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REPORT OF FIELD STUDIES ON THE WILLAPA RIVER
August 29-31, 1972 and September 19-20, 1972

Introduction

The Willapa River is located in southwestern Washington (Figure 1). The river rises in the Willapa Hills to the southeast of the City of Raymond and flows westward into Willapa Bay. The main stem of the Willapa River drains an area of 336 square kilometers above the gaging station near Willapa. The South Fork has a somewhat smaller drainage area of 72 square kilometers. Hydrologic characteristics of the main stem Willapa River and the South Fork are given in Table 1. Low flows occur during the late summer and may persist for two or more months during a dry summer. Rate of runoff is greatly influenced by individual rain storms.

Fishing, shell fishing, logging and lumber processing are the principal industries in the area. The major portion of the lumbering industry is located in Raymond. Logging is an important activity throughout the entire watershed. Fishing is important from South Bend downstream to Willapa Bay and shell fishing is a major industry in Willapa Bay. In addition to the harvesting of natural resources, tourism is becoming an important factor in the economy of the region.

Water quality problems in the main stem and South Fork of the Willapa River have been documented as early as 1950 (Sylvester et al (1950)). These problems were attributed to the discharges of raw domestic sewage and log handling practices.

During the early 1960's construction of treatment facilities by the municipalities of Raymond and South Bend eliminated the discharge of large amounts of raw sewage. However, as late as August 1971, water quality

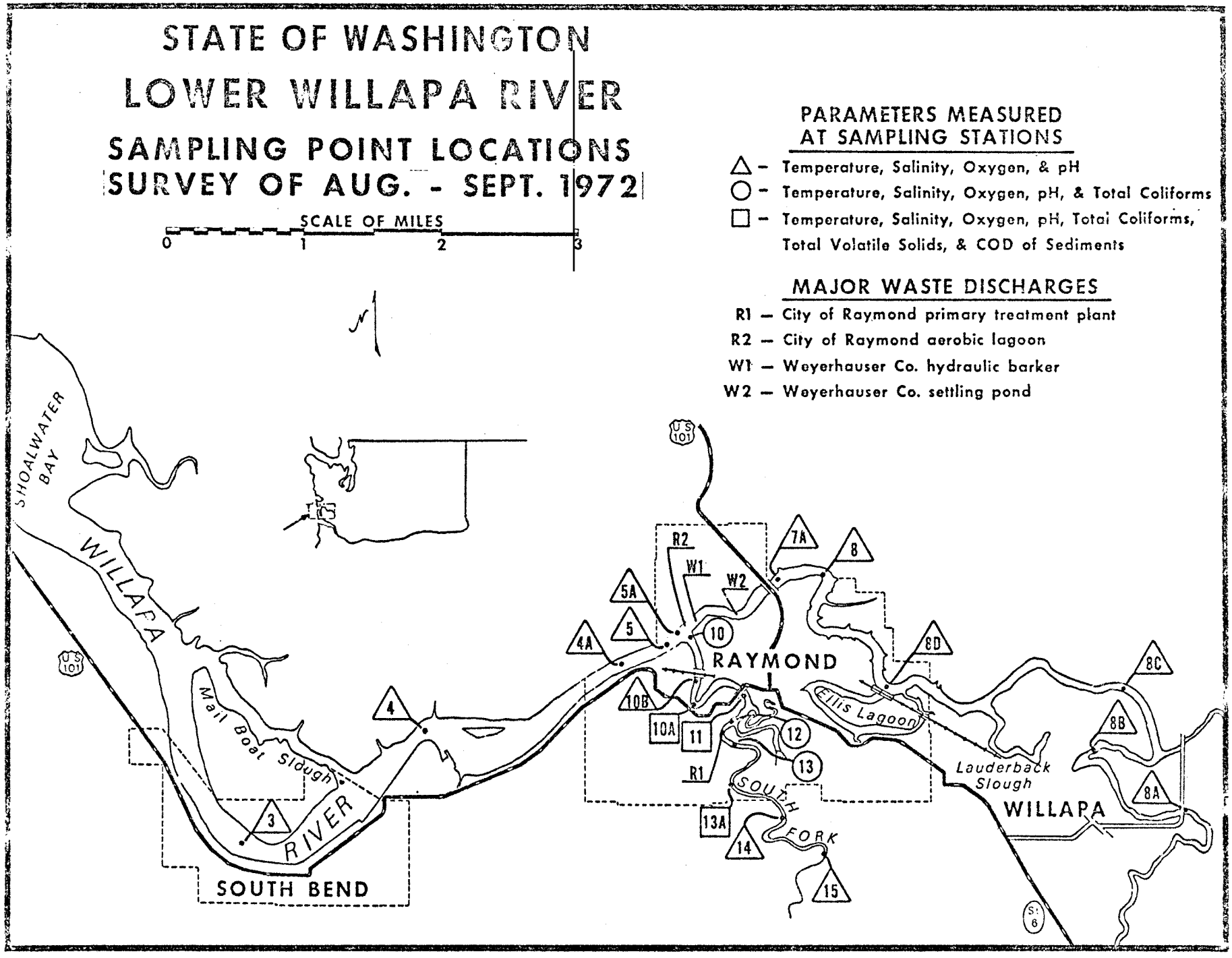


FIGURE 1 - Map of Willapa River in vicinity of Raymond, Washington

violations associated with low dissolved oxygen and high bacteria were observed by the Washington State Department of Ecology (Bishop (1971)).

The construction program was supported by the EPA's construction grants program. In 1970 EPA offered a grant to the City of Raymond to assist in the construction of disinfection facilities at the two Raymond treatment plants. The grant offer was based upon an application by the City of Raymond, in which the City agreed to establish a time schedule for upgrading their primary plant to secondary unless an engineering study could show that primary was sufficient. The engineering report submitted by Cornell, Howland, Hayes and Merrifield (1971), in compliance with this agreement was considered inadequate by EPA and a water quality survey of the Willapa River was scheduled. The survey was carried out in two phases. The first was during the period of August 29-31, 1972 and the second, September 19-20, 1972.

Purpose and Scope

The purpose of the two surveys was to document water quality conditions during low flow conditions and to determine the nature of the major municipal and industrial discharges in the Raymond area.

