Publication No. 82-e18

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
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MEMORANDUM
December 8, 1982

To: Frank Monahan

Through: Dick Cunningham

From: Art Johnson and Shirley Prescott

Subject: Receiving Environment Surveys in the Puyallup River at the Tacoma Central (#1) Sewage Treatment Plant, Tacoma, Washington, July 28, 1981, August 25-26, 1981, and February 16-17, 1982

INTRODUCTION

The Water Quality Investigations Section conducted receiving environment surveys* at six locations in Commencement Bay between March 1981 and February 1982. The object of this work was to assess the impact to the estuary from Tacoma's major industrial and municipal dischargers. This report presents the results of surveys in the Puyallup River at the Tacoma Central (#1) sewage treatment plant (STP).

The primary objectives of each survey have been the determination of priority pollutant concentrations in the immediate vicinity of each discharge and evaluation of the toxicity of this environment to marine life. Conventional water quality parameters were also measured. Source sampling (Class II) surveys to determine NPDES permit compliance and pollutant loadings were conducted by WDOE at each facility in conjunction with the receiving environment surveys. The results of the Tacoma Central STP Class II survey are described in a separate report by Bill Yake (1). EPA Region 10 assisted in the field work, sample handling, and analysis for each project. Their help is gratefully acknowledged.**

*Other surveys included: Reichhold Chemicals, Inc., (4/21/81); U.S. Oil and Refining Co. (5/5/81); Pennwalt Corp. (6/2/81); Sound Refining (6/30/81); and the St. Regis Paper Co. (8/11-12/81). Class II surveys were also conducted at ASARCO and Hooker Chemical Corp. on 2/24/81 and 9/25//9, respectively.

**EPA personnel assisting in the field work were Jim Hileman, Dan Tangarone, Anna DeSilva, Joe Cummins, Barry Townes, and Carolyn Gangmark.

SITE DESCRIPTION

The Tacoma Central STP is a primary treatment facility located on the south bank of the Puyallup River 1.7 miles upstream from the river's mouth on Commencement Bay. The plant was built in 1950-51 and began operating in early 1952. A plant upgrade was completed in the spring of 1982. Current design flow is 28 MGD; peak wet-weather design capacity is 78 MGD. Wastes are discharged at the river's edge via a 48-inch diameter pipe -- there is no diffuser.

The Puyallup River at the outfall site is about 300 feet wide and six feet deep during average flow (3,400 cfs at USGS NASQAN station 12101500, Puyallup R. @ Puyallup). Extreme flows for the period of record at this station are 67,000 cfs and 306 cfs (2). Seasonal changes in monthly average maximum, mean, and minimum flows are depicted in Figure 1. Low flow typically occurs in August or September.

The lower reaches of the river are tidally influenced with the saltwater wedge from Commencement Bay sometimes penetrating upstream beyond the Central STP outfall. Under conditions of low flow and flood tide, flow reversal can occur in the region of the outfall.

WDOE's 1982 "Water Quality Index Analysis" (3) for the lower Puyallup was as follows:

Station Number & Name	Water quality index category and rating									Overall Index Rating
	Temp.	Oxygen	pH	Bacteria	Trophic	Aesthetic	Susp. Solids	Ammonia Tox.		
10A070 - Puyallup R. at Meridian Street Bridge (R.M. 8.3)	6.7	6.0	4.7	31.0	13.4	25.0	25.0	0.7		24.5
10A050 - Puyallup R. at Puyallup (R.M. 5.7)	9.1	6.0	8.7	26.8	15.3	23.9	23.2	0.5		22.0
04B010 - Puyallup R. Mouth	6.2	12.5	4.1	75.6	--	8.7	--	1.9		45.4

Scores between 0 and 20 meet goals of the Federal Water Pollution Control Act. Scores between 20 and 60 are considered marginal in meeting the goals of the Act. Values greater than 60 indicate unacceptable water quality problems exist. The Index uses WDOE routine monitoring data from the last five years.

The Puyallup River above the Central STP was rated marginal for bacteria, aesthetics, and suspended solids. The aesthetic and suspended solids "problems" here are primarily due to large amounts of rock flour contributed by the glacially fed White River tributary. Water quality at the Puyallup River mouth was rated unacceptable in bacterial quality, the parameter largely responsible for this station receiving the 13th worst overall index rating in the state.

SURVEY METHODS

River water and wastewater samples were collected on three separate occasions -- July 28, 1981; August 25-26, 1981; and February 16-17, 1982. The August survey was the most comprehensive and coincided with low flow in the river. This survey was conducted in conjunction with the initial Class II survey of the treatment plant. The July and February samples were part of a larger survey being conducted on priority pollutants in point source discharges to Commencement Bay (report in preparation). The February collection was timed to coincide with a major storm event.

During the low-flow survey, river water samples were collected at low slack on the morning of August 25 from above the STP outfall, in the effluent plume 150 meters below the outfall, and at the river's mouth. A pair of two-hour composites were collected at each site - one for organic priority pollutant analysis; the other for measurement of trace metals, conventional water quality parameters, and toxicity to Pacific oyster larvae (*Crassostrea gigas*) and the freshwater crustacean *Daphnia pulex*. Each composite consisted of four two-liter grab samples. At high slack that afternoon, another pair of composites was collected about 10 meters above the outfall in the pool of effluent that had backed up during tide-caused flow reversal in the lower river. Grab samples were collected at all of the above sites for dissolved oxygen (D.O.), fecal coliforms, cyanide, and oil/grease. Specific conductance, pH, and temperature were determined in the field. Samples of intertidal sediment (2-cm surface layer) were also taken during low tide near each water sampling station for priority pollutant analysis. On the following day, August 26, temperature, specific conductivity, D.O., nutrients, and fecal coliforms were monitored in the effluent and at four sites in the river over a 10-hour period bracketing maximum ebb and maximum flood. Figure 2 shows the relationship between time of sample collection, tide height, and river flow for the August survey.

During the previously mentioned July and February collections for the point source survey, composite samples of three to five hours' duration were collected, each being analyzed as described above except that bioassays were not conducted on February samples. In July, samples were taken of the STP effluent, the river above the outfall, and the river near its mouth (11th Street bridge). The February samples were of the Cleveland Street pump station effluent 750 meters upstream of the STP outfall, river water above the pump station, the STP effluent, and the river near its mouth. Bill Yake collected the February STP effluent sample, a 24-hour composite, as part of the Class II investigation.

Figure 3 shows the location where each of the above samples were collected.

Table 1 gives the details of sample handling and analysis for these surveys. Organic priority pollutant data, including tentatively identified compounds and data from sample blanks, were reviewed by Joe Blazevich, EPA, Region 10 Laboratory, Manchester, Washington, before being included in this report.

RESULTS

Tidal Influence in the Lower River - As shown in Figure 2, the flood tides encountered during the August 25-26, 1981, low-flow survey were sufficient to back up river water at the Central STP outfall for a period of about 3-1/2 hours twice each day, causing the effluent to pool above the outfall. Tide heights at higher high water in Commencement Bay were 11.1 and 11.7 feet, respectively, on the 25th and 26th. River flow ranged from 1590 to 1790 cfs. A review of USGS flow data for the Puyallup River and NOAA tide tables indicated that similar conditions of tide and flow (with resulting accumulation of wastewater in the river) occurred on 90 separate occasions during the 1980 water year. Additional slack-water periods of shorter duration than observed during our survey would also be expected to occur.

Vertical measurements of temperature and salinity showed the saltwater wedge from Commencement Bay had penetrated upstream beyond the outfall during the August survey. The following temperature/salinity data were recorded at the center of the river off the outfall on August 26, 1454 hours: surface, 16.9 °C/0.1 o/oo; 1 meter, 15.1 °C/0.1 o/oo; 2 meters, 14.3 °C/27.9 o/oo; and 3 meters, 14.3 °C/29.1 o/oo. Water depth was 4 meters.

