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WATER QUALITY:
Western Fish Toxicology Station and Western Oregon Rivers

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WATER QUALITY: WESTERN FISH TOXICOLOGY STATION AND WESTERN OREGON RIVERS

by

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ABSTRACT

Seasonal variation in water quality was compared for the Western Fish Toxicology Station (WFTS), Corvallis, Oregon, the adjacent Willamette River and approximately forty major western Oregon rivers from 1972 thru 1974.

Water temperature patterns of the Willamette River and the WFTS well were similar (range, 4.6-20.0°C). While both displayed seasonal trends, well water lagged 7-10 days behind the river in both temperature increases and decreases. Dissolved oxygen values in both the river and well water were inversely related to temperature. Average dissolved oxygen concentrations were higher in the river (10.4 mg/l) than in the well water (4.1 mg/l). Hydrogen ion concentration (pH) was low in the well water (range, 6.6-7.0; median, 6.8) compared to the river (range, 7.0-7.8; median, 7.40). River water was considered to be "soft" with a mean hardness and alkalinity of 22 mg/l and 23 mg/l respectively, while the well water ranged between "soft to moderately hard" (mean hardness, 34 mg/l; mean alkalinity, 31 mg/l). High Willamette River discharges (above Corvallis) were also followed by a 7-10 day lag in corresponding sharp peaks of total hardness, alkalinity and certain cations (Ca^{++}, Mg^{++} and Na^{+}) and anions ($SO_4^{=}$, HCO_3^{-}, NO_3^{-} and Cl^{-}) in the well water. Major cation and anion concentrations were low overall. Trace metals, with the exception of river iron, manganese and zinc, were found to be at or near detection limits. River iron and manganese concentrations were approximately 10 times greater than those found in the well (mean river Fe, 736 μg/l; Mn, 30.7 μg/l; mean well water Fe, 83 μg/l; Mn 3.1 μg/l). River zinc had a mean of 9.4 μg/l, while the well water mean concentration was 5.1 μg/l.

The Station's research water quality was similar in nearly all respects to the Willamette and other western Oregon river samples. A typical western Oregon stream was found to have a near neutral to slightly acid pH, an alkalinity and hardness of between 10-50 mg/l, a temperature range of 6-19°C, a dissolved oxygen range of 9.0-12.0 mg/l, and a relatively low concentration of the trace metals Cd, Cu and Zn.

CONTENTS

FIGURES

ACKNOWLEDGMENTS

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The water quality and daily discharge records and precipitation data supplied by the U.S. Geological Survey and U.S. National Weather Service, Corvallis, Oregon, was appreciated. The services of the U.S. Army Corps of Engineers, Portland, Oregon are also acknowledged.

SECTION I

SUMMARY AND CONCLUSIONS

1. The water temperature patterns of the Willamette River and Western Fish Toxicology Station's well water were similar. Both displayed seasonal trends; however, well water temperature increases and decreases lagged behind the river by 7-10 days.

2. Dissolved oxygen in the WFTS well and Willamette River varied inversely with water temperature and followed a seasonal trend.

3. Willamette River discharge had a major but indirect influence on well water quality. High discharge was followed 7-10 days later by corresponding sharp peaks in total alkalinity, hardness and certain cations (Ca^{++}, Mg^{++} and Na^{+}) and anions ($SO_4^{=}$, HCO_3^{-}, NO_3^{-} and Cl^{-}) in the well water.

4. Hydrogen ion concentration (pH) was low in the well (range, 6.6-7.0; median, 6.8) as compared to the river (range, 7.0-7.8; median, 7.4). This slightly acid condition probably enhanced the leaching and solubilizing effect in the ground, contributing to the increased mineral and nutrient levels found in the well water.

5. Dissolved Ca^{++}, Mg^{++} and Na^{+} were more abundant in well water and showed moderate seasonal variation.

6. Nitrate levels in the river varied directly with discharge, whereas well nitrates followed the same indirect relationship as alkalinity and hardness. River and well sulfates and chlorides were similar in both concentration and annual variation.

7. Concentrations of river and well trace elements (Cd, Cr, Co, Cu, Pb, Hg and Ni) were in close agreement. Iron and manganese concentrations were found to be approximately ten times greater in river water than in well water, while river zinc was twice that of the well. River Fe, Cr, Cu, Mn and Ni displayed seasonal trends.

8. Western Oregon river water quality was similar to that of the WFTS laboratory water supply. Annual temperature variation for all streams was between 6.4-19.2 °C. Dissolved oxygen, which varied inversely with temperature, ranged between 9.4-12.0 mg/l. Hydrogen ion concentration indicated some seasonal variation (range 6.61-8.30).

9. Alkalinity and hardness in western Oregon streams showed no seasonal trend but did coorelate well with geographical location. Northwestern Oregon streams had an alkalinity and hardness of between 10-30 mg/l, while those of southwest Oregon ranged between 31-80 mg/l.

10. Trace elements (Cd, Cu and Zn) were found to be relatively low in concentration. Seventy-five percent of the streams sampled had a Cd concentration of <0.01 μg/l. Mean copper and zinc levels were found to be 1.8 μg/l and 2.4 μg/l respectively.

SECTION II

INTRODUCTION

The Pacific Northwest exhibits a wide range of water quality which is influenced by an equally wide range of geological and climatological factors and broad land use patterns (Highsmith, 1968). Since the chemical and physical properties of these waters are in a constant state of change, it is necessary to establish environmental background levels of naturally occurring constituents as well as suspected pollutants in order to protect aquatic life inhabiting these waters.

The availability and subsequent monitoring and control of a high quality water supply are of critical importance to a fishery research activity. At the Western Fish Toxicology Station (WFTS), a variety of aquatic organisms, which include different life stages, are experimentally exposed to toxic metals and various other pollutants added to the natural water supply. The toxicity of substances added often depends upon substances already present in the receiving waters. Therefore, it is necessary to consider the influence of such factors as temperature, pH, dissolved oxygen, alkalinity and hardness on the solubility and toxic activity of the material being tested. For example, an increase in the hardness and/or alkalinity may reduce the toxic effect of a metal in solution while a decrease enhances it (Cairns and Scheier, 1957). Low pH usually increases the solubility of a metallic substance, thereby presenting a more toxic situation (Sprague, 1964) although this was not the case for zinc (Mount, 1966).

Natural and synthetic organic constituents found in water also affect the toxicity of a given metal. Some compounds act as chelators and others form ligands which bind metals into complexes, thus reducing their toxicity (Remey, 1956; Chau, 1973).

