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A SUMMARY OF PRIORITY POLLUTANT DATA FOR POINT SOURCES AND SEDIMENT IN INNER COMMENCEMENT BAY: A PRELIMINARY ASSESSMENT OF DATA AND CONSIDERATIONS FOR FUTURE WORK

PART 5. MILWAUKEE, PUYALLUP, ST. PAUL, MIDDLE WATERWAYS AND S.W. SHORE COMMENCEMENT BAY

by

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INTRODUCTION

This document is part of a larger compilation and review of data on priority pollutant concentrations in point source discharges and surface sediments in Commencement Bay and adjacent waterways collected between 1979 and 1982 and reported by WDOE, EPA, and NOAA. Also presented here are hitherto unpublished data from WDOE point source sampling and a series of sediment collections made by EPA and WDOE. Water column data were also reviewed for this report; they were not, however, tabulated. Pollutant concentrations in biota and biological responses to water and sediment samples were not, in general, reviewed. Data on organic compounds not classified as priority pollutants were also not reviewed.

The report is arranged by waterway in the six parts listed below; each to be issued in separate installments as the data are compiled and reviewed. The fifth installment covering Milwaukee, Puyallup, St. Paul, and Middle waterways, and the southwest shore of Commencement Bay is included with these introductory remarks.

	Subject	Anticipated Completion Date (1983)
Part 1.	Hylebos Waterway	Completed
Part 2.	City Waterway	Completed
Part 3.	Blair Waterway	Completed
Part 4.	Sitcum Waterway	Completed
Part 5.	Milwaukee, Puyallup, St. Paul, Middle Waterways and S.W. Shore Commencement Bay	Completed
Part 6.	Summary	October

This information was gathered with the aim of providing direction for the next phase of work in the Commencement Bay near-shore marine environment. In the interest of putting together a useful package in a timely fashion, an outline format is used.

SAMPLING AND ANALYTICAL METHODS

The results presented here are from studies conducted by a number of investigators and should be compared with caution because of the variable collection, extraction, and analytical methods employed. Even a casual review of the data will reveal that detection limits vary between laboratories and that certain compounds are regularly reported in some studies and rarely reported in others. The importance of consistent sampling techniques and analytical methods in future Commencement Bay investigations cannot be over-emphasized.

The methods employed in obtaining most of the data compiled here are described in the reports cited at the end of each data package. The WDOE point source data on discharges other than ASARCO, St. Regis,

Tacoma Central STP, U.S. Oil, Reichhold, Pennwalt, Sound Refining, and Hooker (which are documented in WDOE "Class II" reports) and the data on sediment samples collected by EPA and WDOE on 5/13/81, 7/31/81, and 8/03-04/81 are being reported for the first time. The procedures used in obtaining these new data are briefly described below.

The WDOE point source samples were collected in one-gallon glass jars (base/neutrals, acid extractables, pesticides, and PCBs), 40 ml screw-top glass vials with teflon septums (volatiles), and 2-1/2 or 5-gallon polyethylene cubitainers (trace metals and conventional water quality parameters*). Sample bottles were cleaned according to EPA priority pollutant protocol. Laboratory and field blanks were included in conjunction with the point source samples as a check against sample contamination. All samples were composites, typically collected over a 2 - 6 hour period. Rising tides precluded long compositing periods at a number of discharges. Flows were measured with a magnetic flowmeter or bucket and stopwatch.

The analytical plan included sample analysis at several different laboratories. Organics analysis was done by EPA contract laboratories. Trace metals were analyzed at the WDOE Tumwater laboratory. Joe Blazevich, EPA Region X laboratory at Manchester, reviewed the organic priority pollutant data reported by the contract laboratories prior to inclusion in this report.

The intertidal sediment samples taken by WDOE on 7/30-31/81 were collected by hand using a stainless steel "cookie cutter" measuring 9 cm in diameter and 2.5 cm deep. Several samples were taken along a transect of the lower beach, usually below or near a point source discharge, and pooled. After mixing with a glass rod, subsamples were placed in glass (organics analysis) or plastic (trace metal analysis) containers and analyzed as described above. A third portion of the sample was sent to the EPA Newport laboratory for bioassay using amphipods as the test organism. (The results of bioassay tests were reported by R.C. Swartz in the Marine Pollution Bulletin Vol. 13, No. 10, pp. 359-364, 1982.)

The subtidal sediments collected by EPA and WDOE on 5/13/81 and 8/03-04/81 were taken with a Van Veen grab modified with rubber flaps to reduce loss of surface fines during retrieval. Subsamples of the top 2 cm were taken by core and analyzed as described above, except that a few samples were analyzed by the EPA Newport laboratory for a limited number of priority pollutants only.

*These data are available on request.

LIST OF FIGURES

LIST OF TABLES

MILWAUKEE, PUYALLUP, ST. PAUL, MIDDLE WATERWAYS AND S.W. SHORE COMMENCEMENT BAY

General Observations

1. Based on the limited data presently available, neither Milwaukee nor Middle waterways appear to be major sites of contamination in Commencement Bay.

2. The chloroform load to St. Paul Waterway from the St. Regis paper mill effluent and the metals loads (As, Cu, and Zn) in ASARCO discharges to Commencement Bay are the largest point source loads of specific priority pollutants known to occur in Commencement Bay. There is evidence that both St. Regis and ASARCO are responsible for substantial pollution of their adjacent marine environments. Because of outfall location and tidal effects, the Tacoma Central STP effluent does not always rapidly disperse once discharged to the Puyallup River. Priority pollutants present in the STP effluent and detectable in the river near the outfall during episodes of poor dilution have generally not been detected in samples of water from the Puyallup River mouth on Commencement Bay 1-1/2 miles downstream of the STP.

MILWAUKEE WATERWAY

Refer to Data In:

Observations

1. There are no known discharges to Milwaukee Waterway.

2. Water column data are limited to one sample each from the inner and outer waterway collected in October 1980 by Dames & Moore (reference 4). Cu was measured at 5 and 8 µg/L, Zn at 10 and 31 µg/L. As, Cd, Cr, and PCBs were not detected.

3. Only two sediment samples -- one intertidal, the other subtidal -- have been collected in the waterway. Neither sample had high metals concentrations. Trace amounts of PAH compounds were the only organic priority pollutants detected in the intertidal sample. The subtidal sample contained .0059 mg/Kg hexachlorobenzene, .0036 mg/Kg hexachlorobutadiene, up to 1.2 mg/Kg of individual PAH compounds, .037 mg/Kg ΣDDT and .223 mg/Kg PCBs (all concentrations on a dry weight basis). These concentrations are typical of sediments in Commencement Bay waterways other than those in the most contaminated areas; i.e., Hylebos and City waterways. Table 39

Considerations for Future Work

1. A few more sediment samples, preferably cores, should be collected in Milwaukee Waterway to confirm that it is not a major site of contamination in Commencement Bay.

Refer to Data In:

Observations

1. USGS data on the Puyallup River at Puyallup (r.m. 5.7) and WDOE data on the river above the Tacoma Central STP (r.m. 1.7) indicate the river has low background concentrations of metals. Three river water samples have been collected immediately above the STP by WDOE and analyzed for organic priority pollutants. The only compound detected was 8 µg/L cyanide. — Table 32, Table 36

2. The results of WDOE's most recent Class II surveys at the Tacoma Central STP have been reported by Yake (reference 20) who makes the following observations:

   a. "The wide range of priority pollutants found in Tacoma Central's wastewaters is generally typical of municipal wastewaters. Likewise, the concentrations reported are generally typical. The primary exception to this generalization appears to be the chlorinated phenols which are present in substantially higher concentrations than those observed in wastewaters from other municipalities." — Table 32, Table 36

   b. "Although metals concentrations at Tacoma Central do not appear to be unusually high when compared to wastewaters from other major cities throughout the country, they are elevated when compared to sludge concentrations at most other Washington towns and cities. This is particularly true for chromium, cadmium, nickel, and lead. Arsenic is probably also elevated; however, data are not available for arsenic concentrations in other Washington State wastewaters and sludges. Effluent mercury concentrations measured during the low-flow survey are well above EPA receiving water criteria."

   c. "Effluent loads for metals and several other priority pollutants (cyanide, tetrachloroethylene, and the chlorinated phenols) were substantially higher during the storm flow sampling period. Elevation of metals in wastewaters during storm flows in cities with combined sewer systems has been previously documented."

   d. "Many of the priority pollutants detected were only detected in one or two of the three [sampling] periods. Concentrations often varied substantially from one sampling period to another. Because a large portion of Tacoma's wastewater flow is from industrial sources, the potential for slug loads of specific pollutants from spills, upsets, or batch processes is substantial. A continuing program of wastewater analysis would provide a much more comprehensive and complete knowledge of pollutant concentrations and effluent loadings."

   e. "Concentrations of priority pollutants in the effluent are generally low enough that they would not exceed EPA in-stream criteria for the protection of aquatic and marine life after the effluent is fully mixed with the Puyallup River/Estuary. Possible exceptions to this generalization may be mercury, cadmium, and lead. Factors which may hinder ideal dilution include the absence of an effluent diffuser and effluent pooling caused when low river flow and high tidal conditions coincide."