Organic Priority Pollutants - Table 2 shows the concentrations of organic priority pollutants measured in wastewater and river water in July, August, and February. Of the 113 organic compounds classified as priority pollutants by EPA, only trace amounts (12 µg/L or less) of diethyl phthalate and 1,1,1-trichloroethane on July 28 and cyanide on February 16 were detected in the river under free-flowing conditions. The STP effluent may have been the source of the diethyl phthalate and trichloroethane detected below the outfall.

However, the August 25 sample collected near the outfall during slack water contained dilute concentrations of 10 of the 14 organic priority pollutants identified in the STP effluent (2,4,6-trichlorophenol*, 2-chlorophenol, 2,4-dichlorophenol, phenol*, 1,2-dichlorobenzene, 1,4-dichlorobenzene, naphthalene, chloroform, tetrachloroethylene, and trichloroethylene). None of these chemicals were at concentrations in excess of EPA criteria for protection of aquatic life (4). The remaining four compounds in the effluent; 2,4-dimethylphenol, bis(2-ethylhexyl)phthalate, di-n-octyl phthalate, and 1,1,1-trichloroethane; probably escaped detection in the river because of their low initial concentration or transient occurrence in the effluent. Bill Yake (7) discusses the effluent data in detail.

During peak runoff events, wastewater is sometimes bypassed to the Cleveland Street pump station upstream of the Central STP. The STP was not bypassing when the February 16 storm event sample of pump station effluent was collected; 1,2-dichlorobenzene was the only organic priority pollutant detected (3.5 µg/L).

*These two compounds were measured at slightly higher concentrations in the river (4-hour composite) than in the effluent (24-hour composite).

The results of organic priority pollutant analysis on Puyallup River sediment collected in August are shown in Table 3 and compared to data on sediments collected elsewhere in Commencement Bay and in other Washington rivers.

Puyallup River sediment above the outfall and at the river mouth contained approximately equal concentrations of phenol and di-n-butyl phthalate. No other priority organics were detected at these two sites. Compared to the upriver and river mouth sediment samples, about three times as much phenol (170 µg/kg, dry) was measured in sediment immediately below the outfall, along with relatively large concentrations of bis(2-ethylhexyl)phthalate and toluene, 1,700 µg/kg and 4,400 µg/kg, respectively. 98 µg/kg of di-n-octyl phthalate was also found here. The STP is a potential source of the elevated phenol and bis(2-ethylhexyl)phthalate seen in the outfall sediment, as these were constituents of the final effluent. Much higher concentrations of phenol and bis(2-ethylhexyl)phthalate, as shown in Table 3, have been reported for Commencement Bay sediments than were measured below the STP outfall.

The large amount of toluene found in the outfall sediment is probably the result of a spill rather than chronic discharge from the treatment plant. A maximum of 10 µg/L toluene was measured in the effluent samples collected during the surveys reported here. The concentrations of the other compounds identified in the Puyallup River sediments are within the ranges shown in the table for Western Washington river sediments.

Tentatively Identified Organics - A large number of organic compounds, other than priority pollutants, were tentatively identified in the river and wastewater samples by computer match with the EPA-NIH spectra library. The 21 compounds identified in the receiving environment are listed by sample type and collection date in Table 4. The Class II report discusses those compounds found in wastewater.

Except for 1.0 µg/L benzoic acid and 2.9 µg/L 1,3-dimethyl benzene in the July 28 water sample taken near the river mouth, no additional organics were identified in river water under free-flowing conditions. Both of these compounds were present in the STP effluent but not detected in the river upstream of the outfall. Benzoic acid occurs naturally in a variety of plant materials. 1,3-dimethyl benzene is one of three isomers of xylene, a solvent and gasoline additive.

As was the case for the priority pollutants, a number of tentatively identified organic compounds reached detectable levels in the river when the effluent was backed up by flood tide. The August 25 high slack sample contained 10 of these compounds, at least eight of which are naturally occurring*. Benzene acetic acid (phenyl acetic acid), one of the remaining two compounds, is used in the manufacture of perfumes, penicillin, fungicides, and flavoring. No information was found on 3,3,3-trichloro-1-propene in standard chemical reference works. Neither of these two chemicals was identified in the STP effluent. At least one of the higher chlorinated propenes (1,1,2,3-tetrachloro-2-propene) is mutagenic (5).

*The decanoic acids (6 identified) are animal/plant fatty acids. α,α,4-trimethyl-(s)3-cyclohexene-1-methanol is a constituent of plant oils. Benzoic acid, discussed in the text above, was also found in this sample.

In sediment, the tentatively identified organics were largely restricted to the sample just below the outfall where 10 were found. Seven of these were naturally occurring decanoic (fatty) acids or fatty acid esters (methyl tetra- and methyl hexa-decanoate). Octadecanoic acid and methyl hexadeconoate were also found in the sediment from the river mouth. Benzene acetic acid, which had been identified in the effluent plume, was also present in the outfall sediment along with methyl phenol (cresol), a constituent of coal tar and petroleum, and 3α,5α-cholestan-3-ol, an animal sterol structurally similar to cholesterol (5-cholesten-3-β-ol).

2-chloro-*trans* cyclohexanol was the only compound tentatively identified in the Cleveland pump station effluent. Chlorocyclohexanols have been identified in seepage at the Pennwalt facility (*6*) on Hylebos Waterway. The only information found on this compound indicated that it has been isolated in extracts of crude oil (*7*).

Trace Metals - The trace metal data are shown in Tables 5 (river water and wastewater) and 6 (sediment).

Trace metals were higher in the STP and pump station effluents than in the river. Detection limits for cadmium in the river water samples were not low enough to compare to cadmium concentrations measured in the wastewater. Stormwater from the pump station had more arsenic, copper, nickel, and zinc than the treatment plant discharge.

The large river water/wastewater dilution ratios (70:1 on August 25, 99:1 on February 16) brought most metals with the exception of arsenic, to near background levels at the river mouth. The downstream increases in arsenic seen in August and February and the isolated increases of nickel and zinc in February, although not large, are out of proportion to that expected after simple dilution. Nonpoint runoff is a likely reason for the February increases. The cause of elevated arsenic downstream of the STP during dry weather flow in August is not known. It may be due to increased amounts of suspended matter (see Table 7) in the samples at the river mouth.

Wastewater and river water concentrations of arsenic, chromium, and nickel were within the EPA receiving water criteria shown in Table 5 for protection of freshwater life. Most samples of river water and wastewater exceeded the EPA 24-hour average criteria for cadmium (.012 µg/L) and copper (5.6 µg/L). Results of oyster and daphnid bioassays on these samples (discussed later in this report) did not indicate an acute toxicity problem outside the effluent plume.

Zinc exceeded certain of the EPA receiving water criteria in the STP and pump station effluents and in the STP effluent plume at ebb and at high slack. Lead concentrations were not quantified at a sufficiently low level in the July or August samples to compare with protection criteria. In February, lead concentrations above and below the STP were 4 µg/L which exceeds EPA's 24-hour average criterion of 0.75 µg/L.

Sediment trace metal concentrations (Table 6) were higher immediately below the outfall than above the outfall or at the river mouth, except for arsenic and mercury. These two metals were highest upstream of the

outfall and decreased in concentration in a downstream direction. All sediment metal concentrations were low (except for 0.87 µg/kg mercury measured above the outfall) relative to data shown in the table on National Marine Fisheries Service findings for Commencement Bay sediments, background levels in other parts of Puget Sound removed from urban/industrial activity, and results on sediment from EPA's extensive "TOEPATOX" survey of Washington State fresh waters. The reason for the high mercury concentration in sediment upstream of the STP is not known.

Conventional Parameters - The results of conventional water quality measurements made in conjunction with the collection of composite samples for organic and trace metal analyses during low flow in August and high runoff in February are shown in Table 7. A sampling or analytical error is suspected to be responsible for the ammonia concentration of 0.46 mg/L shown in the table for the ebb tide sample above the outfall on August 25. Four samples collected during ebb tide on the following day averaged 0.10 mg/L.

