c)	Chromium (c)	Lead (c)	Zinc (c)	
									(0.10)(c)	(0.10)(c)	(0.2)(c)	(0.02)(c)	(0.002)(c)	(0.001)(c)	(0.008)(c)	(0.01)(c)	(0.002)(c)	
248	1/1320	0.1	13.7	11.230	7.80	7.80	68	42	2.80	MD	MD	MD	MD	MD	MD	MD	0.021	
M	1/1320	9	12.2	30.273	7.96	7.96	11	0.68	2.02	MD	MD	MD	MD	MD	MD	MD	0.021	
B	1/1320	18	12.3	30.401	7.95	7.95	9	0.53	1.10	MD	MD	MD	MD	MD	MD	MD	0.021	
258	2/0850	0.1	12.6	23.979	7.95	7.95	6	3.5	2.34	MD	MD	MD	MD	MD	MD	MD	0.013	
M	2/0850	7	12.4	29.894	7.96	7.96	2	0.42	4.18	MD	MD	MD	MD	MD	MD	MD	0.013	
B	2/0850	14	12.4	29.954	7.95	7.95	73	16	1.67	MD	MD	MD	MD	MD	MD	MD	0.013	
268	2/0915	0.1	12.6	23.750	7.97	7.97	3	3.2	1.31	MD	MD	MD	MD	MD	MD	MD	0.013	
M	2/0915	7	12.3	30.278	7.97	7.97	2	0.32	2.66	MD	MD	MD	MD	MD	MD	MD	0.013	
B	2/0915	14	12.2	30.335	7.97	7.97	7	0.35	0.86	MD	MD	MD	MD	MD	MD	MD	0.013	
278	2/0950	0.1	12.7	22.628	7.98	7.98	2	2.4	2.67	MD	MD	MD	MD	MD	MD	MD	0.010	
M	2/0950	7	12.3	30.225	7.99	7.99	6	0.32	1.05	MD	MD	MD	MD	MD	MD	MD	0.010	
B	2/0950	14	12.3	30.331	7.99	7.99	2	0.31	1.29	MD	MD	MD	MD	MD	MD	MD	0.010	
288	2/1015	0.1	12.6	22.886	7.99	7.99	5	3.3	1.67	MD	MD	MD	MD	MD	MD	MD	0.012	
M	2/1015	5	12.3	30.261	8.00	8.00	<1	0.45	1.12	MD	MD	MD	MD	MD	MD	MD	0.012	
B	2/1015	10	12.4	30.298	8.00	8.00	1	0.50	0.99	MD	MD	MD	MD	MD	MD	MD	0.012	
298	1/1650	0.1	15.5	20.502	8.21	8.21	23	3.3	65.7	MD	MD	MD	MD	MD	MD	MD	0.014	
M	1/1650	4.5	12.9	28.636	7.75	7.75	2	1.1	1.31	MD	MD	MD	MD	MD	MD	MD	0.014	
B	1/1650	9	12.6	29.883	7.72	7.72	9	1.3	0.25	MD	MD	MD	MD	MD	MD	MD	0.014	
308	2/1738	0.1	14.9	25.070	8.31	8.31	4	1.8	11.7	MD	MD	MD	MD	MD	MD	MD	0.016	
M	2/1738	5	12.8	28.196	8.01	8.01	5	1.1	2.14	MD	MD	MD	MD	MD	MD	MD	0.016	
B	2/1738	11	12.5	29.944	7.90	7.90	8	0.73	2.22	MD	MD	MD	MD	MD	MD	MD	0.016	
318	3/1225	0.1	14.6	20.514	7.62	7.62	4	1.3	2.02	MD	MD	MD	MD	MD	MD	MD	0.009	
B	3/1225	4	13.1	29.662	7.92	7.92	2	0.73	1.78	MD	MD	MD	MD	MD	MD	MD	0.009	
328	3/1632	0.2	13.1	<0.500	7.78	7.78	24	18	3.24	MD	MD	MD	MD	MD	MD	MD	0.17	
338	3/1556	0.5	16.6	13.690	7.23	7.23	2	6.8	3.14	MD	MD	MD	MD	MD	MD	MD	0.17	

TABLE 7

COBS WATER QUALITY SUMMARY - DECEMBER 1980 (a)

Sheet 1 of 3

Station Number	Day/Time	Depth (m)	Temp (°C)	Salinity (Ppt)	pH (b)	D.O. (mg/l)	TSS (mg/l)	Turb. (JTU)	Chlor a (µg/m ³)	Sulfide (mg/l)	PCBs (ppb)	Composite Water Samples (equal volumes from depths sampled)										
												Artenic (c)	Copper (c)	Cadmium (c)	Chromium (c)	Lead (c)	Zinc (c)	Artenic (c)	Copper (c)	Cadmium (c)	Chromium (c)	Lead (c)
18	16/1230	0.1	10.2	21.685	7.64	6.048	6	2.9	0.38	MD (d)	MD (d)	0.03	0.007	MD	MD	MD	MD	MD	MD	MD	MD	0.031
M	16/1230	4.5	10.8	28.058	7.90	5.904	11	2.1	MD	MD	MD	MD	0.004	MD	MD	MD	MD	MD	MD	MD	MD	0.021
B	16/1230	9	10.3	29.221	7.89	6.224	5	0.11	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	0.009
28	16/1214	0.1	9.9	21.555	7.66	6.560	17	2.6	MD	MD	MD	0.05	0.006	MD	MD	MD	MD	MD	MD	MD	MD	0.023
M	16/1214	4.5	10.2	28.158	7.90	6.624	26	1.6	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	0.014
B	16/1214	9	10.1	29.817	7.91	6.928	16	0.68	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	0.008
38	16/1144	0.1	9.0	14.783	7.89	9.376	9	5.4	0.28	MD	MD	MD	0.004	MD	MD	MD	MD	MD	MD	MD	MD	0.015
M	16/1144	5	10.1	29.576	7.92	6.960	8	0.78	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	0.006
B	16/1144	10	10.0	29.973	7.93	7.008	14	0.53	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	0.005
48	16/1120	0.1	7.8	11.450	7.89	9.840	15	9.0	0.94	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
M	16/1120	10	10.1	29.992	7.93	6.656	12	0.60	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
B	16/1120	20	10.1	30.144	7.93	6.576	14	0.82	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
58	17/0910	0.1	7.3	14.358	7.95	8.056	21	6.8	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
M	17/0910	25	10.1	30.104	7.93	6.688	11	0.43	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
B	17/0910	50	10.3	30.225	7.90	6.384	27	0.86	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
68	17/0939	0.1	8.2	19.937	7.98	8.752	29	4.1	0.63	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
M	17/0939	50	10.2	30.219	7.92	6.624	14	0.25	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
B	17/0939	125	10.2	30.449	7.92	6.048	10	0.42	0.19	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
78	17/0800	0.1	9.7	25.146	7.75	6.992	17	1.9	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
M	17/0800	5	10.1	27.533	7.79	6.176	32	1.6	0.14	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
B	17/0800	11	10.1	29.580	7.84	6.032	36	1.4	0.24	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
88	17/0817	0.1	9.2	26.469	7.66	6.832	15	1.6	0.10	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
M	17/0817	4.5	10.0	28.999	7.91	7.680	28	1.2	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
B	17/0817	9	10.0	29.732	7.90	6.688	28	0.69	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
98	17/0843	0.1	8.0	17.973	7.94	8.688	28	5.4	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
M	17/0843	30	10.2	30.139	7.92	6.640	30	0.50	0.10	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
B	17/0843	60	10.3	30.300	7.90	6.336	34	0.82	0.20	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
108	17/1020	0.1	9.4	25.010	7.94	7.648	26	2.6	0.33	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
M	17/1020	50	10.1	30.217	7.92	6.624	21	0.33	0.38	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
B	17/1020	150	10.1	30.453	7.92	5.984	34	0.82	0.21	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
118	16/1630	0.1	8.4	21.308	7.98	8.240	28	3.4	0.45	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
M	16/1630	60	10.2	30.253	7.94	6.544	33	0.38	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD
B	16/1630	160	10.2	30.513	7.94	6.176	28	0.58	0.15	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD

(a) Laboratory analysis by AM TEST Inc. using methods described in Standard Methods (1976), EPA (1979a), and EPA (1979b).

(b) Values from field probe measurements--HydroLab model 8002. All other values are from laboratory analyses of water samples.

(c) Detection level.

(d) Not Detected.

TABLE 7

Station Number	Day/Time	Depth (m)	Temp (°C)	Salinity (ppt)	pH (b)	D.O. (mg/L)	TSS (mg/L)	Turb. (JTU)	Chlor. a (mg/m ³)	Sulfide (mg/L)	FCBs (ppb)	Composite Water Samples (equal volumes from depths sampled)						
												Arsonic (c) (0.02)	Copper (c) (0.003)	Cadmium (c) (0.001)	Chromium (c) (0.005)	Lead (c) (0.02)	Zinc (c) (0.002)	
238	16/0818	0.1	9.9	26.760	7.70	6.656	31	2.7	0.53				MD	0.007	MD	MD	MD	0.018
M	16/0818	5.5	10.1	29.751	7.90	6.672	29	0.49	MD				MD	MD	MD	MD	MD	0.010
B	16/0818	11	10.1	30.078	7.92	6.800	33	0.42	0.22				MD	0.004	MD	MD	MD	0.013
248	16/0917	0.1	9.7	24.625	7.79	7.392	34	6.1	0.19									
M	16/0917	9	10.0	29.861	7.93	6.895	27	0.68	1.02									
B	16/0917	18	10.0	30.117	7.93	6.848	62	0.53	MD									
258	16/0938	0.1	9.8	25.730	7.86	7.232	36	2.6	0.26									
M	16/0938	7	10.0	29.934	7.93	6.864	30	0.59	0.17									
B	16/0938	14	10.0	30.101	7.94	6.960	27	0.47	MD									
268	16/0955	0.1	9.8	22.980	7.86	8.000	28	2.7										
M	16/0955	7	10.0	29.737	7.94	6.992	28	0.52	MD									
B	16/0955	14	10.1	30.065	7.94	6.896	30	0.52	0.22									
278	16/1012	0.1	9.9	28.278	7.92	7.216	30	1.4	MD									
M	16/1012	7	10.0	29.722	7.94	6.976	28	0.55	0.24									
B	16/1012	14	10.0	30.000	7.95	6.992	28	0.50	MD									
288	16/1039	0.1	9.9	27.328	7.92	7.280	30	1.7	MD									
M	16/1039	5	10.0	29.816	7.94	7.488	33	0.57	MD									
B	16/1039	10	10.0	29.975	7.95	7.280	28	0.32	0.19									
298	16/1243	0.1	10.3	23.544	7.54	5.312	31	2.0	MD									
M	16/1243	4.5	10.4	28.620	7.74	4.960	34	1.2	MD									
B	16/1243	9	10.2	29.648	7.83	5.744	31	0.69	0.11									
308	17/0720	0.1	9.6	25.412	7.72	7.072	35	1.9	0.11									
M	17/0720	5	10.1	28.225	7.78	6.176	31	1.9	0.15									
B	17/0720	11	10.1	29.423	7.80	6.144	29	1.3	MD									
318	16/0732	0.1	10.4	20.123		6.880	25	1.3	MD									
B	16/0732	4	10.2	29.020		5.488	33	0.92	MD									
328	17/1352	0.1	7.9	0.644	7.14	7.424	5	3.9	0.45									
338	17/1330	0.1	8.4	0.502	7.20	8.688	5	7.3	0.84									

These higher temperatures are likely caused by other freshwater input, such as Wapato and Hylebos Creeks, as well as solar influence on less circulated surface waters (e.g., as in the landward ends of waterways).

The salt wedge in the Puyallup River in both sampling periods was evident at Station 16 (just above the E. 11th Street Bridge) by the large salinity difference between samples at surface and bottom depths (see later stratification section below for more details). This salt wedge in October also showed the largest change in temperature with depth, 4.2°C in 2.9 m (7.5°F in 9.5 ft) identified during the COBS study.

4.1.2 pH

The pH values in October ranged from 7.23 (Station 33 S--Wapato Creek) to 8.31 (Station 30 S--Blair Turning Basin). In December, these values ranged from 7.14 (Station 32 S--Hylebos Creek) to 8.24 (Station 16 S--Puyallup River). Marine water pH values did not change significantly between the two sampling periods. pH values often decreased somewhat with depth in the October samples, while they generally increased with depth in the December samples.

4.1.3 Dissolved Oxygen

Dissolved oxygen (DO) values in October are quite limited due to the lack of probe data and limited water sampling for this parameter (see Section 3.6 above). DO values for October ranged from 4.784 mg/l (Station 29 B--Hylebos Upper Turning Basin) to 8.496 mg/l (Station 8 S--Blair Entrance). In December, DO values obtained for all stations and depths ranged from 4.960 mg/l (Station 29 M--Hylebos Upper Turning Basin) to 12.352 mg/l (Station 15 S--Puyallup River). Sampling data for both periods indicate a decline of DO values with depth. Variations to this pattern at some waterway stations are likely attributable to their multi-layered water systems. As with temperature, the sharpest contrast of DOs in the study period was at Stations 16 S and B on the Puyallup River salt wedge. The range of DO values was from 11.744 (S) to 7.248 (B) mg/l within a depth difference of 2.9 m (9.5 ft) in the December study.

4.1.4 Total Suspended Solids (TSS) and Turbidity

Total suspended solids (TSS) and turbidity increased dramatically from October to December although a few October stations had high values (Stations 25 B, 24 S, 16 S, 12 S, 29 S, and 32 S) (see Table 4 for station locations). The high October values for TSS and turbidity at Station 25 B (Ruston Way, Commencement Park) may have resulted from the sample bottle disturbing the bottom. High TSS were usually associated with high turbidity values; however, there were numerous exceptions. High TSS and turbidity result from glacial flour in the Puyallup plume and also from large biomass concentrations. The river plume is identified by reduced salinity. Biomass concentration is indicated by chlorophyll-a.

TSS in October ranged from <1 mg/l (numerous stations) to 73 mg/l (Station 25 B) and 68 mg/l (Station 24 S--Ruston Way, Stadium High). In December, the range was from 5 mg/l (3 stations) to 62 mg/l (Station 24 B). In October, turbidity ranged from 0.30 Jackson Turbidity Units (JTU) along Ruston Way at the North End Treatment Plant (Station 27 B) to 42 JTU along Ruston Way at Commencement Park (Station 24 S). In December, the range was from 0.25 JTU at Browns Point (Station 6 M) to 13 and 14 JTU in the Puyallup River (Stations 15 S and B, Station 16 S).

In October, relatively high TSS values were measured in Hylebos Creek (Station 32 S). Turbidity was also relatively high in the upper turning basin of Hylebos Waterway (Station 29 S), where Hylebos Creek discharges. High chlorophyll-a (productivity) existed at this station to produce these high turbidity values. The high TSS and turbidity values for Station 24 S (Ruston Way, Commencement Park) are related to the Puyallup River plume as indicated by the 11 ppt salinity.

4.1.5 Chlorophyll-a

Chlorophyll-a values declined significantly between October and December, as would be expected. In October, values for chlorophyll-a ranged from <0.10 mg/l (at one or more depths of 7 stations) to 65.7 mg/l (29 S--Hylebos Upper Turning Basin). In December, chlorophyll-a ranged

from <0.10 mg/l (at one or more depths of 22 stations) to 2.69 mg/l (19 S--Commencement Bay, S.W.--Outer). Glacial flour in the Puyallup River influences light penetration with depth and thus the production of chlorophyll-a.

The locations of several of the higher values in both October and December indicate that the high turbidity and low chlorophyll-a of the Puyallup River result in decreased chlorophyll-a levels in the marine waters near the river mouth. Turbidity and short travel time limit productivity in the Puyallup River. The Puyallup River acts to dilute adjacent marine waters by its own low biomass.

Nutrients in the Puyallup River are likely not lacking due to the Tacoma sewage plant input and other agricultural and domestic input upstream.

4.1.6 Sulfide

No water samples collected from any of the COBS stations in October and from selected and discrete depths stations in December contained sulfide values over the analytical laboratory level of detection (0.10 mg/l).

4.1.7 Polychlorinated Biphenyls (PCBs)

Only one PCB value in excess of the level of detection was obtained at any of the stations during both the October and December sampling. That value was 0.64 ppb (as Aroclor No. 1016) for the composite water sample at Station 3 (mouth of Hylebos Waterway) collected at 1523 on October 1, 1980. This single higher PCB value may be attributable to the station's proximity to industrial areas where PCBs may have been accidentally introduced over the years. Samples taken at discrete depths for all stations in Hylebos Waterway (including Station 3) during the December study failed to detect PCBs. The PCBs detected in October must have been a transient feature.

The single value identified in the COBS study (640 ppt) is similar to the 540 ppt (total selected isomer of PCBs) observed in filtered water in the same general location under Riley et al. (1981), see Section 2.6.3. At Station 5 in the mouth of Hylebos, 6 to 17 times higher concentrations were noted at 2 m than at 9 m in the water column. This indicates that greater contamination is associated with less-saline water closer to the surface. Inputs may include PCBs in runoff or ground water.

COBS sediment studies indicated that the highest value for PCBs in sediments in the study area was found in the inner portion of Hylebos Waterway (see the Sediment Studies Technical Report). Highest PCB value in sediments and suspended matter were reported by Riley et al. (1981) in their Stations 5 and 6 in the mouth of Hylebos Waterway in the vicinity of the COBS Station 3 water quality station.

4.1.8 Arsenic

No water samples collected in October had arsenic levels in excess of the 0.02 mg/l detection limit. As indicated above, all October samples were composite samples. The level of detection for arsenic was not exceeded at most stations during the December sampling, where discrete depths were analyzed at selected stations. No stations near or downwind of the ASARCO Tacoma smelter (the largest major regional source of arsenic)* had detectable levels of arsenic. The smelter had recommenced operations in December after a prolonged strike; however, it is not likely that the smelter was at full operation at the time of this sampling. All three detectable values were associated with surface samples (0.1 m) collected at three stations in Hylebos Waterway (1, 2, and 29). The salinities at these three surface stations (21 to 23 ppt) are relatively low, indicating that the arsenic may be linked with freshwater inputs to Hylebos Waterway. These elevated arsenic levels

*The ASARCO smelter constitutes the single greatest source of arsenic to the water, air, and soils of the COBS study area. Quantification of this impact and associated impacts are described in the Puget Sound Air Pollution Control Agency (PSAPCA 1981) DEIS and FEIS for the continued operation of this facility under a proposed variance.

(0.03 to 0.05 mg/l) may also be related to the leachates recently identified by EPA and DOE that originate from ASARCO slag used as roadway surfaces in log sort/storage yards abutting this waterway (see Section 2.9 above) or used historically as fill. Any arsenic input from log sort/storage areas would be seasonal, increasing in higher rainfall periods. One possible arsenic source that was not measured in December was Hylebos Creek, although this creek had no detectable arsenic level in October 1980.

4.1.9 Copper

In October, copper values from water column composite samples ranged from the level of detection (0.002 mg/l) to 0.009 mg/l at Station 22 in City Waterway. In December, stations with higher values in October were sampled at discrete depths to identify possible stratification and sources of copper values. In December, values again ranged from the level of detection (0.003 mg/l) to 0.009 mg/l at Station 22 S in City Waterway. Higher copper values were always associated with fresher water near the surface (0.1 m depth) at the stations selected for discrete depth samples in December. City Waterway has a large seasonal input of fresh water which comes into the head end of the waterway and in part drains the "Nalley Valley" industrial area. This may be a possible source of this copper and other freshwater-associated contaminants in this waterway.

In addition to the higher copper values associated with City Waterway (Station 22 and 23) in both October and December, relatively high values were obtained in Hylebos Waterway in the December sampling. Stations 29 S, 1 S, 2 S, and 3 S (all in Hylebos) had associated copper values of 0.006, 0.007, 0.006, and 0.004 mg/l, respectively. Copper concentrations in Hylebos and other waterways are related to urban activities including antifouling paints, direct copper inputs from plant processes, and possible copper input from ASARCO slag leachates. The water quality sampling stations located near the smelter (Station 28) had associated higher copper values in October (when ASARCO employees were on strike and the plant was not operating) than in December. This may be

attributable to unknown copper inputs from other urban/industrial sources along the south shore of Commencement Bay, differences in runoff from the ASARCO site, or differences in tide stage (and hence current patterns) between the sampling times.

4.1.10 Cadmium

In October, no composite water samples exceeded the level of detection (0.001 mg/l). In December, only one value, 0.003 mg/l, exceeded the level of detection. That station (10 M--Commencement Bay, Center-mid) was at a depth of 50 m (164 ft). The location and depth of water sampled makes the cadmium value suspect. One possible explanation for this higher cadmium value is that 10 S and 10 M samples were accidentally reversed in field labeling or in the laboratory.

4.1.11 Chromium

The levels of detection for chromium (0.008 mg/l in October and 0.005 mg/l in December) were not exceeded in any water samples collected during the two sampling periods.

4.1.12 Lead

The levels of detection for lead (0.01 mg/l in October and 0.02 mg/l in December) were not exceeded in any water samples collected during two sampling periods.

4.1.13 Zinc

Zinc values equalled or exceeded the level of detection (0.002 mg/l) at all stations in both sampling months. In October, zinc values ranged from 0.004 to 0.17 mg/l (33 S--Wapato Creek). The high zinc value in Wapato Creek is possibly due to the influence of the galvanized culvert through which the creek flows near this station. Generally, higher zinc values were observed in City Waterway (Stations 31, 22, 23, 24) than in either Hylebos or Blair Waterways in October.

In December, discrete depth water samples at selected stations had zinc values ranging from 0.004 to 0.042 mg/l. Zinc values at these selected stations were nearly always highest at the surface with declining values for middle and bottom water samples. While two stations (Stations 31 S and B) in City Waterway had the highest zinc values, these values were only slightly higher than those measured in Hylebos and Blair Waterways. An explanation for the higher zinc level at Station 10 M (50 m depth) than at 10 S (0.1 m depth) is not readily apparent, unless the samples were accidentally reversed in labeling or handling.

As was the case with arsenic and copper, the December sampling indicated that higher zinc concentrations are associated with fresh water near the surface. Freshwater discharges from industrial activities, urban runoff, and leachates from ASARCO slag associated with rainfall runoff are likely sources of these metals. It is not likely that these metals originated from upper Puyallup River water sources as measured concentrations of all three metals were low in the river in 1980 (EPA 1980d).

4.2 DISCUSSION

In general, the traditional water quality parameters measured in the COBS study area are consistent with historical data with the exception of specific values discussed in Section 4.1 for PCBs, arsenic, and heavy metals. For example, when COBS data for Station 23 S (located in the mouth of City Waterway) are compared to the STORET data for CMB006 (at or near the same location), average and range of STORET data for parameters such as temperature, salinity, DO, and chlorophyll-a are comparable. The single chlorophyll-a value in STORET for June 1977 is much higher than the COBS value for December 1980, as would be expected.

For the less traditional parameters measured in the COBS effort (PCBs, arsenic, and heavy metals), some comparisons can be made with EPA (1980c) water quality criteria. This comparison is made to relate the COBS values for these parameters with the values that are thought to place marine and aquatic life at risk.

4.2.1 Polychlorinated Biphenyls (PCB)

The EPA (1980c) PCB criteria for protection of aquatic life are as follows:

- "Saltwater: 0.030 $\mu\text{g}/\text{l}$ as a 24-hr average; acute toxicity probably will only occur at concentrations above 10 $\mu\text{g}/\text{l}$."
- "Freshwater: 0.014 $\mu\text{g}/\text{l}$ as a 24-hr average; acute toxicity probably will only occur at concentrations above 2.0 $\mu\text{g}/\text{l}$."

The one value of 0.64 ppb or $\mu\text{g}/\text{l}$ as Arochlor No. 1016 achieved at Station 3 (mouth of the Hylebos Waterway) in the COBS October sampling exceeds both the 24-hr average criteria to protect saltwater and freshwater aquatic life, but does not exceed the acute toxicity levels suggested by EPA (1980c). The total selected chlorinated biphenyls* exceeded the 24-hour average saltwater criteria in both months sampled (September and December 1980) at all 10 stations except the 9 meter (deepest) sample at Station 5 in December (Riley et al. 1981).