Within the limits of available equipment and manpower the two surveys included measurements of:

1. Temperature, conductivity, dissolved oxygen, and pH at selected stations on the South Fork and main stem of the Willapa River (see Figure 1).

2. Biological Oxygen Demand (BOD) concentrations of the Raymond primary sewage treatment plant, aerobic lagoon, the Weyerhauser hydraulic barker and the Weyerhauser settling pond. BOD of the receiving waters was determined at two locations in the South Fork of the Willapa River (see Figure 1

3. Total coliforms at selected river stations (see Figure 1).

4. Toxicity at two sites near the primary sewage treatment plant outfall.

5. Chemical Oxygen Demand (COD), Total Volatile Solids and general composition of river bottom sediments at three locations on the South Fork.

Methods

The following methods were used:

1. During the August 28-31, 1972 survey dissolved oxygen was measured with the modified Winkler method and temperature, conductivity and salinity were measured with an Industrial Instrument RS5-2 Conductivity Meter.

During the September 19-20, 1972 survey a Hydrolab multi-parameter water quality instrument was used to measure dissolved oxygen, temperature, conductivity and pH.

2. Standard methods were used to determine BOD of the municipal, industrial and receiving water samples.

3. Standard membrane filter method was used to determine total coliforms

4. Two live boxes with silver salmon fingerlings were used to determine, in a qualitative way, the toxicity.

5. COD and Total Volatile Solids of the bottom sediments was done by standard methods. The general composition was estimated by a visual examination.

The receiving water quality data for the two survey periods are shown in Appendix I. BOD concentrations of the municipal and industrial discharges as well as for the receiving water stations are shown in Appendix I. The sediment analysis are shown in Appendix I. Since the live box studies were of a more qualitative nature they are not shown in tabular form.

Hydrology

The USGS discontinued the stream gauge on the South Fork of the Willapa in September of 1971. The USGS still maintains a gauge on the main stem at Willapa, upstream from Raymond. The gauge was not functioning properly during the survey period, but estimates of the discharge were made from rainfall records and water shed characteristics. The discharge estimates made by the USGS are shown in Figure 2.

The main stem of the Willapa River and the South Fork are influenced by the tide up to River Miles 15.6 and 12, respectively. Tidal heights at Raymond during the two surveys are shown in Figure 3.

Estimates of the waste flow rates from the industrial and municipal source are given in Table 2. For the industrial sources these numbers were obtained from the permit applications, municipal discharger from the STORET municipal inventory, Form 245.

Temperature

Average surface temperatures during each of the surveys are plotted in Figure 4. The plotted data is for the main stem of the Willapa River from South Bend to the confluence of the South Fork and up the South Fork from the confluence to the head of tidewater.

During both surveys average surface temperatures were nearly constant from South Bend (River Mile 4.0) to River Mile 9.0 on the South Fork the cooling influence of the South Fork is noticeable. The South Fork is well shaded and the travel time from the source in the surrounding hills is short. During the August 29-31 survey, the temperature in the freely flowing portion of the South Fork was 6°C lower than typical temperatures in the lower reaches of the river.