A drop in D.O. at the river mouth, seen during the low-flow survey, was the only adverse effect attributable to STP or pump station effluents outside the effluent plume. Conductivity, chemical oxygen demand (COD), suspended solids, and turbidity increased at the river mouth during low flow relative to that in the river above the outfall but this was probably due to entrained saltwater (conductivity, COD) and turbulent flow across the shallows at the lower end of the river (solids, turbidity). Neither chlorine nor ammonia were measured at toxic levels in the receiving waters. Class B water quality standards, under which the lower one mile of the Puyallup River is classified, were being met for D.O., temperature, and pH during ebb at both extremes of flow. The fecal coliform standard (less than 200 col/100 mL) was violated above and below the outfall. The STP effluent was not causing an increase in fecal coliform levels in the river during the surveys.

Water quality in the pool of effluent formed near the outfall at high slack was substantially degraded and well below that in the effluent plume during free downstream flow. Accumulation of sewage caused a D.O. drop of 2 to 3 mg/L and large increases in conductivity, oxygen demand, ammonia, phosphate, and oil/grease. Based on water quality data, this pool contained up to 35% effluent.

In addition to the composite samples discussed above, a series of individual grabs of the receiving water and STP effluent were taken over a 10-hour period bracketing maximum ebb and high slack in the river during the low-flow survey. The results from these samples are shown in Figure 4.

D.O. dropped about 2 mg/L (to 80 percent saturation) when the effluent was held in check by the tide. Large peaks of ammonia and phosphorus, 9.0 and 4.1 mg/L, respectively, were also observed here at slack water. Downstream decreases in D.O. and peaks in ammonia and phosphate were evident but did not occur simultaneously at a given site nor in a progressive downstream sequence as might be expected. Fecal coliforms varied erratically above and below the outfall. A longer time series of samples is probably needed to describe the short-term variations in river water quality caused by the STP effluent and tidal mixing.

Receiving Water Toxicity - The results of oyster larvae and daphnid bioassays* on composite samples of Puyallup River water and STP influent and effluent collected in the July and August surveys are discussed in a separate report (8,9) by Joe Cummins, EPA, Region 10 Laboratory, Manchester, Washington. His results for the STP final effluent and receiving waters are summarized below in Table 8.

Table 8. Results of STP effluent and Puyallup River bioassays.

Sample Type	Collection Date	Net Percent Oyster Larvae Mortality at 20% Sample Concentration	Net Percent Oyster Larvae Abnormality at 20% Sample Concentration	Percent Daphnid Mortality at 100% Sample Concentration
Puyallup R. above Outfall	7/28/81	29.1**	5.9	10
Tacoma Central STP Effluent	7/28/81	17.9	99.7	50
Puyallup R. nr. Mouth at 11th St.	7/28/81	8.5	6.5	10
Puyallup R. abv. Outfall (ebb)	8/25/81	3.6	12.6	0
Puyallup R. abv. Outfall (high slack)	8/25/81	10.0	100	20
Tacoma Central STP Effluent	8/25/81	43.4	100	100
Puyallup R. 150 m below Outfall	8/25/81	0	14.0	5
Puyallup R. at Mouth	8/25/81	0	19.1	5

**Response suspect due to high variation in duplicate larval counts.

*The oyster bioassay procedure involves seeding test waters with recently fertilized oyster embryos at a density of 20,000 to 30,000 per liter, incubating them at 20°C for 48 hours, and enumerating a subsample of 150 to 250 larvae under a microscope. Larvae are counted as abnormal when not fully shelled. Wastewater and river water samples are diluted with seawater prior to testing to achieve a salinity of at least 24 o/oo as required by oyster larvae. The daphnid bioassays were performed by exposing daphnids to undiluted water samples for 48 hours.

Exposure to STP effluent was lethal to a high percentage of the oysters and daphnids. Essentially all oyster embryos failed to develop into normal larvae in 20 percent concentrations of effluent. The toxicity of the receiving waters, however, increased only slightly below the outfall, even in the sample from within the plume. At high slack, poor dilution of the effluent resulted in 100 percent oyster abnormality and increased mortality in both test species.

DISCUSSION

The survey results presented here indicate that poor river water quality and associated toxic effects on marine and freshwater test organisms are primarily associated with tide-caused flow reversal in the river and subsequent stagnation of the STP effluent. Samples collected in the effluent plume 150 meters below the outfall during normal downstream flow were not substantially more toxic than river water upstream of the outfall.* Dilution had reduced organic priority pollutant concentrations to levels below limits of detection. Effluent trace metal concentrations were reduced to near background levels except for zinc which was present in the effluent in relatively large amounts.

The effects on river water quality after complete dilution of the STP effluent with Puyallup River water at a flow of 1,590 cfs (August 26, 1981) and at the 7-day, 10-year low flow of 910 cfs (*10*) were calculated below for selected parameters. WDOF's recommended (*11*) dilution ratio of 20:1 is met under both flow regimes. STP effluent flows of more than 45 cfs into the 7-day, 10-year low of 910 cfs, or river flows below 510 cfs receiving the 25.5 cfs wasteload measured August 25-26, 1981, would have violated the recommended ratio.

Parameter	Concentration in Tacoma Central STP Effluent (8/25-26/81)	Concentration in Puyallup River (8/25-26/81)	Resulting receiving water concentration under 8/25-26/82 dry weather wasteload of 25.5 cfs: River at 1,590 cfs (8/25/81)	% Change in River	River at 910 cfs (7-day, 10-yr low flow)	% Change in River
Dissolved Oxygen (mg/L)	2.8	9.9	9.8	-1%	9.7	-2%
BOD_5 (mg/L)	250	6	10	+70%	13	+120%
Suspended Solids (mg/L)	170	270	270	0%	270	0%
Fecal Coliform (col/100 mL)	300	230	230	0%	230	0%
NH_3-N (mg/L)	22	.10	.45	+350%	.70	+600%
Total Inorganic Nitrogen (mg/L)	22	.20	.54	+170%	.79	+300%
T-PO_4-P (mg/L)	9.2	.12	.26	+120%	.37	+210%
Zinc (µg/L)	340	28	33	+18%	37	+32%

*Although not observed in the surveys discussed here, perhaps largely due to turbidity, aerial photos have shown that the effluent sometimes hugs the west bank of the Puyallup for long distances downstream. Figure 5 is an example of such a photo showing minimal wastewater dilution.

Dissolved oxygen, suspended solids, fecal coliform, and zinc concentrations in the river change little after mixing with effluent at either flow. The principal adverse impacts are increased biochemical oxygen demand, ammonia, and phosphate concentrations.

Figure 6 illustrates how D.O., fecal coliform, total inorganic nitrogen, and phosphate have varied in the lower river over the last five years using data from WDOE's routine monitoring stations at Meridian Street Bridge (10A070) located at river mile 8.3 above the Central STP and the Puyallup River mouth station (CMB010). The station at the river mouth has a wide range of salinity (0.9 to 27.5 o/oo for the period discussed here) and, therefore, represents river water diluted with varying amounts of saltwater. No data are available from this station for the winter months. Dissolved oxygen was often considerably lower at the river mouth than upstream of the STP, although never falling below the marine or freshwater Class B standards. In the last two years, however, D.O. has been at or above 95 percent saturation below the STP. The reason for this apparent improvement is not known. Bacterial contamination below the STP also shows improvement in 1981 and 1982 compared to previous years when 85 percent of the samples exceeded the 200 col/100 mL Class B standard -- a change probably reflecting improvement in chlorine contact time at the treatment plant. On the average, the inorganic nitrogen concentration at the river mouth has been more than double that observed upstream. Phosphate has not been consistently higher downstream. The other point sources in this eight-mile reach of the Puyallup River are the Puyallup STP and two small creeks (Clark and Clear/Swan creeks). These are small discharges not expected to have an important influence on river water quality.

SUMMARY

The major findings of the Tacoma Central STP receiving environment surveys reported here are as follows:

1. Flood tides cause stagnation of the STP effluent in the river for periods of several hours when Puyallup River flows of 1790 cfs (or lower) occur in conjunction with tide heights in excess of 11 feet. This combination of conditions occurs frequently during late summer and fall. Slack-water periods of shorter duration would be expected at lower tide heights. Water quality data suggest the resulting pool can contain up to 35 percent Tacoma Central STP effluent.