The method of sample collection in October needs to be considered in evaluating the COBS PCB value. As indicated in Section 3.6, the October sample at this location consisted of a composite of equal parts of surface (S), middle (M), and bottom (B) water samples. It is unlikely that PCB concentrations were equal at all depths at a given station. At least at one water depth, therefore, a higher PCB concentration than measured likely existed.

Another possibility is that laboratory or field contamination contributed to this higher value; however, a sediment station in inner Hylebos Waterway also had a high PCB value (see Sediment Studies Technical Report). As noted, Riley et al. (1981) reported PCBs at a station close to the COBS Station 3.

*EPA criteria are for total PCBs while Riley et al. (1981) data are for total selected chlorinated biphenyls. Therefore, the Riley et al. data underestimate total PCBs by an unknown amount.

The only PCB (1242) detected in the two EPA screening surveys was in effluent from a drain entering Blair Waterway. The PCB was detected during the September 1980 sampling (EPA 1980b).

4.2.2 Arsenic

In December, all three surface (S) stations in inner Hylebos Waterway (29, 1, and 2) had associated detectable arsenic levels from 0.03 to 0.05 ppm or mg/l (30 to 50 ppb or $\mu\text{g/l}$).

The EPA (1980c) criteria for protecting aquatic life are as follows for total recoverable trivalent inorganic arsenic:

"Saltwater: acute toxicity as low as 508 $\mu\text{g/l}$ and lower for more sensitive organisms."

"Freshwater: should not exceed 440 $\mu\text{g/l}$ at any time; short-term effects on aquatic vertebrate embryos and larvae as low as 40 $\mu\text{g/l}$."

COBS values for Hylebos exceed only the EPA 40 $\mu\text{g/l}$ criterion, the minimal level for possible effects on freshwater aquatic vertebrate embryos and larvae. While these COBS values were not found in fresh water, they were present in lower salinity surface waters of Hylebos Waterway that are, in fact, seasonally occupied by rearing juvenile salmonids prior to their migration into the more marine waters of Puget Sound. In any case, the relative sensitivity of these fry (not embryos or larvae) to arsenic under these low salinity conditions is not known.

Arsenic was not detected in composite COBS water samples collected in October; the October level of detection was 0.02 ppm or mg/l (20 $\mu\text{g/l}$). If the same arsenic concentration patterns existed in October as existed for discrete December sampling, surface values in October would have been the highest for each station. It is therefore conceivable that surficial arsenic concentrations exceeded the level of detection, with such values masked in the composite sampling procedure.

The relationship of actual values of arsenic at the surface to EPA criteria for protection of aquatic life cannot be determined.

4.2.3 Copper

The highest copper values (0.009 mg/l or 9 µg/l) observed in City Waterway and the surface waters of the study area occurred in the December sampling. The EPA (1980c) criteria for copper for the protection of aquatic life are as follows:

"Saltwater: 4.0 µg/l as 24-hr average; and should not exceed 23 µg/l at any time."

"Freshwater: 5.6 µg/l as a 24-hr average."

The maximum COBS copper value for City Waterway exceeds the EPA 24-hr average criterion of 4.0 µg/l but not the not-to-exceed criterion (23 µg/l) for copper. Again, it is not known what the actual surface copper value for October was due to the diluting effects of composite sampling. If the source of copper input to City Waterway is stormwater runoff, it is likely that the surficial input is highest in the winter due to greater rainfall totals although greater flows would also dilute the copper concentration in water.

Comparisons of copper values for October and December at Station 15 S (Puyallup River, Lincoln Street) are interesting as both constituted a discrete surface (0.1 m) sample. In October, the copper value at this location was higher (0.007 mg/l) than in December (<0.003 mg/l). The Tacoma Central Wastewater Treatment Plant (S.T.P. No. 1), discharged 22.2 and 39.8 µg/l in a dry and wet weather period, respectively (City of Tacoma 1979a). What contribution this sewage treatment plant has on these varying river values is not known. If the October value was representative of input during the COBS study period, it is unlikely this plant alone accounted for changes in copper levels between October and December 1980.

Instantaneous copper values in the COBS area equalled or exceeded the 24-hr average criterion in 16 of 33 stations (composite samples) in

October and in 9 of 13 stations (12 of 34 discrete samples) in December. If these values are representative of a 24-hr average at these sampling locations, copper levels at numerous locations in the COBS area are sufficient to place marine aquatic life at risk with respect to levels of copper present.

4.2.4 Cadmium

No October stations exceeded the level of detection (0.001 mg/l). One station and depth (10 m) had a level over the same detection limit in December. The cadmium level was 0.003 mg/l, or 3 µg/l, which is below the 24-hr average criteria of 4.5 µg/l and well below the not-to-exceed level of 59 µg/l (marine aquatic life) for total recoverable cadmium (EPA 1980c).

4.2.5 Chromium

Chromium levels were below the 0.008 (October) and 0.005 (December) mg/l levels of detection at all stations. Therefore, chromium values at all stations were well below the EPA chromium criteria for the protection of marine aquatic life, which states that total recoverable hexavalent chromium should not exceed 18 µg/l as a 24-hr average and should not exceed 1,260 µg/l at any time (EPA 1980c).

4.2.6 Lead

No lead levels exceeded the 10 µg/l (October) and 20 µg/l (December) levels of detection. Therefore, lead levels at all stations were well below the EPA (1980c) lead criteria for the protection of marine aquatic life (acute toxicity--668 µg/l; chronic toxicity 25 µg/l, EPA 1980c).

4.2.7 Zinc

Zinc values were highest (0.17 mg/l or 170 µg/l) in Wapato Creek (Station 33) with highest marine values (0.042 mg/l or 42 µg/l) in City Waterway (Station 31). The EPA (1980c) zinc criteria for the protection of aquatic life is as follows for total recoverable zinc:

"Saltwater: 58 $\mu\text{g/l}$ as a 24-hr average; and should not exceed 170 $\mu\text{g/l}$ at any time."

"Freshwater: 47 $\mu\text{g/l}$ as a 24-hr average, and is a function of hardness in not-to-exceed values (at 50, 100, and 200 mg/l CaCO_3 , the zinc levels should not exceed 180, 320, and 570 $\mu\text{g/l}$ at any time)."

The zinc value for Wapato Creek, which had a salinity of 13.69 ppt at the time of sampling, equals the not-to-exceed saltwater value. Even if it is assumed that the zinc values obtained represent an approximate 24-hr average, the other high single zinc values recorded in the COBS study area (30 to 42 $\mu\text{g/l}$) are below the EPA (1980c) criterion of 58 $\mu\text{g/l}$.

4.2.8 Vertical Stratification

A comparison of the salinities (Tables 6 and 7) and Appendix E (December conductivities) for the stations on the three track line stations (described in Section 3.1) was made along with evaluations of other data (NCO data in Appendix A and the COBS Physical Oceanography Technical Report).

Unfortunately, the STD-pH-DO probe used in the COBS program did not provide suitable values to calculate density with depth. The limited salinities and the high conductivity values in December do agree with patterns seen in other studies.

The vertical stratification is generally greater in the waterways and in bay areas closest to the Puyallup River mouth. The general pattern when stratification is greatest in the study area (high Puyallup flow periods) has the base of the pycnocline located at about 2 m. Basically, the majority of the density change is from this depth to the surface, although with time and location there are exceptions. This is most graphically shown in the density profiles shown for most measurements in the 301(h) studies (Appendix A).

The density profile below this active 2-m to surface zone is fairly constant with depth. Between October and December 1980, values below 2 m were very similar generally within 0.200 to 0.500 ppt in the outer bay stations on each transect line with the slight reduction in salinities from October to December. In some shallower waterways, the October to December change in salinity was somewhat greater, but in general salinities were fairly constant below about 2 to 3 m.

The sharpest vertical stratification occurred in the salt wedge in the lower Puyallup River between surface (S) and bottom (B) at Station 16 in both October and December. Upstream at Station 15 in December both surface (S) and bottom (B) stations were <0.500 ppt, indicating the salt wedge ended somewhere between these two stations. The boundary of the salt wedge in the river migrates with tidal changes.

Current studies by NCO in 1979 and in the COBS studies (Physical Oceanography Technical Report) indicated that the Puyallup River plume was a shallow surface feature of the bay and the waterways. Water characteristics from the University of Washington (1974-1975) and from probe measurements for this study and in the NCO study also indicate a uniform shallowness to this plume, a confinement to the upper meter or two. Aerial photographs often indicate clear water in vessels' wakes as they pass through the turbid plume. Density stratification determined by salinity and temperature, is largely controlled by the Puyallup River in the bay and waterways. It may serve to hold pollutants just below the surface at the base of the pycnocline or it may hold pollutants in the surface waters where they will be laterally dispersed rapidly, yet restrained in vertical mixing.

4.3 WASTEWATER CHARACTERIZATION

Numerous point-source and nonpoint-source discharges occur into the waters of the COBS study area. Many of the nonpoint-source discharges are likely intermittent and reflect local stormwater runoff. Some point-source discharges also reflect local rainfall activity (e.g., storm drains, sewer plant outfalls). The body of literature available to

support the wastewater characterization presented in this section reflects data that are generally from 1 to 5 years out-of-date (depending upon the source). This data base is presently being expanded and updated in phases by joint EPA/DOE studies directed at identifying and characterizing new and historic wastewater influences. It is likely that these joint studies will continue over the next few years as well, especially with possible Superfund support. Therefore, the analysis of wastewater influences herein will be subject to review in light of new data resulting from these and other studies.

Figure 6 presents the known (before 1980) point-source discharge points into the water of the COBS study area as provided by DOE. Some 122 sources of liquid effluent have been located within the COBS study area through these studies. Of these, 48 are City of Tacoma storm sewers. A few of these storm sewers are known to still discharge raw sewage; others still receive industrial effluents both directly and as runoff from developed sites.

DOE has divided the COBS study area into four areas in their coding system (see Figure 6). These areas and their corresponding DOE codes include: (1) Marine Water Undesignated (05-10-08); (2) Commencement Bay (05-10-02); (3) Inner Commencement Bay (05-10-01); and (4) Puyallup River (above RM 1) (05-10-03).

Table 8 summarizes the NPDES limitations associated with the release of point-source discharges. Unfortunately, most outfalls that may have heavy metal or organic chemical constituents do not require monitoring beyond that of traditional water quality parameters. Some of the exceptions are detailed below.

Several of these point sources as well as unmapped shore seeps, leaks, and discharges as sampled by EPA are summarized in Appendix D. As indicated by data in Appendix D, many of these seeps and leaks discharge high concentrations of some organics and heavy metals. Since such inflows are usually of relatively small volume, even high concentrations of potentially harmful constituents in inflows are significantly reduced

A

- 1-WESTERN FISH AND OYSTER
- 2-COAST IRON MACHINE WORKS #1
- 3-TACOMA STEAM
- 4-HYGRADE
- 5-JOHNINY'S SEAFOOD
- 6-CONSUMER CENTRAL HEATING CO.
- 7-PUGET SOUND PLYWOOD #2
- 8-PUGET SOUND PLYWOOD #3
- 9-FOSS L'YVICH TUGBOAT
- 10-PETERSON BOAT BUILDERS
- 11-WOODMORTH & CO.
- 12-SHELL OIL CO
- 13-PUGET SOUND PLYWOOD #4
- 14-CHICAGO MILWAUKEE #1
- 15-CHICAGO MILWAUKEE #2

- 16-TACOMA STORM SEWER #2
- 17-TACOMA STORM SEWER #1
- 18-FORE TERMINAL
- 19-UNITED GRAIN
- 20-DICKMAN LUMBER #2
- 21-DICKMAN LUMBER #1
- 22-STADIUM HIGH STORM SEWER
- 23-WESTERN PLASTICS CORP
- 24-PACIFIC RESINS & CHEMICALS
- 25-PUREX
- 26-U.S. OIL & REFINING #1
- 27-U.S. OIL & REFINING #2
- 28-MOBILE OIL CO
- 29-UNION OIL CO
- 30-CERTAIN-TEED
- 31-ALLIED CHEMICAL
- 32-STAUFFER CHEMICAL
- 33-CONCRETE TECH INC. #6

- 34-CONCRETE TECH INC #4
- 35-REICHALD CHEMICALS INC
- 36-NATIONAL GYPSUM
- 37-DONTAR-CHEM INC
- 38-TACOMA STEAM PLANT #2
- 39-BUFFELIN WOOD WORKING CO
- 40-TACOMA STEAM PLANT #2
- 41-HOOKER CHEM CORP #2
- 42-HOOKER CHEM CORP #1
- 43-U.S. GYPSUM CO
- 44-SOUND REFINING
- 45-MENASHA
- 46-ZIDELL
- 47-TACOMA STP #3
- 48-SYMONS FROZEN FOOD
- 49-HIBBARD-STEMART
- 50-ST. REGIS #2
- 51- " #4
- 52- " #5
- 53- " #6

- 54) ST. REGIS SAMMILL 001
- 55) " " 002

- 56-AERO JET
- 57-97 TACOMA STORM SEWERS
- 98) LAKE HAVEN S D LANDATA

B

- 1-PENNHALT CORP
- 2-TACOMA BOAT BUILDER
- 3-CLAGIER SAND & GRAVEL
- 4-KAISER ALUMINUM & CHEM #001
- 5) LAKE HAVEN S D
- 6) FRANK ANDERSON #001

C

- 1-AM. SMELTING & REF.#1
- 2- " #2
- 3- " #3
- 4- " #4
- 5- " #5
- 6- " #6
- 7-TACOMA STP #2

D

- 1-TACOMA CENTRAL STP #1
- 3-BURLINGTON NORTHERN ENGINE SERVICE FAC
- 4-NORTH PACIFIC PLYWOOD CORP
- 5-GEORGE SCHOFIELD CO #2
- 6-GEORGE SCHOFIELD CO #1
- 7-PACIFIC LUTHERAN UNIV.
- 9-FRANKLIN PIERCE STP
- 10-FLETT DAIRY INC.
- 11-PUGET SOUND RENDERING
- 12-LIGE DICKSON CO.

- 13-NORTH SLOPE INDUST.
- 14-CARLING BREW CO
- 15-TACOMA SS
- 18-21 TACOMA SS

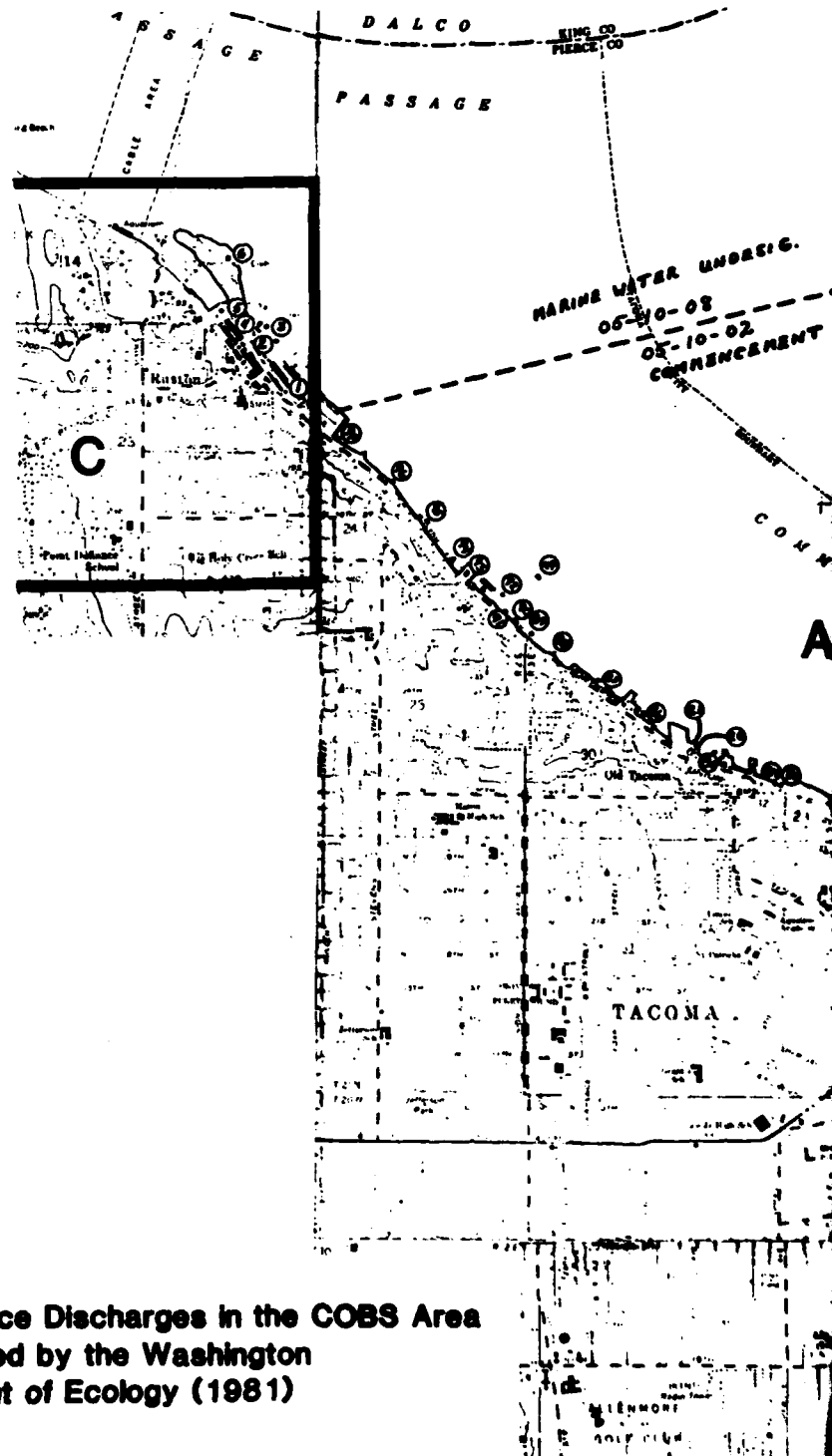
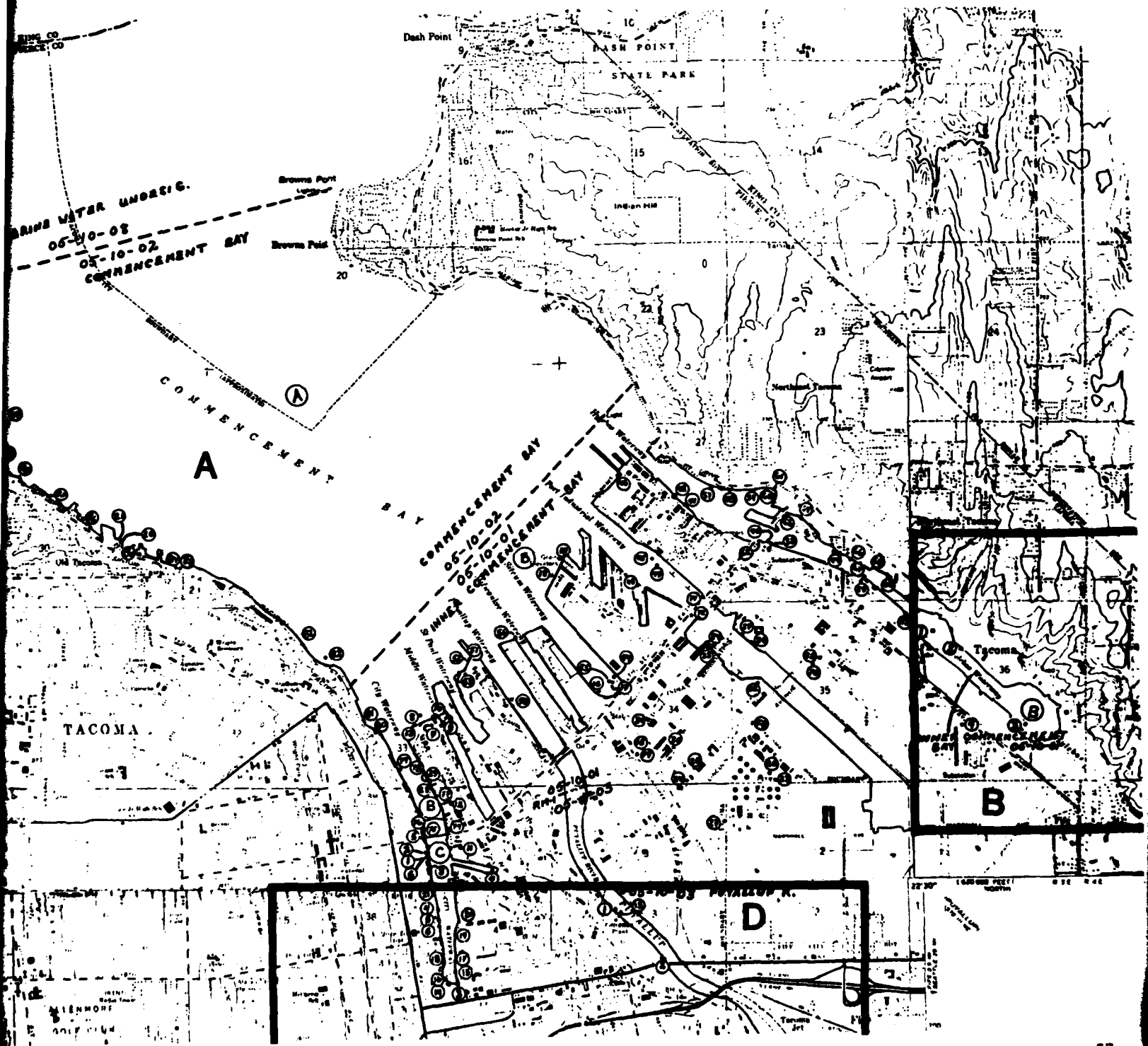


Figure 6 - Point Source Discharges in the COBS Area as Identified by the Washington Department of Ecology (1981)



RAIN WATER UNDERG.
 05-10-02
 05-10-02
 COMMENCEMENT BAY

A

B

D

TABLE 8
SELECTED POINT SOURCE DISCHARGES AND ASSOCIATED PERMIT LIMITATIONS (a)

Company/Address (b)	Discharge Point	State/Federal Permits (c)	Effluent Volume Limit (d)	Other Effluent Limitations (e)
American Plating Company, Inc. 2110 E. "D" Street	S.T.P. No. 1(f)	MDP	30,000	Cadmium: 0.5 mg/l Chromium: 1.0 mg/l Copper: 0.5 mg/l Nickel: 1.0 mg/l Zinc: 1.0 mg/l pH: 6.0 to 9.0 No discharge allowed to City Waterway
ASARCO P.O. Box 1677 Tacoma, WA 98401	3 outfalls to Commencement Bay	NPDES	8,640,000	Oil and grease: 15 mg/l, no visible sheen pH: 6.5 to 8.5 Heavy metals: Monitoring requirement No process water No slag granulation discharge to state water
Atlas Foundry & Machine 3021 S. Wilkeson Street	Storm sewer to City Waterway	NPDES	1,500,000	Temperature: 150°F Oil and grease: 15 mg/l, no visible sheen pH: 6.5 to 8.5
Buffelen Woodworking Company P.O. Box 1383	Eylebos Waterway	NPDES	17,000	Oil and grease: 15 mg/l, no visible sheen Temperature: 90°F Phenolic glue wastes to holding tank for ultimate pumping and waste disposal
Chemical Processors, Inc. 5501 Airport Way S. Seattle	S.T.P. No. 1	MDP	50,000	No flammable solvents Temperature: 100°F Oil and grease: 50 mg/l, no free floating pH: 6.0 to 9.0 Free cyanide: 0.20 mg/l or 0.03 lb/day Cyanide total: 0.64 mg/l or 0.10 lb/day Phenols: 1.0 mg/l Settleable solids: 0.1 ml/l No halogenated organics--except case-by-case with DOE and City of Tacoma permission Cadmium: 0.5 mg/l Chromium IV: 0.25 mg/l Total chromium: 1.0 mg/l Copper: 1.0 mg/l Lead: 1.0 mg/l Mercury: 0.05 mg/l Nickel: 1.0 mg/l Zinc: 1.0 mg/l

(a) Data from: Selected NPDES Permits at Department of Ecology, Lacey.
 (b) All addresses in Tacoma unless otherwise indicated.
 (c) MDP - State Waste Discharge Permit, NPDES - National Pollutant Discharge Elimination System.
 (d) Daily maximum, in gallons, except where noted as daily average.
 (e) Daily maximum permitted, except where noted as weekly average.
 (f) S.T.P. No. 1 - City of Tacoma Central Wastewater Treatment Plant discharge to Puyallup River.