FIGURE 2. DISCHARGE OF THE WILLAPA RIVER AT WILLAPA, 8/26/72-9/20/72

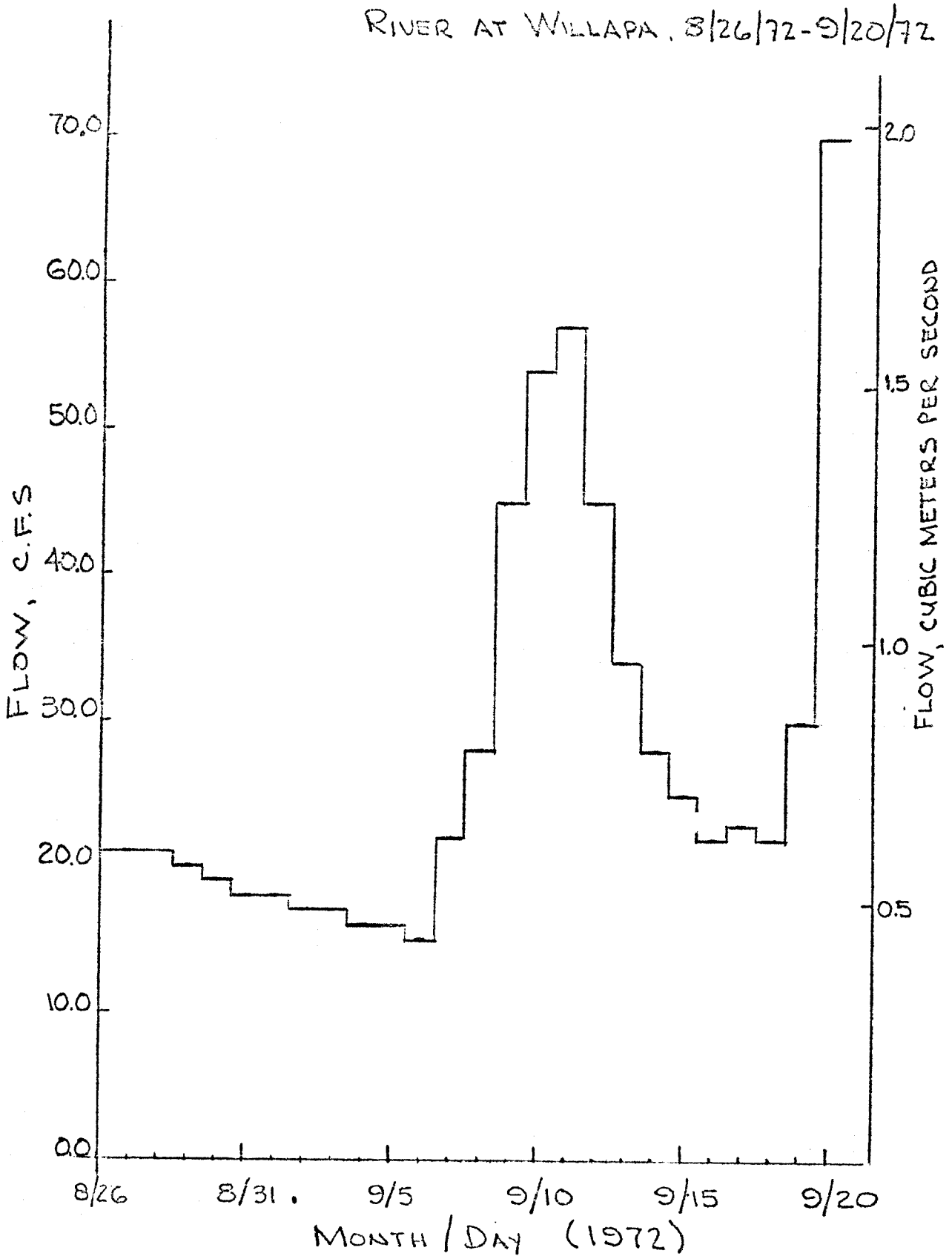


FIGURE 3 TIDAL AMPLITUDE AT RAYMOND, WASHINGTON
8/29/72 - 8/31/72 AND 9/19/72 - 9/20/72

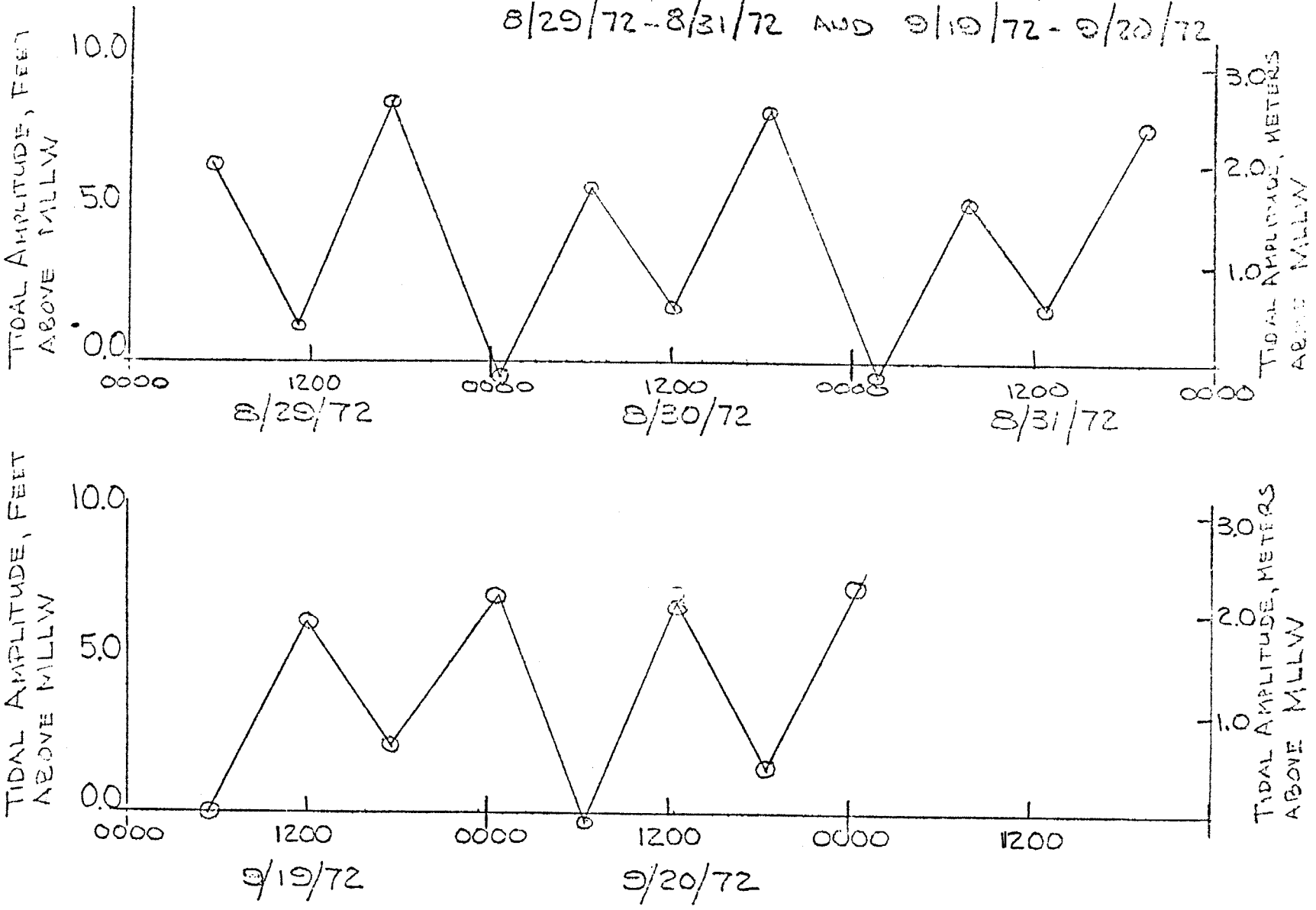
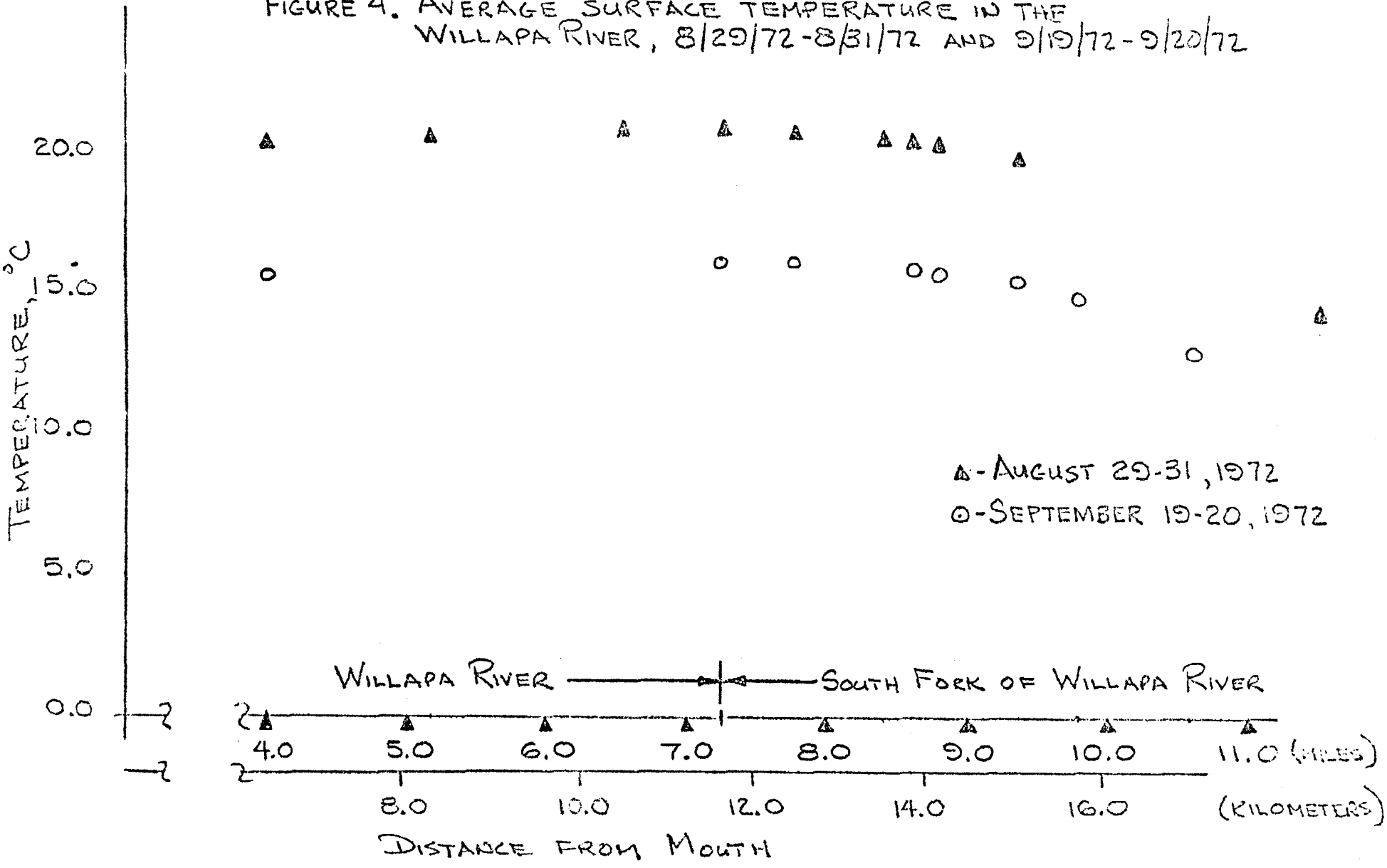