2. Trace amounts of diethyl phthalate, 1,1,1-trichloroethane, and cyanide were the only organic priority pollutants detected in Puyallup River water samples collected during normal downstream flow.

3. Ten of the 14 organic priority pollutants detected in the STP effluent on August 25-26, 1981, reached quantifiable concentrations in the Puyallup River during slack water when effluent accumulated near the outfall under the constraining influence of flood tide. EPA criteria for protection of aquatic life were not, however, exceeded.

4. The STP effluent may have been responsible for elevated concentrations of phenol and bis(2-ethylhexyl) phthalate in sediment below the outfall. A large amount of toluene, 4,400 µg/kg, was found in sediment below the outfall, probably due to a spill rather than chronic discharge in the plant's wastewater.

5. Concentrations of cadmium, copper, and mercury in river water above and below the outfall occasionally exceeded EPA criteria for the protection of aquatic life. As a result of the river's large dilution capacity, the concentrations of trace metals in the STP effluent were usually reduced to background levels downstream of the effluent plume.

6. The STP's effect on river water quality, as measured by conventional parameters (D.O., ammonia, etc.) was largely restricted to the effluent plume.

7. Oyster larvae and daphnids exposed to samples of river water taken in the pool of effluent backed up by the tide experienced almost 100 percent abnormality (oysters) or mortality (daphnids). Receiving waters during periods of normal downstream flow were not appreciably toxic, based on these bioassay results.

AJ:SP:cp

Attachments

cc: Section Files
Bill Yake

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9. Cummins, J., 1982b. Results of acute toxicity tests conducted on samples collected during the Tacoma Central wastewater treatment plant surveys August 25, 1981. EPA intra-agency memorandum to J.R. Hileman.

10. CTA Engineers, 1975. Facilities planning report, Tacoma Central sewage treatment plant.

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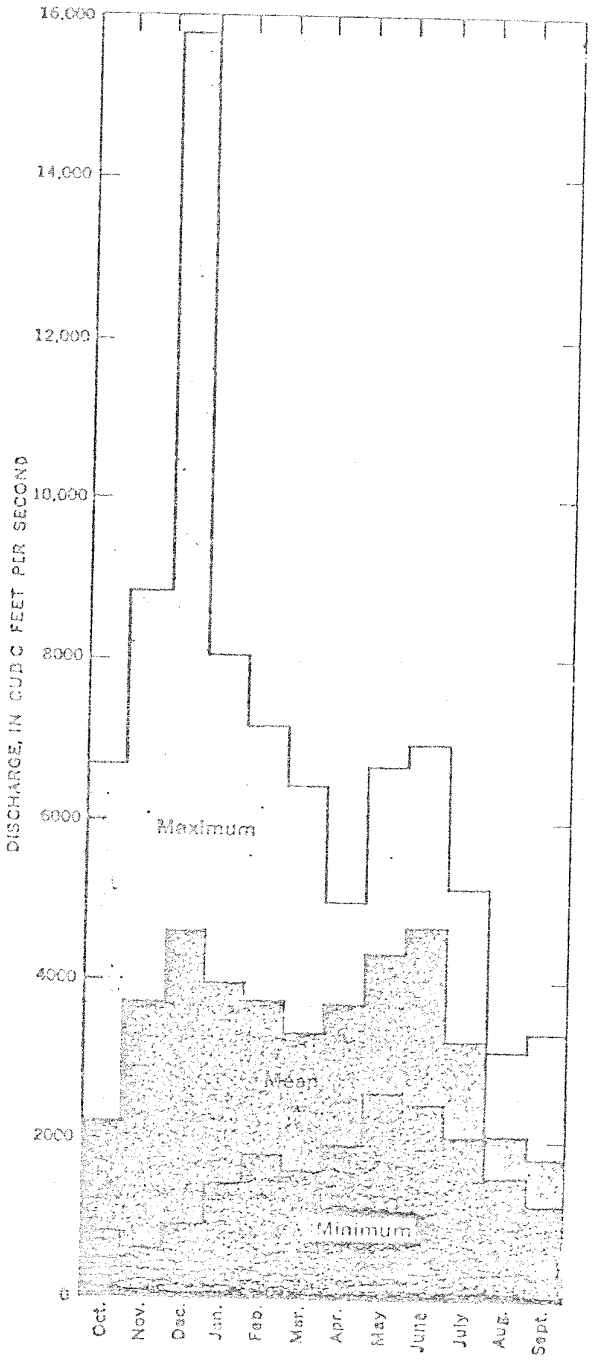

Figure 1. Maximum, mean and minimum monthly discharges, Puyallup River at Puyallup, 1931-1960. Source: Puget Sound Task Force - Pacific Northwest River Basins Commission, 1970.

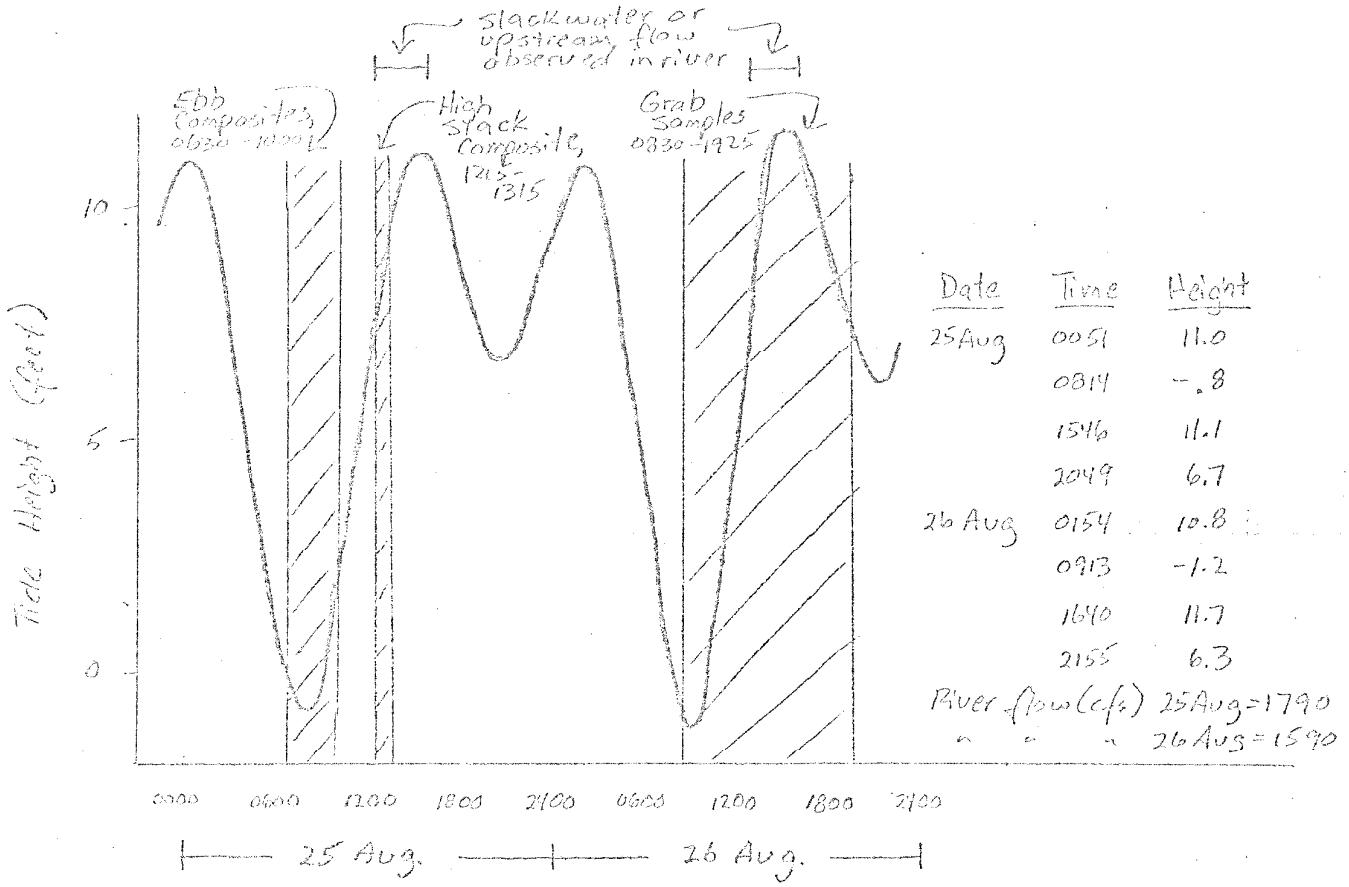

Figure 2. Commencement Bay tide stage and timing of sample collection for the WDOE receiving environment survey in the Puyallup River at the Tacoma Central STP, August 25-26, 1981.