TABLE 8

Company/Address (b)	Discharge Point	State/Federal Permits (c)	Effluent Volume Limit (d)	Other Effluent Limitations (e)
Cascade Pole Company P.O. Box 1496	Blair Waterway via Tacoma storm sewer	NPDES	--	Daily maximums: Oil and grease: 15 mg/l, no visible sheen Total phenols: 1 mg/l No process water permitted
Certain-teed Products Corporation 1718 Thorne Road	Sitcom Waterway	NPDES	135,000	Temperature: 85°F Oil: no visible sheen Contact water is to be recycled
Concrete Technology Corporation 1123 Port of Tacoma Road	Blair Waterway	NPDES	9,000	Turbidity: no increase over 10 JTU over 50-foot radius of outfalls 004 and 006. Settleable solids: 0.1 mg/l pH: 6.0 to 9.0 Oils: 15 mg/l, no visible sheen Drydock pump effluent to continuously submerged outfall and diffuser
Container Corporation of America 817 East 27th Street	S.F.P. No. 1	MDP	380,000	Must meet City of Tacoma guidelines
Pick Foundry 1005 East "E" Street	City Waterway	NPDES	Noncontact cooling water: 361,000	Temperature: 76°F Oil and grease: no visible sheen
George Scofield Company, Inc. 1543 Dock Street	City Waterway	NPDES	Cooling water: 1,500	Oils: 15 mg/l, no visible sheen Oils:
Georgia Pacific 1754 Thorne Road	Sitcom Waterway via Tacoma storm sewer	NPDES	Noncontact cooling water: 45,000	Temperature: 65°F Oil and grease: 15 mg/l, no visible sheen pH: 6.0 to 9.0 Contaminated wastes to S.F.P. No. 1 per city sewer system requirements and ordinances.
Hocker Chemicals and Plastics Corporation 605 Alexander Avenue	Hylebos Waterway	NPDES	18,500,000	Temperature: 94°F Chlorine residual: 1 mg/l pH: 6.0 to 10.5 Suspended solids: 544 lb/day Ammonia (as N): 25 lb/day Lead: 4.3 lb/day Iron, nickel, copper, and zinc: may be discharged at maximum levels existing at time of permit application

TABLE B

Company/Address (b)	Discharge Point	State/Federal Permits (c)	Effluent Volume Limit (d)	Other Effluent Limitations (e)
Hygrade Food Products Corporation 1623 East "J" Street	Wheeler Osgood (City Waterway)	NPDES	Noncontact cooling and yard drainage: 190,000	Temperature: 78°F Oil and grease: 15 mg/l, no visible sheen
Jones Chemical, Inc. 1919 Marine View Drive	S.T.P. No. 1	NDP	Must meet all requirements and ordinances of City of Tacoma for discharges to city sanitary sewer system.	
Kaiser Aluminum and Chemical Corporation 3400 Taylor Way	Eylebos Waterway	NPDES	3,000,000	Fluorides: 820 lb/day TSS: 1,230 lb/day Oil and grease: 15 mg/l, no visible oils Cyanides: 0.10 mg/l pH: 6.0 to 9.0 Temperature: 90°F
Lillybled Petroleum Inc. 2244 Port of Tacoma Road	Blair Waterway	NPDES	--	Oil and grease: 15 mg/l pH: 6.5 to 8.5
Mobil Oil Company Los Angeles, CA (Tacoma Bulk Plant, East "D" Street)	City Waterway	NPDES		Oil and grease: 15 mg/l pH: 6.5 to 8.5
Malley's Fine Foods 3303 S. 35th Street	S.T.P. No. 1 and Tacoma storm sewer	NPDES	Noncontact cooling: 750,000 Process waste water (daily average): 1,050,000	pH: 6.0 to 9.0 Oil and grease: 15 mg/l, no visible sheen Temperature: 100°F pH: 5.5 to 9.0
North Pacific Plywood 1549 Dock Street	City Waterway and S.T.P. No. 1	NPDES	Cooling water (daily average): 43,200	Temperature: 65°F Oil: no visible sheen Other wastes to S.T.P. No. 1
Pacific Northern Oil 5501 Airport Way S., Seattle (1002 East "D" Street, Tacoma)	City Waterway	NPDES	--	Oil and grease: 15 mg/l pH: 6.5 to 8.5
Pennwalt Corporation 2901 Taylor Avenue	Eylebos Waterway	NPDES	9,491,000	Difference of temperature outside dilution zone and temperature of final receiving water must be less than: 52°F Temperature of final receiving water in °F -30°F
				Chlorine residual: 1 mg/l pH: 6.0 to 9.0 TSS: 256 lb Total lead: 21 lb/day Zinc, copper, iron, and nickel are to be monitored.

TABLE 8

Company/Address (b)	Discharge Point	State/Federal Permits (c)	Effluent Volume Limit (d)	Other Effluent Limitations (e)
Pegat Sound Plywood, Inc. 230 East "p" Street	City Waterway	NPDES	100,000	Oil: no visible sheen No direct discharge of boiler blowdown Glue waste, dryer cleaning, car wash water, boiler blowdown to S.T.P. No. 1.
Purex Corporation Wilmingon, CA (2001 Thorne Road, Tacoma)	Sitcum Waterway	NPDES	Cooling and sealing water: 8,000	Temperature: 65°F pH: 6.5 to 8.5 Oil: 15 mg/l, no visible sheen No tank and flour wash water to state waters.
Reichhold Chemicals, Inc. 2340 Taylor Way	Blair Waterway and S.T.P. No. 1	NPDES	Noncontact cooling and storm water: 2,000,000	Temperature: 66°F pH: 6.5 to 8.5 Oil: 15 mg/l, no visible sheen Phenols: 1 mg/l COD: 1,000 mg/l pH: 6.5 to 8.5 Heavy metals monitoring required to meet DOE 1970 interim policy.
St. Regis Paper Company 1216 St. Paul Avenue (Sawmill)	St. Paul Waterway	NPDES	Process water (to S.T.P. No. 1): 300,000 Hydraulic bunker and waste treatment: 920,000	BOD: 860 lb TSS: 675 lb Oil and grease: 15 mg/l, no visible sheen pH: 6.0 to 9.0 Temperature: 75°F Oil and grease: 15 mg/l, no visible sheen
St. Regis Paper Company 1216 St. Paul Avenue (Pulpmill)	Commencement Bay at mouth of Puyallup River	NPDES	Noncontact cooling water: 315,000 Boiler blowdown: 15,000	TSS: 100 mg/l Copper: 1.0 mg/l Iron: 1.0 mg/l Storm water may be discharged with imposed conditions
Shell Oil Company San Francisco, CA (702 East "D" Street, Tacoma)	City Waterway	NPDES	Stormwater runoff	No floatable solids TSS: 14,000 lb/day (on monthly average--no day over 27,000 lb/day) Temperature: 66°F or greater than "t" (calculated t = 52/(T-32)) Dilution zone boundary specified. BOD ₅ : 6,800 lb/day (on monthly average of 6,800 lb/day) pH: 6.0 to 9.0 Toxic discharges: 100% survival of salmonid test fishes in a 65% concentration of treated effluent for a 96-hr bioassay period. Conduct sludge bed survey No visible foam discharge No solid waste discharges Oil and grease: 15 mg/l

TABLE 3

Company/Address (b)	Discharge Point	State/Federal Permits (c)	Effluent Volume Limit (d)	Other Effluent Limitations (e)
Sound Refinery Company Marine View Drive	Hylebos Waterway	NPDES	Process water: 9,000,000	Via Discharge 001: BOD: 180 lb/day TSS: 110 lb/day Oil and grease: 55 lb/day or 15 mg/l, whichever is more restrictive Visible oil: None Phenols: 1.35 lb/day Sulfides: 1.20 lb/day Ammonia: 22.4 lb/day pH: 6.0 to 9.0
				Via Discharge 002: BOD: 0.40 lb/1,000 gallons TSS: 0.24 lb/1,000 gallons Oil and grease: 0.126 lb/1,000 gallons
Stauffer Chemical Company New York, NY (2545 Lincoln Ave., Tacoma)	Blair Waterway	NPDES	Process water (volumes related to rainwater in impoundments)	Via Discharge 002, 003, 004: Visible oil: None
				For 10 or more consecutive days: Phosphorus (as P): 35 mg/l Fluoride (as F): 15 mg/l Nitrogen (as N): 5 mg/l Total suspended nonfilterable solids 25 mg/l pH: 6.0 to 9.0
Supreme Dairy 6601 Pacific Highway E.	Hylebos Creek	NPDES	1,000	Oil and grease: no visible sheen
City of Tacoma (g) S.T.P. No. 1	Poyallup River (h)	NPDES	78,000,000	Weekly averages: BOD ₅ : 45 mg/l, 29,273 lb/day Suspended solids: 45 mg/l, 29,273 lb/day Fecal coliform bacteria: 400/100 ml pH: 6.0 to 9.0 Large accompanying monitoring program includes heavy metals.
S.T.P. No. 3	Ruston Bay shoreline of Commencement Bay	NPDES	10,000,000	Weekly averages: BOD ₅ : 45 mg/l, 3,753 lb/day Suspended solids: 45 mg/l, 3,753 lb/day Fecal coliform bacteria: 400/100 ml pH: 6.0 to 9.0

(g) Tacoma also has a discharge outside the study area (S.T.P. No. 2).

(h) This discharge includes effluent from point sources directed through S.T.P. No. 1 that are both subject to and not subject to NPDES requirements.

TABLE 8

Company/Address (b)	Discharge Point	State/Federal Permits (c)	Effluent Volume Limit (d)	Other Effluent Limitations (e)
Union Carbide Corporation Tombanda, NY (2902 20th St. East, Pike, WA)	S.T.P. No. 1	NWP	60,000	Temperature: 100°F Oil and grease: 50 mg/l, no visible sheen pH: 5.0 to 10.0 Chlorine residual: 1.0 mg/l
Union Oil Company of California 516 East "D" Street	City Waterway	NPDES	Intermittent stormwater	Oil and grease: 15 mg/l pH: 6.5 to 8.5
U.S. Oil and Refining Company P.O. Box 2225 Tacoma, WA	Blair Waterway	NPDES	Process water: 9,000,000	COD: 3,400 lb/day BOD: 460 lb/day Suspended solids: 320 lb/day Oil and grease: 140 lb/day or 15 mg/l, whichever is more restrictive Visible oil: None Total chromium: 7.0 lb/day Hexavalent chromium: 0.56 lb/day Sulfides: 3.0 lb/day Phenolic compounds: 3.4 lb/day Ammonia: 300 lb/day pH: 6.0 to 9.0
Woodworth and Company, Inc. 1200 East "D" Street	City Waterway	NPDES	Ballast and stormwater runoff	BOD: 0.40 lb/1,000 gallons COD: 3.1 lb/1,000 gallons TSS: 0.24 lb/1,000 gallons Oil and grease: 0.126 lb/1,000 gallons After June 30, 1977--no scrubber waste was permitted.
Zidell Dismantling, Inc. 401 Alexander Avenue	Bylebos Waterway	NPDES	Can be exceeded in special conditions	Oil and grease: 15 mg/l, no visible sheen Turbidity: 15 JTU above receiving water to 75 JTU (maximum)

through dilution in receiving waters. Depending on the volume of input, dilution can, in some cases, reduce such concentrations to below detection levels in more open waters. While dilution tends to mitigate the harmful effects of such constituents to aquatic and marine biota, combinations of certain harmful constituents, even in relatively small amounts, can impart cumulative biological stress on organisms, thereby increasing an organism's susceptibility to toxic influences of a given or combination of constituents. This cumulative stress is generally not accommodated in the EPA (1980) criteria for biological protection associated with the constituents discussed above in Section 4.2.

Conversely, organisms with relatively short reproductive cycles may adapt to levels of contaminants that exceed the EPA criteria for the protection of biota. Field or laboratory bioassays of acclimated and unacclimated biota must be completed to fully define the water quality risk to which local biota (both resident and migratory) are exposed in the COBS study area.

5.0 CONCLUSIONS

The following conclusions are drawn from the COBS water quality studies:

1. Observed water quality conditions for October and December 1980 are sufficient to reasonably represent the influence of time and variable Puyallup River flow on COBS area water quality for the selected parameters studied.
2. The COBS study and studies conducted by other investigators (e.g., EPA surveys, DOE/EPA Class II surveys, and NOAA/MESA-sponsored studies) demonstrate that measurable amounts of toxic chemicals are currently entering the freshwater and marine receiving waters of the study area. High levels of contaminants in receiving waters are attributable to both point and non-point sources on shore as well as in surface sediments which interface with study area waters.
3. Traditional water quality parameters (excluding PCBs and heavy metals) did not show any extraordinary values for or unexplainable differences between the two months sampled.
4. The December discrete-depth sampling indicated that concentrations of zinc, arsenic, and copper are inversely proportional to salinity; that is, higher concentrations are normally associated with less-saline (fresher) waters. This relationship along with data derived during single measurements of dry and wet flows from the two sewage treatment plants (City of Tacoma 1979 a,b) indicate that storm water runoff may be a source of these pollutants. Studies indicate leachate from ASARCO slag used to line roads in log sort yards on the industrial waterways (Hylebos and Blair) also contribute to levels of these constituents. The sources of the output from the sewage plants are not known but may be attributable, at least in part, to fallout of airborne pollutants originating from the ASARCO smelter. This fallout

would have greatest effect at the North End Wastewater Treatment Plant (S.T.P. No. 3) near ASARCO. Additional leachable wastes in the treatment plant outfalls may also originate from storm water runoff from other industrial locations.

5. The fresher water association of some contaminants (arsenic, copper, and zinc) place juvenile salmonids and other biota dependent on this less saline water at some risk.

6. Based upon chlorophyll-a evaluations and fish and invertebrate studies in other COBS efforts, it is known that biological communities exist where concentrations of certain pollutants exceed EPA criteria (1980c) for the protection of marine biota. The impacts of water quality in the area are likely much more subtle than exhibited by the presence and absence of marine life forms. At certain locations in the study area (i.e., inner waterways), the invertebrate communities contained a relatively low number of taxa with a few species being very abundant. This pattern is characteristic of a stressed biological community in an area with a high level of organic enrichment or pollution (see Invertebrate Studies Technical Report).

Similarly, according to Long (1981), "(S)tudies conducted by EPA-Newport and NMFS have shown that adverse biological effects are clearly demonstrable as a result of exposure to ambient toxicant conditions in the Tacoma waterways. High incidences of diseases among fish and crustaceans are statistically correlated with high metals and organics levels in these waterways. Infauna richness and indices are depressed. Elevated mortalities occur as a result of exposure to waterway sediments in bioassays."

Studies underway or sponsored by EPA and NOAA/MESA will provide more insight into water quality and biota interactions in the COBS area.

7. Vertical stratification in the COBS study area is greatly influenced by Puyallup River flows and distance from the river mouth. The active density change is defined as from about 2 m (6 ft) to the surface. The base of the pycnocline is defined at about 2 m.

8. Some 122 point sources of liquid effluent are known to exist in the COBS area. Many more small seeps and leaks exist. The DOE and EPA have conducted extensive historic mapping of these point sources. The constituents of many of these inflows have been determined through NPDES monitoring and EPA screening studies (see Appendix D). However, extensive additional surveys are required to characterize the wastewater released to study area waters.

6.0 REFERENCES

- American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1976. Standard methods for the examination of water and wastewater. American Public Health Association, Washington, DC. 1,193 pp.
- Collias, E.E., 1970. Index to physical and chemical oceanographic data of Puget Sound and its approaches, 1932-1966. Department of Oceanography, University of Washington Special Report No. 43.
- Collias, E.E., and J.H. Lincoln, 1977. A study of the nutrients in the main basin of Puget Sound. Department of Oceanography, University of Washington. Prepared for the Municipality of Metropolitan Seattle, 151 pp.
- Collias, E.E., N. McGary, and C.A. Barnes, 1974. Atlas of physical and chemical properties of Puget Sound and its approaches. University Press, Seattle, Washington. (This atlas permits observing the relationships of water masses through Puget Sound by use of longitudinal profiles of various parameters.)
- Hileman, J., 1981. Letter of November from EPA Region X to Dr. Steve Martin, Seattle District Corps of Engineers.
- Long, E.R., 1981. Letter of October 28 from NOAA/MESA to Dr. Steve Martin, Seattle District Corps of Engineers.
- NOAA-National Oceanic Survey, 1979. Tide tables 1980, high and low water predictions. U.S. Department of Commerce.
- Paquette, R.G., 1958. A modification of the Wenner-Smith-Soule salinity bridge for the determination of salinity of seawater. University of Washington Technical Report No. 61, 62 pp.
- Parametrix, Inc., 1979. Sediment and water quality analyses--proposed channel improvements study--Blair and Sitcum Waterways, Tacoma Harbor, Washington. Summary Report for Seattle District Corps of Engineers. October.
- Puget Sound Air Pollution Control Agency (PSAPCA), 1981. PSAPCA DEIS and FEIS on a variance application by ASARCO for the Tacoma smelter.
- Riley et al., 1980. Qualification of pollutants in suspended matter and water from Puget Sound. Report to NOAA-MESA, Puget Sound Project Office.
- Riley et al., in press. Organic pollutants in waterways adjacent to Commencement Bay (Puget Sound). Report to NOAA/MESA, Puget Sound Project Office.
- Tacoma, City of, 1974. City Waterway quality and biological conditions. Department of Public Works. Sewer Utility Division. September.

- _____, 1979a. Application form for modification of the requirements of secondary treatment [Section 301(h) waiver] for central wastewater treatment plant (S.T.P. No. 1).
- _____, 1979b. Application form for modification of the requirements of secondary treatment [Section 301(h) waiver] for north end wastewater treatment plant (S.T.P. No. 3).
- _____, 1981. Supplemental Water Quality Information for City Waterway--Tacoma. Personal communication from Ron Nelson to John Isakson (September 25).
- Thompson, T.G., and R.J. Robinson, 1939. Notes on the determination of dissolved oxygen in seawater. *Journal of Marine Research* 2(1):1-8.
- U.S. Environmental Protection Agency, 1979. Guidelines establishing test procedures for the analysis of pollutants; proposed regulations. *Federal Register* Vol. 44, No. 233, pp. 69468-69552.
- _____, 1980a. Unpublished. Commencement Bay/Port of Tacoma field study--June 3, 1980. [Memo of August 25, 1980].
- _____, 1980b. Unpublished. Commencement Bay waterways survey--September 23-24, 1980. [Memo of January 6, 1981].
- _____, 1980c. Water quality criteria documents; availability. *Fed. Reg.* 45(231):79318-79345.
- _____, 1980d. STORET data base--computer printout from EPA (April 9, 1980).
- U.S. Geological Survey, 1980. Telephone input from several Tacoma USGS staff personnel.
- University of Washington, 1975. Unpublished data collected from 1974 to 1975 for the City of Seattle Sewage Authority (METRO).
- University of Washington. Assorted oceanographic data reports and unpublished oceanographic data on file as listed on pages 305 and 306 of Reference 3. These include University of Washington Department of Oceanography Technical Reports Nos. 24, 28, 35, 45, 46, 51, 110, 113, 114, and 116.
- Washington State Department of Ecology. Unpublished. Log and inspection reports for three yards. Obtained from Richard Pierce, S.W. Laboratory of DOE.
- Yake, B., 1981a. Internal memo to F. Monahan--Reichhold Chemicals, Inc. Class II Inspection of April 21, 1981. Washington Department of Ecology, September 25.
- _____, 1981b. Internal memo to F. Monahan--U.S. Oil and Refining Co. Class II Inspection of May 5 and 6, 1981. Washington Department of Ecology, October 22.

APPENDIX A

HISTORIC OCEANOGRAPHIC DATA*

*University of Washington and Northwest Consultant Oceanographers, Inc.
Studies

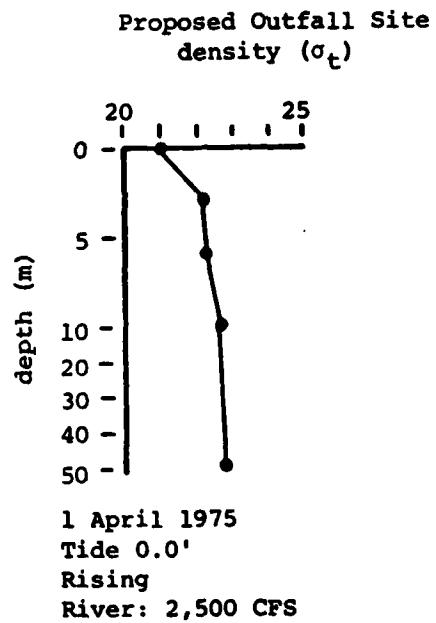
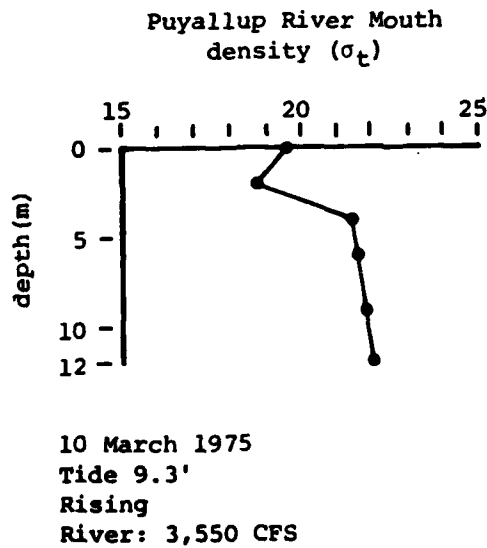
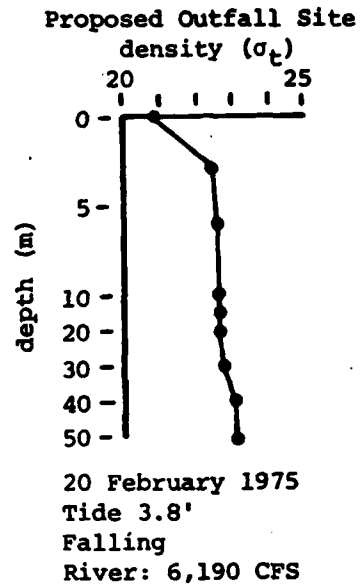
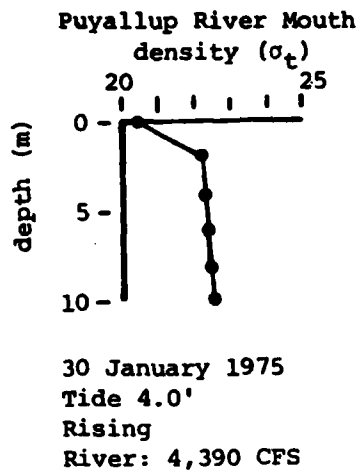
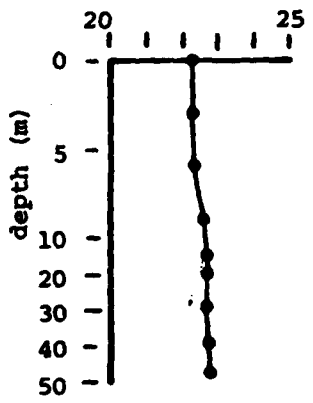


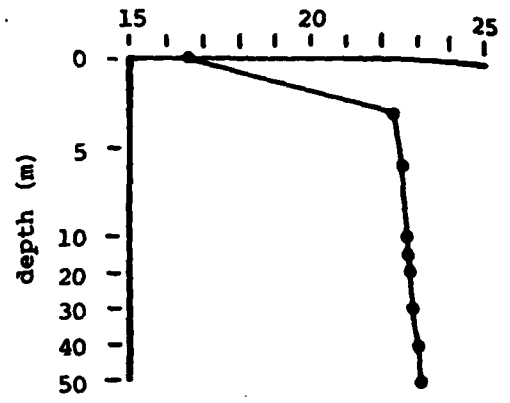
FIGURE A-1

Proposed Outfall Site
density (σ_t)