Developing tolerance criteria to establish "safe-level" concentrations of toxicants is most often accomplished using laboratory water. Attempts to apply these criteria to another water system directly is inadequate unless the water quality of both waters has been well defined. Many of the water quality data available from western Oregon streams in the past were incomplete and for many variables absent altogether. Available data on trace elements were especially lacking.

This study was designed to summarize and compare seasonal characteristics of water quality in the WFTS well (which constitutes the primary water supply of the Station), the adjacent Willamette River, and to a more limited extent, approximately forty western Oregon rivers.

SECTION III

DESCRIPTION OF STUDY AREAS

WESTERN FISH TOXICOLOGY STATION

Western Fish Toxicology Station is located approximately three miles southeast of downtown Corvallis, Oregon, and two-hundred meters west of the Willamette River (Figure 1).

Water Supply and Distribution: Water is obtained from two wells located in Willamette Park about 100 feet (30 m) from the bank of the Willamette River. Wells number one and two were drilled in June 1968 and February 1971 respectively. Figure 2 describes both wells in terms of the soil conditions, their relative depths, and their relationship to the river.

Water is pumped from number two well via 1050 feet (315 m) of 6-inch (15 cm) PVC pipe using a Peerless submersible pump. A second submersible pump in well number one provides a back up water supply. A pressure switch in the water line at the main building automatically starts the number one pump when the pressure drops below a pre-set level. Distribution of water throughout the laboratory complex is also via PVC pipe.

Water Treatment: Incoming well water temperatures vary from 2°C in January-February to 10°C in August-September. Dissolved oxygen and pH of the well water entering the laboratory is low and the water is somewhat supersaturated (D.O. ≈3.0 ppm, pH ≈6.8, percent gas saturation ≈ 110%). Aeration is provided by subsequent pumping and jetting of water to saturate the water with oxygen, raise the pH and reduce total supersaturation.

Much of the water is treated with ultraviolet light to control fish pathogens. Temperature control (both chilling and heating) is used to maintain experiments at desired temperatures. Reverse osmosis is used during periods of atypical hardness (>30 mg/l) to provide low hardness water for blending with ambient water for metal toxicity tests

WILLAMETTE RIVER BASIN

The Willamette River indirectly supplies the water for WFTS wells and influences, to a degree, the quality of the water supply.

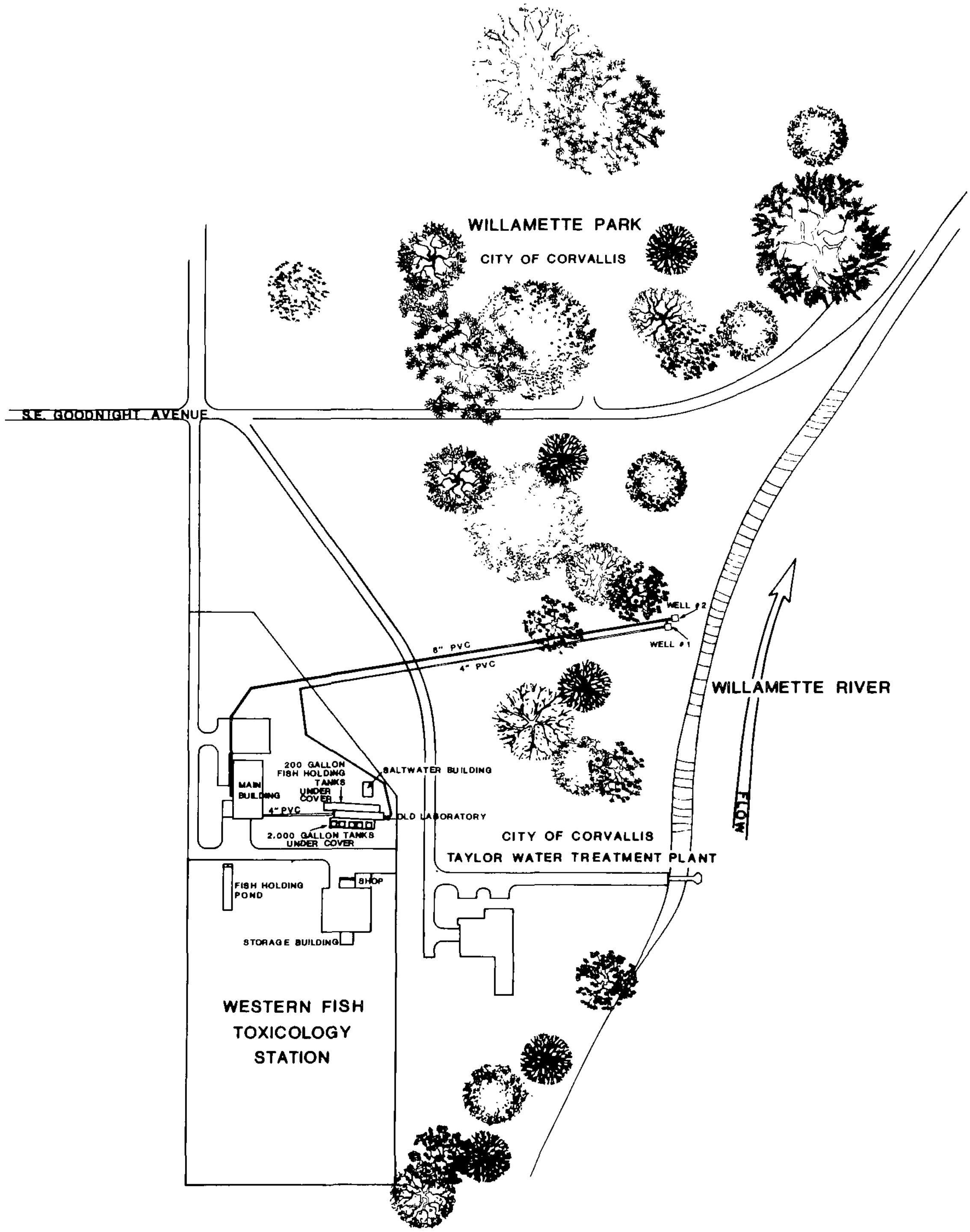


Figure 1. Site layout of Western Fish Toxicology Station.