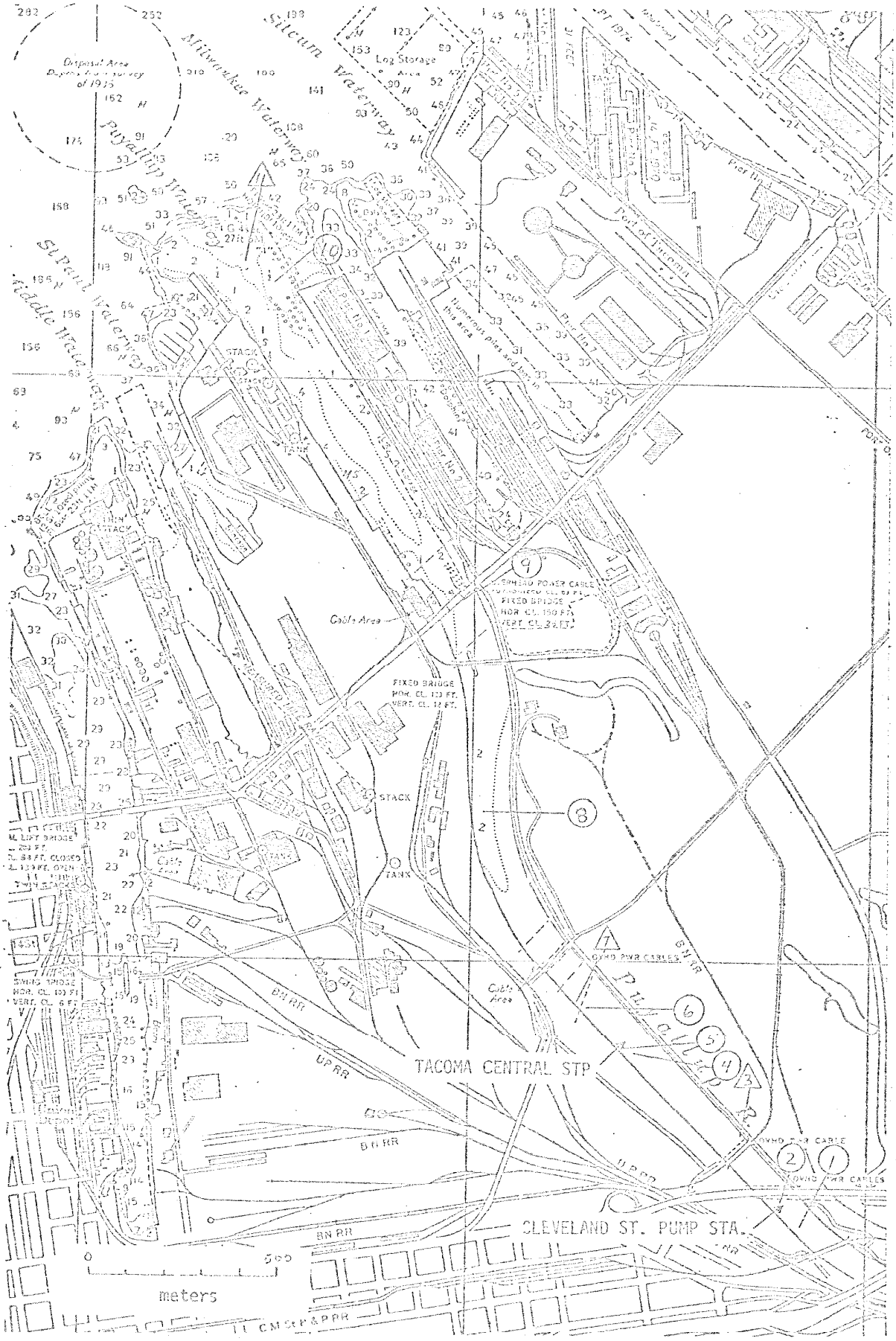

Figure 3. Locations where water (○) and sediment (△) samples were collected during WDOE's receiving environment surveys at the Tacoma Central STP, July 28, 1981 (4, 5, 9 only), August 25-26, 1981, and February 16-17, 1982 (1, 2, 5, 9 only).

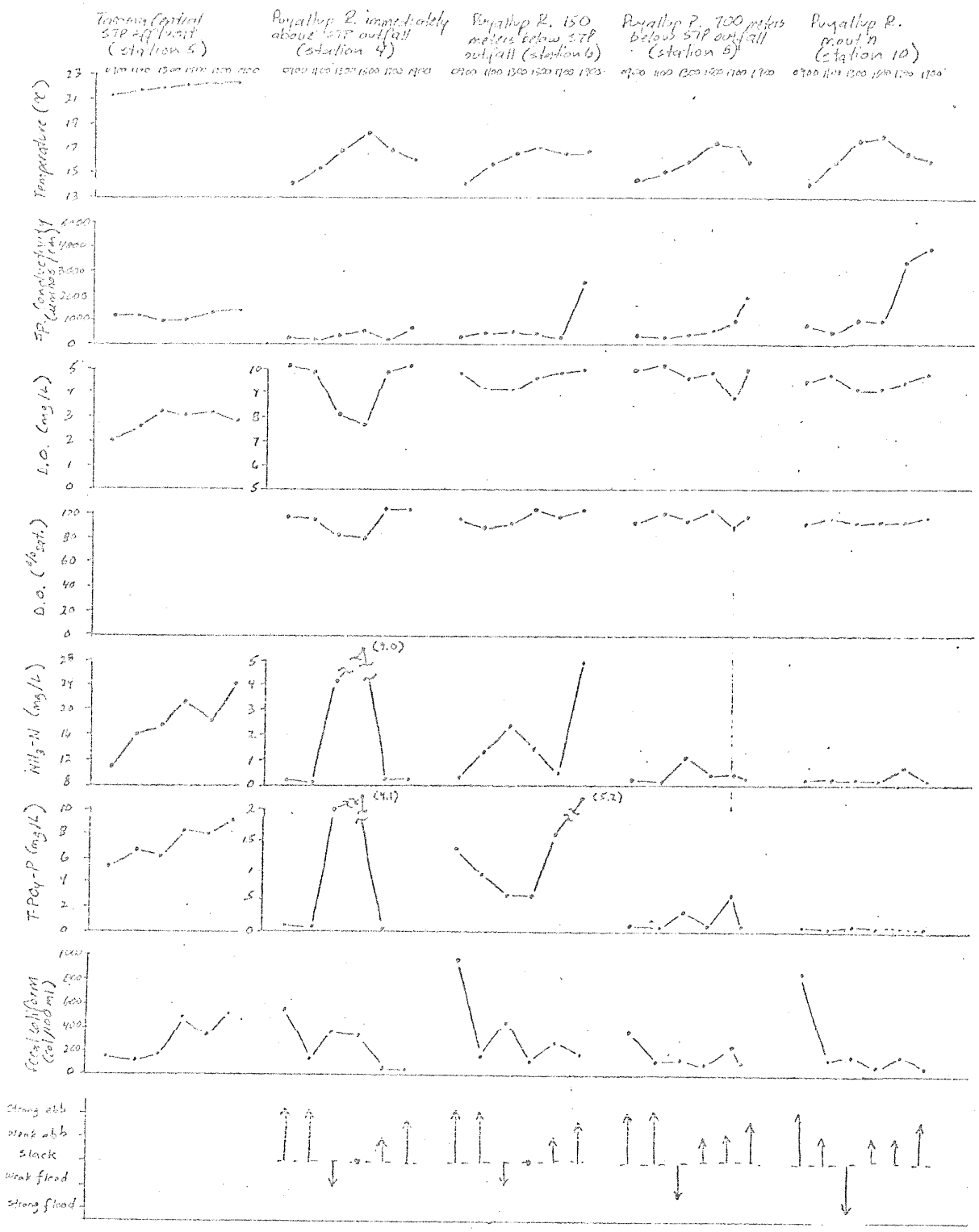

Figure 4. Changes in temperature, specific conductance, dissolved oxygen, ammonia, phosphorus, and fecal coliform with time in the Puyallup River and Tacoma Central STP effluent, 0830 - 1930 hours, August 26, 1981 (river flow 1590 cfs; STP flow 25.5 cfs; LLW 0913 hours; -1.2 feet, HHW 1640 hours, 11.7 feet).