FIGURE 4. AVERAGE SURFACE TEMPERATURE IN THE WILLAPA RIVER, 8/29/72-8/31/72 AND 9/19/72-9/20/72



The average temperature at each station decreased approximately 5°C between the August 29-31 survey and the September 19-20 survey.

Temperature data is shown in Appendix I Table 4.

Salinity

Average surface salinities during each of the surveys are plotted in Figure 5. Surface salinity was slightly lower during the September 19-20 survey because of the increase in river discharge.

Salinity data is shown in Appendix I Table 4.

Dissolved Oxygen

Average dissolved oxygen during each of the surveys are plotted in Figure 6. At individual stations the average dissolved oxygen values during the September 19-20 survey were from 1.7 to 2.2 mg/l greater than corresponding values from the August 29-31 survey. In addition, the ratio of the instream dissolved oxygen to the saturation value of dissolved oxygen (percent saturation) (Figure 1) increased between 10% and 20% from August 29-31 and September 19-20. Dissolved oxygen deficit (Figure 8) decreased between 0.8 mg/l and 1.4 mg/l.

Lower river temperatures, resulting in higher saturation levels for dissolved oxygen, were the cause of part of the increase in dissolved oxygen. However, the significant change in deficit implies that a large amount of dissolved oxygen was added to the river during the period of higher discharge (September 9-12) and/or a large demand on the oxygen resource was removal. A possible source of this demand is the low dissolved oxygen appears along the Washington coast in late summer due to upwelling. However, there is no data from the Willapa Bay area which indicates that upwelling was a major factor during the survey period.