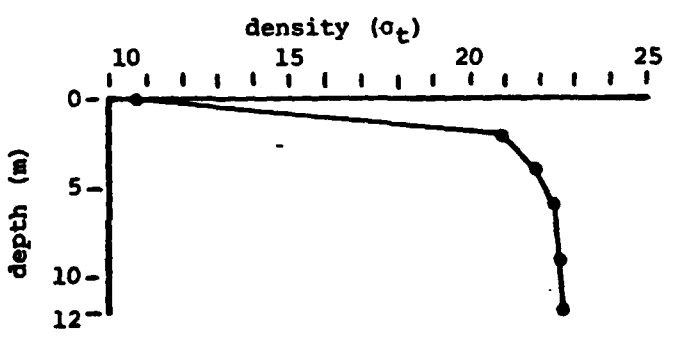
22 April 1975
Tide 9.5'
High water
River: 1,850 CFS

Proposed Outfall Site
density (σ_t)



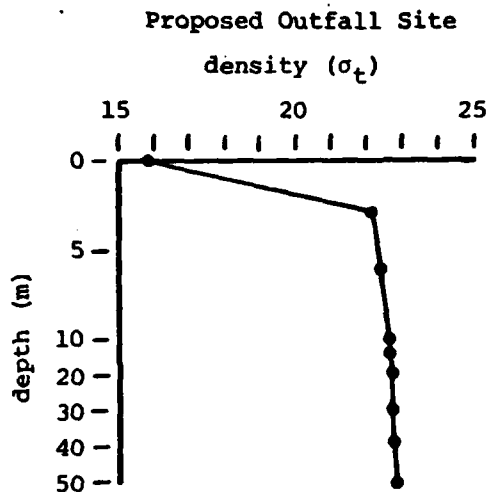
15 May 1975
Tide 1.5'
Falling
River: 6,690 CFS

Puyallup River Mouth

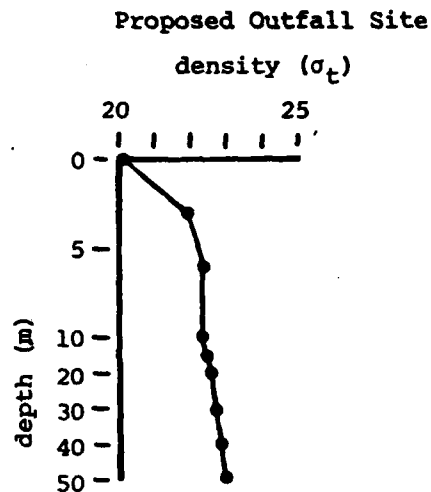


3 June 1975
Tide 7.0'
Falling
River: 3,800 CFS

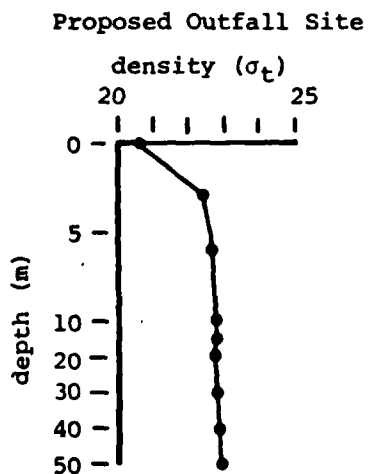
FIGURE A-1 (Continued)



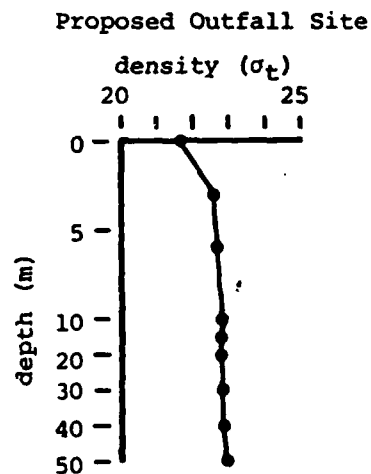
26 June 1975
Tide 4.5'
Rising
River: 5,580 CFS



16 July 1975
Tide 6.1'
Falling
River: 3,770 CFS

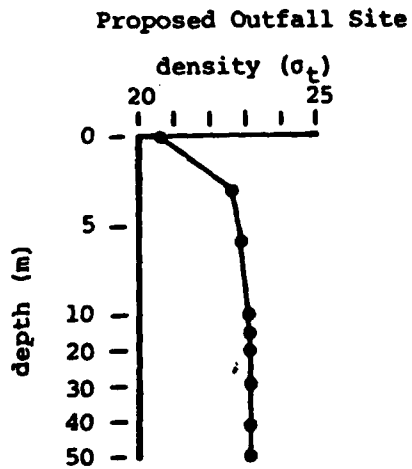


26 August 1975
Tide 8.0'
Rising
River: 2,850 CFS

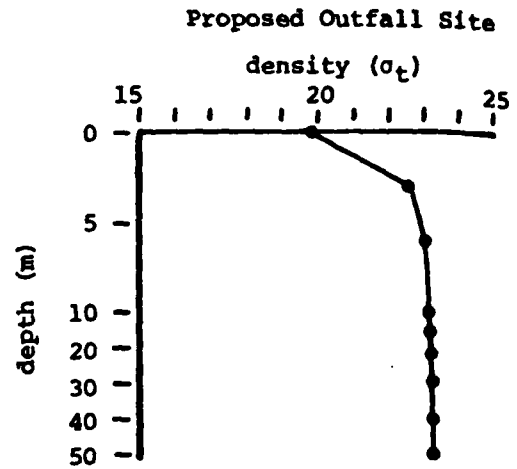


16 September 1975
Tide 10.0'
High Water
River: 2,240 CFS

FIGURE A-1 (Continued)



7 October 1975
 Tide 11.0'
 Rising
 River: 2,100 CFS



30 October 1975
 Tide 9.1'
 Falling
 River: 3,800 CFS

FIGURE A-1 (Continued)