Figure 6. Aerial photo illustrating poor dilution of the Tacoma Central STP effluent in the Puyallup River (from Aerial Reconnaissance of Oil, Chemical and Industrial Facilities in Tacoma, Washington, April 1981. EPA. June 1981).

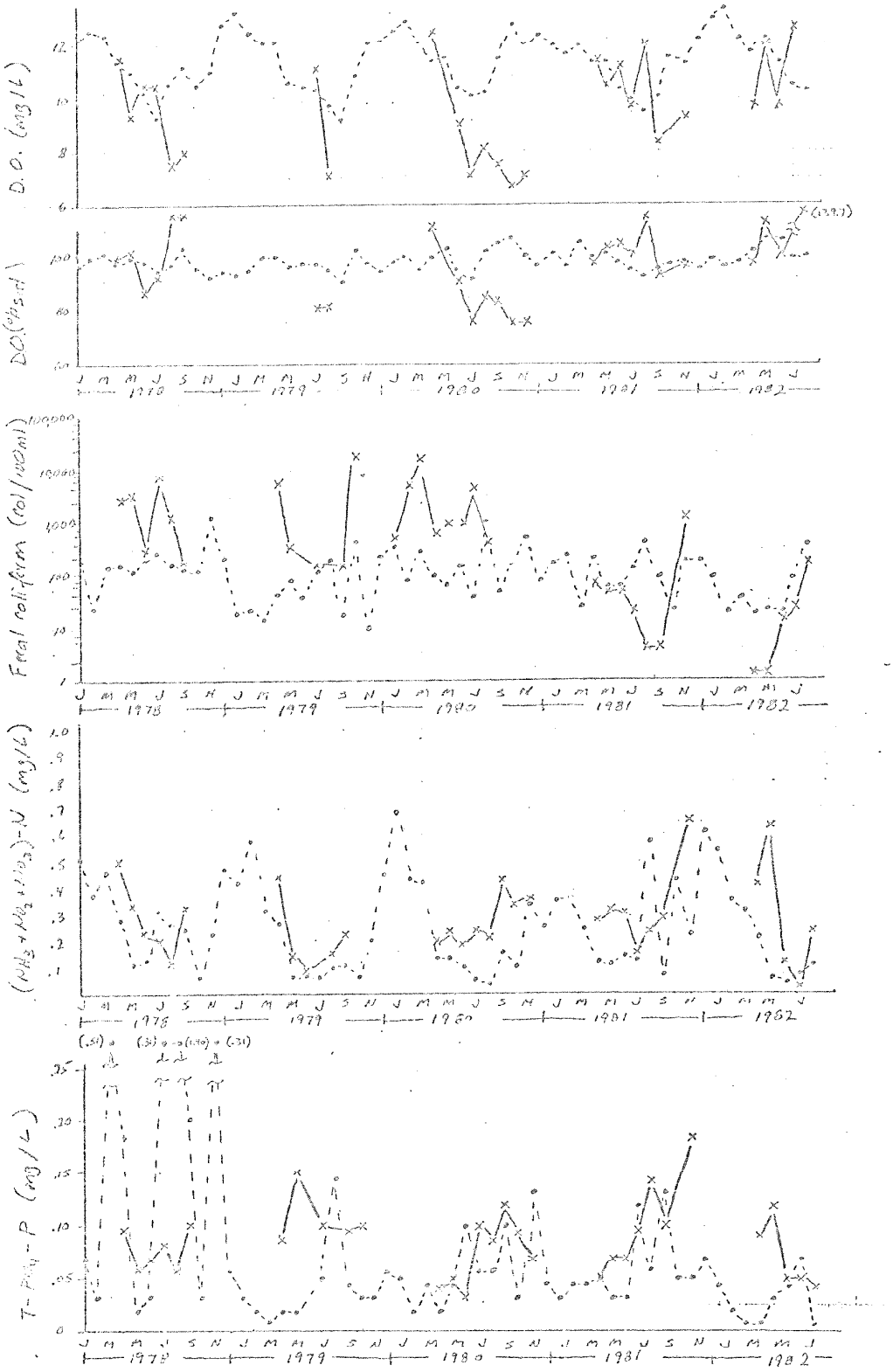

Figure 6. WDOE routine monitoring data on dissolved oxygen, fecal coliform, total inorganic nitrogen, and phosphate from station 10A070 "Puyallup River (r.m. 8.3) at Meridian Street Bridge" (o—o—o) and station CMB010 "Commencement Bay-Puyallup River Mouth" (x—x—x), January 1978 to August 1982.

Table 1. Sample handling and analysis for WDOE's receiving environment surveys in the Puyallup River at the Tacoma Central STP, July 28, 1981, August 25-26, 1981, and February 16-17, 1982.

Sample Type	Parameter(s)	Sampling Method[a]	Sample Container[b]	Analysis	Laboratory
Water	Organic Priority Pollutants	Manual composites	1-gallon glass. Volatiles in 40 ml vial.	As per 1979 EPA guidelines[c]	California Analytical Laboratories, Inc., August and February. Science Applications, Inc., July.
	Trace Metals, Conventional Water Quality Parameters, and Bioassay	Manual composites. (Grabs for selected conventional parameters - Aug. 26)	Metals - 250 ml poly., HNO_3 pres. Nutrients - 250 ml poly., H_2SO_4 pres. Turbidity, Suspended solids, BOD, COD - 2 liter poly. Fecal coliform - 250 ml glass, sterilized.	Metals, conventional parameters - Standard methods[f]	WDOE, Tumwater, Washington
			Bioassay - 1-gallon poly.	Bioassay - 18-hr. oyster embryo[d] and daphnid[e] techniques	EPA, Region 10, Manchester, WA
	Cyanide	Grab	1-qt. poly., NaOH pres.	Standard methods[f]	WDOE, Tumwater, Washington
	Total Phenolics	Grab	1-qt. glass, H_2SO_4 pres.	Standard methods[f]	WDOE, Tumwater, Washington
	Oil and Grease	Grab	1-qt. glass	Standard methods[f]	WDOE, Tumwater, Washington
	Dissolved Oxygen	Field Measurement	--	Winkler, azide modification	--
	pH	Field Measurement	--	Orion Research pH meter	--
	Salinity	Field Measurement	--	Beckman salinometer	--
	Chlorine Residual	Field Measurement	--	LaMotte-Pomeroy field kit	--
Sediment (Aug. only)	Priority Pollutants	Surface layer sampled by hand to depth of 2 cm.	Organics - 8-oz. glass	As above	California Analytical Laboratories, Inc.
			Trace metals - 4-oz. poly.	As above	WDOE, Tumwater, Washington

[a] All samples placed on ice at time of collection.

[b] Containers for organic priority pollutants cleaned with sequential rinses of soap and water, 15% HNO_3, 50% HCl, distilled water, de-ionized water, nannograde acetone, and nannograde methylene chloride. Trace metal procedure omits solvent rinses.

[c] EPA. 1979. Guidelines establishing test procedures for the analysis of pollutants; and proposed regulations. *Federal Register* Vol. 44 No. 233.