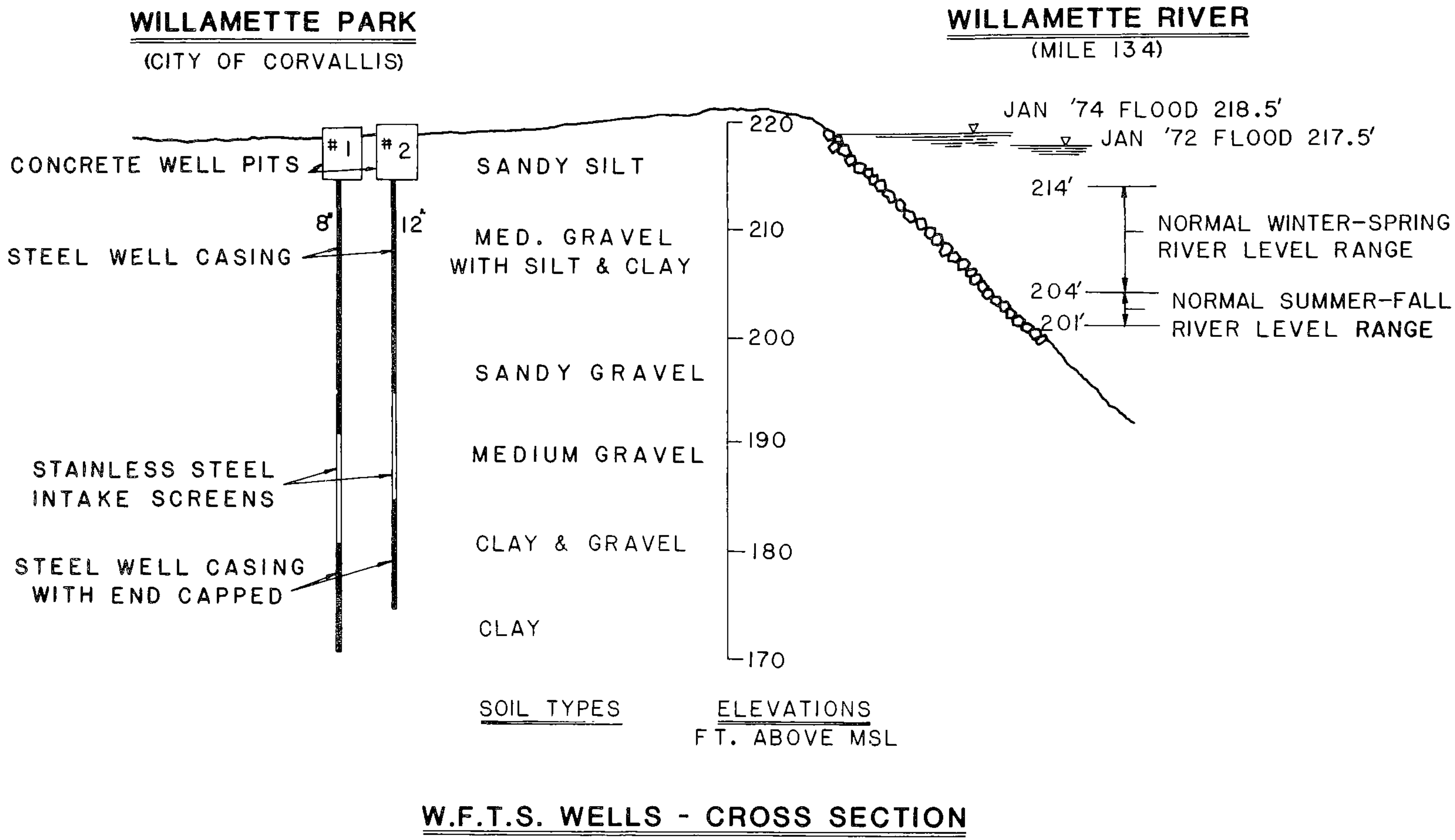


Figure 2. Western Fish Toxicology Station well description.

The Willamette River Basin (Figure 3) is approximately 150 miles in length and 25 miles wide. It is bordered by mountains on both sides. On the west, peaks of the Coast Range are 2,000-3,000 feet high. On the east, the Cascade Range reaches elevations of 5,000-10,000 feet. At lower elevations the mountains are heavily forested, primarily with Douglas-fir. Lakes, rock outcroppings, and meadows appear at the higher elevations in the Cascades.

Most of the Willamette River water originates in the mountains and flows down into the river via major tributaries (Figure 4).

The Willamette Valley is relatively flat--its primary land use being agricultural. Willamette River water at the WFTS comes primarily from several main tributaries in the southern part of the Willamette Valley, namely, the coast and middle fork of the Willamette River, the McKenzie, the Long Tom and Muddy Rivers.