FIGURE 5. AVERAGE SURFACE SALIDITY IN THE WILLAPA RIVER, 8/29/72 - 8/31/72 AND 9/19/72 - 9/20/72

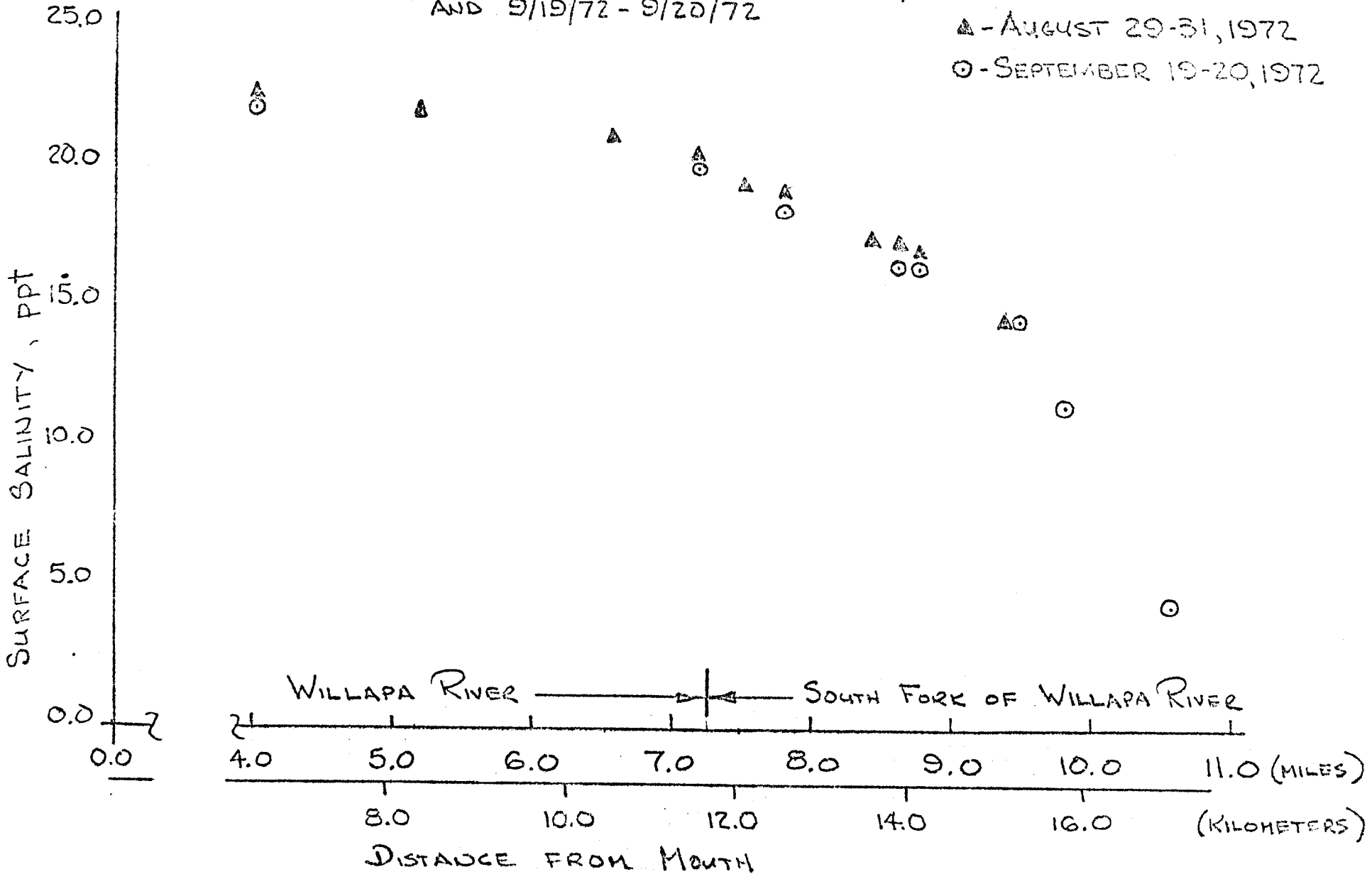


FIGURE 6. AVERAGE DISSOLVED OXYGEN IN THE WILLAPA RIVER, 8/29/72-8/31/72 AND 9/19/72 - 9/20/72