[d] American Society for Testing and Materials. 1980. *Standard Practice for Conducting Static Acute Toxicity Tests with Larvae of Four Species of Bivalve Molluscs*. Ann. Book ASTM Standards. Philadelphia, PA.

[e] Weber, C.I. and W. Peltier. 1980. *Effluent Toxicity Screening Test Using Daphnia and Mysid Shrimp*. EPA-600/4-81-000 (draft).

[f] EPA. 1979. *Methods for Chemical Analysis of Water and Wastes*. EPA-600/4-79-020.

Table 2. Organic priority pollutants in Puyallup River water and in effluents from the Tacoma Central STP and Cleveland Street pump station, July 28, 1981, August 25-26, 1981, and February 16-17, 1982 (concentrations in µg/L).

Station Description	River Above STP Outfall	STP Effluent	River nr. Mouth at 11th St.	River Above STP Outfall (eob)	River Above STP Outfall (high slack)	STP Effluent	River 150 m below STP Outfall	River Mouth	River Above Cleveland St. Pump Station	Cleveland St. Pump Station Effluent	STP Effluent	River nr. Mouth at 11th St.
Station Number	4	5	9	4	4	5	6	10	1	2	5	9
Collection Date	7/28/81	7/28/81	7/28/81	8/25/81	8/25/81	8/25-26/81	8/25/81	8/25/81	2/16/82	2/16/82	2/16-17/82	2/16/82
Time	0930-1400	0900-1400	0800-1200	0745-1000	1215-1315	0940-0940	0800-1000	0830-0830	1300-1715	1300-1600	1230-1230	1400-1730
Acid Compounds												
2,4,6-trichlorophenol	--	--	--	--	5.7	5.3	--	--	--	--	11	--
2-chlorophenol	--	--	--	--	1.1	8.2	--	--	--	--	5.7	--
2,4-dichlorophenol	--	--	--	--	0.8	4.5	--	--	--	--	8.5	--
2,4-dimethylphenol	--	5.1	--	--	--	3.9	--	--	--	--	--	--
pentachlorophenol	--	<40	--	--	--	--	--	--	--	--	24	--
phenol	--	27	--	--	80	34	--	--	--	--	18	--
Base/Neutral Compounds												
1,2-dichlorobenzene	--	--	--	--	4.2	5.6	--	--	--	3.5	--	--
1,3-dichlorobenzene	--	3.6	--	--	--	--	--	--	--	--	--	--
1,4-dichlorobenzene	--	--	--	--	2.1	3.3	--	--	--	--	--	--
naphthalene	--	2.5	--	--	1.9	4.5	--	--	--	--	4.9	--
bis(2-ethylhexyl)phthalate	--	17	--	--	--	25	--	--	--	--	--	--
di-n-butyl phthalate	--	--	--	--	--	--	--	--	--	--	--	--
butylbenzylphthalate	--	21	--	--	--	--	--	--	--	--	--	--
di-n-octyl phthalate	--	10	--	--	--	2.1	--	--	--	--	--	--
diethyl phthalate	0.01	1.7	3.2	--	--	--	--	--	--	--	--	--
anthracene/phenanthene	--	0.7	--	--	--	--	--	--	--	--	--	--
Volatile Compounds												
benzene	--	63	--	--	--	--	--	--	--	--	3	--
1,1,1-trichloroethane	--	~~16~~	~~12~~	--	--	1.1	--	--	--	--	1	--
chloroform	--	~~18~~	~~12~~	--	5.6	16	--	--	--	--	8	--
ethyl benzene	--	2	--	--	--	--	--	--	--	--	--	--
dichlorobromomethane	--	3.2	--	--	--	--	--	--	--	--	--	--
tetrachloroethylene	--	2.6	--	--	1.4	2.3	--	--	--	--	110	--
toluene	--	10	--	--	--	--	--	--	--	--	8	--
trichloroethylene	--	~~4.4~~	--	--	8.6	10	--	--	--	--	--	--
Pesticides												
BHC-D	--	--	--	--	--	--	--	--	--	--	0.1	--
Cyanide	--	--	--	--	--	18	--	--	8	8	8.5	5

Table 3. Organic priority pollutant concentrations in Puyallup River sediment collected August 25, 1981 near the Tacoma Central STP compared to concentrations of these chemicals observed in sediment from Commencement Bay and from other Washington rivers.

	Phenol	Bis(2-ethylhexyl)phthalate	Di-n-butylphthalate	Di-n-octylphthalate	Toluene
WDOE, Present Study					
Puyallup River above outfall, Station 3 (µg/kg, dry)	44	--	71	--	--
Puyallup River 150 meters below outfall, Station 7 (µg/kg, dry)	170	1700	--	98	4400
Puyallup River mouth, Station 11 (µg/kg, dry)	50	--	74	--	--
WDOE, Other 1981 Commencement Bay Sediment Samples (report in preparation)					
Total number of samples	45	45	45	45	45
Frequence of detection	27%	51%	2%	2%	18%
Maximum concentration observed (µg/kg, dry)	9100 (near St. Regis outfall)	9900 (Blair Waterway at Lincoln Avenue)	Below limit of quantification	1350 (St. Regis bleach crib on Puyallup River)	Below limit of quantification
METRO (unpublished data)					
Duwamish R. at Harbor Is. (µg/kg, dry)	N/A	1606.0	90.5	87.6	--
Duwamish R. at r.m. 5.3 (µg/kg, dry)	N/A	--	24.8	--	--
Sammamish R. mouth (µg/kg, dry)	N/A	269.0	43.0	--	2.6
Cedar R. mouth (µg/kg, dry)	N/A	288.9	46.4	--	7.2
EPA, "LOEPATOX" Survey (freshwaters statewide, unpublished)					
Duwamish R. blw Renton STP (µg/kg, dry)	20	200	30	30	--
Puyallup at Puyallup (µg/kg, dry)	32	--	--	--	.16
Total number of samples	35	35	35	35	33
Frequency of detection	34%	63%	34%	20%	33%
Maximum concentration observed (µg/kg, dry)	500 (Newaukum River)	200 (Duwamish River below Renton STP)	90 (Chehalis River near Centralia)	1300 (Columbia River at Richland)	1 (Spokane R. at Spokane STP)

N/A = Not included in analysis.

Table 4. Organic compounds, other than priority pollutants, tentatively identified in Puyallup River water, sediment, and Puyallup STP effluent, July 28, 1981, August 25-26, 1981, and February 16-17, 1982.

July 28, 1981

	River above STP Outfall, Station 4	STP Effluent, Station 5	River nr. Mouth @ 11th St. Station 9
benzoic acid	--	21 (est.)	1.0 (est.)
1,3-dimethyl benzene	--	12 (est.)	2.9 (est.)

- 46 other compounds identified in effluent only.

August 25-26, 1981

	River above STP Outfall (ebb) Station 4	River above STP Outfall (high slack) Station 4	STP Effluent Station 5	River 150 m below STP Outfall Station 6	River Mouth Station 10	Sediment above STP Outfall Station 3	Sediment 150 m below STP Outfall Station 7	Sediment at River Mouth Station 11
decanoic acid	--	--	--	--	--	--	TI	--
dodecanoic acid	--	TI	--	--	--	--	TI	--
tridecanoic acid	--	TI	TI	--	--	--	TI	--
tetradecancic acid	--	TI	TI	--	--	--	TI	--
pentadecanoic acid	--	TI	TI	--	--	--	TI	--
heptadecanoic acid	--	TI	TI	--	--	--	--	--
octadecanoic acid	--	TI	--	--	--	--	--	TI
methyltetradecanoate	--	--	--	--	--	--	TI	--
methylhexadecanoate	--	--	--	--	--	--	TI	TI
3,3,3-trichloro-1-propene	--	TI	--	--	--	--	--	--
benzene acetic acid	--	TI	--	--	--	--	TI	--
2-methyl benzoic acid	--	TI	--	--	--	--	--	--
2-methyl phenol	--	--	--	--	--	--	TI	--
α,α,4-trimethyl-(s)3-cyclohexene-1-methanol	--	TI	TI	--	--	--	--	--
3α,5α-cholestan-3-ol	--	--	--	--	--	--	TI	--
1,2-dimethyl benzene	--	--	TI	--	--	--	--	--
1,2,4-trimethyl benzene	--	--	TI	--	--	--	--	--

February 16-17, 1982

- No compounds tentatively identified in river water or STP effluent. One compound (2-chloro-*trans*cyclohexanol) was identified in Cleveland Street pump station effluent at 100 µg/L (est.).

est. = estimated.
TI = tentatively identified.