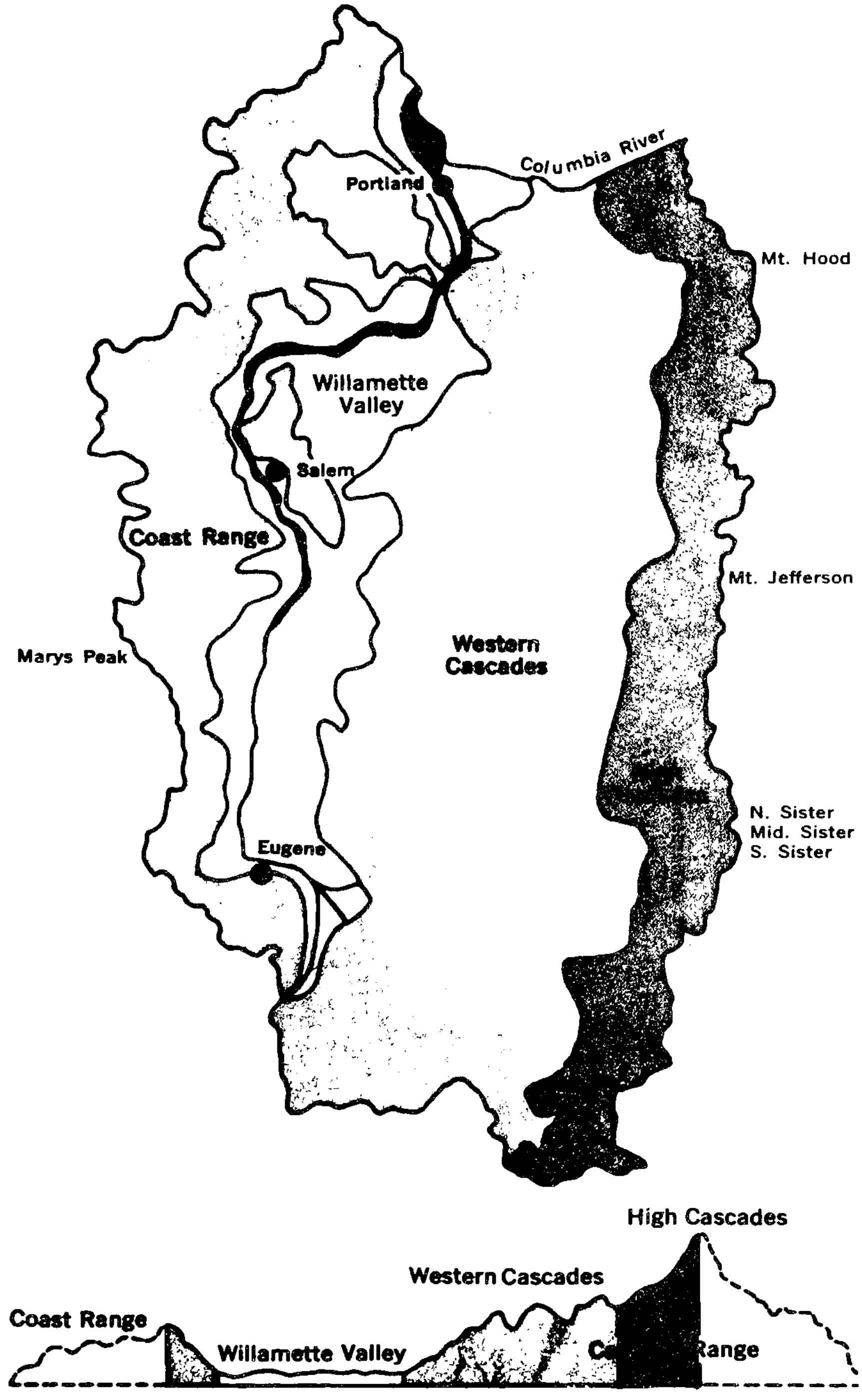
The Willamette River has an annual runoff of 26 million acre feet. Almost 75 percent of this total stream runoff occurs between November-March and less than 10 percent between June and September.

Historically, Willamette River water quality has received much attention. In the late 1920's the river was so polluted that complete depletion of dissolved oxygen was noted during a low-flow summer period around Portland, Oregon (Willamette Basin Task Force Study, 1969). The principal causes were untreated municipal and industrial wastes being discharged directly into the river. Since then, municipalities and industry have had to comply with pollution abatement measures set forth by the Oregon Department of Environmental Quality. These regulations require at least secondary treatment for domestic wastes such that a dissolved oxygen content of 5.0 ppm could be maintained at all times in the Willamette River and Portland, Oregon,harbor.

WESTERN OREGON RIVER DRAINAGES (GENERAL DESCRIPTION)

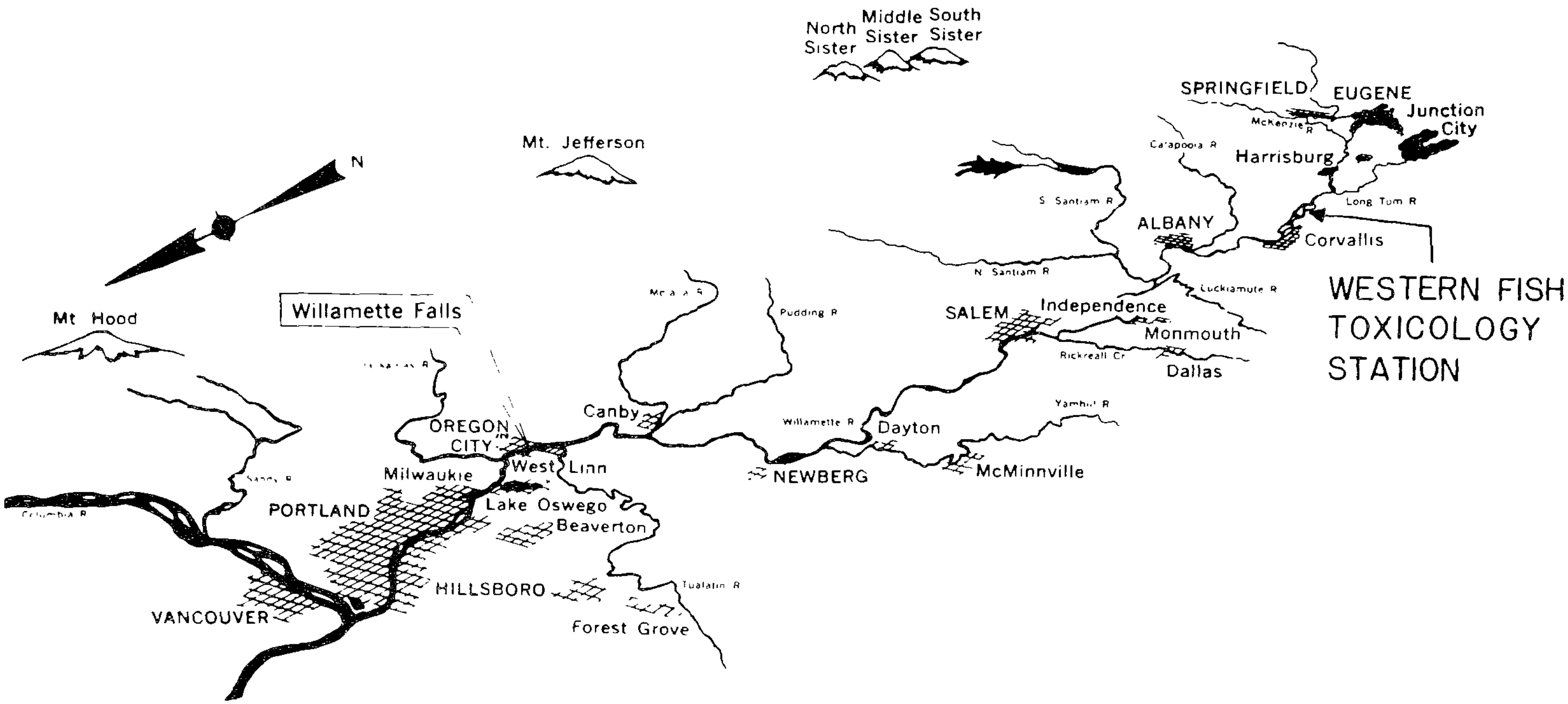
Most western Oregon rivers and their tributaries are used as migratory routes, temporary habitats and spawning areas for anadromous fishes. These streams also serve as a permanent home for many resident warm and cold water species.