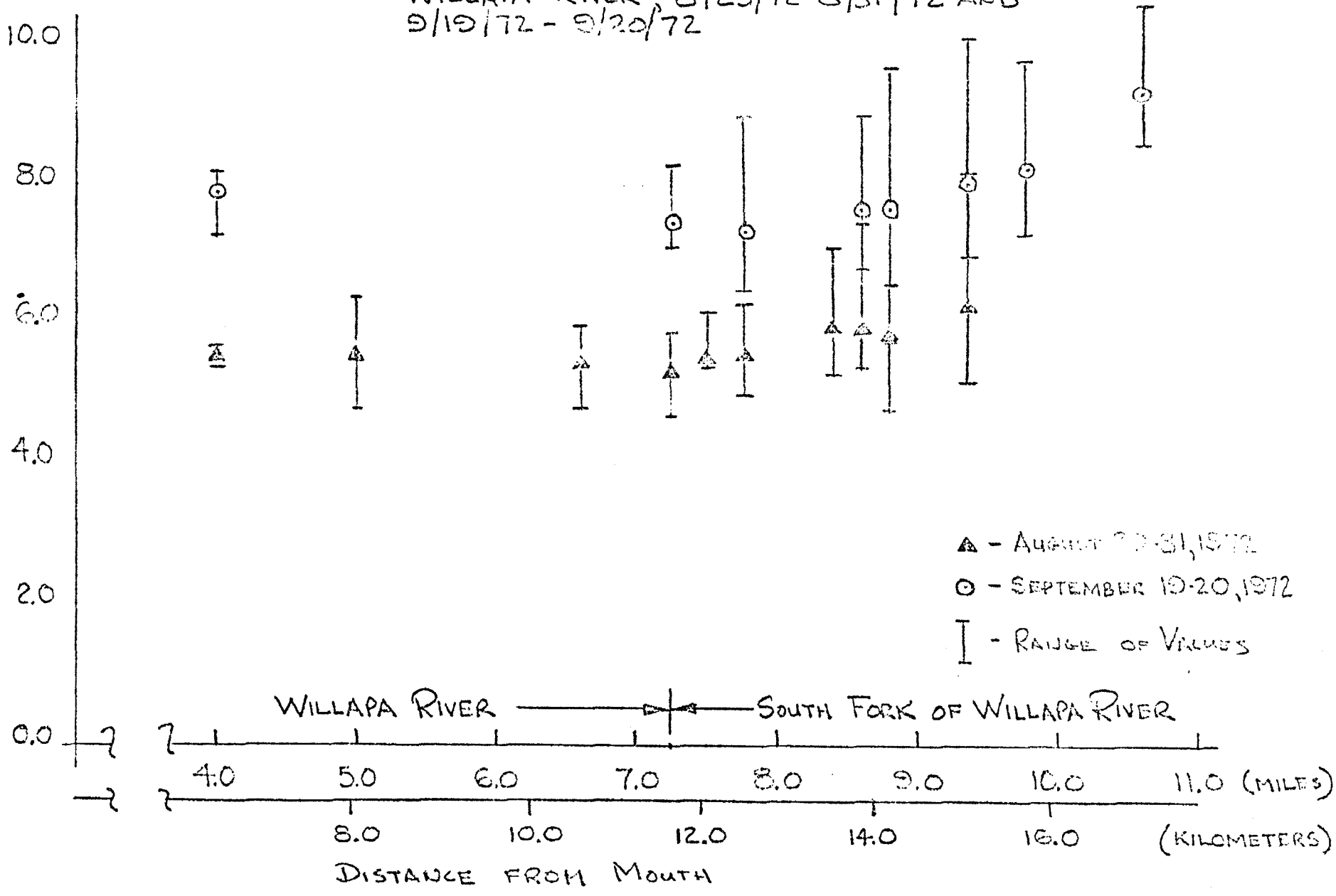


FIGURE 7. PER CENT SATURATION (DISSOLVED OXYGEN) IN THE WILLAPA RIVER, 8/29/72 - 8/31/72 AND 9/19/72 - 9/20/72

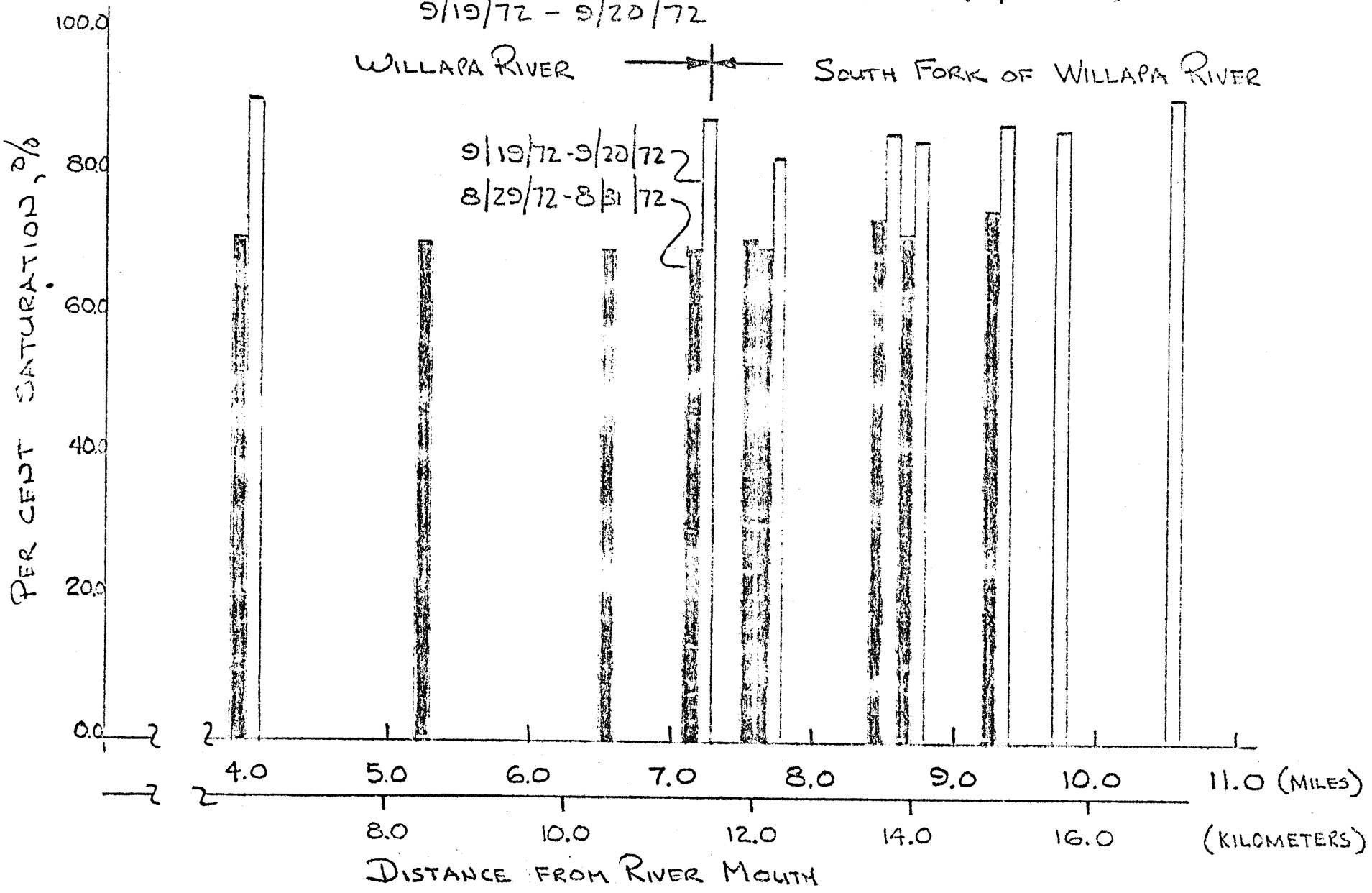
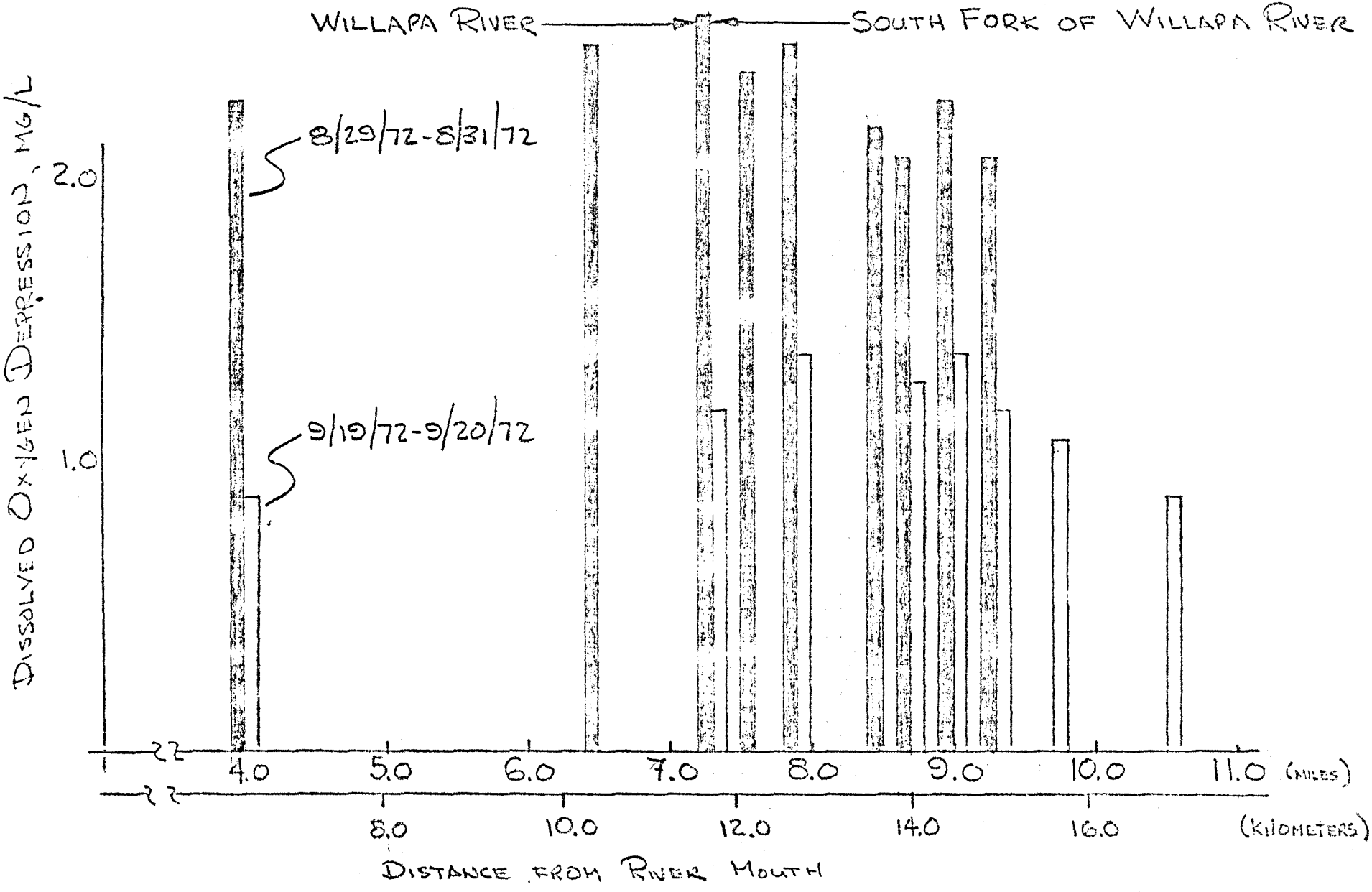