		Refer to Data In:
	f. "Based on data available, the primary treatment process employed at the Tacoma Central plant does not appear to be very effective in reducing priority pollutant concentrations in the wastewater stream. Available literature suggests that secondary treatment would be much more effective."	
3.	The Cleveland Street pump station effluent, about 1/3 mile upstream of the STP, was sampled once by WDOE during wet weather. 3.5 µg/L 1,2-dichlorobenzene and 8 µg/L cyanide were detected. Metals concentrations were slightly higher than in the Tacoma Central STP effluent sample collected during the same period.	Table 32 Table 36
4.	The STP effluent appears to account for a large percentage of the priority pollutants load to Commencement Bay, as measured in WDOE point source surveys. (A comparison of loads for Commencement Bay point sources will be included in the summary to this series of reports.	Table 33 Table 37
5.	During normal downstream flow, dilution generally reduces metal and organic priority pollutant concentrations in the Puyallup River to background or non-detectable levels. An increase in arsenic concentrations has been observed at the river mouth in some samples. This does not appear to be attributable to the STP effluent.	Table 32 Table 36
6.	Riley (reference 14) analyzed samples of water and suspended matter collected in July 1979 from the mouth of the Puyallup River. Trichloroethylene and tetrachloroethylene were detected at <.1 µg/L. Chlorodibromomethane and bromoform were tentatively identified at <.1 and <.2 µg/L, respectively. Samples of Puyallup River suspended matter had low concentrations of metals and PAH. Samples were not analyzed for chlorinated base/neutrals, acid extractables, or pesticides.	
7.	WDOE receiving environment surveys at the Tacoma Central STP (reference 9) showed that with sufficiently large flood tide and low river flow, slack water conditions occur at the STP outfall site causing pooling of the effluent. It was estimated that pooling equal or greater in magnitude to that observed during the survey would have been expected to occur on approximately 90 separate occasions during water year 1980. Water samples from within this effluent pool were the only river water samples collected during the surveys in which effluent organic priority pollutants were present at detectable concentrations and oyster larvae (*Crassostrea gigas*) and daphnid (*Daphnia pulex*) mortality or abnormality were observed during bioassays.	
8.	Priority pollutant analysis has been done on four samples of intertidal sediment and two samples of subtidal sediment from the lower Puyallup River. Sediment immediately below the STP outfall (station PI-2) had high concentrations of toluene and bis(2-ethylhexyl) phthalate, 7.9 and 3.1 mg/Kg, respectively. Sediment from the old St. Regis bleach crib	Table 39

Refer to
Data In:

had a relatively high PAH concentration and was acutely toxic in EPA amphipod bioassays (reference 17). Hexachlorobutadiene has not been detected in Puyallup River sediments.

Consideration for Future Work

1. Concentrations of priority pollutants in the Puyallup River appear to be generally low. In order to accurately estimate priority pollutant loads in the river, extremely sensitive (low detection level) analytical methods would be required for most pollutants.

2. Sediment from the St. Regis bleach plant crib and portions of the Puyallup River reach adjacent to the Tacoma STP outfall are localized areas of concern because of elevated levels of contaminants and toxic effects on bioassay organisms.

Refer to Data In:

Observations

1. The three major discharges to St. Paul Waterway are from the St. Regis paper mill, log yard, and sawmill operations. The paper mill effluent is the largest-volume industrial discharge to Commencement Bay.

2. A high concentration of Hg, 1.2 µg/L, was measured in the single sample WDOE has collected of the sawmill effluent. With this exception, metals concentrations in sawmill and log yard effluents were low (one sample each). — Table 32

3. A Cu concentration of 100 µg/L was measured in the St. Regis paper mill effluent during WDOE's most recent Class II inspection (reference 19). A net load of 30 lbs/day Cu, the largest metals load measured by WDOE for St. Paul Waterway, was calculated for this discharge. — Table 32, Table 33

4. Only a few organic priority pollutants, in trace amounts, were detected in the sawmill and log sort yard effluents. — Table 34

5. 1800 µg/L of chloroform was measured in the St. Regis paper mill effluent during the WDOE Class II survey. A chloroform load of 480 lbs/day was calculated for this discharge. This is the largest load of an organic priority pollutant known to occur in Commencement Bay. — Table 34, Table 35

   Receiving water samples (reference 8) collected during the Class II survey showed 420 µg/L chloroform in surface waters near the outfall and 8.1 µg/L chloroform in inner St. Paul Waterway. There are no EPA criteria for chloroform in marine waters. Some laboratory experiments (references 10 and 16) have demonstrated adverse effects on aquatic organisms at chloroform concentrations as low or lower than 420 µg/L.

6. Oyster larvae (*C. gigas*) bioassays (references 8 and 19) on the paper mill effluent and receiving waters showed both to be acutely toxic.

7. Three sediment samples have been analyzed from St. Paul Waterway. Metals concentrations were not high relative to other Commencement Bay waterways. High naphthalene concentrations (.72 - 3.0 mg/Kg) were characteristic of each St. Paul sediment sample. An extremely high phenol concentration of 91 mg/Kg was measured in the sample collected nearest the St. Regis outfall. 0.84 mg/Kg pentachlorophenol and traces of 2,4,6-trichlorophenol, chloroform, and toluene were also detected in this sample. Amphipod bioassays (reference 8) on the outfall and innermost waterway sediment samples showed both to be toxic. — Table 39

Considerations for Future Work

1. The following concerns appear worth additional study:

Refer to Data In:

a. The persistence of chloroform in the waters off St. Regis and its effect on salmonids and other pelagic organisms;

b. Areal extent and degree of toxicity of sediments adjacent to St. Regis;

c. Verification of high concentrations of phenol and naphthalene in St. Paul Waterway sediments; and

d. The quantification and environmental fate of chlorinated resin acids, guaicols, propenes, and other potentially toxic or mutagenic compounds which may be present in the St. Regis effluent.

MIDDLE WATERWAY

Refer to Data In:

Observations

1. The major discharge to Middle Waterway is the storm drain at the head of the waterway. Only one water sample has been collected here. Metals concentrations were low except for 990 µg/L of Zn. The flow rate from the drain, however, was only 0.01 MGD, resulting in a Zn load to the waterway of .08 lbs/day. — Table 32, Table 33, Table 34

   Detection limits for the organic priority pollutants analysis of this sample were high. Chloroform and cyanide were measured at <10 µg/L and 5 µg/L, respectively.

2. Dames & Moore (reference 4) was unable to detect As, Cu, Cd, Cr, Pb, or PCBs in a water column sample collected in October 1980. Zn was measured at 9 µg/L.

3. One intertidal sample and one subtidal sample have been taken of Middle Waterway sediment. A third sample (subtidal) has also been taken outside the waterway entrance. The subtidal sample from within the waterway had high Cu, Hg, Pb, and Zn concentrations (486, 2.2, 230, and 353 mg/Kg, respectively) compared to the data on most other Commencement Bay sediments. High metals concentrations were not reported in the other two samples. — Table 39

4. Results of organic priority pollutant analyses of Middle Waterway sediments compare closely to the findings discussed earlier in this report for Milwaukee Waterway sediments. — Table 39

Considerations for Future Work

1. The available data indicate Middle Waterway, like Milwaukee Waterway, is not a major site of contamination for organic priority pollutants. More data are needed on metals in the sediments and in the drain at the head of the waterway.

Refer to Data In:

Observations

1. Relatively few samples have been collected in this part of Commencement Bay.

2. Metals data on the Old Tacoma storm drain and Ruston STP effluent indicate these are not major sources of metals to the bay. Chloroform and cyanide at <10 µg/L and 5 µg/L, respectively, were the only compounds detected in the storm drain. A variety of organic priority pollutants were detected in the Ruston STP effluent. The types and concentrations of compounds found are not unusual for municipal wastewaters. — Table 32, Table 34

3. There is little usable data on intertidal or nearshore sediments between City Waterway and the ASARCO smelter. One intertidal sample near the Ruston outfall has been analyzed for priority pollutants. Concentrations were low, but weak acid digestion was used for the metals analyses and detection limits were high in the base/neutral and volatiles analyses. — Table 39

4. Extremely high concentrations of As, Cu, and Zn (2000 - 8900 µg/L) were measured in ASARCO's south and middle outfalls during WDOE's most recent Class II inspection (reference 7). Concentrations were one to two orders of magnitude lower in the north outfall. Considerable dilution (up to 1649:1 for Cu) would be required to bring these effluent metals concentrations within EPA criteria for protection of marine life. The ASARCO discharges constitute the largest known point source metals loads to Commencement Bay. These loading data have not been corrected for the concentrations of metals in the intake water.