Western Oregon water quality is considered to be good. In any stream, however, the governing quality factor is the worst condition that can exist, not the average. For example, low discharge, high water temperature and low dissolved oxygen usually occur at the same time.



Source: Pacific Northwest River Basins Commission

Figure 3. Willamette River Basin



Source: Pacific Northwest River Basins Commission

Figure 4. Willamette River and Major Tributaries.

Principal factors affecting water quality in western Oregon streams are climate, geomorphology of the basins, soil conditions, mineral deposits and land use effects.

CLIMATE

The Willamette lowlands have slightly larger annual temperature ranges (higher maxima and lower minima) than Oregon coastal regions. Summer daily maximums are 70-80°F and night time minimums of 50-60°F are usual in the Willamette Valley.

Precipitation ranges from less than 1-inch per month in the summer to a mean of 6-9 inches per month in the winter for a total of 35-45 inches annually. Lowlands in southern Oregon such as the Rogue Valley are more cut off from the marine influence than other lowlands by continuous terrain barriers. They experience warmer summers and cooler winters and lower annual precipitation totals (Highsmith, 1968).

GEOMOPHOLOGY, MINERALS, AND SOIL CONDITIONS

The bedrock at WFTS, and along the Willamette River and other western Oregon drainages consists of Cenozoic unmetamorphosed marine sedimentary strata. Soils of the Willamette Lowlands are dark, silty, nearly level and somewhat acid. These soils are light in weight, changing to clay with depth.

Soils of the coastal areas contain a high content of organic matter. They are dark and strongly acid-saturated. Clay content may be high in narrow horizons. These soils are also light in weight, friable and porous.

Mineral deposits are varied and widespread. Except for the southwestern Oregon lowlands which have significant deposits of copper, gold and zinc, the remaining study area had comparatively small deposits of these minerals.

LAND USE EFFECTS ON WESTERN OREGON WATER QUALITY

The diversity of land use practices in western Oregon substantially affects the physical and chemical environment of its streams.

The production and transport of sediment constitutes the most significant impairment to water quality resulting from land use (Willamette Basin Task Force Study, 1969). Sediment is damaging both while suspended and after settling. The major single source of sediment is bank cutting caused by flood flows; however, stripping of vegetation cover and massive disturbance of soil from urban and rural development, highway construction, and, to a limited extent, logging activities, have a major input to sedimentation in our streams.

During winter months, pulp mills discharge nearly all of their wastes. Additional organic material is discharged from storm sewers and bypasses from overloaded sanitary sewage treatment plants; however, dilution is usually adequate to prevent oxygen depletion.

Nutrients are carried to streams from a number of sources: agriculture, cattle (feed lots and stock watering), rain, food processing and municipal wastes. About two-thirds of the phosphates and about twelve percent of the nitrates are contributed by agriculture. The remaining amounts are divided between the other sources. The majority of these nutrients flow into Oregon rivers during periods of winter runoff. Temperatures are low enough and flows high enough to prevent major eutrophication problems.

Toxic elements and related compounds are not normally found in western Oregon rivers; however, accidental spills and improper application of pesticides, certain minerals, and petroleum products do result in infrequent and localized pollution and fish kills.

Coastal streams, except near their mouths and in estuaries, are of limited usefulness to industry. This is due to low summer flows and high temperatures. Wastes from natural surface runoff and logging operations, small sawmills and log rafting cause minor changes in the water quality of these areas.

SECTION IV

METHODS

SAMPLING PROCEDURE

Routine water samples and field measurements were collected at various intervals, depending on their nature in support of the Station's research.

Physical characteristics such as wet and dry bulb air temperature, Willamette River and well water temperature and discharge were measured daily. Water samples for chemical analysis such as dissolved oxygen, pH, total alkalinity and hardness were also collected daily. Ambient levels of ammonia and trace heavy metals, in the Station's water supply and individual test tanks, were monitored on a schedule compatible with the research work load.

Remaining chemical characteristics were collected, preserved and delivered to Consolidated Laboratory Services, Pacific Northwest Environmental Research Laboratory, National Environmental Research Center (NERC), Corvallis, Oregon, for analysis on a weekly basis.

Field sampling on western Oregon rivers for temperature, D.O., pH, hardness, alkalinity and heavy metals was conducted once quarterly during 1972-1973.

PHYSICAL CHARACTERISTICS

Air and water temperatures were taken daily with a centigrade glass thermometer or continuously on a Taylor, manually wound, thermograph. Willamette River stage, in feet above sea level, was correlated with U.S. Geological Survey's discharge records for the reporting period.

Rainfall records were supplied by the U.S. Department of Commerce, Environmental Science Services Administration, National Weather Service, Corvallis, Oregon.

CHEMICAL CHARACTERISTICS

All chemical analyses were carried out according to Standard Methods-APHA 13th Ed., 1971, unless otherwise stated.

Dissolved oxygen was determined using a Yellow Springs Instruments Model 54-RC dissolved oxygen meter equipped with a B.O.D. stirring probe. Daily, or in some cases, twice daily, standardization of the dissolved oxygen meter was performed using the azide modification of the Winkler method. Hydrogen ion concentration was measured with either a Beckman Zeromatic SS-3 or Orion Model 701 glass electrode pH meter. Hardness was determined using the EDTA titrametric method (KCN used as inhibitor for Fe). Alkalinity was determined potentiometrically with 0.02N H_2SO_4, titrating to end points of pH 4.2 and 4.5.

Nitrates and nitrites were determined by the automated cadmium copper reduction method. Within 15 minutes after collection, samples were preserved by the addition of 40 mg $HgCl_2$ per liter. Nitrates were reduced to nitrites and total nitrites (those originally present plus reduced nitrites) were determined by the azo dye intensity method. The sameprocedure was then carried out without the Cd-Cu reduction step for original nitrite. Separate nitrate-nitrite values were then readily obtainable.

Ammonia was determined by an automated method using a Technicon Autoanalyzer. Samples were preserved in the same manner as for NO_2 and NO_3. The intensity of the idophenol blue color, formed by the reaction of ammonia with alkaline phenol hypochlorite, was measured. Sodium nitroprusside was used to intensify the blue color.