FIGURE 8. DISSOLVED OXYGEN DEPRESSION IN THE WILLAPA RIVER, 8/29/72 - 8/31/72 AND 9/19/72 - 9/20/72



During the August 29-31 sampling period, dissolved oxygen values below the marine waters standard of 6.0 mg/l were measured throughout the sample area. Table 3 shows the ratio of water quality criterion violations to number of samples taken. The ratio increases downstream. On the South Fork the ratio doubles between the primary treatment plant outfall and the confluence of the main stem and the South Fork.

Dissolved oxygen data for both surveys is shown in Appendix I Table 4.

Biological Oxygen Demand

Samples from the major waste sources in the Raymond area, as well as from selected receiving water stations were analyzed for BOD. The results of the analysis are shown in Appendix I Table 5. The highest BOD_5 concentration in the receiving waters, 19 mg/l, was observed at Station 12, near the primary treatment plant outfall.

Coliform

Measurements of total coliforms were made during Survey I, August 29-31, 1972 only. All measurements were made while the tide was ebbing. The water quality criterion for total coliform counts was violated at Stations 5, 10, 10A and 12. The most severe violations occurred in the lower portion of the South Fork particularly in the area of heaviest industrial activity (Stations 10 and 10A).

Much of the wood processing industry is located on that stretch of the river where the most severe violations occur. Land use by these industries is not of high quality. Large quantities of slash and waste wood can be seen on the banks of the main stem and South Fork. The Weyerhauser facility located at the confluence of the mainstem and the South Fork has at least three (3) open pipes discharging untreated waste to the river. These

practices contribute to the water quality problems in the Willapa River but the data taken during the survey is not adequate to quantify their impact upon the level of total coliform bacteria.

The single high count of 2300 organisms per 100 ml observed in the Raymond primary treatment plant effluent indicates that there are at times, a sufficient number of organisms in the plant effluent to cause a violation of the water quality criterion. This problem can be compounded if regrowth occurs. However, the total coliform count at Station 12, just below the primary plant outfall, on August 30, 1972 was only 100 organisms/100 ml and less than 100 organisms /100 ml on the following day, August 31, 1972. These results imply that regrowth is not occurring directly below the primary treatment plant outfall. The treatment plant operators have indicated that they attempt to maintain a chlorine residual of approximately 1.5 mg/l. This high residual may be the reason that no regrowth of coliform bacteria was observed below the primary treatment plant outfall. Total coliform data for both surveys is shown in Appendix I Table 4.

Toxicity

A live box test was performed during Survey I, August 29-31, 1972. The purpose of the test was to determine, qualitatively, the toxicity associated with the primary sewage treatment plant discharge. Fifteen silver salmon fingerlings were obtained from the Willapa Hatchery, Washington State Fisheries on August 29, 1972. The fish were transported from the hatchery to Raymond in an ice chest filled with hatchery water. Over a period of twenty four hours the water in the ice chest was gradually replaced with brackish water from the South Fork of the Willapa River.

On August 30, 1972 the fish were placed in two live boxes seven in one

and eight in the other. The live box with the seven fish was positioned approximately 200 meters upstream from the primary sewage treatment plant outfall in eight meters of water. The other live box with the eight fish was positioned approximately fifteen meters from the primary sewage treatment plant outfall in four meters of water. All fish were alive and appeared to be in good condition at the time they were set, which was 5:30 PM on August 30, 1972.

At 7:00 AM on August 31, 1972 a check of the live boxes showed that all the fish in the live box upstream from the outfall were alive. Two of the fish in the live box near the outfall were still alive, but obviously very severely stressed, the other six were dead. At 12:30 PM, only one of the fish in the live box near the outfall was alive, and just barely, at that.

The demise of the fish in the live box near the treatment plant was attributed to the high level of chlorine residual in the treatment plant effluent. The toxicity associated with high chlorine residual has been well documented (Merkens (1958)).

Chemical Oxygen Demand (COD), Total Volatile Solids and General Composition of of Bottom Sediments.

Three bottom samples were taken from the South Fork of the Willapa River and analyzed for COD, total volatile solids and general composition. The values for each station are given in Appendix I Table 6 and Table 7.

Log storage and handling practices in the Raymond area have resulted in the deposition of bark and wood fibers on the river bottom. The increase in COD and total volatile solids in the Raymond area is a manifestation of these practices.

Aesthetics

Several factors contribute to the degradation of aesthetic values on

both the main stem and the South Fork of the Willapa River. Among the most important are log handling practices, municipal discharges and industrial discharges.

Decaying logs, bark and waste timber products can be seen on the river banks throughout the developed part of the main stem and South Fork of the Willapa River. This discharge from the City of Raymond's primary treatment plant is by way of an open pipe. The pipe is exposed at low tide and the discharge is turbid.

The Weyerhauser plant at the confluence of the main stem and the South Fork has at least three open pipe discharges, none of which can be classified as aesthetically acceptable. In addition, particulate matter from the plant stack rains down upon the river during certain weather conditions and production schedules.