5. Although several investigators report metals concentrations for ASARCO receiving waters, a comprehensive study has not been performed. Tatomer (reference 18) reported up to 42.6 µg/L Cu in surface water samples collected adjacent to the smelter in 1972. More recently, Battelle researchers (references 6 and 15) measured Cu in surface water samples from seven sites in Commencement Bay along the ASARCO shoreline (sampled August 19, 1982) and two sites in the yacht basin behind the slag pile (sampled January-September 1982). Copper (total Cu, unfiltered samples) ranged from 0.1 to 7.0 µg/L in the seven bay samples. Variable concentrations of Cu -- some extremely high -- were found within the yacht basin. The results from nine samples are reported; eight from the basin entrance and one at the far end of the basin. Cu concentrations ranged from 3 to 1200 µg/L at the entrance. The median Cu concentration was 28 µg/L. 4 µg/L Cu was measured in the single sample from within the basin. Zn, Cd, Hg, and Ag were one to two orders of magnitude above concentrations measured at the study's control station (Sequim Bay) in the six basin samples analyzed for these metals.

   One other source of data on the nearshore receiving waters is from samples collected by Dames & Moore (reference 4). These data, however, were

Refer to Data In:

collected during a strike at ASARCO, so metals loads were at a minimum. A composite of surface, middle, and bottom waters taken in October had 5 µg/L Cu. A discrete surface sample collected in December had no detectable Cu. As was not detected in the Dames & Moore samples.

Carpenter (reference 1) conducted a comprehensive survey of As in Puget Sound waters. He found uniform As concentrations everywhere in Puget Sound except "within a few kilometers of the smelter". Fifty surface water samples north of the smelter in the channel between the mainland and Vashon Island averaged 2.2 µg/L As compared to 1.5 to 1.7 µg/L As everywhere north of Seattle.

6. Data on metals in ASARCO nearshore sediments are limited to a single WDOE intertidal sample which had high As, Zn, and Cu concentrations -- 280, 300, and 900 mg/Kg, respectively. Table 39

   There are considerable data available on metals in Commencement Bay deepwater sediments, but this is outside the area addressed in this report. Those samples nearest ASARCO were collected at depths of about 60 meters by Crecelius (reference 3) and Malins (references 11 and 12). Crecelius analyzed three samples and found 980 to 10,000 mg/Kg As and similar amounts of Sb. He did not test for other priority pollutant metals. Malins does not report As data for the NOAA station nearest ASARCO (station number 10-09036). 126 mg/Kg Cu and 140 mg/Kg Zn were measured in samples collected at this site in 1979.

7. EPA (reference 5) and WDOE (reference 7) analyses on tissue from demersal fish and from mussels indicate specimens collected near ASARCO have higher metals concentrations than in other parts of Commencement Bay and Puget Sound.

8. Organic priority pollutant analyses have been conducted on the south outfall only. One sample, a grab, was collected by WDOE on August 15, 1982 and analyzed for base/neutrals at the EPA Manchester laboratory. 7.2 µg/L bis(2-ethylhexyl) phthalate was detected.

9. The toxicity of the ASARCO receiving environment to marine life has not been closely investigated. Chapman (reference 2) recently conducted bioassays on two sediment samples collected off the ASARCO facility. His report states that the metals in these samples are "probably refractory and not toxic."

Considerations for Future Work

1. More study is required at ASARCO. The slag processing operation next to the smelter should be included in future survey work. Among the types of studies suggested are:

   a. Determine net metals loads for ASARCO discharges.

Refer to
Data In:

b. Measure metals concentrations in the receiving waters and assess their toxicity.

c. Determine the availability of metals in sediments near ASARCO to marine organisms. Determine if these sediments are toxic.

d. Analyze ASARCO discharges for organic priority pollutants.

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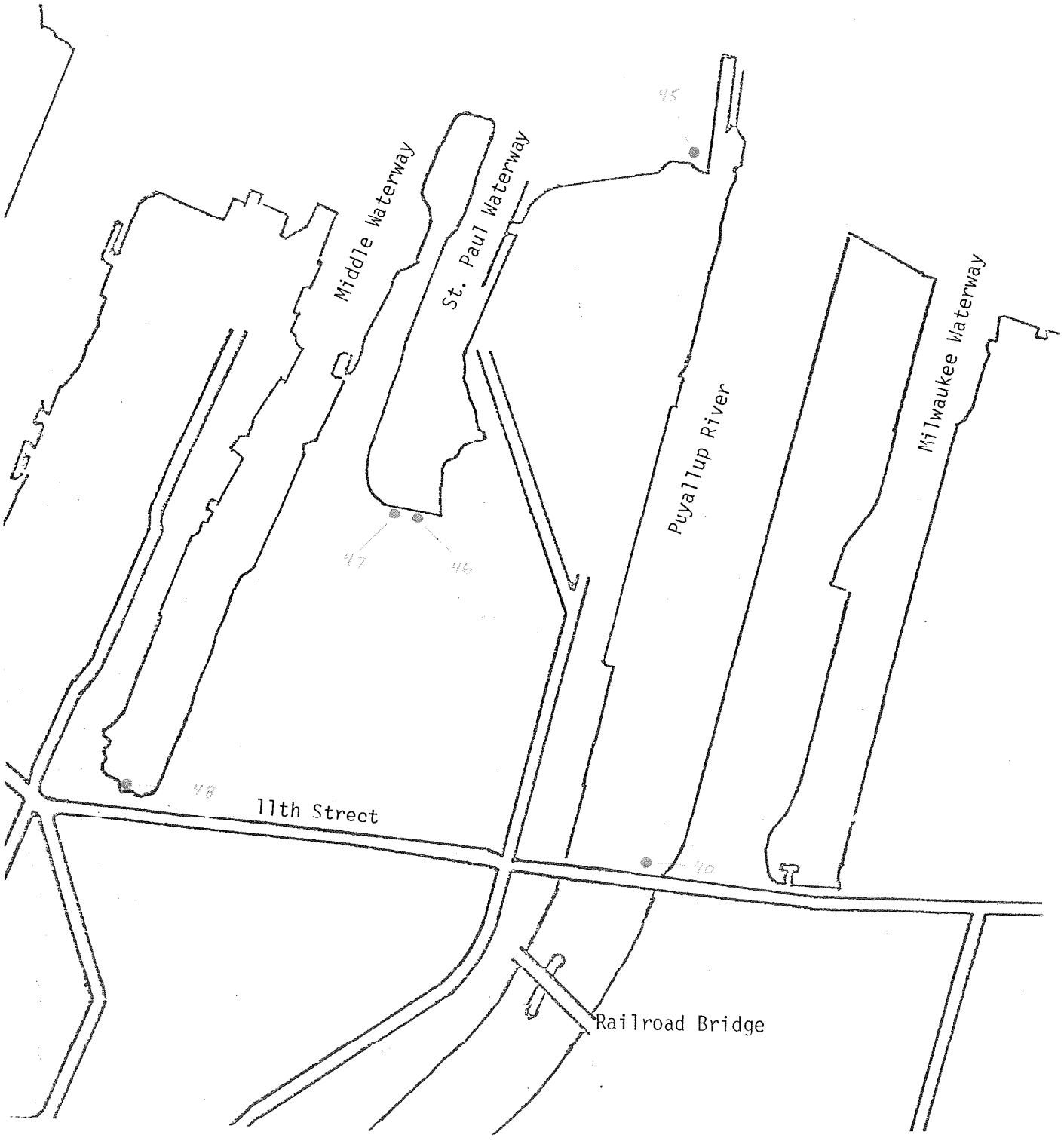

Figure 19a. Puyallup, St. Paul, and Middle Waterways: Point Source Samples.