Chloride was determined by mercuric nitrate titration. Dilute mercuric nitrite solution was added to an acidified sample in the presence of mixed diphenylcarbazone-bromophenol blue indicator. The end point of the titration was the formation of the blue-violet mercury diphenylcarbazone complex.

Sulfate was determined by the turbidometric method. Sulfate ion was converted to a barium sulfate suspension and the resulting turbidity was determined on a Hach Turbidimeter and compared to a curve prepared from standard sulfate solutions.

Suspended and dissolved solids were determined by suction filtering a well-mixed sample through a 4.7 cm diameter glass fiber filter (Gelman Type A, without organic binder). The filter and filtrate were dried to a constant weight at 180°C, the residue being the filterable dissolved solids. A Gooch crucible and glass fiber filter was used to measure suspended solids. After filtration, the crucible and disc were dried in an oven at 103-105°C for 1 hour, desiccated and weighed.

Turbidity was measured by a nephilometer which compared the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension, using a Hach Model 2100 Turbidimeter. Readings taken were in Jackson Turbidity Units.

Total calcium, magnesium, sodium, and potassium were determined directly on unstabilized samples by atomic absorption spectrophotometry using an Instrument Laboratories Model 353 A.A. spectrophotometer. To mask interferences due to phosphate, sulfate and aluminum (in determining calcium and magnesium), lanthanum chloride1/ was added at the rate of 1 ml of $LaCl_3$ solution for each 10 ml of sample volume.

Total trace metals such as Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni and Zn were preserved at the time of collection with 25 ml concentrated HNO_3 per liter. Samples were concentrated by evaporation (except for Fe when concentrations were >50 μg/liter). A 200 ml aliquot of well-mixed sample was transferred to a covered 250 ml Griffin Beaker. The sample was evaporated to dryness overnight (temperature set low enough to prevent boiling). The beaker was then cooled, 1.0 ml of HNO_3 added, and the volume was adjusted to 10.0 ml with distilled water (20 X concentration factor). Any residue still remaining in the beaker, prior to volume adjustment, was broken up and dissolved by sonication. Samples were then analyzed on an Instrument Laboratories Model 353 A.A. spectrophotometer.

Total mercury was determined using the flameless cold vapor atomic absorption method. Water samples were nitric acid-preserved as for other trace metals. The mercury was reduced to the elemental state and vaporized from solution in a closed system. The mercury vapor passed through a cell positioned in the light path of an atomic absroption spectrophotometer. Mercury concentration was measured as a function of Absorbance (peak height).

FIELD SAMPLES

Water samples collected from western Oregon streams were analyzed in the field for temperature, dissolved oxygen and pH. Total hardness and alkalinity were determined within 24 hours after sampling, in the laboratory. Trace metals (cadmium, copper and zinc) were analyzed either by flame using a Perkin-Elmer 403 or by the Perkin-Elmer 305B and 403 A.A. spectrophotometer equipped with the HGA-2000 heated graphite atomizer. The heated graphite atomizer afforded certain advantages for examining background levels of Cd, Cu, and Zn such as direct analysis (no pre-concentration), improved sensitivity (up to 100 times better than those obtained previously by flame A.A.) and extremely low detection limits (that minimum concentration detectable from zero) (Fernandez and Manning, 1971). Graphite furnace operating conditions are listed in Table 1.

1/ $LaCl_3$ solution was made by adding 58.0 g LaO_3 in small portions into 500 ml concentrated HCl and diluting to 1.0 liter with distilled H_2O.

Table 1. Atomic absorption spectrophotometer and graphite furnace operating conditions for analyzing ambient concentrations of cadmium, copper and zinc in western Oregon rivers.

Element	Sample Volume (µl)	Wave Length (A°)	Absolute Sensitivity (gram X 10^{-12})	Detection Limits (µg/l)[1/] HGA 2000	Detection Limits (µg/l)[1/] Flame A A	Slit Width	Absorption Mode (X Abs)	Recorder Range (mv)[3/]	Chart Speed (mm/min)
Cadmium	25	2288	1.3	0.02	1.0	4	3	20	20
Copper	25	3246	60	0.10	2.0	4	3	10	20
Zinc	5	2138	1.8	0.02	2.0	5 (4)[2/]	2 (1)	10 (50)	10 (20)

HGA - 2000 Programmed Sequence Settings

Element	Flushing Gas	Gas Flow (lites/min)	Gas Interrupt	Dry Temp. (°C)	Dry Time (sec.)	Char Temp. (°C)	Char Time (sec.)	Atomize Temp. (°C)	Atomize Time (sec.)
Cadmium	Argon or N_2	3	on	200	10	400	12	1600	10
Copper	Argon or N_2	3	on	200	10	1000	12	2600	10
Zinc	Argon or N_2	3	off	200	10	400	10	1500	11

[1/] Detection limits using the HGA-2000 heated graphite atomizer on the Perkin-Elmer 403 and 305B A.A. spectrophotometer are compared with limits obtained using a 3-slot burner head on the Perkin -Elmer 403 (Fernandez and Manning 1971).

[2/] Operating parameters listed in parenthesis apply only to the Perkin-Elmer 403 A.A. spectrophotometer (using the HGA-2000). All other parameters are applicable to both the Perkin-Elmer 403 and 305B.

[3/] Recorder: Perkin -Elmer Model 56.

SECTION V

RESULTS AND DISCUSSION

PHYSICAL CHARACTERISTICS

Weekly minimum, maximum and mean water temperatures are plotted for the Willamette River in Figure 5a. River water temperature followed a seasonal trend. The extreme range during the reporting period was from a low of 3.5°C (January 1973) to a high of 19.7°C (August 1973). Greatest diel variation occurred during the months of June-August and least from October-April.

Mean water temperature for both the river and WFTS well closely followed the mean ambient air temperature (Figure 5b). While both river and well temperature patterns were similar, the river displayed somewhat higher high and lower low temperatures than the well. There was approximately 7-10 days lag time in well water response for both temperature increases and decreases. Figure 6 gives local precipitation in inches, and Willamette River discharge in cubic feet per second for 1972-1974. Discharge was primarily influenced by rainfall and snow melt from the western Cascades and eastern coastal ranges. Eight reservoirs on the upper Willamette River and McKenzie River are used primarily for flow regulation and valley flood control (U.S. G. S. Water Resources Data for Oregon, 1972).