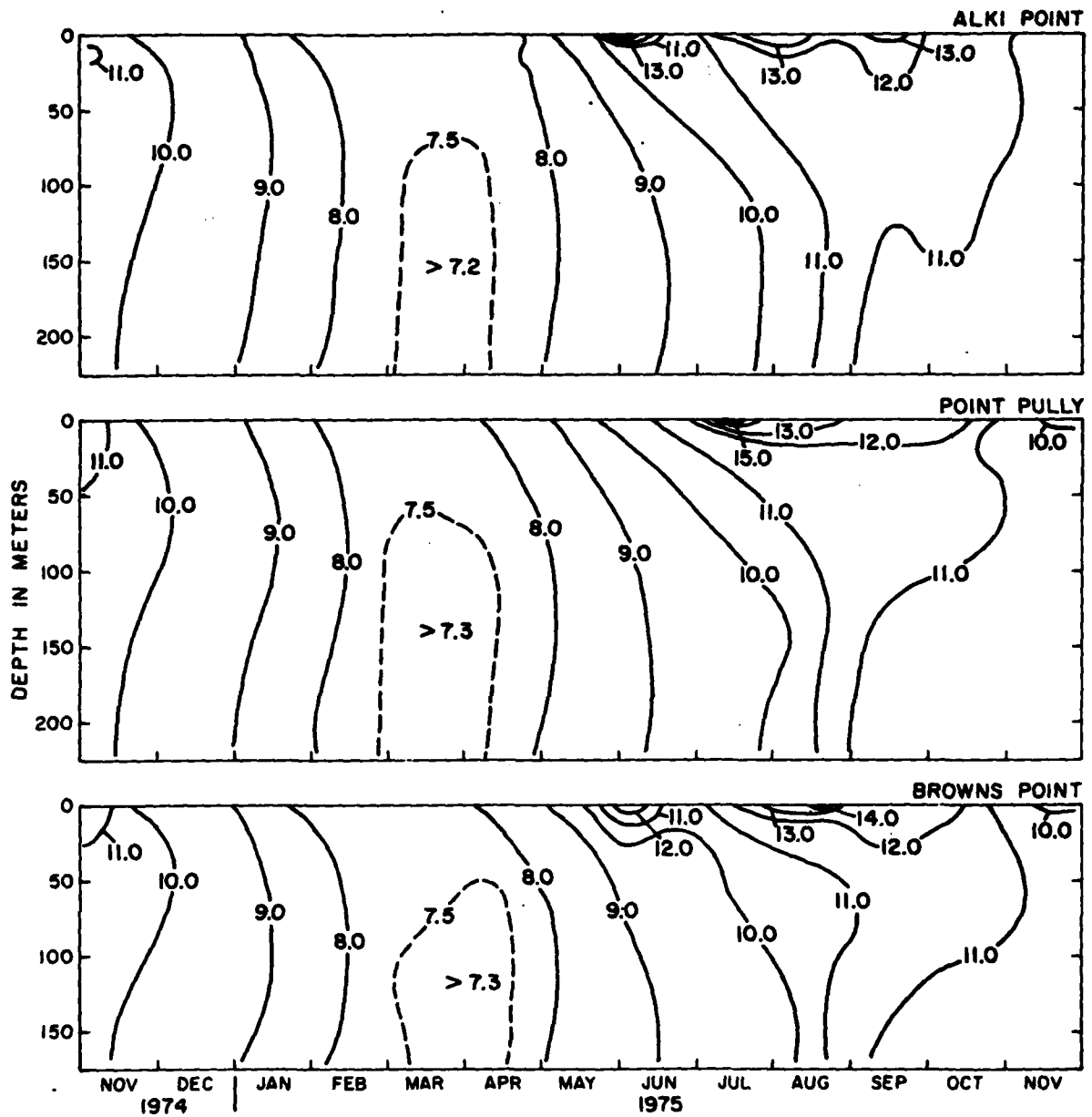


FIGURE A-2
 SEASONAL VARIATIONS IN TEMPERATURE AT
 ALKI POINT, POINT PULLY, AND BROWNS POINT

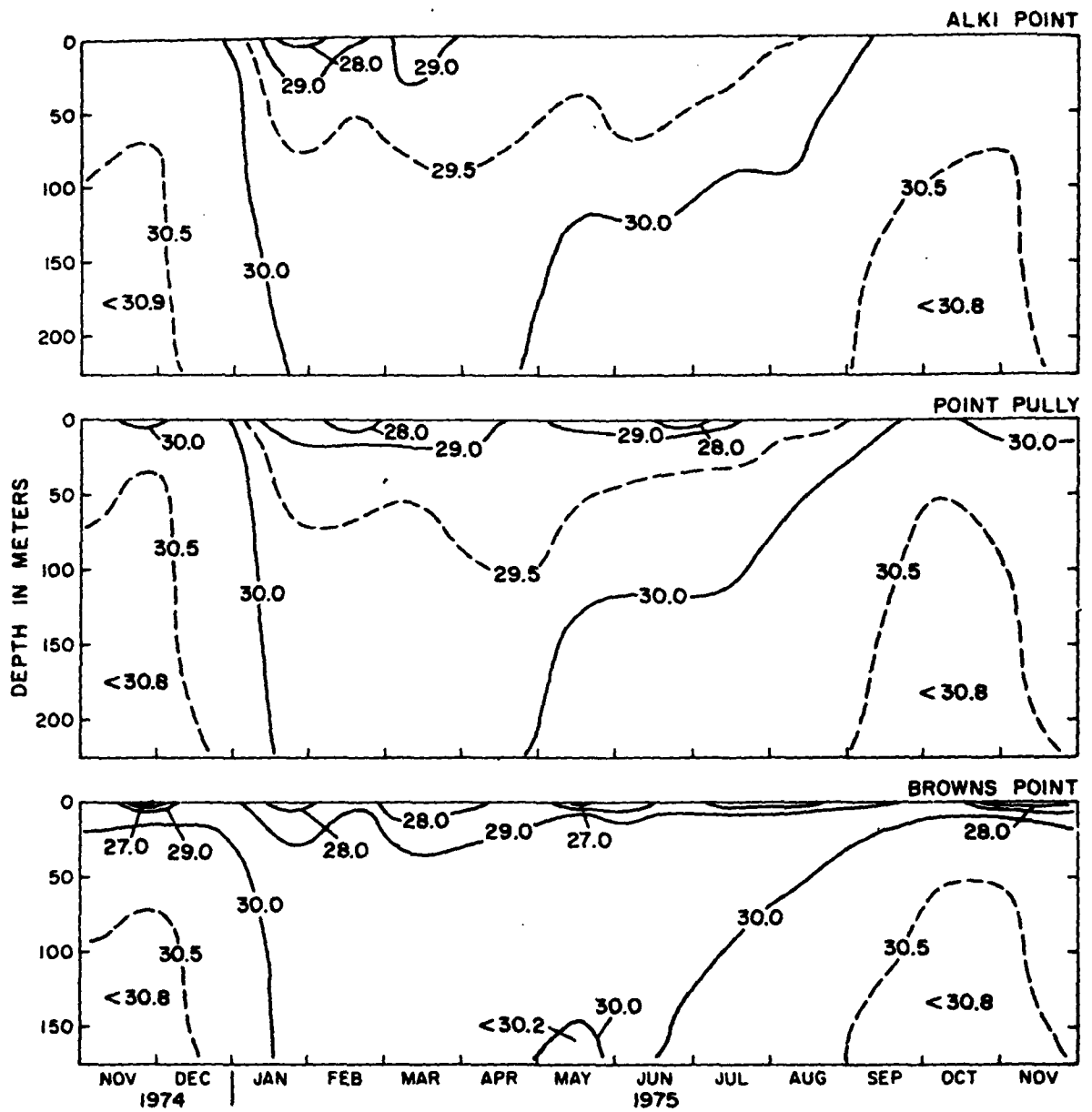


FIGURE A-3
 SEASONAL VARIATIONS IN SALINITY AT
 ALKI POINT, POINT PULLY, AND BROWNS POINT

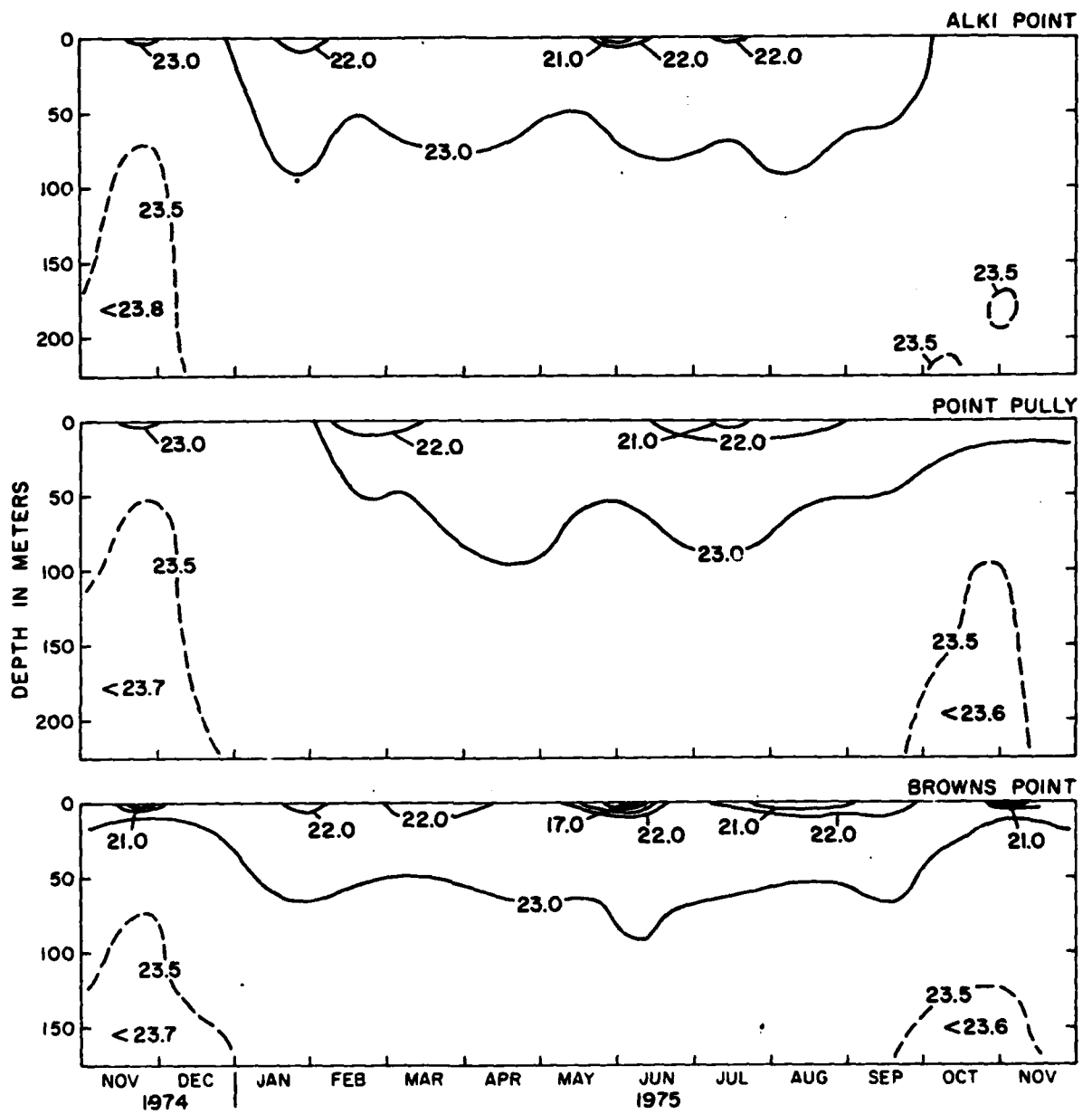


FIGURE A-4
 SEASONAL VARIATIONS IN DENSITY (AS σ_t) AT
 ALKI POINT, POINT PULLY, AND BROWNS POINT

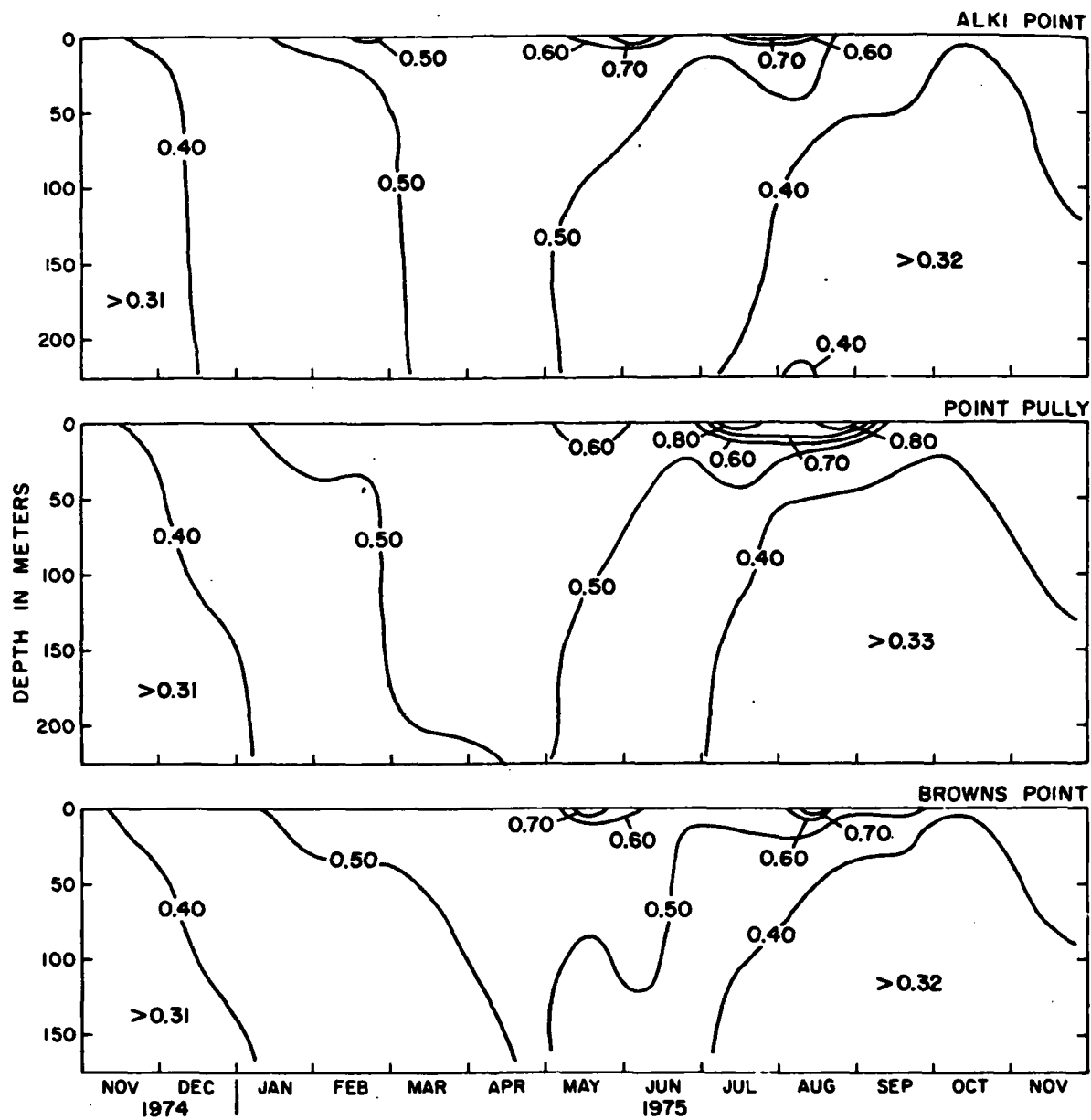


FIGURE A-5
 SEASONAL VARIATIONS IN DISSOLVED OXYGEN AT
 ALKI POINT, POINT PULLY, AND BROWNS POINT

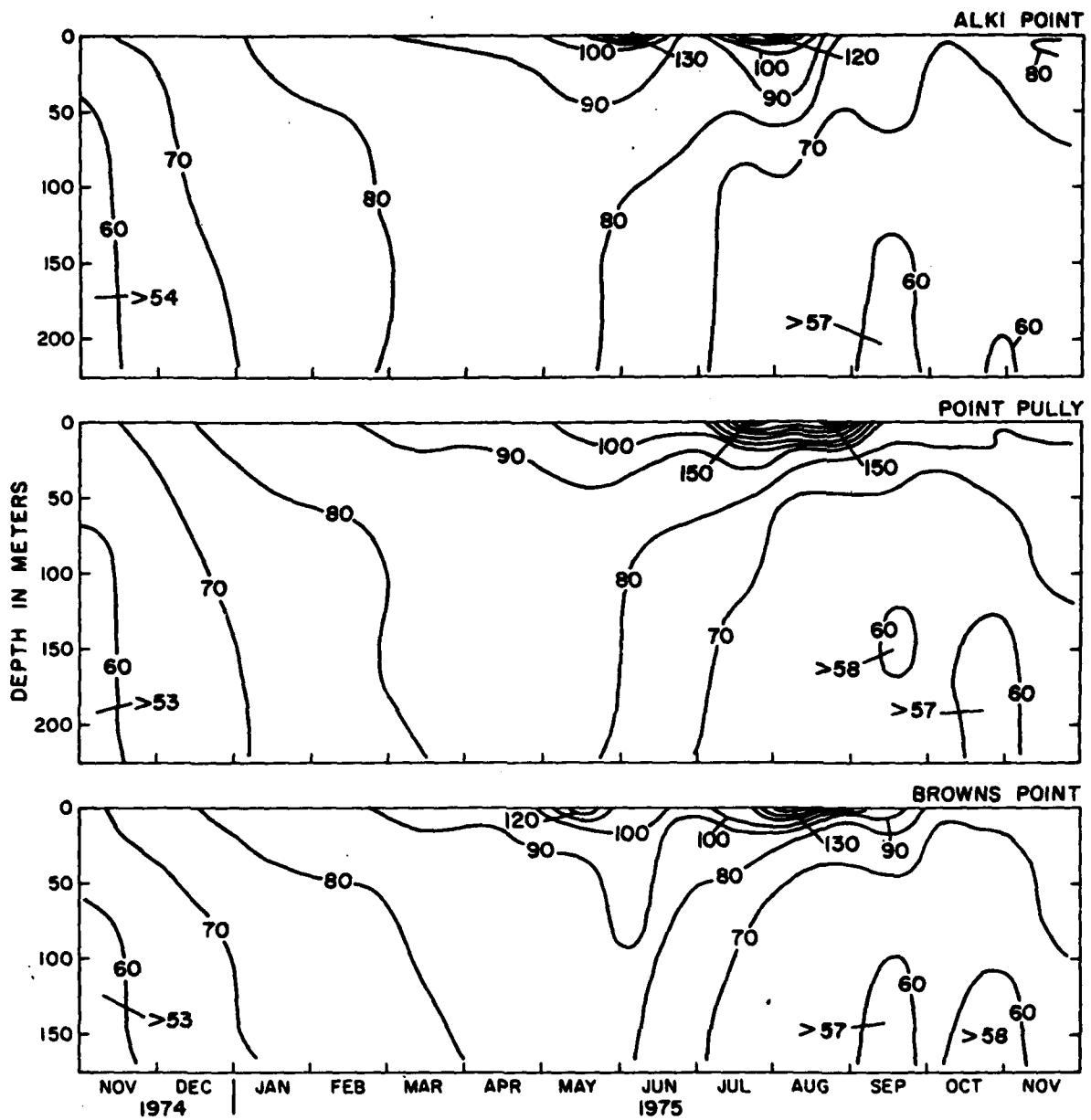


FIGURE A-6
 SEASONAL VARIATIONS IN % OXYGEN SATURATION AT
 ALKI POINT, POINT PULLY, AND BROWNS POINT

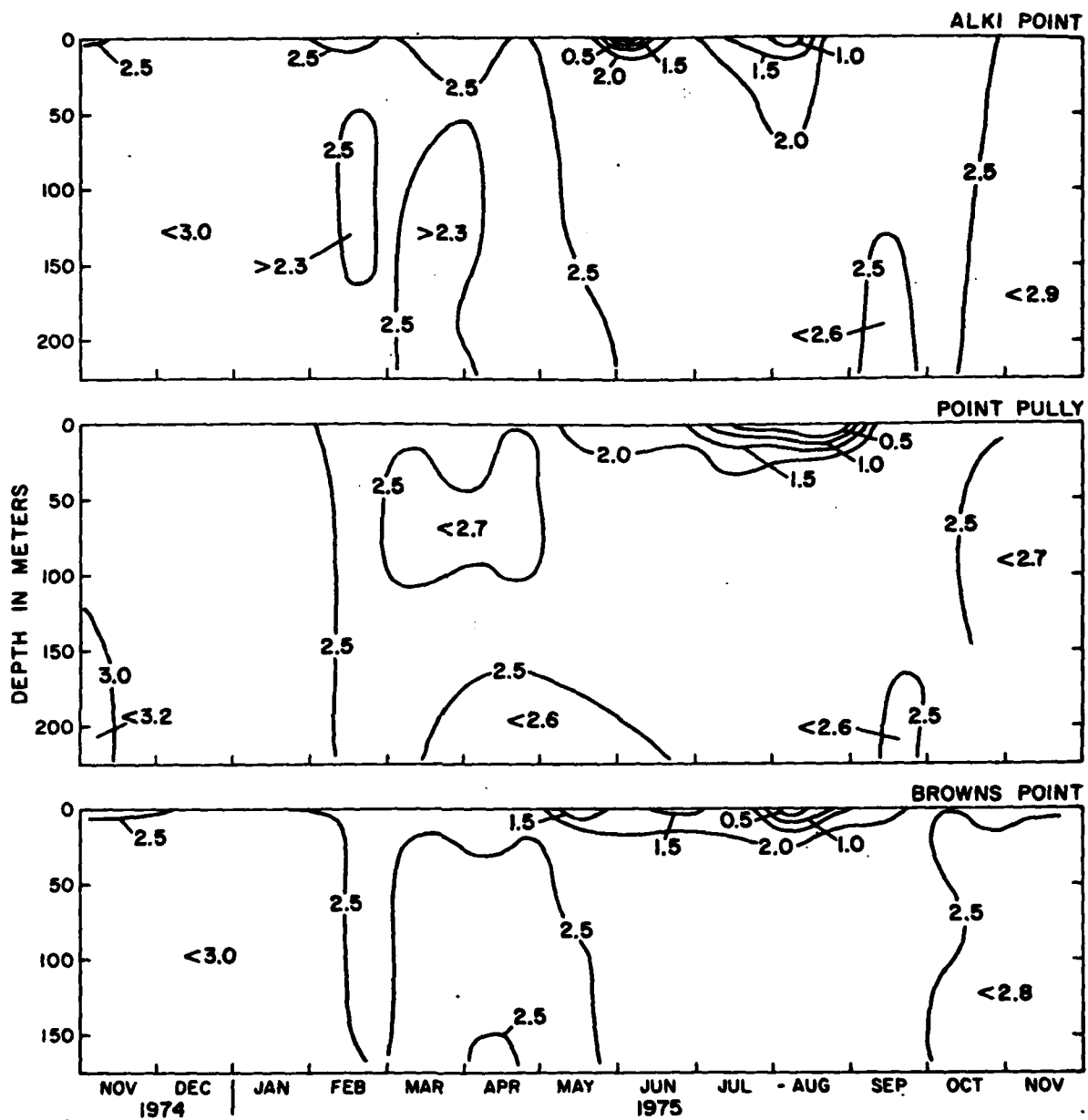


FIGURE A-7
 SEASONAL VARIATIONS IN PHOSPHATE AT
 ALKI POINT, POINT PULLY, AND BROWNS POINT

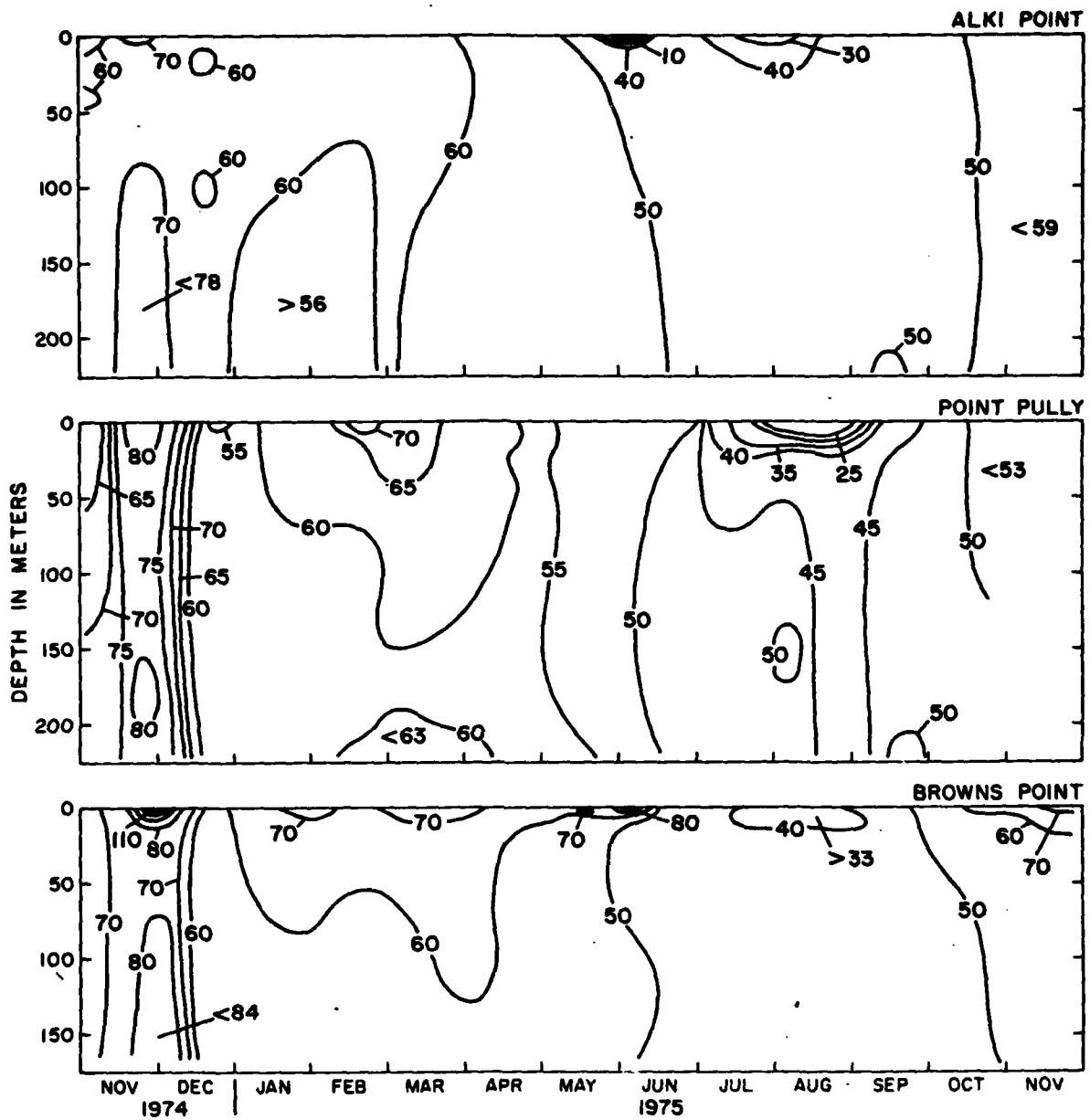


FIGURE A-8
 SEASONAL VARIATIONS IN SILICATE AT
 ALKI POINT, POINT PULLY, AND BROWNS POINT

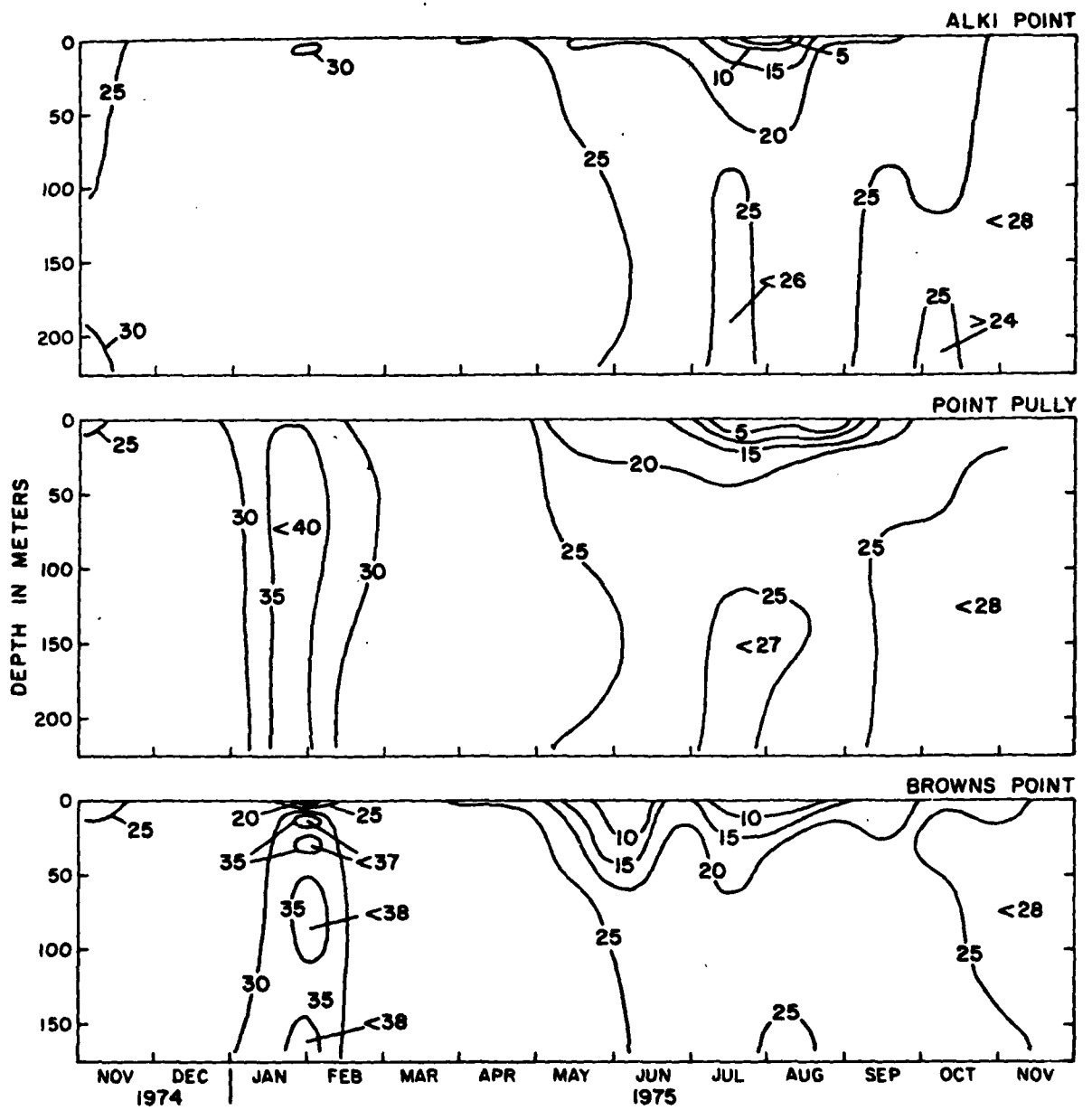


FIGURE A-9
 SEASONAL VARIATIONS IN NITRATE AT
 ALKI POINT, POINT PULLY, AND BROWNS POINT

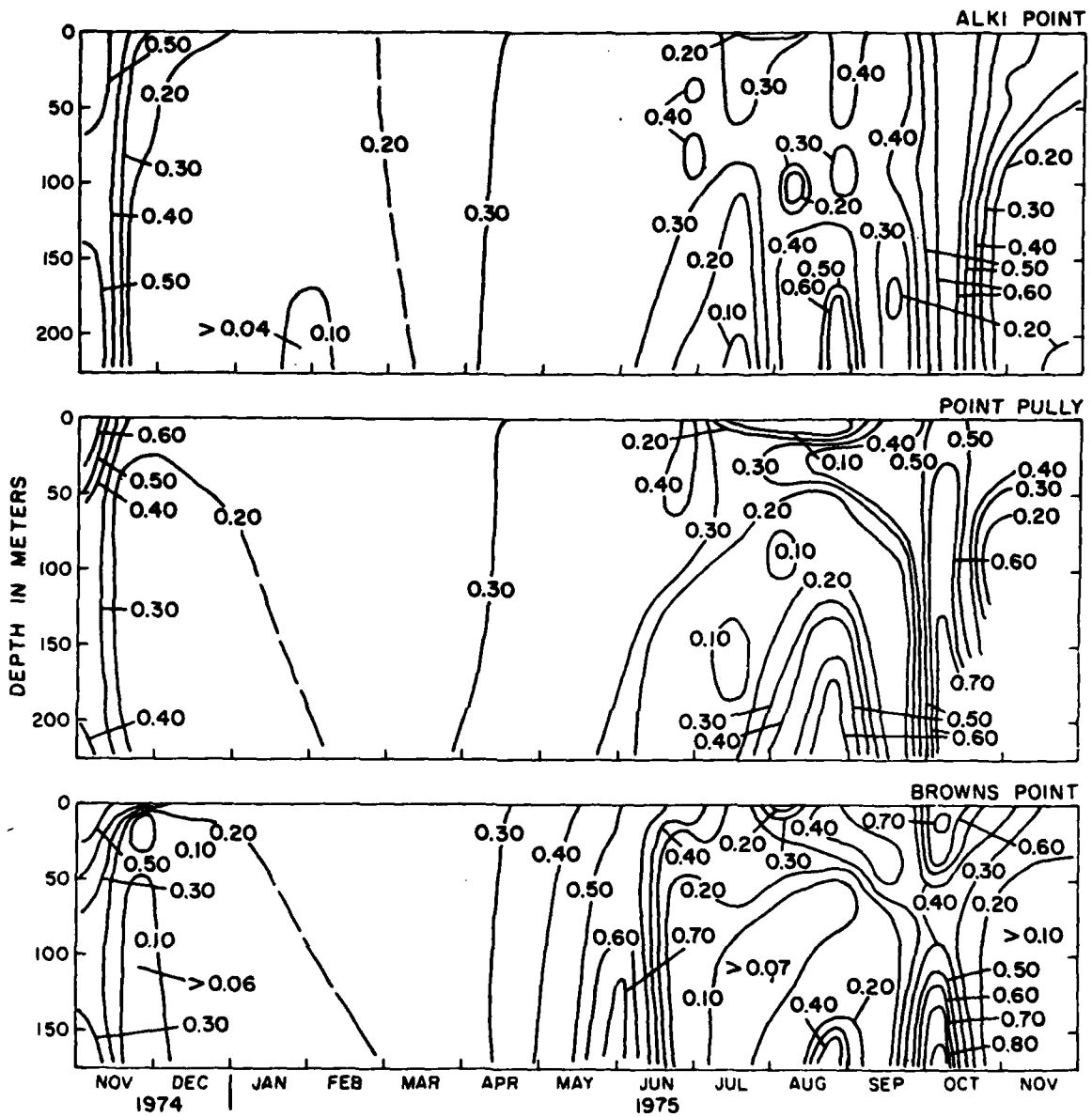


FIGURE A-10
 SEASONAL VARIATIONS IN NITRITE AT
 ALKI POINT, POINT PULLY, AND BROWNS POINT

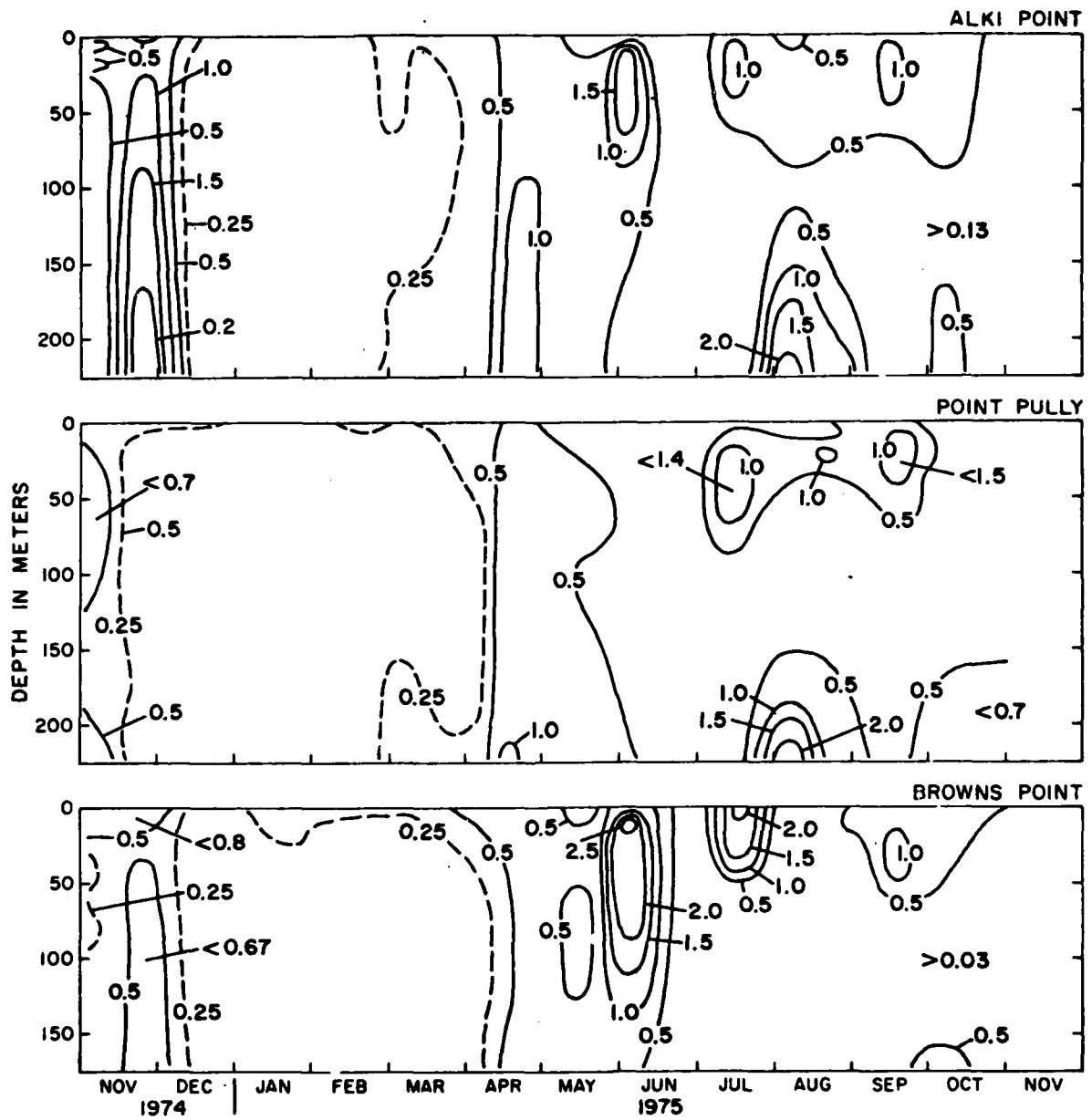


FIGURE A-11
 SEASONAL VARIATIONS IN AMMONIA AT
 ALKI POINT, POINT PULLY, AND BROWNS POINT

APPENDIX B

SUPPLEMENTAL WATER QUALITY INFORMATION FOR CITY WATERWAY--TACOMA

687-682-021



COMMUNITY DEVELOPMENT DEPARTMENT
740 ST. HELENS STREET, TACOMA, WASHINGTON 98402

DAMES & MOORE
SEATTLE

September 25, 1981

Mr. John Isakson
Project Manager, COBS
Dames and Moore
155 NE 100th Street, Suite 500
Seattle, WA 98125

Routing	JSI
File	

Re: Supplemental Water Quality Information for City Waterway-Tacoma

Dear Mr. Isakson:

Please find enclosed a summary of information recently collected by City of Tacoma sanitary engineering staff, including dissolved oxygen, temperature, and salinity data for City Waterway.

As you know, the City of Tacoma has been promoting new marina development in City Waterway. Several marina projects have occurred in this waterway in the past three to five years, and we expect that more will follow in the near future.

Most recently, in the processing of permits for some of these developments, concern has been expressed by some permit review agencies that there is not adequate water quality data available for City Waterway. One of the most frequently expressed concerns is the lack of data on dissolved oxygen levels, particularly during the critical warm summer months.

Because of these concerns, we have asked our Public Works Sewer Utilities Division to survey dissolved oxygen levels in the waterway once each month throughout the period May to September to help supplement other available data.

Enclosed for your information and reference are copies of each monthly survey report to date. It is requested that this information be considered as supplemental data to be included in the final COBS reports, and particularly for reference for all of the COBS participant agencies which are involved in permit review.

This information has been collected at five reporting stations spaced equally along the length of City Waterway, as indicated on the enclosed maps. Two of these stations, Nos. W-1 and W-2, are coincident with the only two previously established (DOE and COBS) stations in City Waterway. The data is carefully controlled and adjusted for saltwater, as noted in the various enclosed monthly reports.

Mr. John Isakson
September 25, 1981
Page Two

This supplemental data includes a total of 98 separate readings over the five-month period. For 91 of these readings, the dissolved oxygen levels ranged from 6.0 to 9.0, four readings were above 9.0, and only three were less than 6.0 (one at 5.1, one at 5.2, and one at 5.7). It is noted, with few exceptions, that these readings were taken during the more critical morning hours of the day. Please note also that the August survey was taken on August 10, following three consecutive days at temperatures in excess of 90°.

As you know, the Department of Ecology marine water quality classifications for City Waterway are class "B" (north of 11th Street) and class "C" (south of 11th Street). It is particularly noted that all of the temperature and dissolved oxygen levels for all stations reported in this survey are above the minimum Department of Ecology criteria for class "B" as well as class "C" waters.

It is our hope that this information will not only supplement other available data, but will also relieve some fears and speculation concerning dissolved oxygen levels in City Waterway, particularly as it concerns future proposals and permits for additional marina development in the waterway. It appears that the 700 boats (approximate) regularly moored in City Waterway at this time are not having a significant negative influence on dissolved oxygen levels. It also appears that there must be a reasonably acceptable level of flushing, circulation and aeration characteristics in the waterway which allows dissolved oxygen to maintain at the levels found in this data.