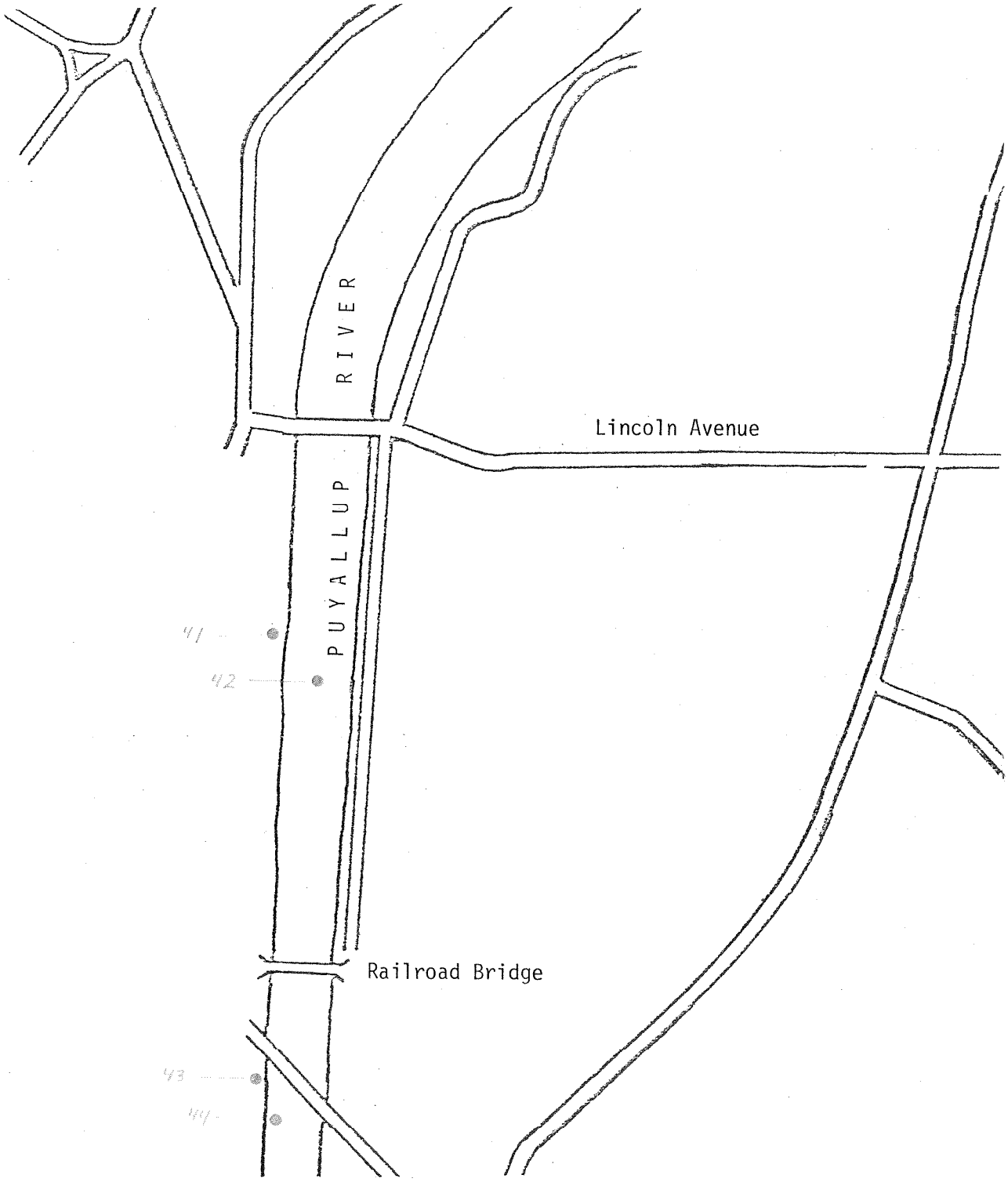

Figure 19b. Puyallup River: Point Source Samples.

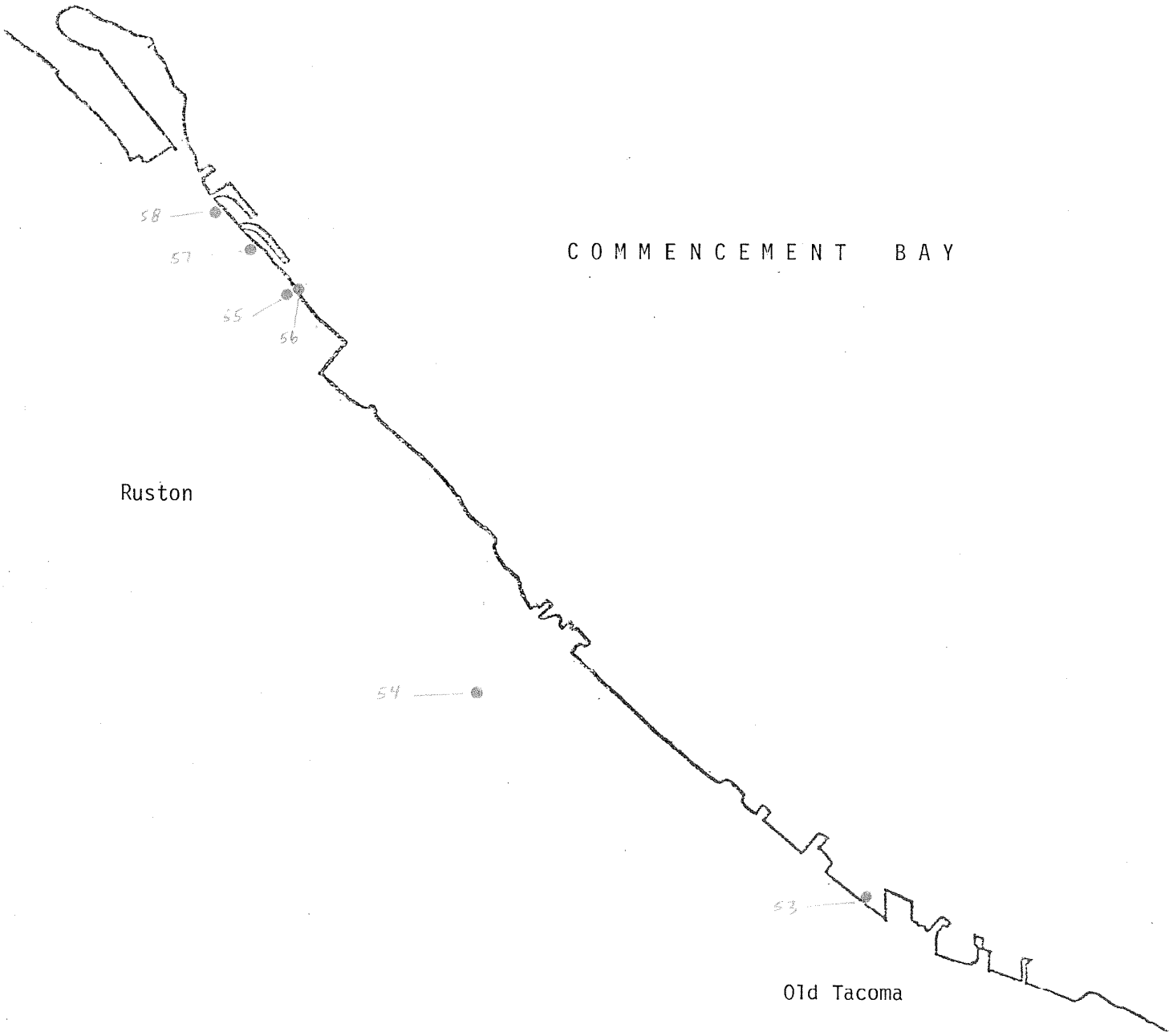

Figure 19c. S.W. Shore Commencement Bay: Point Source Samples.