Figure 7 compares turbidity for the river and well between June 1972 thru April 1974. The turbidity of the well water, which was essentially ground filtered river water, remained relatively constant between May 1973 thru April 1974 (range 1-13; mean 6, Jackson Turbidity Units) while the river was extremely variable (range 2-52; mean 14 Jackson Turbidity Units).

CHEMICAL CHARACTERISTICS

Dissolved oxygen values from the well and river were inversely related to temperature (Figure 8). Dissolved oxygen in the river, however, was higher overall than in the well with a range of 7.7-13.0 mg/l; mean, 10.4 mg/l. The D.O. concentration of the well was comparatively lower (range 1.8-8.5 mg/l; mean, 4.1 mg/l). This was attributed to two factors: (1) the depletion of oxygen as river water filtered through river rock, sand, and soil into the well; and, (2) the obvious lack of water movement within the well. Hydrogen sulfide, while not actually measured, was present in the wells at the time of start-up; the sulfide gas being detectable by its characteristic "rotten egg" odor.

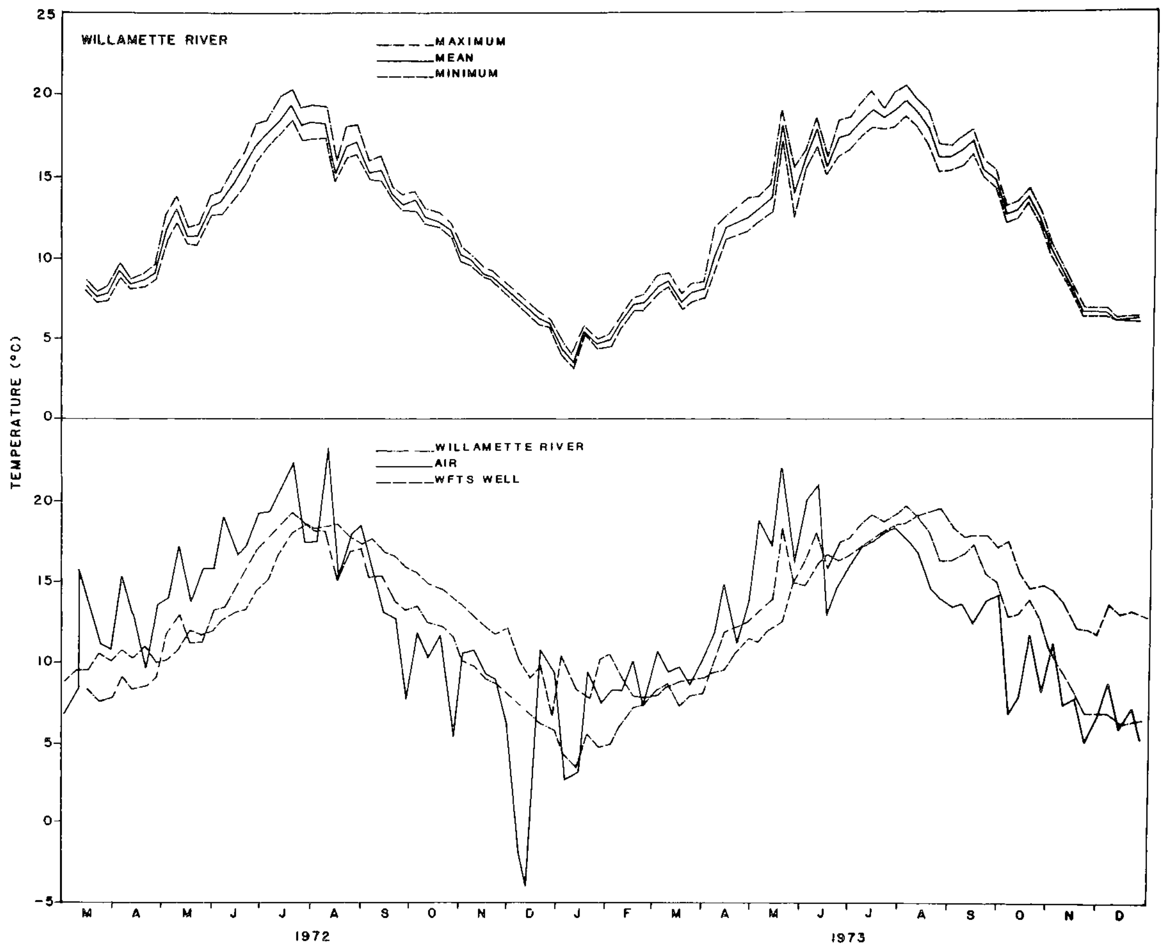


Figure 5(a). Diel and seasonal fluctuation of Willamette River water temperature (°C).

Figure 5(b). A comparison of Willamette River and WFTS well water temperature (°C) with ambient air temperature (°C).