Sincerely,



RON NELSON
Waterfront Development Manager (City Waterway)

RN:sw

Enclosures

cc: Dr. Steve Martin, Corps of Engineers

AD-A112 556

DAMES AND MOORE SEATTLE WA*
COMMENCEMENT BAY STUDY. VOLUME V. WATER QUALITY. (U)
DEC 81 J S ISAKSON, L C LOEHR
682-021-05-VOL-5

F/6 B/1

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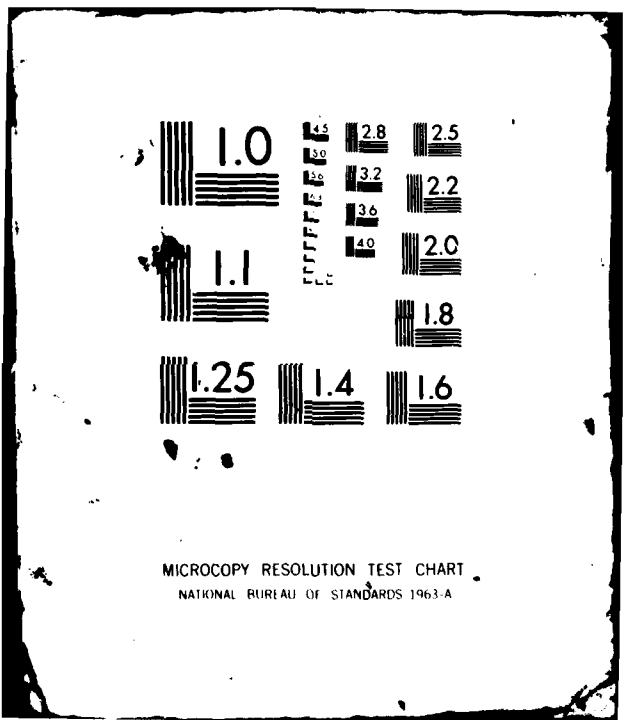
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MICROCOPY RESOLUTION TEST CHART
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CITY OF TACOMA

INTER-DEPARTMENTAL COMMUNICATION

To: Ron Nelson

From: David Hufford



Subject: City Waterway Study 576/81

Date: May 7, 1981

The Wastewater Lab conducted some tests of the City Waterway, Wednesday, May 6, 1981. The tests were run at the five locations shown on the map, W-1 thru W-5. We tested at outgoing, low, & incoming tide conditions.

The tests run were temperature, dissolved oxygen, and salinity at various depths. The surface and three meter samples were taken in place with various probes. The bottom sample (greater than three meters) was taken with a Van Dorn sampler and the tests were run with the probes in the boat. A Y.S.I. instrument was used in conjunction with the probes for all tests. The dissolved oxygen results were standardized for saltwater.

Below are the results of each station.

Location	Depth Meter	Time	D.O. Mg/l	Temp OC	Salinity ‰
W-1 Wheeler Osgood Mouth	Surface	9:05	8.0	13	17.1
	3 M	9:05	8.4	12	26.4
	6 M	9:05	8.3	12	27.5
	Surface	12:30	7.3	12.5	21
	3 M	12:30	6.6	11	27.2
	Surface	15:05	7.9	13	24
W-2 22nd St.	2 M	15:05	8.0	11.5	26.9
	Surface	9:22	8.4	13	22.2
	3 M	9:22	7.7	12	26.1
	6 M	9:22	6.9	12	27.0
	Surface	12:50	7.3	13	21.2
	3 M	12:50	6.1	11.5	27.5
W-3 Johnny's Dock	Surface	15:15	7.4	13	23
	3 M	15:15	6.5	11.5	27.3
	Surface	9:15	7.7	14	23.2
	3 M	9:15	7.9	12	26.5
	5 M	9:15	8.4	12	25.0
	Surface	12:40	7.4	13	22
W-4 Dock	2 M	12:40	7.3	12	26.2
	Surface	15:10	7.3	12	25.2
	3 M	15:10	7.2	12	27

Location	Depth Meter	Time	D.O. Mg/l	Temp OC	Salinity ‰
W-4	Surface	8:30	8.6	12	24
Totem	3 M	8:30	8.6	11	26.5
Fuel	12 M	8:30	8.6	11	27.8
Dock	Surface	12:05	7.3	12.5	24.1
	3 M	12:05	7.4	11	27
	9 M	12:05	8.1	11	28
	Surface	14:40	8.0	12	25.5
	3 M	14:40	7.9	12	26.5
	9 M	14:40	7.9	11	27.5
W-5	Surface	8:50	8.6	13	21.1
4th St.	3 M	8:50	8.7	11.5	27.3
	12 M	8:50	8.8	11.5	27.9
	Surface	12:15	7.9	13	23.9
	3 M	12:15	8.2	12	27
	12 M	12:15	8.1	11	27.5



David Hufford, Asst. Supervisor
 Treatment Plant Operations
 Sewer Utility Division

DKH:sb

TABLE 422.I. SOLUBILITY OF OXYGEN IN WATER EXPOSED TO WATER-SATURATED AIR*

Temperature C	Chloride Concentration in Water mg/l				Difference /100 mg Chloride	
	0	5,000	10,000	15,000		20,000
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.016
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010
15	10.2	9.7	9.1	8.6	8.1	0.010
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008
25	8.4	8.0	7.6	7.2	6.7	0.008

* As a seal pressure of 760 mm Hg. Under any other barometric pressure, P , the solubility, S' (mg/l), can be obtained from the corresponding value in the table by the equation:

$$S' = S \frac{P-p}{760-p}$$

in which S is the solubility at 760 mm and p is the pressure (mm) of saturated water vapor at the temperature of the water. For elevations less than 1,000 m and temperatures below 25 C, p can be ignored. The equation then becomes:

$$S' = S \frac{P}{760} = S \frac{P}{29.92}$$

Dry air is assumed to contain 20.90% oxygen. (Calculations made by Whipple and Whipple, 1911. J. Amer. Chem. Soc. 33:162.)

OXYGEN (DISSOLVED)/Azide Modification

TABLE 422.I. (Continued)

Temperature C	Chloride Concentration in Water mg/l				Dissolved Oxygen mg/l	Diffc /100 Cmk
	0	5,000	10,000	15,000		
26	8.2	7.8	7.4	7.0	6.6	0.0
27	8.1	7.7	7.3	6.9	6.5	0.0
28	7.9	7.5	7.1	6.8	6.4	0.0
29	7.8	7.4	7.0	6.6	6.3	0.0
30	7.6	7.3	6.9	6.5	6.1	0.0
31	7.5					
32	7.4					
33	7.3					
34	7.2					
35	7.1					
36	7.0					
37	6.9					
38	6.8					
39	6.7					
40	6.6					
41	6.5					
42	6.4					
43	6.3					
44	6.2					
45	6.1					
46	6.0					
47	5.9					
48	5.8					
49	5.7					
50	5.6					

Row 10-15 to 150 mg/l

5. Precision and Accuracy

The DO can be determined with a precision, expressed as a standard deviation, of about 20 µg/l in distilled water and about 60 µg/l in wastewater and secondary effluents. In the presence of appreciable interference, even with the proper modifications the standard deviation may be as high as 100 µg/l. Greater errors may occur in the test waters having organic suspended matter or heavy pollution. Avoid errors due to carelessness in collecting samples and prolonging the completion of the test, or the use of an unsuitable modification.

CITY OF TACOMA

INTER-DEPARTMENTAL COMMUNICATION

To: Ron Nelson, Manager
Waterfront Development

From: David Hufford, Asst. Sup.
Treatment Plants

Subject: City Waterway Study - 6/9/81

Date: June 17, 1981



The Wastewater Lab conducted the tests on the City Waterway for the month of June on June 9, 1981. All samples were run with two Y.S.I. meters. The oxygen probe was calibrated for saltwater. Below are the results for each station.

Location	Depth Meter	Time	D.O. mg/l	Temp. °C	Salinity ‰
W-1	Surface	9:03	6.6	11.9	25.1
Wheeler	3		7.0	11.0	28.0
Osgood	4 Bottom		6.9	11.0	28.0
W-2	Surface	9:18	6.9	12.0	22.3
22nd St.	5		6.4	11.0	28.0
	6 Bottom		6.1	11.0	27.9
W-3	Surface	9:12	7.0	11.8	28.2
Johnny's	5		6.6	11.0	28.1
Dock	7 Bottom		6.1	10.8	28.1
W-4	Surface	8:54	6.4	11.5	24.6
Totem	5		6.7	10.5	28.2
Fuel	10		6.6	10.2	28.1
Dock	14		6.1	10.4	27.1
W-5	Surface	8:43	7.6	11.0	27.4
4th St.	5		8.0	11.0	28.1
	10		7.9	10.5	28.2
	14		6.7	10.1	28.1

The weather previous to the sampling was very rainy.

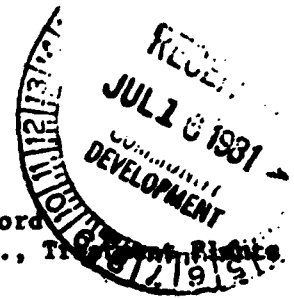
David Hufford

David Hufford, Asst. Sup.
Treatment Plants

DKH:sb

cc: M. Price, P.E.
G. Moore

CITY OF TACOMA
INTER-DEPARTMENTAL COMMUNICATION



To: Ron Nelson
Mgr. Waterfront Development

From: Dave Hufford
Asst. Sup., Treatment Plants

Subject: City Waterway Study 7/14/81

Date: July 15, 1981

The Lab ran another series of tests on the City waterway using the same instruments as before. Below are the results.

<u>Location</u>	<u>Depth Meter</u>	<u>Time</u>	<u>D.O. Mg/l</u>	<u>Temp °C</u>	<u>Salinity ppt</u>
W-1 Wheeler Osgood	Surface	14:06	8.7	14.0	11.0
	5 Bottom		7.8	12.0	24.8
W-2 22nd St.	Surface	14:20	8.7	16.0	14.6
	5		8.0	12.0	28.0
	6 Bottom		7.3	12.0	28.0
W-3 Johnny's Dock	Surface	14:12	8.7	14.2	22.2
	5		8.3	12.2	28.0
	10		6.7	11.5	27.9
	14 Bottom		6.5	11.3	27.9
W-4 Totem Fuel Dock	Surface	13:35	8.1	15.5	16.0
	5		8.2	12.0	27.8
	10		7.7	11.0	27.8
	12 Bottom		5.1	11.0	28.5
W-5 4th St.	Surface	13:54	8.8	15.0	15.0
	5		8.9	12.0	27.9
	10		8.6	11.5	28.0
	14		7.6	11.0	27.9

The weather the previous day was rainy with sun the day of sampling.

David Hufford
Asst. Supervisor, Treatment Plants
Sewer Utility Division

DKH:sb

cc: Michael P. Price
George Moore

CITY OF TACOMA

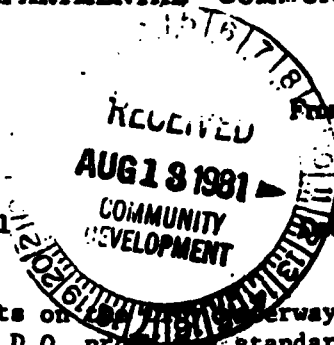
INTER-DEPARTMENTAL COMMUNICATION

To: Ron Nelson, Mgr.
Waterfront Development

From: David K. Hufford, Asst. Sup.
Treatment Plants

Subject: City Waterway Study, 8/10/81

Date: Aug. 12, 1981



The Lab ran a series of tests on the waterway using two YSI meters. Below are the results. The D.O. probe was standardized using salt water from a depth of 5 feet.

Location	Depth Meter	Time	D.O. Mg/l	Temp. °C	Salinity PPT
W-1 Wheeler Osgood	Surface 4 B	9:20	10.5 7.8	17 14	24.2 29.1
W-2 22nd St.	Surface 4 B	9:30	10.2 6.1	19 13	23.0 29.0
W-3 Johnny's Dock	Surface 3 M	9:36	11.2 7.7	20.1 14.5	20.9 29.0
W-4 Totem Fuel Dock	Surface 5 10 B	9:11	10.2 7.5 6.8	16.1 13.2 12.6	26.8 29.1 29.1
W-5 4th Street	Surface 5 10 14		8.6 8.1 6.8 6.5	15 14 12.1 12.5	28.8 29.7 23.0 28.9

The weather the previous day was hot and sunny; temperature was in the 90's.

David K. Hufford, Asst. Supervisor
Treatment Plants
Sewer Utility Division

DKH:sb

cc: M. Price
G. Moore

CITY OF TACOMA**INTER-DEPARTMENTAL COMMUNICATION****To:** Ron Nelson, Mgr.
Waterfront Development**From:** David K. Hufford, Asst. Sup.
Treatment Plants**Subject:** City Waterway Study, 9/17/81**Date:** Sept. 17, 1981

The Lab ran a series of tests on the City Waterway using two YSI meters. Below are the results. The D.O. probe was standardized using salt water from a depth of 5 feet.

Location	Depth Meter	Time	D.O. Mg/l	Temp. °C	Salinity PPT
W-1 Wheeler Osgood	Surface	10:00	5.2	15	28
	-4 M		5.7	13.8	29.5
W-2 22nd St.	Surface	10:15	6.3	15	28.5
	-5 M		6.1	13.7	29.8
	-7 M		5.3	13.7	29.5
W-3 Johnny's Dock	Surface	10:20	6.0	15	28
	-5 M		6.3	13.8	29.6
W-4 Totem Fuel Dock	Surface	9:30	6.0	15	27
	-5 M		7.3	13	29.9
	-10 M		6.7	12.8	29.5
	-12 M		6.8	12.8	29.5
W-5 4th Street	Surface	9:45	6.1	15	27.2
	-5 M		6.4	13	29.8
	-10 M		6.0	12.9	29.5
	-14 M		6.5	12.9	29.4

The weather has been hot and sunny the previous day but was overcast the day of sampling.



David K. Hufford, Asst. Supervisor
Treatment Plants
Sewer Utility Division

DKH:sb

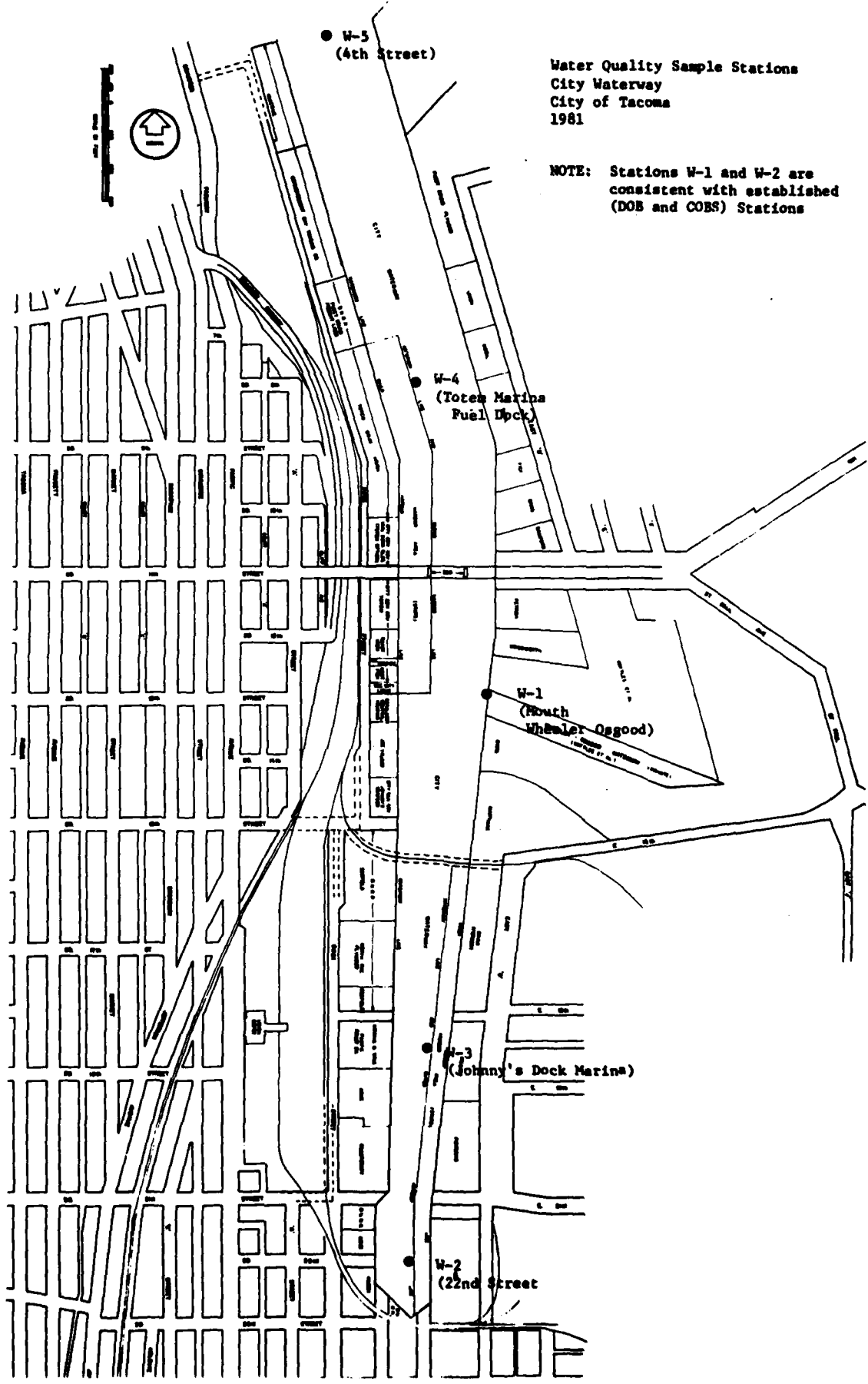
cc: M. Price
G. Moore



● W-5
(4th Street)

Water Quality Sample Stations
City Waterway
City of Tacoma
1981

NOTE: Stations W-1 and W-2 are
consistent with established
(DOB and COBS) Stations



APPENDIX C

STORET DATA FOR SELECTED COMMENCEMENT BAY STATIONS*

*CMB-004, -005, -006, -008, -011, -604

SECRET RETRIEVAL DATE 01/08/10 - INVENT - VERSION OF MAR. 1981

CMR004
 47 16 59.0 122 26 30.0 2
 COMMENCEMENT BAY AT OLD TACOMA
 53083 WASHINGTON A 131112
 PACIFIC NORTHWEST
 PUGET SOUND (CHAMBERS CLOVER-12)
 21940000
 0000 CLASS 00 CEN-RSP 0036802-0592417

/STPA/AMBT/OCEAN

PARAMETER	IDENT.	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM	BEG DATE	END DATE
00000 LAB	TEMP	40	2482.95	2649146	1627.62	.653938	257.349	4992.00	43.0000	69/01/13	70/09/09
00010 WATER	PRESSURE	50	10.9020	9.33091	2.30888	.213746	.326524	16.2000	6.60000	67/10/24	70/09/09
00020 BAROMETR	CODE	22	768.198	34.9524	5.91205	1.007696	1.26008	776.600	749.400	67/10/24	70/09/09
00030 WEATHER	VELOCITY	25	8.84000	235.367	15.3197	1.73826	3.06794	50.0000	.000000	67/10/24	70/09/09
00038 WIND	DIR FROM	22	4.86364	7.93291	2.81684	.579102	.600489	10.0000	1.00000	67/10/24	70/09/09
00036 WIND	STAGE	25	224.400	17109.0	130.802	.582894	26.1803	360.000	.000000	67/10/24	70/09/09
00005 STREAM	STAGE	24	6.12083	12.1556	3.48649	.569411	.711677	12.1000	.400000	67/10/24	70/09/09
00067 TIDE	CODE	20	3599.50	4563648	2136.27	.593491	477.684	7310.00	1010.00	68/06/11	70/09/09
00076 SEA	JKSW	28	1.12000	.360001	.600001	.935715	.120000	2.00000	.000000	67/10/24	70/09/09
00070 TUBS	AT 25C	48	2.62500	3.32447	1.53462	.580808	.220000	8.00000	1.00000	68/03/27	70/09/09
00098 CONDUCTV		15	32.9066	5.01395	2.23919	.068047	.578158	39.2000	30.9000	67/10/24	70/09/09
00300 DO		48	8.46246	3.71103	1.92640	.227641	.278052	15.3000	5.20000	67/10/24	70/09/09
00400 PH		48	7.74372	.024186	.155917	.020083	.022447	8.00000	7.40000	68/02/27	70/09/09
00480 SALINITY		49	27.7122	7.64876	2.76864	.099799	.395091	36.8000	23.2000	67/10/24	70/09/09
00700 SWL	PBI	40	9.72800	53.4866	7.31348	.752026	1.15336	41.0000	2.00000	68/04/08	70/08/10
31801 TOT COLI	MPINENDO	25	1787.52	.148E+08	3850.06	2.18386	770.012	17100.0	8.00000	67/10/24	70/09/09

TABLE C-1
 STORET DATA FOR SELECTED COMMENCEMENT BAY STATIONS

STORET RETRIEVAL DATE 01/09/10 - INVENT - VERSION OF MAR. 1991

CM8011
 47 15 36.0 122 25 02.0 2
 PUYALLUP RIVER AT 11TH ST BRIDGE
 53053 WASHINGTON B 131110
 PACIFIC NORTHWEST
 PUGET SOUND (PUYALLUP WHITT-10)
 21840000
 0000 CLASS 00 CBR-RSP 0035822-0592456

/TTPA/ANWT/STREAM

INDEX	LAB	IDENT.	NUMBER	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM	BEG DATE	END DATE
0000	WATER	TEMP	CELT	33	2516.64	286498	1692.63	.672575	294.648	5006.00	97.0000	69/01/13	70/09/09
0001	BAROMTRC	PRESSURE	MM OF HG	30	10.8605	11.0443	3.32330	.305999	.539111	16.2000	3.50000	67/10/24	70/09/09
0002	WEATHER	CODE		21	767.975	34.7000	9.89067	.007670	1.28945	777.000	749.400	67/10/24	70/09/09
0003	WIND	VELOCITY	MPH	23	6.39130	171.522	13.0966	2.04913	2.73084	50.0000	.00000	67/10/24	70/09/09
0004	WIND	DIP FROM	NORTH=0	23	6.91304	4.81029	2.19324	.317261	.457322	10.0000	2.00000	67/10/24	70/09/09
0005	STREAM	STAGE	FEET	23	265.652	8616.68	92.8261	.349427	19.3556	360.000	90.0000	67/10/24	70/09/09
0006	TIDE	STAGE	CODE	21	7.18095	8.99260	2.98877	.417600	.654385	11.4000	.200000	67/10/24	70/09/09
0007	SEA	CODE		18	4260.00	9226134	2286.07	.536637	538.233	7410.00	1110.00	69/02/10	70/09/09
0008	TURB	JTS		23	1.04348	.225298	.474656	.454878	.098972	2.00000	.000000	67/10/24	70/09/09
0009	CHDUCTVY	AT 2SC	MICROMHO	37	31.1351	2944.94	94.2664	1.74293	8.92134	240.000	1.30000	67/10/24	70/09/09
0010	DO		MG/L	7	9.05713	130.560	11.4263	1.26158	4.31872	34.0000	4.30000	67/10/24	70/09/09
0011	PH	SU		36	9.95831	9.84267	3.13727	.315041	.522878	20.0000	4.30000	67/10/24	70/09/09
0012	SALINITY	PPTH		37	7.48647	.038625	.196559	.026255	.032314	7.90000	7.10000	68/02/27	70/09/09
0013	SWL	MG/L		36	11.5694	141.597	11.8995	1.02853	1.98324	30.6000	.200000	68/04/08	70/09/09
0014	TOT COLI	PF1	/100ML	32	16.8750	267.091	16.2426	.968451	2.88999	70.0000	2.00000	68/04/08	70/09/10
31801	TOT COLI	PF1	/100ML	22	10905.9	.368E+09	19184.9	1.75913	4090.23	88000.0	20.0000	67/10/24	70/09/09

TABLE C-1
 (Page 2 of 6)

STORE RETRIEVAL DATE 01/09/18 - INVENT - VERSION OF MAR. 1981

CH8904
 47 15 07.0 122 25 50.0 2
 CITY WATERWAY/COMMENCEMENT BAY
 53053 WASHINGTON
 PACIFIC NORTHWEST
 PUGET SOUND (PUTALLUP-10)
 21540000 770207
 0000 CLASS 00 CSM-RSP 0299006-0592816