Table 5. Trace metals in Puyallup River water and in effluents from the Tacoma Central STP and Cleveland Street pump station, July 28, 1981, August 25-26, 1981, and February 16-17, 1982 (µg/L of total metal in unfiltered samples).

Station Description	River above STP Outfall	STP Effluent	River nr. Mouth at 11th St.	River above STP Outfall (ebb)	River above STP Outfall (high slack)	STP Effluent	River 150 m below STP Outfall	River Mouth	River above Cleveland St. Pump Station	Cleveland St. Pump Station Effluent	STP Effluent	River nr. Mouth at 11th St.
Station Number	4	5	9	4	4	5	6	10	1	2	5	9
Collection Date	7/28/81	7/28/81	7/28/81	8/25/81	8/25/81	8/25-26/81	8/25/81	8/25/81	2/16/82	2/16/82	2/16-17/82	2/16/82
Collection Time	0930-1400	0900-1400	0800-1200	0748-1000	1215-1315	0940-0940	0800-1000	0630-0830	1300-1715	1300-1600	1230-1230	1400-1730
Flow (cfs)	2,550	*		1,790		25.5			18,900	79	111	
Arsenic	18	<1	28	4	8	12	18	11	<2	32	23	5
Cadmium	10	10	10	<5	<5	2.0	<5	<5	<5	<5	1	<5
Chromium	<2	57	<2	<10	<10	76	<10	<10	<20	<20	<10	<20
Copper	10	50	9	<10	30	53	10	20	20	220	50	20
Lead	<100	<100	<100	<20	<20	39	<20	<20	4	200	80	4
Mercury	.24	<.20	<.20	.20	.32	.63	.44	<.20	<.20	<.20	<.20	<.20
Nickel	<1	39	<1	<10	<10	59	<10	<10	<5	9	170	8
Zinc	30	150	15	28	140	340	370	15	35	220	130	50

*STP flow measuring device out of order.

	EPA Criteria for protection of freshwater aquatic life**		
	Max. Allowed	24-hr. Avg.	Chronic Toxicity
Arsenic	440 (As^{+++})		
Cadmium	1.5	.012	
Chromium	2,200		44
Copper	12	5.6	
Lead	74	.75	
Mercury	4.1	0.2	
Nickel	1,100	56	
Zinc	180	47	

**at 50 mg/L hardness, as $CaCO_3$.

Source: EPA. 1980. Water Quality Criteria Documents; Availability. *Fed. Reg.* Vol. 45 No. 231

Table 6. Trace metals concentrations in Puyallup River sediment collected August 25, 1981 near the Tacoma Central STP compared to concentrations observed in sediment from Commencement Bay, Puget Sound, and Washington rivers.

	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
WDOE, Present Study								
Puyallup River above outfall, Station 3 (mg/kg, dry)	9.4	0.19	4.6	20	5.8	0.89	9.7	14
Puyallup River below outfall, Station 7 (mg/kg, dry)	8.0	0.56	7.9	28	12	0.28	12	42
Puyallup River Mouth, Station 11 (mg/kg, dry)	5.4	0.17	3.8	16	3.4	0.09	8.1	13
NMFS, Commencement Bay[a]								
Range (mg/kg, dry)	3.2-50[b]	4.7-16.2	25.6-58.7	22.7-1602	14.0-793	.06-1.03	18.7-64.4	35.1-1720
Number of Samples	13[b]	14	14	14	14	14	14	14
Puget Sound "background"[c] (mg/kg, dry)	3-15[b]	3	101	35	21	0.06	42	87
EPA, "10EPATOX" Survey (unpublished)								
Range of 36 Samples	3.7-134	.03-2.3	2.7-281	1.3-540	1.6-103	.005-.43	5.8-144	12-455

[a]Malins, D.C., *et al.* 1980. *Chemical Contaminants and Biological Abnormalities in Central and Southern Puget Sound.* Nat. Mar. Fish. Service, NOAA Tech. Memo. OMPA-2.

[b]Crecelius, E.A., M.H. Bothner, and D. Carpenter. 1972. Geochemistries of arsenic, antimony, mercury and related elements in sediments of Puget Sound. *Sci. Technol.* 9(4):325-333 (Commencement Bay data exclude samples taken within 1-kilometer radius of ASARCO smelter).

[c]Dexter, R.N., *et al.* 1981. *A Summary of Knowledge of Puget Sound Related to Chemical Contaminants.* NOAA Tech. Memo. OMPA-13.

Table 7. Conventional water quality measurements of Puyallup River water and effluents from the Tacoma Central STP and Cleveland Street pump station during low flow on August 25-26, 1981, and during high runoff on February 16-17, 1982.

Station Description Station Number Collection Date Collection Time	River above Outfall (ebb) 4 8/25/81 0745-1000	River above Outfall (high slack) 4 8/25/81 1215-1315	STP Effluent 5 8/25-26/81 0940-0940	River 150 m below Outfall 6 8/25/81 0800-1000	River Mouth 10 8/25/81 0630-0830	River above Cleveland Pump Station 1 2/16/82 1300-1715	Cleveland Pump Station Effluent 3 2/16/82 1300-1600	STP Effluent 5 2/16-17/82 1230-1230	River near Mouth @ 11th St. 9 2/16/82 1400-1730
Flow (cfs)	1790	--	25.5	--	--	18,900	79	111	--
Temperature (°C)	13.6-14.0	16.7-17.4	21.3	13.9-14.3	14.0	7.0-7.9	8.4	10.7-11.7	6.3-6.6
pH (S.U.)	7.7	7.2	6.4	7.5	7.5	7.2	7.4	7.2	7.2
Spec. Conductance (μmhos/cm)	118	609	1240	151	77	535	235	480	837
Dissolved Oxygen (mg/L)	9.5-9.6	6.4;7.6	1.5-3.2	9.4;9.6	8.2;9.3	11.6-12.0	--	9.2	12.0
BOD_5 (mg/L)	6	250	250	18	8	--	--	120	--
COD (mg/L)	9	260	590	40	40	25	62	260	17
Total Chlorine Residual (mg/L)	N.D.	N.D.	.2	N.D.	N.D.	--	--	1.2	N.D.
Fecal Coliform (col/100 mL)	480;150	390;350	2,600*; 11,400	960;150	840;140	780;480; 670	3,200	480;220	520;380; 290
NH_3-N (mg/L)	0.46	7.8	22	0.37	0.11	0.20	0.26	4.4	0.15
NO_2-N (mg/L)	<0.01	0.01	<.1	<0.01	<0.01	0.01	0.01	<0.1	<0.01
NO_3-N (mg/L)	0.13	0.09	<.1	0.14	0.11	0.40	0.65	2.7	0.36
T-PO_4-P (mg/L)	0.18	3.6	9.2	0.22	0.18	0.09	0.12	2.7	0.11
O-PO_4-P (mg/L)	0.13	2.0	5.6	0.07	0.06	--	--	1.3	--
Total Susp. Solids (mg/L)	270	160	170	290	600	330	290	81	410
Turbidity (NTU)	150	140	168	160	230	190	190	57	180
Oil and Grease (mg/L)	<1	4;16	26;27	<1;9	<1	<1	<1	--	<1
Recoverable Phenolics (mg/L) (as phenol)	0.009	0.13	0.45;0.22	0.008	0.011	0.002	0.002	0.67	0.001

N.D. = none detected
*Six effluent samples collected August 25 averaged 300 col/100 mL with a range of 100 - 530 col/100 mL.