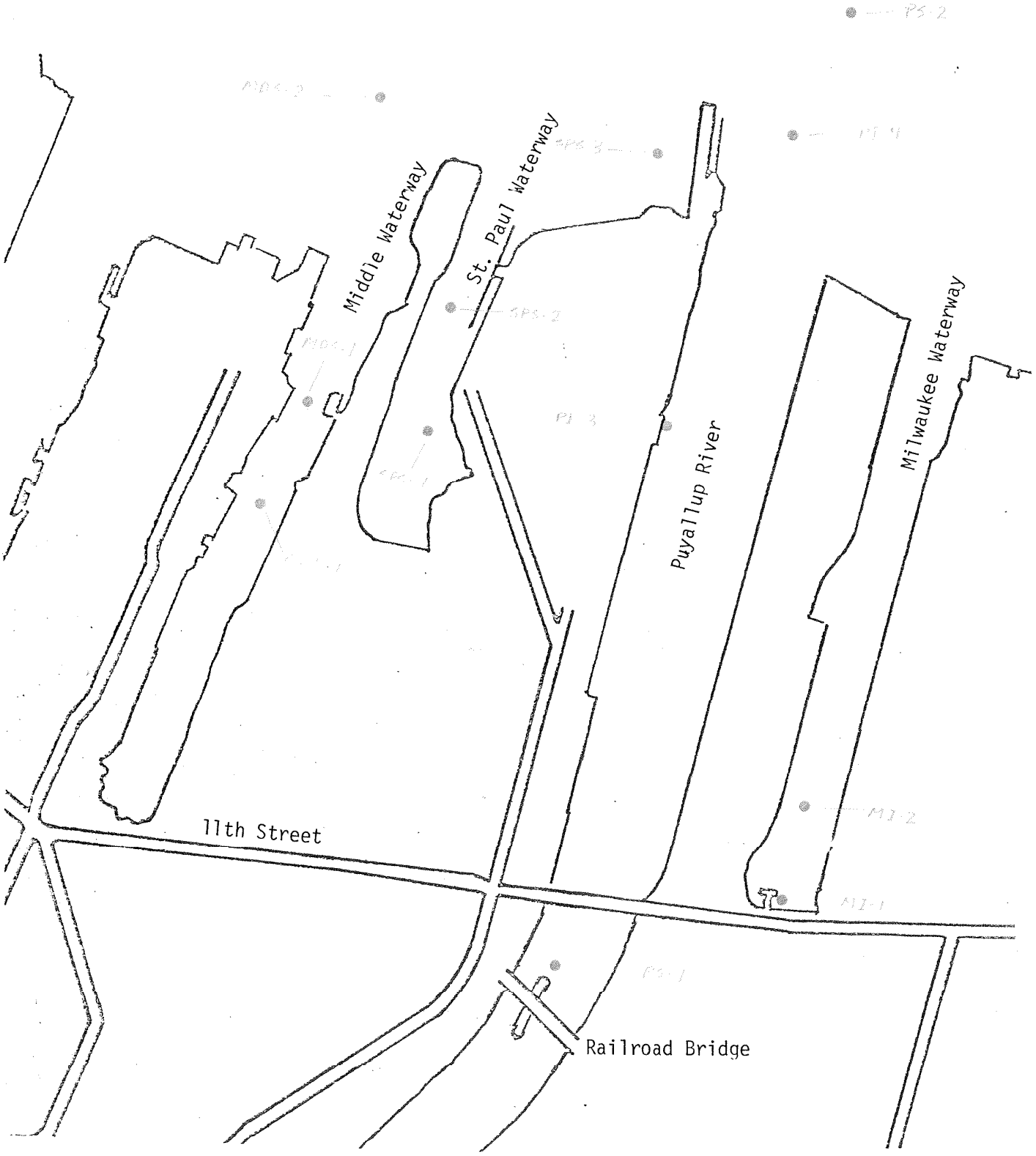

Figure 20a. Milwaukee, Puyallup, St. Paul, and Middle Waterways: Sediment Samples.

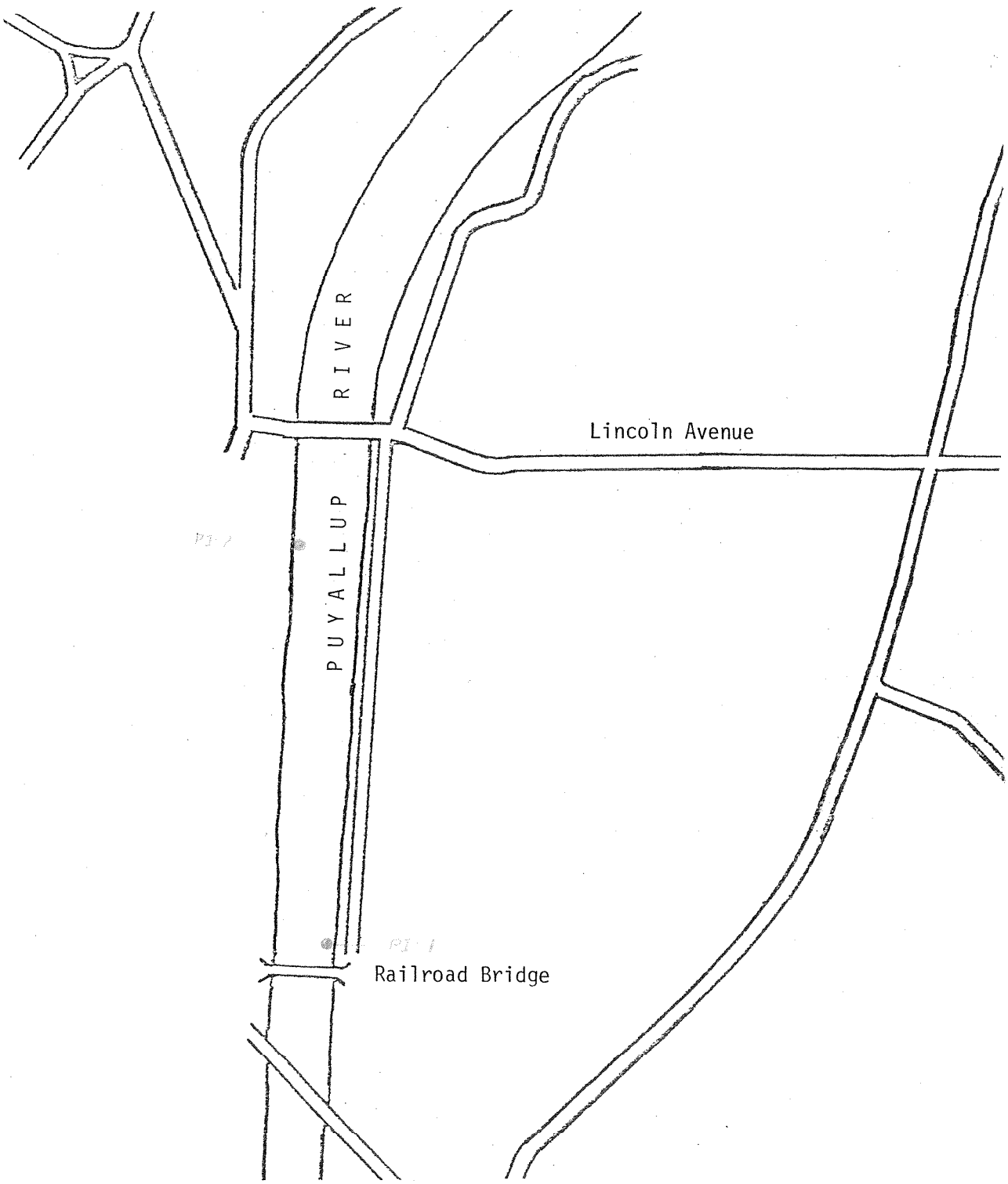

Figure 20b. Puyallup River: Sediment Samples.