Conclusions

Established water quality standards for dissolved oxygen, total coliform bacteria, toxicity and aesthetics are violated in the main stem and South Fork of the Willapa River. These violations are caused by poor log storage and handling practices, inadequate treatment of municipal and industrial wastes and poor stewardship by the various entities which use the river and adjacent lands.

Violations of the dissolved oxygen criterion are caused by (1) the discharge of organic wastes from the City of Raymond sewage treatment plants and Weyerhauser Co. industrial processes; (2) oxygen demand associated with decaying wood.

Total coliform bacteria counts in the lower portion of the river violated the water quality criterion. For bacteria, the high counts are associated wit the area of industrial development on the South Fork. In one case a violation

of the total coliform standard in the primary treatment plant effluent was recorded. Only one of the three total coliform counts just downstream from plant violated the criterion, however.

The discharge from the primary sewage treatment plant is toxic to silver salmon fingerlings.

Log storage and handling practices, municipal and industrial discharges into both air and water are major contributors to the degradation of aesthetic values in the Raymond area.

Recommendations

With the exception of the dissolved oxygen criterion, violations of water quality can be eliminated by implementing a number of remedial measures. Some of these could be accomplished without great expense. They include:

1. Debris on the banks of the river should be cleaned up and reasonable housekeeping measures should be initiated to maintain the shoreline.

2. All open pipe discharges should be eliminated and discharge made throug a diffuser which is not exposed at low tide.

3. The City of Raymond should dechlorinate its effluent whenever the chlorine residual is greater than 1.0 mg/l.

Remedial actions which require considerably more resources include the following

1. Secondary or equivalent treatment should be provided for all domestic wastes.

2. Best practicable treatment should be provided for industrial wastes, both in the air and the water.

The above measures should increase the dissolved oxygen in the river from 0.4 to 0.6 mg/l. This will reduce, but not eliminate, violations of the dissolved oxygen criterion. Further control of oxygen demand will probably require dredging of bottom sediments in the Raymond area.

To protect the natural resources of the Willapa River and Willapa Bay these remedial measures should be accomplished as rapidly as possible.

No increase in any waste discharge to the Willapa River should be permitted until adequate municipal and industrial treatment facilities are constructed.

Bibliography

Bishop, Bob 1971. Willapa River Survey. Memorandum to to Nelson Graham, Washington State Department of Ecology, November 18, 1971.

Merkens, J. C. 1958. Studies on the toxicity of chlorine and chloramines to the rainbow trout. Water and Waste Treatment Journal 7:150-151

Sylvester, R. O. 1950. A report on the Willapa River estuary. Washington Pollution Control Commission. September 1950.

APPENDIX I

	Drainage Area (kilometers2)	Average Discharge meters3 sec	Maximum Discharge meters3 sec	Minimum Discharge meters3 sec
Main stem of the Willapa River above Willapa	336 (130 sq.mi.)	18.7 (662 c.f.s.)	32.3 (11400 c.f.s.)	0.4 (13 c.f.s.)
South Fork of the Willapa River above Rue Creek	72 (28 sq.mi.)	4.7 (165 c.f.s.)	9.3 (3280 c.f.s.)	0.5 (16 c.f.s.)

Table 1. Hydrologic characteristics of the main stem and South Fork of the Willapa River.

Discharger	Average Flow (meters3/sec)
1. City of Raymond	
Primary plant	0.018 (0.40 mgd)
Aerobic Lagoon	0.0026 (0.060 mgd)
2. Weyerhauser Co.	
Hydraulic Barker	0.025 (0.57 mgd)
Settling Pond	Not reported

Table 2. Average waste flow rates for major discharges in the Raymond area. Data obtained from permit applications and the municipal inventory, EPA Form 245.

Station Number	Study I 8/29/72-8/31/72		Study II 9/19/72-9/20/72	
	Percent Violations (%)	Average Deficit (mg/l)	Percent Violations (%)	Average Deficit (mg/l)
3	100	2.3	0	0.9
4	80	2.3	---	---
4A	88	2.5	---	---
5	100	2.6	0	1.2
7A	100	2.5	0	1.4
8	86	2.4	---	---
8D	---	---	---	1.0
8C	---	---	---	1.5
8B	---	---	--	1.9
8A	---	---	---	---
10	100	2.5	0	1.1
10B	88	2.4	---	---
10A	83	2.5	0	1.4
11	58	2.2	---	---
12	50	2.1	0	1.3
13	58	2.3	0	1.4
13A	54	2.1	0	1.2
14	---	---	0	1.1
15	---	---	0	0.9

Table 3. Percent of observations violating the dissolved oxygen criterion of 6.0 mg/l and average oxygen deficit during the two surveys, August 29-31, 1972 and September 19-20, 1972.

TABLE 4

Pages 26 through 50 of this publication are too illegible to be viewed online. To request a printed publication, please contact the Environmental Assessment Program at the Washington State Department of Ecology.

Discharger	BOD_5 (mg/l)	BOD_{10} (mg/l)	BOD_{15} (mg/l)	BOD_{20} (mg/l)
1. City of Raymond Primary plant	63.0	73.0	---	108.0
Aerobic lagoon	30.0	48.0	62.0	65.0
2. Weyerhauser Co. Hydraulic barker	32.0	43.0	51.0	46.0
Settling pond	94.0	107.0	116.0	112.0
3. South Fork at Willapa River Primary plant outfall	19.0	19.0	15.0	13.0
near City Dock	2.0	2.0	3.0	2.0

Table 5. BOD of municipal-industrial discharges and receiving water, August 31, 1972.

Station Number	COD		Volatile Solids
	Wet Basis (mg/kg)	Dry Basis (mg/kg)	(%)
13a	9376	13491	7.7
11	35953	83612	11.9
10a	60849	167168	15.1

Table 6. COD and Total Volatile Solids of sediment samples taken of sediment samples taken in the South Fork of the Willapa River near Raymond, August 30, 1972.

Station Number	General Compositions
13a	clean clay-like particles - 100%
11	sand and silt - 75% wood particles - 15% decaying organic matter - 10%
10a	sand and silt - 70% wood particles - 5% decaying organic matter - 25%

Table 7. General composition of sediment samples taken in the South Fork of the Willapa River near Raymond, August 30, 1972.