/STPA/AMBT/STREAM

PARAMETER	TEMP	JEN	AT 2BC	CONDUCTY	DO	PH	AM3-HR0-	N02-N	N03-N	PH08-TOT	TOT COBI	FEC COBI	SALINITY	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010 WATER														10	8.51428	.161414	.001764	.047187	.107376	8.60000	7.20000	77/02/01	78/02/21
00070 TURB														4	42.2500	2009.28	44.8284	1.06103	22.4142	84.0000	2.00000	77/01/17	77/02/08
00095 CONDCTY														13	30.6307	2.74877	1.68704	.054097	.489579	32.6000	28.4000	78/01/04	78/02/21
00300 DO														11	6.99999	.106006	.328588	.046512	.08168	7.00000	5.60000	77/02/01	78/01/18
00400 PH														6	7.98666	.010742	.103645	.013698	.023313	7.70000	7.40000	78/01/18	78/02/29
00610 NH3-HR0-														12	.184166	.031063	.176247	1.07359	.080878	.600000	.020000	77/01/17	78/02/29
00615 N02-N														10	.019000	.000040	.006326	.351366	.020000	.000000	.000000	77/02/01	78/02/29
00620 N03-N														12	.462499	.073748	.271565	.687169	.078394	1.30000	.220000	77/01/17	78/02/29
00665 PH08-TOT														12	.130833	.009299	.096433	.737085	.027838	.410000	.050000	77/01/17	78/02/29
00671 PH08-D18														12	.119000	.013700	.117047	1.01780	.033789	.410000	.000000	77/01/17	78/02/29
31804 TOT COBI														6	2400.00	.101E+08	3187.28	1.30626	1301.20	7000.00	90.0000	77/01/17	78/02/29
31616 FEC COBI														13	89.6154	9795.26	98.9710	1.10460	27.4496	200.000	2.00000	77/01/17	78/02/29
70305 SALINITY														14	28.4871	3.36178	1.83351	.064431	.490028	30.5000	28.5000	77/02/01	78/02/21

TABLE C-1
 (Page 3 of 6)

STORE RETRIEVAL DATE 01/08/10 • INVENT • VERSION OF MAR. 1981

CH8005
 47 16 10.0 122 26 45.0 2
 COMMENCEMENT BAY NEAR STADIUM
 53053 WASHINGTON A 13110
 PACIFIC NORTHWEST
 PUGET SOUND (PUYALLUP WHITE-10)
 2184000
 0000 CLASS 00 CBM-RBP 0035816-0592420

/TTPA/AMBT/OCEAN

PARAMETER	IDENT.	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM	BEG DATE	END DATE
00000 LAB	TEMP	42	2413.85	2642062	1625.44	.673466	250.811	4994.00	48.0000	68/04/87	70/08/89
00010 WATER	PRESSURE	52	10.9480	6.66713	2.58208	.238023	.388070	17.2000	0.30000	67/10/24	70/08/89
00020 BAROMETR	CODE	21	767.908	39.2000	8.92396	.007726	1.29468	776.600	749.400	67/10/24	70/08/89
00030 WEATHER	VELOCITY	26	8.36461	220.726	14.8569	1.77192	2.91367	50.0000	.000000	67/10/24	70/08/89
00035 WIND	DIR FROM	24	8.20833	13.5634	3.68285	.707108	.781759	20.0000	2.00000	68/02/27	70/08/89
00036 WIND	STAGE	23	226.682	17496.5	132.282	.586220	27.5827	350.000	.000000	68/02/27	70/08/89
00040 STREAM	CODE	25	6.15998	13.0933	3.61847	.587414	.723694	12.2000	.000000	67/10/24	70/08/89
00047 TIDE	SEA	21	3966.67	5005504	2237.30	.564028	488.218	7310.00	1010.00	68/04/87	70/08/89
00049 SEA	CODE	26	1.07692	1.18348	.392235	.364218	.076924	2.00000	.000000	67/10/24	70/08/89
00070 TURB	JRMN	49	3.30612	5.42818	2.32920	.704811	.332743	10.0700	1.00000	68/02/27	70/08/89
00095 CONDUCTV	AT 28C	17	32.8294	0.62134	2.93621	.090263	.712136	41.4000	28.1000	67/10/24	70/08/89
00300 DO	MG/L	50	8.25986	4.47173	2.11465	.256012	.299086	16.0000	5.10000	67/10/24	70/08/89
00400 PH	SD	50	7.71997	.023991	.154889	.020062	.021908	8.00000	7.30000	68/02/27	70/08/89
00480 SALINITY	PPTH	51	27.4901	12.2423	3.49889	.127278	.489943	36.8000	20.3000	67/10/24	70/08/89
00700 SUL	MG/L	45	15.0888	262.037	16.1876	1.23674	2.41310	110.000	2.00000	68/04/87	70/08/10
31801 TOT COLI	MP/100ML	26	6837.69	.323E+09	17993.2	2.63148	3528.76	88000.0	100.000	67/10/24	70/08/89

TABLE C-1
 (Page 4 of 6)

STOREY RETRIEVAL DATE 01/08/10 - INVENT - VERSION OF MAR. 1981

CH8006
 47 15 42.0 122 26 10.0 2
 COMMENCEMENT BAY MTH CITY WTRWAY
 93083 WASHINGTON B
 PACIFIC NORTHWEST 131110
 PUGET SOUND (PUYALLUP WHITE-10)
 21840000
 0000 CLASS 00 CSM-REP 0038817-0892424

/TTPA/ANBST/OCEAN

PARAMETER	IDENT.	NUMBER	MEAN	VARIANCE	STAN DEV	CORF VAR	STAND ER	MAXIMUM	MINIMUM	BEG DATE	END DATE
0000 LAB	TEMP	76	64150.2	.449E+11	211908	3.30424	24314.3	783870	67.0000	69/01/13	81/08/18
0001 WATER	PRESSURE	143	11.2839	5.06170	2.24982	.199384	.188140	18.2000	6.00000	67/10/24	81/08/18
0002 BAROTRC	CODE	22	767.939	32.4752	5.69879	.007421	1.21498	776.900	749.400	67/10/24	70/09/09
0003 WEATHER		26	6.84615	177.975	13.3607	1.94865	2.61633	50.0000	.000000	67/10/24	70/09/09
0004 WIND	VELOCITY	26	5.89461	9.78616	3.12828	.531604	.613507	15.0000	2.00000	67/10/24	70/09/09
0005 WIND	DIR FROM	26	276.836	10271.6	101.349	.366492	19.8762	350.000	60.0000	67/10/24	70/09/09
0006 STREAM	STAGE	26	6.07999	11.9325	3.45438	.568150	.690869	12.2000	.300000	67/10/24	70/09/09
0007 TIDE	STAGE	21	4047.62	5008489	2237.87	.552910	488.364	7310.00	1010.00	68/06/11	70/09/09
0008 SEA	CODE	26	1.00000	.240000	.489898	.489898	.096077	2.00000	.000000	67/10/24	70/09/09
0009 SURF	JKSN	146	3.39356	10.9583	3.30988	.978224	.273928	30.0000	1.00000	68/02/27	81/08/18
0010 TURB	SECCHI	19	3.22895	2.07448	1.44100	.446276	.330588	6.00000	.300000	77/06/22	81/08/18
0011 TRANSP	AT 25C	113	29674.8	-326E+09	18062.3	.507879	1416.94	59000.0	20.1000	67/10/24	81/08/18
0012 CHDCTVY		129	8.10227	3.09241	1.75882	.217041	.184829	15.7000	5.00000	67/10/24	81/08/18
0013 DO	BATOR	8	83.5499	137.609	11.7307	.140403	4.14742	105.100	79.1000	80/04/21	80/08/18
0014 DO	SU	146	7.71772	.045558	.213236	.027655	.017664	8.50000	6.90000	68/02/27	81/08/18
0015 SALINITY	PPTH	91	27.1219	13.2020	3.63345	.133969	.508785	37.0000	19.8000	67/10/24	70/09/09
0016 NH3-NH4-	MG/L	94	.045638	.002113	.045948	1.00722	.004741	.300000	.000000	73/08/22	81/08/18
0017 NH3-N	MG/L	94	.003911	.000023	.004799	1.36688	.000495	.010000	.000000	73/08/22	81/08/18
0018 NH3-N	MG/L	94	.259891	.008714	.093348	.389183	.009628	.460000	.000000	73/08/22	81/08/18
0019 PHOS-TOT	MG/L P	91	.079381	.001014	.031843	.408410	.003338	.160000	.000000	73/08/22	81/08/18
0020 PHOS-DIS	MG/L P	94	.041995	.000607	.024640	.592362	.002541	.120000	.000000	73/08/22	81/08/18
0021 SWL	MG/L	134	11.9149	526.702	22.9500	1.99306	1.98258	226.000	.000000	68/04/08	81/08/18
31991 TOT COLI	/100ML	26	19286.9	.112E+09	33867.3	2.19669	6983.08	160000	200.000	67/10/24	70/09/09
31994 TOT COLI	/100ML	47	976.290	.168E+08	4068.20	4.16697	593.408	27000.0	.000000	73/08/22	77/08/16
31610 FEC COLI	/100ML	70	83.9871	33088.4	161.847	2.16898	21.7349	1000.00	.000000	73/08/22	81/08/18
32310 CHLORPHYL	A	1	4.14900					4.14900	4.14900	77/06/22	77/06/22
70308 SALINITY	CONDCTVY	92	27.1847	14.0364	3.74882	.137988	.306601	34.0000	13.7300	73/08/22	81/08/18

TABLE C-1
 (Page 5 of 6)

STORM RETRIEVAL DATE 01/09/16 • INVENT - VERSION OF MAR. 1991

CM8009
 47 18 93.0 122 25 46.0 2
 COMMENCEMENT BAY-ST PAUL WTRWAY
 53093 WASHINGTON B 13110
 PACIFIC NORTHWEST
 PUGET SOUND (PUTALLUP WHITE-10)
 21540000
 0000 CLASS 00 CON-RSP 0035010-0892438

/TTPA/AMBNY/OCEAN

PARAMETER	IDENT.	NUMBER	MEAN	VARIANCE	STAN DEV	COEF VAR	STAND ER	MAXIMUM	MINIMUM	BEG DATE	END DATE
0000 LAB	TEMP	42	2331.93	2858931	1690.84	.725091	260.902	5000.00	51.0000	69/01/13	70/09/09
0001 WATER	PRESSURE	52	11.0768	5.93673	2.33684	.219928	.337887	17.3000	6.80000	67/10/25	70/09/09
0002 BAROMETR	VELOCITY	23	768.208	32.5454	5.70486	.007426	1.19958	779.000	749.500	67/10/25	70/09/09
0003 WEATHER	DIR, FROM	26	6.26923	162.605	12.7517	2.03400	2.50080	80.0000	.000000	67/10/25	70/09/09
0004 WIND	STAGE	24	5.25000	6.63043	2.57496	.690469	.528612	10.0000	2.00000	67/10/25	70/09/09
0005 WIND	CODE	26	240.385	17275.9	131.438	.546782	25.7771	360.000	.000000	67/10/25	70/09/09
0006 STREAM	AT 25C	28	6.01599	14.4672	3.80095	.631807	.760189	11.5000	.200000	67/10/25	70/09/09
0007 TIDE	JTU	21	3585.71	8070860	2291.86	.664992	491.399	7930.00	1110.00	69/06/11	70/09/09
0008 SEA	MG/L	76	.807692	.161539	.401919	.497616	1.07328	1.00000	.000000	67/10/25	70/09/09
0009 TURB	PPH	80	6.90000	53.2693	7.39831	1.07748	1.03214	48.0000	1.00000	69/02/27	70/09/09
0009 CONDUCTVY	MG/L	17	33.1235	10.4832	3.23777	.097748	.783274	44.3000	30.4000	67/10/25	70/09/09
0000 DO	PPH	80	7.37197	5.86288	2.32134	.328452	.342429	15.8000	3.00000	67/10/25	70/09/09
0000 PH	MG/L	80	7.65997	.030966	.175972	.022973	.024886	6.00000	7.20000	69/02/27	70/09/09
0000 SALINITY	MG/L	51	27.1548	13.6034	3.88855	.138834	.518800	36.7000	19.7000	67/10/25	70/09/09
0000 SVL	PPH	46	51.0000	9418.93	97.0512	1.90296	14.3094	610.000	2.00000	69/04/08	70/09/10
31991 TOT COLI	MPH	26	2993.46	.596E+08	7732.59	2.62354	1514.52	40000.0	40.0000	67/10/25	70/09/09

TABLE C-1
 (Page 6 of 6)

APPENDIX D

SUPPLEMENTAL DATA ON
ENVIRONMENTAL PROTECTION AGENCY
STUDIES IN COMMENCEMENT BAY

- Field Study - June 3, 1980
- Field Study - September 23-24, 1980

APPENDIX D

Commencement Bay/Port of Tacoma*

Field Study - June 3, 1980

Both the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Army Corps of Engineers (COE) are conducting extensive studies in the Commencement Bay area which include water quality evaluations. Chlorinated organics (such as hexachloro-1,3-butadiene), and various metals (such as arsenic) have been found in bottom sediments at various points in the bay and its waterways. Fish abnormalities such as liver lesions have been observed. In a study conducted in 1979 by Battelle Pacific Northwest Laboratories for NOAA (Quantification of Pollutants in Suspended Matter and Water from Puget Sound, NOAA Technical Memorandum ERL-MESA-49, April 1980), it was reported that both chlorinated organics and polynuclear aromatic compounds (such as naphthalene) were found in water samples taken from the mouths of the Hylebos and Blair Waterways. Based on that finding, NOAA determined to conduct intensive follow-up studies within the two waterways. Subsequently, they requested the Environmental Protection Agency's assistance in locating areas of concentration of actual or potential sources of chlorinated organics, polynuclear aromatics, and/or heavy metals in the surface waters of the two waterways and their respective drainages. EPA Region X was also interested in obtaining additional data in this area due to concern over the chemicals reported in the NOAA study and the region's continuing program of investigating known or potential hazardous waste disposal sites. For the reasons cited above, a field investigation was planned and conducted.

The purpose of the investigation was to obtain preliminary information to be used by both EPA and NOAA in planning more detailed studies of toxic contaminants in the Commencement Bay area. Samples were obtained both from the waterways and from possible sources along the banks. The survey did not include collection of bottom sediment or fish samples.

*The text of this appendix was taken verbatim from the unpublished study summaries prepared by EPA for their June (EPA 1980a) and September (EPA 1980b) field studies. Extensive data tables are deleted and available from EPA or Corps offices.

Stations sampled are shown on Figure 2 (in main text). All stations were sampled at the water surface. Additionally, some of the waterway stations were sampled at 20 feet below the surface to determine if water quality was influenced by depth. Those samples taken at depth have a (D) included on their station number in the tables. In addition to the two waterways referenced above, samples were collected at a control station near Browns Point, at the mouth of the Sitcum Waterway, and just offshore midway between the Blair and Hylebos Waterways.

Purgeable halocarbons and chlorinated hydrocarbons, as represented in the tables, are subgroups of chlorinated chemicals divided for the purpose of this study primarily due to the method of analysis used to identify the specific chemical. Polynuclear aromatics represent a group of chemicals related to benzene in that they all contain one or more benzene ring (C_6H_6) as part of their chemical structure. They are presented separately here due to that unique characteristic.

It should be stressed that all samples were grab rather than composite and thus represent a point in time rather than a longer term condition. Also, abbreviated laboratory procedures modified from EPA's priority pollutant analytical protocol were used in hopes of obtaining rapid indications of possible trouble spots worthy of further study. Procedures used are referenced in the tables. All waterway sampling was done during the late stages of ebb tide and into the early stages of flood tide with the sequence of sampling going from the mouth of the waterways to the head.

In general, all groups of chemicals analyzed for were present to some extent in the waterways; however, there were very few indications of waterway concentrations in excess of suggested aquatic life criteria for salt water.* There were higher concentrations noted in some storm drains, bank seepage, and effluent samples. The amount of discharge at these points was generally low.

More specifically, the following observations were made:

*EPA-R3-73-033, March 1973; EPA-440/9-76-023, July 1976.

Metals

Copper and selenium concentrations were in excess of recommended criteria in many of the waterway stations, including the control station. For other metals where criteria have been suggested, only arsenic was present in extremely high concentrations and only in "shoreside" samples. These shoreside samples were either storm drains or bank seepage and of low volume.

Purgeable Halocarbons

None of the waterway stations had concentrations in excess of recommended criteria (while 54 $\mu\text{g/l}$ of trichloroethene was measured at Station H₂, no criteria are available for comparison). Two shoreside stations (a bank seepage and storm drain both located on the property of Pennwalt Chemical Company) had elevated levels of tetrachloroethene and chloroform; however, these chemicals did not exceed criteria limits at the nearby waterway stations.

Chlorinated Hydrocarbons

One waterway station (H₇) had 2-chloronaphthalene at a concentration exceeding average criteria in the sample taken at 20 feet. A concentration of 3.6 $\mu\text{g/l}$ was measured (average criteria level recommended is 2.8 $\mu\text{g/l}$; the maximum recommended level is 6.4 $\mu\text{g/l}$). Also, a large number of unidentified chlorinated hydrocarbons were present at Station H₆. Shoreside samples included large amounts of unknown chemicals in the Hooker effluent, and elevated hexachloroethane concentrations in a storm drain and bank seepage at Pennwalt. Again, while concentrations of hexachloroethane were high (101 and 225 $\mu\text{g/l}$) the flow rates were low and a relationship between these values and those observed in the waterway could not be established.

Polynuclear Aromatics

Benzene was the only identified aromatic present in high concentrations at any station--in this case the storm drain along Lincoln Avenue flowing north to the Blair Waterway (S₂) and the Sound Refinery effluent (E₈). Large quantities of unidentified aromatics were present in three waterway samples as well as four shoreside samples.

Priority Pollutant Scan

Due to the high concentrations of chemicals from the above groups found in samples from Stations E₄, E₅, and E₆, the samples were analyzed for EPA's list of priority pollutants which includes 115 organics and 14 inorganic chemicals. This scan confirmed the presence of chemicals from the groups referenced in previous tables as well as additional chemicals representative of the pesticides group. The pesticides found were Dieldrin, 4,4'DDT, 4,4'DDE, Alpha Endosulfan, Endrin, Alpha BHC, Beta BHC, Lindane, and Delta BHC. Overall, 59 of the 129 chemicals were identified.

Commencement Bay Waterways Survey

September 23-24, 1980

On September 23 and 24, EPA collected water samples in the Hylebos and Blair Waterways of Commencement Bay including several bank seepages, storm drains, and other drainages to the waterways. This study was a follow-up and expansion of work reported by memorandum of August 25, 1980 describing EPA's June 3, 1980 field study of the same waterways.

Stations sampled are shown on Figure 3 (in main text) and described briefly in Table D-1. All stations were sampled at the water surface or from bank seepage, except for Station Number 38301, which was sampled approximately 50 feet offshore and at the bottom of the waterway. The same location was also sampled at the water surface and is reported as Station Number 38302. Additionally, a sample was collected from the outfall of Tacoma's Central Wastewater Treatment Plant which discharges to the Puyallup River (reported as Station Number 38212). As in the June survey, all samples were grab (rather than composite) and abbreviated laboratory procedures were used in order to obtain data as expeditiously as possible.

DISCUSSION OF DATA

Of 39 samples collected, 11 were collected in the waterways, only 4 of which could be considered outside the influence of immediate mixing zones from bank seeps, storm drains, discharge pipes, or other drainages to the waterways. Those stations are 38309 and 38313, at which all parameters were measured, and 38301 and 38302, at which all but metals were measured.

Metals

- Copper, nickel, and mercury concentrations were in excess of the new criteria at most of the waterway stations including 38309 and 38313. This was also the case for June 3 data where several additional waterway stations were sampled (35 data points).

- Zinc concentrations exceeded suggested criteria at several waterway points including 38309.
- Silver exceeded suggested criteria at one station within a mixing zone area.
- No criteria are available for lead and arsenic. The suggested chronic effects threshold level was exceeded for lead at several waterway stations including Stations 38309 and 38313. Suggested chronic effects level was exceeded for arsenic immediately offshore at Pennwalt.
- Many shoreside stations had one or more heavy metals at elevated concentrations. Reference to aquatic life criteria is not appropriate when reviewing these data since high potential for dilution exists. Additional studies over the long term might be considered for several of the shore stations as well as screening investigation of additional sites; however, four locations are recommended for closer scrutiny in the near future based on the September sampling:
 1. Station 38202 (North bank of Hylebos Waterway across from Lincoln Avenue). Elevated lead, copper, zinc, and nickel as well as other metals in bank seepage.
 2. Area represented by Stations 38204-38210 (Pennwalt). Elevated arsenic, chromium, and mercury as well as other metals in bank seepage and along shoreline.
 3. Station 38310 (U.S. Gypsum). Elevated copper, lead, arsenic, and zinc as well as other metals in bank seepage.
 4. Station 38318 (Pan Pacific). Elevated copper, lead, arsenic, and zinc as well as other metals in storm drain.

Purgeable Halocarbons

No saltwater aquatic life criteria are available presently from EPA for the pollutants identified from this group in these studies. For those pollutants where apparent threshold levels for acute and/or chronic effects are given, none were exceeded either in shoreside or waterway samples.

One chemical, chloroform, was present at levels which have been shown to cause chronic effects in some freshwater aquatic species. While sufficient data were not available for the agency to develop saltwater species criteria or threshold level recommendations, toxic effects studies on local species may be justified.

The highest concentrations of this group of chemicals were found in bank seepage samples at Pennwalt and Hooker.

Chlorinated Hydrocarbons

Saltwater aquatic life criteria are not yet available for the compounds identified from this group. Where apparent threshold levels have been indicated none were exceeded in waterway samples. The only stations where several compounds from this group were found in quantifiable concentrations were bank seeps at Pennwalt and Hooker.

Polynuclear Aromatics

Again, criteria for saltwater aquatic life are not yet available. Apparent threshold levels for acute effects were not exceeded at any station.

Priority Pollutant Scan

Samples from five of the stations were selected for complete priority pollutant analysis. This scan confirmed the presence of chemicals from groups referenced in Tables III through V as well as additional chemicals

representative of the pesticides group. Additional scans for metals were not made since this group was already analyzed for by priority pollutant methods. Overall, 55 of the EPA's 129 priority pollutants were identified.

Human Health

Several of the chemicals found in the June and September surveys are considered to be carcinogens or to have potential carcinogenic effects due to ingestion of contaminated water and/or contaminated aquatic organisms. The recently published EPA criteria documents include discussion of carcinogenic risk levels for many of the chemicals and suggested risk levels for some of the noncarcinogens where health effects have been demonstrated. The reader is referred to the Federal Register publication cited above for summary information and to the separate "Ambient Water Quality Criteria" documents (EPA 440/5-8-(015 through 079*)) for more in-depth discussion of potential health effects.

The agency feels that maximum protection of human health from potential carcinogenic effects can only be obtained with zero concentration of these chemicals, however, zero concentrations may not be obtainable at this time. Therefore, levels for incremental increase of cancer risk are given in the publications, assuming consumption of 6.5 grams/day of fish and shellfish harvested from contaminated waterways. The agency does not represent these risk levels as "acceptable," but rather guidelines for reference. Examples of chemicals found in these studies for which risk levels are given are: arsenic, carbontetrachloride, chlorinated benzenes, chloroform, DDT, halomethanes, hexachlorobutadiene, and tetrachloroethene (tetrachlorethylene).

*Number 072 on TCCD should be available early in 1981.