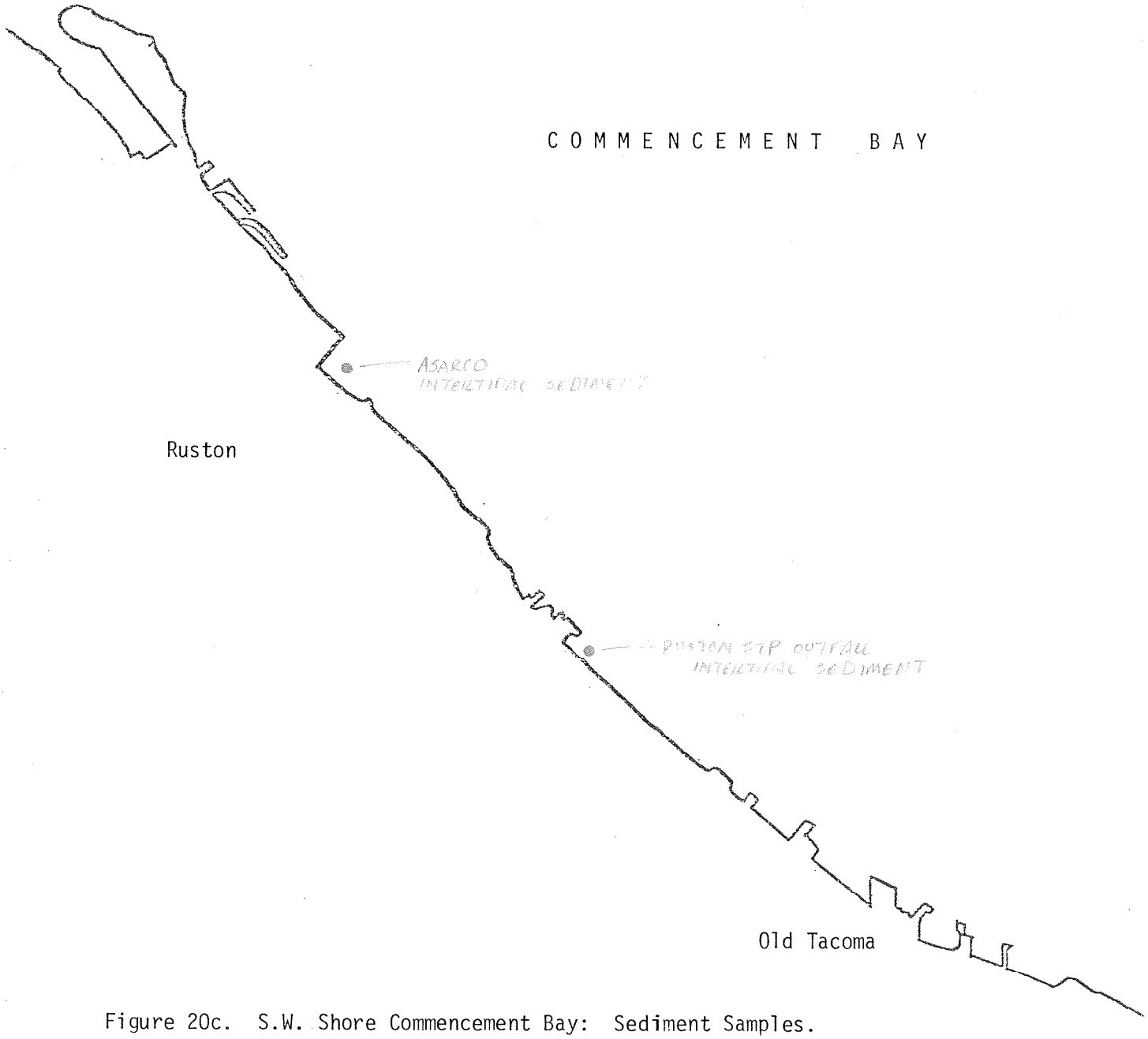

Figure 20c. S.W. Shore Commencement Bay: Sediment Samples.

Table 32. Trace metal concentrations in discharges to the Puyallup River, St. Paul and Middle Waterways and S.W. Commencement Bay (ug/L, total metal).

Discharge	Date Sampled	Time Sampled	Investigator	Station No.	Flow (MGD)	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Puyallup River													
Puyallup River at Puyallup[1]	Jan-May, 1978-1982		USGS		2,264	2	.8	7	9	.1	5	8	19
" " " "	July-Nov, 1978-1982		USGS		1,374	2	.5	8	15	.07	8	17	26
River above Pump Station	2/16/82	1300-1715	WDOE	44	12,210	2	<5	20	20	<.20	<5	4	30
Cleveland Street Pump Station	2/16/82	1300-1600	WDOE	43	51	32	<5	<20	220	<.20	9	200	220
River above STP	7/28/81	0930-1400	WDOE	42	1,650	18	10	<2	10	.24	<1	<100	30
" " "	8/25/81	0745-1000	WDOE	42	1,160	4	<5	<10	<10		<10	<20	28
Central STP Effluent	7/28/81	0900-1400	WDOE	41	(17)	<1	10	57	50	<.20	39	<100	150
" " "	8/25-26/81	0940-0940	WDOE	41	16.5	12	2.0	76	53	.63	59	39	340
" " "	2/16-17/82	1230-1230	WDOE	41	71.7	23	1	<10	50	<.20	170	80	130
River Mouth	7/28/81	0800-1200	WDOE	40	1670	28	10	<2	9	<.20	<1	<100	15
" "	8/25/81	0630-0830	WDOE	39	1,170	11	<5	<10	20	<.20	<10	<20	15
" "	2/16/82	1400-1730	WDOE	40	12,330	5	<5	<20	20	<.20	8	4	50
St. Paul Waterway													
St. Regis Paper Co. Final Eff.	8/11-12/81	0930-0930	WDOE	45	32.2	16	<10	20	100	<.2	<50	<100	53
St. Regis Log Sort Yard Effluent	9/14/81	0930-1330	WDOE	46	.232	2	<1	<3	10	.21	11	6	65
St. Regis Sawmill Effluent	9/14/81	0930-1330	WDOE	47	.116	10	2	<3	10	1.2	<3	2	25
Middle Waterway													
Drain at Head of Waterway	4/28/82	1230-1500	WDOE	48	.010	25	2	<10	30	<.2	<20	<20	990
Southwest Shore Commencement Bay													
Old Tacoma Storm Drain	9/14/81	1030-1355	WDOE	53	.64	2	<1	5	<10	.43	<3	<2	20
" " " "	4/28/82	1415-1630	WDOE	53	1.18	5	2	<10	10	.26	<20	<20	62
Ruston STP Effluent	9/14/81	0955-1330	WDOE	54	4.8	32	<1	10	65	.36	<3	6	380
" " "	4/28/82	1545	WDOE	54	5.8*	21	5	<10	50	.39	<20	<20	250
ASARCO													
South Outfall (into disp. pond)	2/24-25/81	24 hr. comp	WDOE	55	4.32	8900	250	<20	6600		170	140	3500
Dispersion Pond Seepage	2/24/81	1115	WDOE	56		6100	150	~20	4500		190	70	2000
Middle Outfall	2/24-25/81	24 hr. comp	WDOE	57	1.02	5500	70	<10	3600		<50	270	2000
North Outfall	2/24-25/81	24 hr. comp	WDOE	58	.32	150	<5	21	700		<50	80	75

[1] USGS NASQAN station 12101500 (means for period indicated)

* = Average April flow 1979-1982

( ) = Estimated

Table 33. Trace metal loads to the Puyallup River, St. Paul and Middle Waterways and S.W. Commencement Bay (pounds/day).

Discharge	Date Sampled	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Puyallup River									
Puyallup R. at Puyallup	Jan-May, 1978-1982	29	15	130	170	2	100	140	420
" " "	July-Nov, 1978-1982	25	6	98	170	.8	76	150	290
River above Pump Station	2/16/82	--	--	--	2,000	--	--	410	3,600
Cleveland Street Pump Station	2/16/82	14	--	--	94	--	3.8	85	94
River above STP	7/28/81	250	140	--	140	3.3	--	--	410
" " "	8/25/81	39	--	--	--		--	--	270
Central STP Effluent	7/28/81	--	(1.4)	(8.1)	(7.1)	--	(5.5)	--	(21)
" " "	8/25-26/81	1.7	1.4	11	7.3	.087	8.1	5.4	47
" " "	2/16-17/82	14	0.6	--	30	--	102	48	78
River Mouth	7/28/81	390	140	--	130	--	--	--	210
" "	8/25/81	110	--	--	200	--	--	--	150
" "	2/16/82	510	--	--	2,100	--	820	410	5,100
St. Paul Waterway									
St. Regis Paper Co. Effluent	8/11-12/81	4.3	--	5.4	30	--	--	--	14
St. Regis Log Sort Yard Effluent	9/14/81	.0039	--	--	.019	.0004	.021	.012	.13
St. Regis Sawmill Effluent	9/14/81	.0097	.0019	--	.0097	.012	--	.0019	.024
Middle Waterway									
Drain at Head of Waterway	4/28/82	.0021	.0002	--	.0025	--	--	--	.080
Southwest Shore Commencement Bay									
Old Tacoma Storm Drain	9/14/81	.011	--	.027	--	.0023	--	--	.11
" " " "	4/28/82	.049	.020	--	.098	.0026	--	--	.61
Ruston STP Effluent	9/14/81	1.3	--	.40	2.6	.014	--	.24	15
" " "	4/28/82	(1.0)	(.24)	--	(2.4)	(.019)	--	--	(12)
ASARCO[a]									
South Outfall	2/24-25/81	320	9.0	--	238		6.1	5.0	126
Middle Outfall	2/24-25/81	47	.6	--	31		--	2.3	17
North Outfall	2/24-25/81	.4	--	.1	1.9		--	.2	.2

( ) = Calculated using an estimated flow
a = Gross metal loads, influent metals concentrations not measured
-- = Load not calculated for "less than" (<) concentrations

Table 36. Organic Priority Pollutant Concentrations in the Puyallup River and Associated Discharges (µg/L).

Discharge	River above Pump Station	Cleveland Street Pump Station	River above Central STP		Central STP Effluent				River Mouth	
Date Sampled	2/16/82	2/16/82	7/28/81	8/25/81	7/28/81	8/25-26/81	2/16-17/82	7/28/81	8/25/81	2/16/82
Time Sampled	1300-1715	1300-1600	0930-1400	0745-1000	0900-1400	0940-0940	1230-1230	0800-1200	0630-0830	1400-1730
Investigator	WDOE	WDOE	WDOE	WDOE	WDOE	WDOE	WDOE	WDOE	WDOE	WDOE
Sample Number	J0438	J0439	30171		30123	27J-11	J0432	30119		J0440
Station Number	44	43	42			41		40	39	40
Flow (MGD)	12,210	51	1,650	1,160	(17)	16.5	71.7	1,650+	1,170	12,330
Volatiles										
chloroform	--	--	--	--	18	16	8	12	--	--
dichlorobromomethane	--	--	--	--	3.2	--	--	--	--	--
1,1 dichloroethane	--	--	--	--	--	1.1	--	--	--	
1,1,1-trichloroethane	--	--	--	--	--	1.1	1	--	--	--
trichloroethylene	--	--	--	--	--	10	--	--	--	--
tetrachloroethylene	--	--	--	--	2.6	2.3	110	--	--	--
toluene	--	--	--	--	10	--	8	--	--	--
benzene	--	--	--	--	63	--	3	--	--	--
ethyl benzene	--	--	--	--	2	--	--	--	--	--
Base/Neutrals										
naphthalene	--	--	--	--	2.5	4.5	4.9	--	--	--
anthracene/phenanthrene	--	--	--	--	0.7	--	--	--	--	--
1,2-dichlorobenzene	--	3.5	--	--	--	5.6	--	--	--	--
1,3-dichlorobenzene	--	--	--	--	3.6	--	--	--	--	--
1,4-dichlorobenzene	--	--	--	--	--	3.3	--	--	--	--
bis(2-ethylhexyl) phthalate	--	--	--	--	17	25	--	--	--	--
butylbenzyl phthalate	--	--	--	--	21	--	--	--	--	--
di-n-octyl phthalate	--	--	--	--	--	2.1	--	--	--	--
Acid Extractables										
phenol	--	--	--	--	27	34	18			
2,4-dimethylphenol	--	--	--	--	5.1	3.9	--	--	--	--
2-chlorophenol	--	--	--	--	--	8.2	5.7	--	--	--
2,4-dichlorophenol	--	--	--	--	--	4.5	8.5	--	--	--
2,4,6-trichlorophenol	--	--	--	--	--	5.3	11	--	--	--
pentachlorophenol	--	--	--	--	<40	--	24	--	--	--
Pesticides										
Δ-BHC	--	--	--	--	--	--	0.1	--	--	--
Miscellaneous										
cyanide	8	8	--	--	--	18	85	5	--	5

( ) = Estimated
-- = Not detected

Table 34. Organic Priority Pollutant Concentrations in Discharges to St. Paul and Middle Waterways and S.W. Commencement Bay (ug/l).

	St. Paul Waterway			Middle Waterway	S.W. Shore Commencement Bay			
		St. Regis Log Sort Yard						
Discharge	Papermill Effluent	Effluent	Sawmill Effluent	Drain at Head of Waterway	Old Tacoma Storm Drain		Ruston STP Effluent	
Date Sampled	8/11-12/81	9/14/81	9/14/81	4/28/82	9/14/81	4/29/82	9/14/81	4/29/82
Time Sampled	0930-0930	0930-1330	0930-1330	1230-1500	1030-1355	1415-1630	0955-1330	1545-1600
Investigator	WDOE	WDOE	WDOE	WDOE	WDOE	WDOE	WDOE	WDOE
Sample Number		35704	30705	J0479	35720	J0477	35700	J0476
Station Number	45	46	47	48	53		54	
Flow (MGD)	32.2	.232	.116	.010	.64	1.18	4.8	5.8*
Volatiles								
chloroform	1800	--	--	<10	--	<10	--	<10
dichlorobromomethane	7.0	--	--	a	--	a	--	<10
chlorodibromomethane	--	--	--	a	--	a	--	<10
trichlorofluoromethane	--	--	--	a	--	a	--	a
1,1,1-trichloroethane	--	--	--	a	--	a	--	a
trichloroethylene	--	--	--	a	--	a	--	a
tetrachloroethylene	--	--	--	a	--	a	9.7	<10
1,1,2,2-tetrachloroethane	--	2	--	a	--	a	--	a
toluene	3.0	--	--	a	--	a	--	<10
Base/Neutrals								
naphthalene	4.4	0.4	--	a	--	a	5	a
anthracene/phenanthrene	--	--	--	a	--	a	--	a
1,3-dichlorobenzene	--	--	--	a	--	a	2	a
butylbenzyl phthalate	--	--	4	a	--	a	44	a
di-n-octyl phthalate	--	--	--	a	--	a	27	a
Acid Extractables								
phenol	--	--	--	a	--	a	--	<10
pentachlorophenol	--	--	--	a	--	a	--	a
Pesticides								
γ-BHC	--	--	--	--	--	--	--	.040
Miscellaneous								
cyanide				5	--	5	12	88

* = Average April flow 1979-1982
-- = Not detected
a = Not detected, but detection limit high relative to other analyses

Table 35. Organic Priority Pollutant Loads to St. Paul and Middle Waterways and S.W. Commencement Bay (pounds/day).

	St. Paul Waterway			Middle Waterway	S.W. Shore Commencement Bay			
		St. Regis						
Discharge	Papermill Effluent	Log Sort Yard Effluent	Sawmill Effluent	Drain at Head of Waterway	Old Tacoma Storm Drain		Ruston STP	
Date Sampled	8/11-12/81	9/14/81	9/14/81	4/28/82	9/14/81	4/28/82	9/14/81	4/28/82
Volatiles								
chloroform	480	--	--	.0004*	--	.049*	--	(.24)*
dichlorobromomethane	1.9	--	--	--	--	--	--	(.24)*
chlorodibromomethane	--	--	--	--	--	--	--	(.24)*
trichlorofluoromethane	--	--	--	--	--	--	--	--
1,1,1-trichloroethane	--	--	--	--	--	--	--	--
trichloroethylene	--	--	--	--	--	--	--	--
tetrachloroethylene	--	--	--	--	--	--	.39	(.24)*
1,1,2,2-tetrachloroethane	--	.0039	--	--	--	--	--	--
toluene	.81	--	--	--	--	--	--	(.24)*
Base/Neutrals								
naphthalene	1.2	.0008	--	--	--	--	.20	--
anthracene/phenanthrene	--	--	--	--	--	--	--	--
1,3-dichlorobenzene	--	--	--	--	--	--	.080	--
butylbenzyl phthalate	--	--	.0039	--	--	--	1.8	--
di-n-octyl phthalate	--	--	--	--	--	--	1.1	--
Acid Extractables								
phenol	--	--	--	--	--	--	--	(.24)*
pentachlorophenol	--	--	--	--	--	--	--	--
Pesticides								
γ-BHC	--	--	--	--	--	--	--	(.0019)
Miscellaneous								
cyanide				.0004	--	.049	.48	(4.3)

( ) = Calculated using an estimated flow
* = Calculated using 1/2 quantification limit
-- = Not detected

Table 37. Organic Priority Pollutants Loads to the Puyallup River from the Central STP and Cleveland Street Pump Station (pounds/day).

Discharge	Central STP			Cleveland Street Pump Station
Date Sampled	7/28/81	8/25-26/81	2/16-17/82	2/16/82
Volatiles				
chloroform	(2.6)	2.2	4.7	--
dichlorobromomethane	(.45)	--	--	--
1,1-dichloroethane	--	.15	--	--
1,1,1-trichloroethane	--	.15	.6	--
trichloroethylene	(.62)	1.4	--	--
tetrachloroethylene	(.37)	.32	66	--
toluene	(1.4)	--	4.7	--
benzene	(8.9)	--	1.8	--
ethylbenzene	(.28)	--	--	--
Base/Neutrals				
naphthalene	(.35)	.62	2.9	--
anthracene/phenanthrene	(.10)	--	--	--
1,2-dichlorobenzene	--	.45	--	1.5
1,3-dichlorobenzene	(.51)	--	--	--
1,4-dichlorobenzene	--	.77	--	--
bis(2-ethylhexyl) phthalate	(2.4)	3.4	--	--
di-n-octyl phthalate	--	.29	--	--
butylbenzyl phthalate	(3.0)	--	--	--
Acid Extractables				
phenol	(3.8)	4.7	11	--
2,4-dimethylphenol	(.72)	.54	--	--
2-chlorophenol	--	1.1	3.4	--
2,4-dichlorophenol	--	.62	5.0	--
2,4,6-trichlorophenol	--	.73	6.6	--
pentachlorophenol	(2.8)*	--	14	--
Pesticides				
Δ-BHC	--	--	.060	--
Miscellaneous				
cyanide	--	2.5	51	--

( ) = Calculated using an estimated flow
-- = Not detected
* = Calculated using 1/2 quantification limit

Table 38. Sediment Sites: Milwaukee, Puyallup, St. Paul, and Middle Waterways and the Ruston Shoreline.