TABLE D-1

COMMENCEMENT BAY WATERWAYS SURVEY - SEPTEMBER 23-24, 1980
STATION DESCRIPTIONS

Date	Sample Time (DST)	Lab (Station) Number	Station Location
9/23/80	8:53	38200	Surface Runoff to Hylebos North Bank--West of 11th Street
	9:15	38201	Surface Runoff to Hylebos North Bank--East of 11th Street
	9:35	38202	Bank Seepage--North bank of Hylebos--across from Lincoln Ave.
	9:58	38203	Drain Ditch from Kaiser on Taylor Way (E7 June Survey)
	10:31	38204	Waters edge at Pennwalt (See Figure #1)
	10:34	38205	Waters edge at Pennwalt (See Figure #1)
	10:39	38206	Waters edge at Pennwalt (See Figure #1)
	11:18	38207	Bank Runoff at Pennwalt (See Figure #1) (E6 June Survey)
	11:24	38208	Waters edge at Pennwalt (See Figure #1)
	11:38	38209	Bank Runoff at Pennwalt (See Figure #1)
	11:53	38210	Drain Ditch--East edge of Pennwalt Property
	12:19	38211	Tidal Drain--SW corner of Reichhold Property (S1a June Survey)
	13:30	38212	Tacoma-Puyallup River SIP effluent
9/24/80	10:15	38213	Drainage Ditch near Jones Chemical
	11:15	38214	Drain ditch from Reichhold--NE of tidegate
	11:45	38215	Lincoln Ave. drain to Blair from South--Vicinity Landscape Bark
	11:53	38216	Lincoln Ave. drain to Blair from South--Vicinity Thorne Rd.
	12:05	38217	Lincoln Ave. drain to Blair from South--Near Milwaukee Way
	12:17	38218	Storm drain at Reichhold near SE property corner above overflow weir
9/23/80	9:30	38300	Drain from north to Lower Turning basin--Hylebos
	10:30	38301	Hylebos Waterway--offshore from old Hooker solvent plant (bottom sample)
	10:35	38302	Hylebos Waterway--offshore from old Hooker solvent plant (surface sample)
	10:15	38303	Bank seepage at Hooker near old solvent plant
	10:45	38304	Hylebos Waterway--surface sample over Hooker outfall
	11:00	38305	Shore drainage to Hylebos--south side across from Sound Refining
	11:10	38306	Shore seepage near Buffelen
	11:15	38307	Heated discharge to Hylebos--South shore upstream from Lincoln Ave.
	11:40	38308	Mouth of drain from Kaiser to Hylebos Waterway
	11:55	38309	Hylebos Waterway--near north shore across from Lincoln Ave. (H6 June Survey)
	11:50	38310	Bank seepage near #38307
9/24/80	10:15	38311	Shore seepage near Zidell--Blair Waterway
	10:40	38312	Shore seepage to Blair--upstream from Zidell
	10:55	38313	Blair Waterway--under 11th St. Bridge
	11:00	38314	Surface drain to Blair at Donta Chemical
	11:15	38315	Surface runoff to Blair--Stauffer Property
	11:30	38316	Blair Waterway--just offshore from south drain Lincoln Ave.
	11:35	38317	South Drain--Lincoln St. at mouth (Blair)
	11:45	38318	Pan Pacific Drain to Blair (south side)
	12:30	38319	Sound Refining--drainage from bulkhead

APPENDIX E

COBS WATER QUALITY STATION PROFILES

- Field Study - October 1980
- Field Study - December 1980

TABLE E-1

Sheet 1 of 6

WATER QUALITY STATION PROBE PROFILES, OCTOBER 1980

Station					
Date					
Time	Sample	Depth (m)	T (°C)	pH	
1 10-1-80 16:22	S	0.1	14.8	8.05	
		0.5	14.7	8.04	
		1.0	14.5	8.01	
		1.5	14.3	7.85	
		2.0	14.1	7.82	
		2.5	14.0	7.81	
		3.0	13.6	7.84	
		3.5	13.3	7.85	
		4.0	13.3	7.87	
		M	4.5	13.3	7.86
	B	9.0	12.5	7.90	
	2 10-1-80 15:48	S	0.1	14.2	7.96
			0.5	14.2	7.96
1.0			13.9	7.90	
1.5			13.6	7.88	
2.0			13.5	7.88	
2.5			13.3	7.88	
4.0			13.3	7.87	
M			4.5	13.0	7.89
B		9.0	12.5	7.90	
3 10-1-80 15:23		S	0.1	13.5	7.96
	0.5		13.4	7.97	
	1.0		13.2	7.96	
	1.5		12.9	7.95	
	2.0		12.7	7.95	
	2.5		12.6	7.95	
	3.0		12.4	7.84	
	4.0		12.4	7.96	
	M	5.0	12.4	7.95	
	B	10.0	12.3	7.95	
5 10-1-80 18:10	S	0.1	12.7	8.02	
		1.0	12.7	8.02	
		2.0	12.7	8.02	
		3.0	12.7	8.02	
		4.0	12.7	8.02	
		5.0	12.7	8.02	
		6.0	12.6	8.01	
		7.0	12.5	8.01	
		8.0	12.3	7.99	
		9.0	12.3	7.99	
		10.0	12.3	7.99	
	M	25.0	12.1	7.98	
B	50.0	11.7	7.95		

TABLE E-1

Sheet 2 of 6

Station	Date	Time	Sample	Depth (m)	T (°C)	pH
6	10-1-80	18:40	S	0.1	12.6	8.02
				1.0	12.5	8.02
			M	2.0	12.6	8.02
				3.0	12.5	8.01
				4.0	12.4	8.01
				5.0	12.4	8.00
				6.0	12.3	7.99
				7.0	12.3	7.99
				8.0	12.2	7.98
				9.0	12.2	7.98
				10.0	12.2	7.98
				25.0	12.0	7.97
			50.0	12.0	7.95	
7	10-2-80	17:17	S	0.1	14.7	8.17
				1.0	14.2	8.29
				2.0	13.2	8.15
				3.0	13.1	8.09
			M	4.0	12.4	8.05
				5.0	12.8	8.00
				6.0	12.7	7.99
				7.0	12.6	7.99
				8.0	12.5	7.98
				9.0	12.5	7.97
B	10.0	12.5	7.97			
	11.0	12.5	7.96			
8	10-2-80	16:37	S	0.1	14.7	8.00
				1.0	13.0	8.02
				2.0	12.7	8.00
				3.0	12.6	8.00
			M	4.0	12.6	8.00
				5.0	12.6	8.00
				6.0	12.5	8.01
				7.0	12.5	7.99
				8.0	12.4	7.98
				9.0	12.5	7.97
B	9.0	12.5	7.97			

TABLE E-1

Sheet 3 of 6

Station				
Date				
Time	Sample	Depth (m)	T (°C)	pH
9 10-2-80 16:03	S	0.1	14.4	7.95
		1.0	14.0	7.93
		2.0	12.7	8.03
		2.5	12.7	8.04
		3.0	12.7	8.05
		3.5	12.6	8.05
		4.0	12.7	8.05
		5.0	12.6	8.05
		6.0	12.5	8.04
		7.0	12.4	8.03
		8.0	12.3	8.03
		9.0	12.3	8.02
		10.0	12.3	8.01
		20.0	12.2	7.99
	M	30.0	12.1	7.99
	40.0	12.1	7.97	
	50.0	11.8	7.96	
10 10-2-80 12:15	S	0.1	13.2	8.05
		1.0	13.0	8.05
		2.0	12.8	8.05
		3.5	12.7	8.06
		4.0	12.7	8.06
		5.5	12.6	8.06
		6.0	12.6	8.06
		7.0	12.6	8.06
		8.0	12.6	8.06
		9.0	12.5	8.05
		10.0	12.5	8.04
		20.0	12.3	8.00
		30.0	12.3	8.01
		40.0	12.2	8.00
	M	50.0	12.2	8.00

TABLE E-1

Sheet 4 of 6

Station				
Date				
Time	Sample	Depth (m)	T (°C)	pH
11	S	0.1	13.0	8.04
10-2-80		1.0	12.7	8.04
11:32		2.0	12.5	8.04
		3.0	12.5	8.03
		4.0	12.5	8.03
		5.0	12.5	8.03
		6.0	12.5	8.02
		7.0	12.5	8.02
		8.0	12.5	8.02
		9.0	12.5	8.01
		10.0	12.4	8.00
		20.0	12.3	7.96
		30.0	12.3	7.94
		40.0	12.2	7.98
	M	50.0	11.1	7.96
15	S	0.1	12.6	7.89
10-3-80		0.5	12.7	8.00
13:45		1.0	13.2	7.51
		1.5	13.1	7.83
		2.0	13.1	7.80
		2.5	13.1	7.80
		3.0	13.1	7.78
16	S	0.1	12.7	8.04
10-3-80		0.5	12.7	7.88
13:25		1.0	13.4	7.85
		1.5	13.3	7.84
	B	2.0	13.2	7.89
		2.5	13.3	7.87
		3.0	13.2	7.83
17	S	0.1	13.8	7.95
10-2-80		0.5	13.6	7.99
13:42		1.0	12.7	7.95
		1.5	12.7	8.02
	M	2.0	12.6	8.02
		2.5	12.5	8.02
		3.0	12.5	8.02
		3.5	12.5	8.02
		4.0	12.4	8.02
		5.0	12.5	8.01
		6.0	12.5	8.00
		7.0	12.5	8.02
		8.0	12.5	8.02
		9.0	12.5	8.02
		10.0	12.6	8.03
	B	15.0	12.5	8.02

TABLE E-1

Sheet 5 of 6

Station				
Date				
Time	Sample	Depth (m)	T (°C)	pH
18	S	0.1	13.8	8.00
10-2-80		1.0	13.4	8.01
11:32		2.0	12.8	8.03
		3.0	12.6	8.04
		4.0	12.5	8.03
		5.0	12.5	8.03
		6.0	12.5	8.03
		7.0	12.5	8.04
		8.0	12.5	8.05
		9.0	12.5	8.04
		10.0	12.5	8.05
		20.0	12.4	8.91
		30.0	12.4	8.91
		40.0	12.2	7.99
	M	50.0	12.2	7.98
19	S	0.1	12.6	8.05
10-3-80		1.0	12.6	8.05
13:45		2.0	12.4	8.03
		3.0	12.5	8.04
		4.0	12.5	8.05
		5.0	12.5	8.04
		6.0	12.5	8.04
		7.0	12.5	8.04
		8.0	12.5	8.04
		9.0	12.5	8.04
		10.0	12.4	8.04
		20.0	12.4	8.00
		30.0	12.4	8.00
		40.0	12.3	7.99
	M	50.0	12.2	7.95
20	S	0.1	14.7	7.70
10-2-80		0.5	14.0	7.86
14:57		1.0	13.6	7.91
		1.5	13.3	7.97
		2.0	13.1	8.01
		2.3	13.0	8.03
		3.0	12.9	8.04
		3.5	12.9	8.05
	M	4.0	12.8	8.06
	B	8.0	12.9	8.07

TABLE E-1

Sheet 6 of 6

Station	Date	Time	Sample	Depth (m)	T (°C)	pH
29	10-1-80	16:50	S	0.1	15.5	8.21
				0.5	15.1	8.01
				1.0	15.0	7.99
				1.5	14.8	7.94
				2.0	14.4	7.85
				2.5	13.9	7.77
				3.0	13.5	7.78
				3.5	13.5	7.77
				4.0	13.1	7.77
			M	4.5	12.9	7.75
			B	9.0	12.6	7.72
			30	10-2-80	17:38	S
	1.0	14.8				8.29
	2.0	13.6				8.23
	3.0	13.0				8.15
	4.0	12.9				8.02
M	5.0	12.8				8.01
	6.0	12.8				7.99
	7.0	12.7				7.97
	8.0	12.7				7.96
	9.0	12.6				7.94
	10.0	12.5				7.91
B	11.0	12.5				7.90
31	10-3-80	12:25	S	0.1	14.6	7.62
				1.0	13.2	7.91
				2.0	13.0	7.88
				3.5	13.0	7.89
			B	4.0	13.1	7.92

TABLE E-2

Sheet 1 of 6

WATER QUALITY STATION PROBE PROFILES, DECEMBER 1980

Station	Date	Sample	Depth (m)	T (°C)	Corrected D.O. (ppm)	pH	Conductivity ^(a) (mmho/cm x 1000)
1	12-16-80 12:30	S	0.1	10.2	6.35	7.64	32.3
			1	10.8	5.83	7.76	39.3
			2	10.7	6.07	7.81	41.3
			3	10.8	6.10	7.83	41.6
		M	4.5	10.8	6.28	7.90	42.7
		B	9	10.3	6.61	7.89	43.2
2	12-16-80 12:14	S	0.1	9.9	6.84	7.66	31.8
			1	10.3	6.63	7.80	39.4
			2	10.3	6.56	7.84	41.5
			3	10.3	6.60	7.87	42.4
		M	4.5	10.2	6.80	7.90	42.9
		B	9	10.1	6.93	7.91	43.7
3	12-16-80 11:44	S	0.1	9.0	8.83	7.89	23.0
			1	9.9	7.15	7.89	39.6
			2	10.0	6.99	7.90	41.5
			3	10.1	6.90	7.91	42.5
			4	10.1	6.95	7.92	43.3
		M	5	10.1	7.01	7.92	43.6
4	12-16-80 11:20	S	0.1	7.8	9.77	7.89	18.3
			1	9.6	7.85	7.88	30.7
			2	10.1	6.73	7.87	42.3
			3	10.1	6.74	7.89	43.3
			4	10.1	6.90	7.92	43.5
			5	10.1	6.92	7.93	43.7
5	12-17-80 9:10	S	0.1	7.3	9.48	7.95	20.5
			1	9.4	7.19	7.93	34.0
			2	10.0	6.98	7.93	43.2
			3	10.0	6.67	7.93	43.4
			4	10.0	6.74	7.93	43.6
			5	10.0	6.76	7.93	43.6
6	12-17-80 9:39	M	25	10.1	6.64	7.93	44.0
		B	50	10.3	6.60	7.90	44.1
		S	0.1	8.2	9.05	7.98	27.0
			1	9.7	7.39	7.96	42.5
			2	9.8	7.20	7.96	42.5
			3	9.8	6.91	7.96	42.5
6	12-17-80 9:39		4	9.9	6.90	7.95	42.0
			5	10.0	6.87	7.93	43.4
		M	50	10.2	6.75	7.92	44.0

(a) Conductivity values are higher than occurred and are likely a calibration problem.

TABLE E-2

Sheet 2 of 6

Station	Date	Sample	Depth (m)	T (°C)	Corrected D.O. (ppm)	pH	Conductivity(a) (mmho/cm x 1000)
7		S	0.1	9.7	7.07	7.75	38.1
12-17-80			1	9.9	6.56	7.76	40.5
8:00			2	10.0	6.43	7.77	41.3
			3	10.1	6.39	7.78	41.7
			4	10.1	6.42	7.78	41.9
		M	5	10.1	6.34	7.79	42.4
		B	11	10.1	6.74	7.84	43.3
8		S	0.1	9.2	7.72	7.86	35.7
12-17-80			1	10.0	6.59	7.82	41.0
8:17			2	10.1	6.39	7.83	42.1
			3	10.0	6.58	7.87	42.8
		M	4	10.0	6.84	7.91	43.3
		B	9	10.0	6.87	7.90	43.5
9		S	0.1	8.0	9.00	7.94	23.7
12-17-80			1	9.9	6.85	7.90	41.0
8:43			2	10.0	7.08	7.94	43.3
			3	10.0	7.06	7.95	43.6
			4	10.0	7.00	7.94	43.6
			5	10.0	7.00	7.93	43.7
		M	30	10.2	6.75	7.92	44.0
		B	60	10.3	6.43	7.90	44.2
10		S	0.1	9.4	7.51	7.94	38.2
12-17-80			1	9.8	6.89	7.94	41.9
10:20			2	9.8	7.07	7.94	42.3
			3	9.8	7.12	7.94	42.7
			4	9.9	7.04	7.94	43.0
			5	9.9	7.08	7.94	43.0
		M	50	10.1	6.80	7.92	44.0
11		S	0.1	8.4	8.83	7.98	26.4
12-16-80			1	9.7	7.55	7.96	41.0
16:30			2	9.8	7.37	7.96	42.6
			3	9.8	7.32	7.96	43.0
			4	9.8	7.31	7.96	43.0
			5	9.8	7.38	7.96	43.3
		M	50	10.2	6.91	7.94	44.1
12		S	0.1	8.7	9.38	7.85	21.5
12-16-80			1	10.0	7.01	7.90	41.9
13:17			2	10.1	6.98	7.92	43.5
		M	3	10.1	6.98	7.92	43.6
			4	10.1	6.90	7.92	43.7
			5	10.1	6.99	7.92	43.7
		B	6	10.0	7.01	7.92	43.7

TABLE E-2

Sheet 3 of 6

Station Date Time	Sample	Depth (m)	T (°C)	Corrected D.O. (ppm)	pH	Conductivity (a) (mmho/cm x 1000)
13	S	0.1	8.9	7.99	7.84	30.0
12-17-80		1	10.0	6.76	7.90	42.6
11:10		2	10.0	6.69	7.89	43.3
		3	10.0	6.59	7.89	43.5
	M	4	10.1	6.85	7.90	43.6
		5	10.1	6.58	7.88	43.7
	B	12	10.1	6.20	7.83	43.9
14	S	0.1	8.1	9.35	7.94	23.6
12-17-80		1	10.0	7.49	7.92	43.1
10:50		2	10.0	6.93	7.92	43.4
		3	10.0	6.97	7.93	43.6
	M	4	10.0	6.99	7.93	43.6
		5	10.0	7.03	7.93	43.6
	B	8	9.9	6.99	7.92	43.5
15	S	0.1	5.3	12.26	7.80	0.0
12-17-80		1	5.3	12.20	7.88	0.0
12:11	B	2	5.3	12.35	7.85	0.0
		3	5.3	12.45	8.03	0.0
16	S	0.1	5.4	11.96	8.24	0.0
12-17-80		1	5.4	11.75	8.07	0.3
11:52		2	5.8	10.92	7.82	1.0
	B	3	9.6	7.10	7.89	41.5
17	S	0.1	8.0	8.37	7.81	24.5
12-17-80		1	10.0	6.81	7.92	43.5
11:33	M	2	10.0	6.83	7.93	43.6
		3	10.0	6.80	7.92	43.6
	B	4	10.0	6.80	7.93	43.7
18	S	0.1	8.9	8.46	7.79	30.1
12-16-80		1	10.0	7.08	7.95	43.2
15:13		2	10.0	7.07	7.94	43.5
		3	10.0	7.12	7.95	43.5
		4	10.0	7.10	7.95	43.6
		5	10.0	7.06	7.95	43.6
	M	50	10.2	6.97	7.94	44.1
19	S	0.1	9.3	8.68	8.00	32.6
12-16-80		1	9.5	7.85	7.97	38.7
15:47		2	9.6	7.67	7.97	40.0
		3	9.7	7.54	7.95	40.5
		4	9.8	7.31	7.95	42.5
		5	9.8	7.39	7.96	42.8
	M	50	10.0	7.20	7.96	43.9

TABLE E-2

Sheet 4 of 6

Station	Date	Time	Sample	Depth (m)	T (°C)	Corrected D.O. (ppm)	pH	Conductivity (a) (mmho/cm x 1000)	
20 12-16-80 14:50			S	0.1	10.6	6.90	7.37	37.7	
				1	10.1	6.72	7.78	42.3	
				2	10.1	6.33	7.77	42.9	
			M	3	10.1	6.28	7.78	43.1	
				4	10.1	6.08	7.75	43.2	
				B	8	10.0	6.78	7.89	43.7
21 12-16-80 13:45			S	0.1	10.1	7.00	7.63	39.8	
				1	10.0	6.77	7.77	42.2	
				2	10.0	6.84	7.83	42.6	
			M	3	10.1	6.87	7.88	43.4	
				B	4	10.0	6.93	7.88	43.5
22 12-16-80 7:55			S	0.1	10.1	6.51	7.53	35.4	
				1	10.1	6.70	7.82	42.5	
				2	10.1	6.32	7.81	43.2	
				3	10.1	6.25	7.81	43.4	
				M	4	10.1	6.27	7.82	43.6
			B	5	10.1	6.44	7.86	43.7	
				6	10.1	6.60	7.86	43.7	
				7	10.1	6.74	7.86	43.8	
				8	10.1	6.82	7.86	43.8	
				9	10.1	6.89	7.86	43.8	
23 12-16-80 8:18			S	0.1	9.9	7.12	7.70	38.2	
				1	10.1	6.83	7.86	42.9	
				2	10.0	7.00	7.90	43.3	
				3	10.1	6.94	7.91	43.6	
				4	10.1	6.86	7.90	43.6	
			M	5.5	10.1	6.84	7.90	43.6	
				6	10.1	6.90	7.90	43.7	
				7	10.1	7.06	7.92	43.8	
				8	10.1	7.06	7.92	43.8	
				9	10.1	7.06	7.92	43.9	
				10	10.1	7.12	7.92	43.9	
B	11	10.1	7.13	7.92	43.9				
24 12-16-80 9:17			S	0.1	9.7	7.63	7.79	36.0	
				1	10.0	7.02	7.92	43.0	
				2	10.0	7.01	7.92	42.2	
				3	10.0	6.99	7.92	43.3	
				4	10.0	7.01	7.92	43.4	
			M	5	10.0	6.98	7.93	43.5	
				9	10.0	6.96	7.93	43.8	
				B	18	10.0	7.01	7.93	43.9

TABLE E-2

Sheet 5 of 6

Station	Date	Sample	Depth (m)	T (°C)	Corrected D.O. (ppm)	pH	Conductivity(a) (mmho/cm x 1000)	
25 12-16-80 9:38		S	0.1	9.8	7.51	7.86	38.5	
			1	10.0	7.03	7.91	42.9	
			2	10.0	7.01	7.92	43.3	
			3	10.0	6.97	7.92	43.5	
			4	10.0	6.93	7.92	43.6	
			5	10.0	6.95	7.92	43.6	
			M	7	10.0	6.96	7.93	43.7
			B	14	10.0	7.14	7.94	43.9
26 12-16-80 9:55		S	0.1	9.8	7.62	7.86	37.5	
			1	9.9	7.15	7.91	42.0	
			2	10.0	7.08	7.93	43.1	
			3	10.0	7.09	7.94	43.3	
			4	10.0	7.09	7.95	43.6	
			5	10.0	7.09	7.96	43.7	
			M	7	10.0	7.06	7.94	43.7
			B	14	10.1	7.06	7.94	43.9
27 12-16-80 10:12		S	0.1	9.9	7.28	7.92	41.7	
			1	10.0	7.15	7.93	42.8	
			2	10.0	7.12	7.93	43.2	
			3	10.0	7.14	7.94	43.4	
			4	10.0	7.10	7.94	43.6	
			5	10.0	7.08	7.94	43.6	
			M	7	10.0	7.09	7.94	43.7
			B	14	10.0	7.18	7.95	43.8
28 12-16-80 10:39		S	0.1	9.9	7.41	7.92	40.5	
			1	10.0	7.21	7.94	43.2	
			2	9.9	7.30	7.95	43.3	
			3	10.0	7.22	7.96	43.4	
		M	4	10.0	7.15	7.94	43.5	
			5	10.0	7.14	7.94	43.6	
	B	10	10.0	7.27	7.95	43.9		
29 12-16-80 12:43		S	0.1	10.3	5.79	7.54	32.0	
			1	10.6	5.10	7.60	39.2	
			2	10.5	5.27	7.67	40.6	
			3	10.5	5.23	7.70	41.5	
		M	4.5	10.4	5.27	7.74	42.7	
		B	9	10.2	6.11	7.83	43.4	
30 12-17-80 7:20		S	0.1	9.6	7.11	7.72	37.7	
			1	9.9	6.63	7.76	40.2	
			2	10.1	6.49	7.75	41.0	
			3	10.1	6.39	7.76	41.6	
			4	10.1	6.41	7.78	41.9	
		M	5	10.1	6.48	7.78	42.2	
		B	11	10.1	6.40	7.80	43.5	

TABLE E-2

Sheet 6 of 6

Station				Corrected		Conductivity(a)
Date	Sample	Depth (m)	T (°C)	D.O. (ppm)	pH	(mmho/cm x 1000)
Time						
31	S	0.1	10.4	6.88		33.3
12-16-80		1	10.2	6.11		42.1
7:32		2	10.2	6.17		42.4
		3	10.2	6.08		42.6
	B	4	10.2	5.86		42.7
32	S	0.1	7.9	8.31	7.14	1.7
12-17-80						
13:52						
33	S	0.1	8.4	8.90	7.20	1.5
12-17-80						
13:30						

**DAT
FILM**