Station Code	Original Agency Code	Collector	Analysis by	Location Name	Latitude (47°)	Longitude (122°)	Date Collected
			Milwaukee Waterway				
MI-1	I-8	DOE	EPA/DOE[b]	Head of Milwaukee Waterway	15' 45"	24' 53"	7/30/81
MS-1	16-09044	NOAA	NCAA[g]	"	15' 49"	24' 58"	1980
			Puyallup Waterway				
PI-1		DOE	EPA/DOE	Above Central STP	14' 55"	24' 18"	8/25/81
PI-2		DOE	EPA/DOE	Below "	14' 55"	24' 43"	8/25/81
PI-3	I-40	DOE	EPA/DOE	St. Regis Old Bleach Crib	15' 57"	25' 28"	8/11/81
PI-4		DOE	EPA/DOE	River Mouth	16' 15"	25' 35"	8/25/81
PS-1	17-09045	NOAA	NCAA	Below Railroad Bridge	15' 33"	25' 01"	1981
PS-2	A-3	EPA	EPA/New[c]	Off River Mouth	16' 22"	25' 44"	5/13/81
			St. Paul Waterway				
SPS-1	I-39	DOE	EPA/DOE	Inner St. Paul Waterway	15' 48"	25' 39"	8/11/81
SPS-2	18-09046	NOAA	NCAA	St. Paul Waterway Entrance	15' 53"	25' 46"	1980
SPS-3	I-38	DOE	EPA/DOE	St. Regis Outfall Boom	16' 07"	25' 42"	8/11/81
			Middle Waterway				
MDI-1	I-6	DOE	EPA/DOE	Middle Waterway off Building #21	15' 38"	25' 45"	7/30/81
MDS-1	19-09047	NOAA	NCAA	Middle Waterway Entrance	15' 44"	25' 49"	1980
MDS-2	A-2	EPA	EPA-New	Off Middle Waterway Entrance	15' 58"	26' 02"	5/13/81
			Ruston Shoreline				
Ruston STP	I-3	DOE	EPA-Con	Inshore of Ruston STP Outfall	17' 11"	29' 09"	7/31/81
ASARCO	I-2	DOE	DCE	Adjacent to ASARCO Property	17' 43"	29' 51"	7/31/81

[b]USEPA - contract laboratory (organics), WDOE - Tumwater laboratory (metals)

[c]USEPA (Schwartz)

[g]NOAA (Malins, *et al.*), OMPA-2, etc.

Table 39. Sediment Data: Milwaukee, Puyallup, St. Paul, and Middle Waterways and Ruston Shoreline (mg/Kg, dry weight).

	Milwaukee Waterway		Puyallup Waterway						St. Paul Waterway			Middle Waterway			Ruston Shoreline	
	Intertidal	Subtidal	Intertidal				Subtidal		Subtidal			Intertidal	Subtidal		Intertidal	
Station Code	MI-1	MS-1	PI-1	PI-2	PI-3	PI-4	PS-1	PS-2	SPS-1	SPS-2	SPS-3	MDI-1	MDS-1	MDS-2	Ruston STP	ASARCO
Agency Responsible for Analysis	EPA/DOE	NOAA	EPA/DOE	EPA/DOE	EPA/DOE	EPA/DOE	NOAA	EPA-New	EPA/DOE	NOAA	EPA/DOE	EPA/DOE	NOAA	EPA-New	EPA-Con	DOE
Original Agency Code	I-3	16-09044	P-4	P-3	I-40	P-2	10-09045	A-3	I-3S	18-09046	I-38	I-6	19-09047	A-2	I-3	I-2
Miles from Head of Waterway	0.30	.11	2.03**	1.61**	.31**	0.00**	.88**		.11	.24	.46	.35	.46	.79		
Year Collected	1981	1980	1981	1981	1981	1981	1981	1981	1981	1980	1981	1981	1980	1981	1981	1981
Percent Solids	50	41.1	30.5	35.3	41.4	23.9	76	68.1	26.9	33.2	13.2	68	43.0	49.7	82.2	69
Metals																
As	37	29.2	9.4	8.0	23	5.4	1.6	16	40	9.0	21	22	70	37	[1.8]	280
Cd	.92	2.7	.19	.56	1.2	.17	<.10	.14	3	2.8	2.2	.44	3.6	.64	[<.1]	1.6
Cr	17	23.6	4.6	7.9	25	3.8	12	7.5	28	20.5	25	13	27.2	17.5	[1.7]	19
Cu	97	120	20	28	180	16	15	16	170	105	160	76	486	102	[<5]	900
Hg	.13	.10	.89	.28	.35	.090	.02		.47	.15	.080	.67	2.2		[<.02]	.04
Ni	14		9.7	12	41	8.1			22		25	10			[6.7]	39
Pb	120	109	5.8	12	100	3.4	<1.5	4	100	53.6	70	75	230	43	[2.6]	230
Sb	4.2											3.2				6.0
Zn	170	214	14	42	120	13	23	3	200	114	100	64	353	81	[85]	300
Volatiles																
chloroform	--		--	--	--	--			--		T	--			a	
toluene	--		--	7.9	T	--			--		T	--			a	
Base/Neutrals																
hexachlorobenzene	--	.0059	--	--	--	--	.00014	--	--	.019	--	--	.0048	--	a	
hexachlorobutadiene	--	.0036	--	--	--	--	--	--	--	.0062	--	--	.0029	--	a	
naphthalene	--	.420	--	--	2.1	--	.0079	.94	3.0	1.4	.72	--	.510	.536	a	
acenaphthene	--	.099	--	--	.29	--	.00047		T	.19	--	--	.140		a	
acenaphthylene	--	.075	--	--	--	--			--	.21	--	--	.083		a	
anthracene/phenanthrene	T	.380	--	--	1.1	--	.039	.053	.82	.941	.64	--	.530	.264	a	
fluorene	--	.120	--	--	.31	--	.0043	--	T	.27	--	--	.160	T	a	
pyrene	T	.99	--	--	1.09	--	.010	T	.97	.95	--	T	1.6	1.57*	a	
chrysene/benzo(a)anthracene	--	1.25	--	--	.29	--	.018	--	T	.77	--	--	1.2	.171	a	
fluoranthene	.25	1.2	--	--	1.35	--	.012	--	1.15	1.2	--	T	1.3		a	
dibenzo(a,h)anthracene	--		--	--	--	--			--		--	--			a	
benzo(a)pyrene	T	.24	--	--	--	--	.0046		--	.021	--	T	.26		a	
benzo(k)fluoranthene/ 3,4-benzofluoranthene	T	.61+	--	--	--	--			--	.081+	--	T	.54+		a	
benzo(g,h,i)perylene	--		--	--	--	--			--		--	--			a	
ideno(1,2,3-cd)pyrene	--	.150	--	--	--	--			--	.0091	--	--	.140		a	
di-methyl phthalate	--		--	--	--	--		--	--		--	--		--	a	
di-ethyl phthalate	--		--	--	--	--		--	--		--	--		--	a	
di-n-butyl phthalate	--		T	--	--	T		--	--		--	--		.163	a	
di-n-octyl phthalate	--		--	T	1.35	--		3.33	--		--	--		.372	a	
bis(2-ethylhexyl) phthalate	--		--	3.1	--	--		.38	--		--	T		.429	a	
butylbenzyl phthalate	--		--	--	--	--		--	--		--	--		--	a	
Acid Extractables																
phenol	--		T	.31	1.2	T			1.6		91	--			a	
2,4,6-trichlorophenol	--		--	--	--	--			--		T	--			a	
pentachlorophenol	--		--	--	--	--			--		.84	--			a	
Pesticides and PCBs																
4,4'-DDT	--	.015	--	--	--	--	.00002	--	--	.0028	--	--	--	--	--	
4,4'-DDE	--	.0033	--	--	--	--	.00002	--	--	.0027	--	--	.0005	--	--	
4,4'-DDD	--	.012	--	--	--	--	--	--	--	.0072	--	--	--	--	--	
Total DDT forms	--	.037	--	--	--	--	.00004	--	--	.017	--	--	.0013	--	--	
PCB-1242	--	--	--	--	--	--	--	--	--	--	--	--	--	T	--	
Total PCBs	--	.223	--	--	--	--	.00074	--	--	.25	--	--	.229	T	--	

** = River miles from mouth
[ ] = Weak acid digestion (.1 N HNO_3 with 5 wet grams sediment)
-- = Not detected
T = Trace, value is greater than the limit of detection but less than the limit of quantification
a = Not detected, but detection levels too high to be useful
* = Pyrene + fluoranthene
+ = Benzofluoranthenes