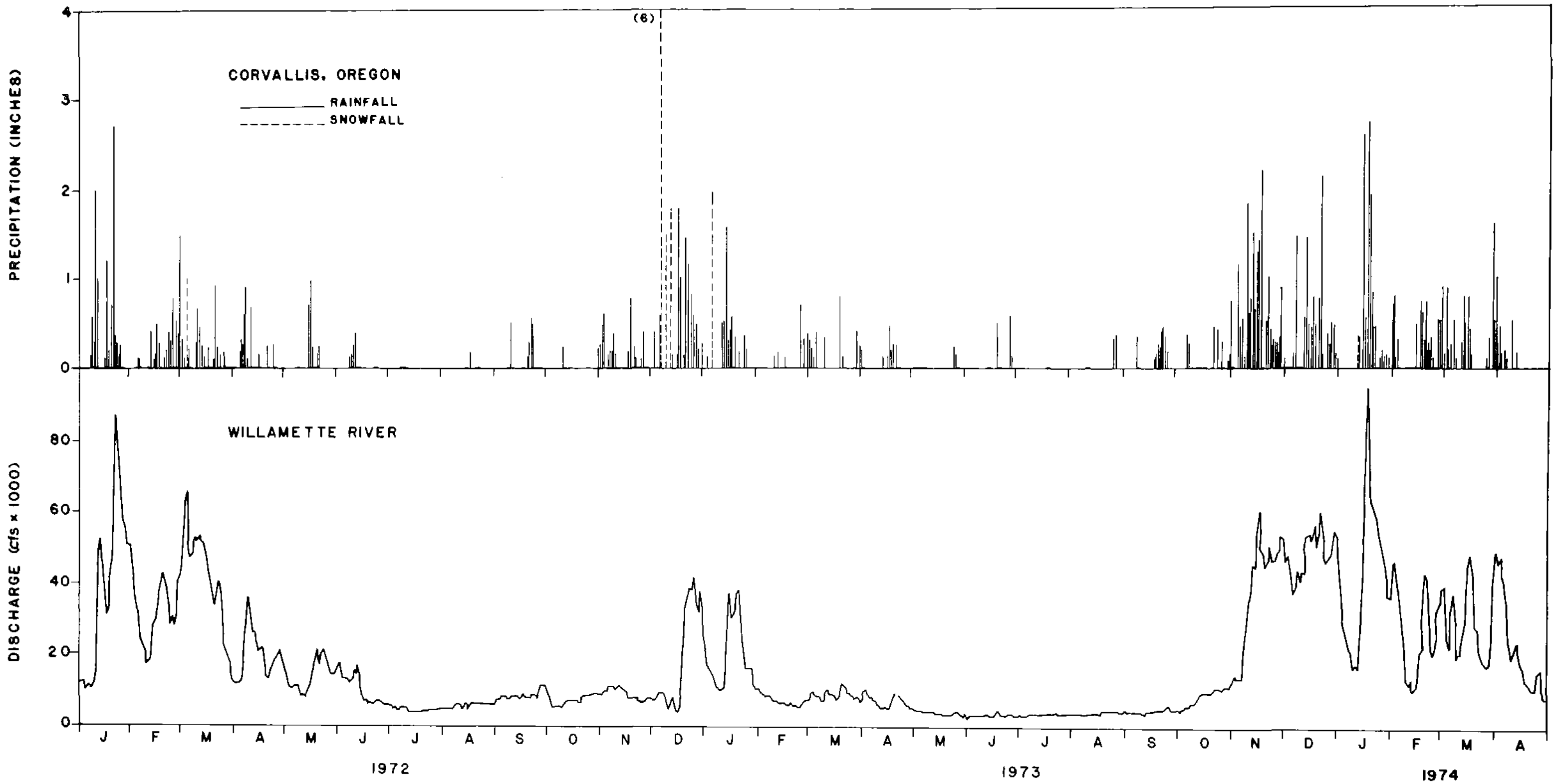


Figure 6. Relationship between daily precipitation (inches) at Corvallis, Oregon, and mean daily discharge (cfs X 10000) for the Willamette River from January 1972 thru April 1974.

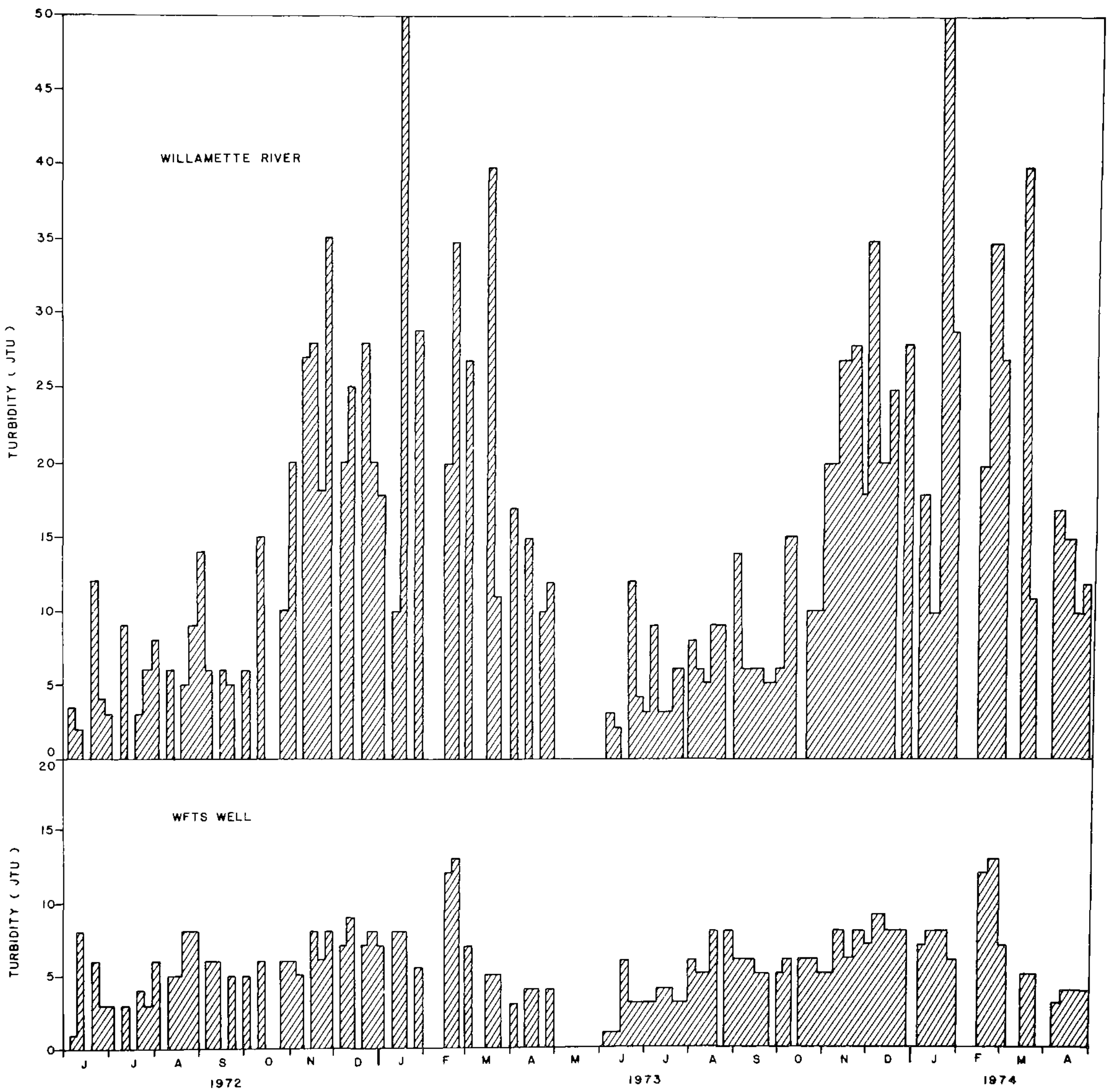


Figure 7. Seasonal variation of mean turbidity (Jackson Turbidity Units) for the Willamette River and WFTS well from June 1972 thru April 1974.

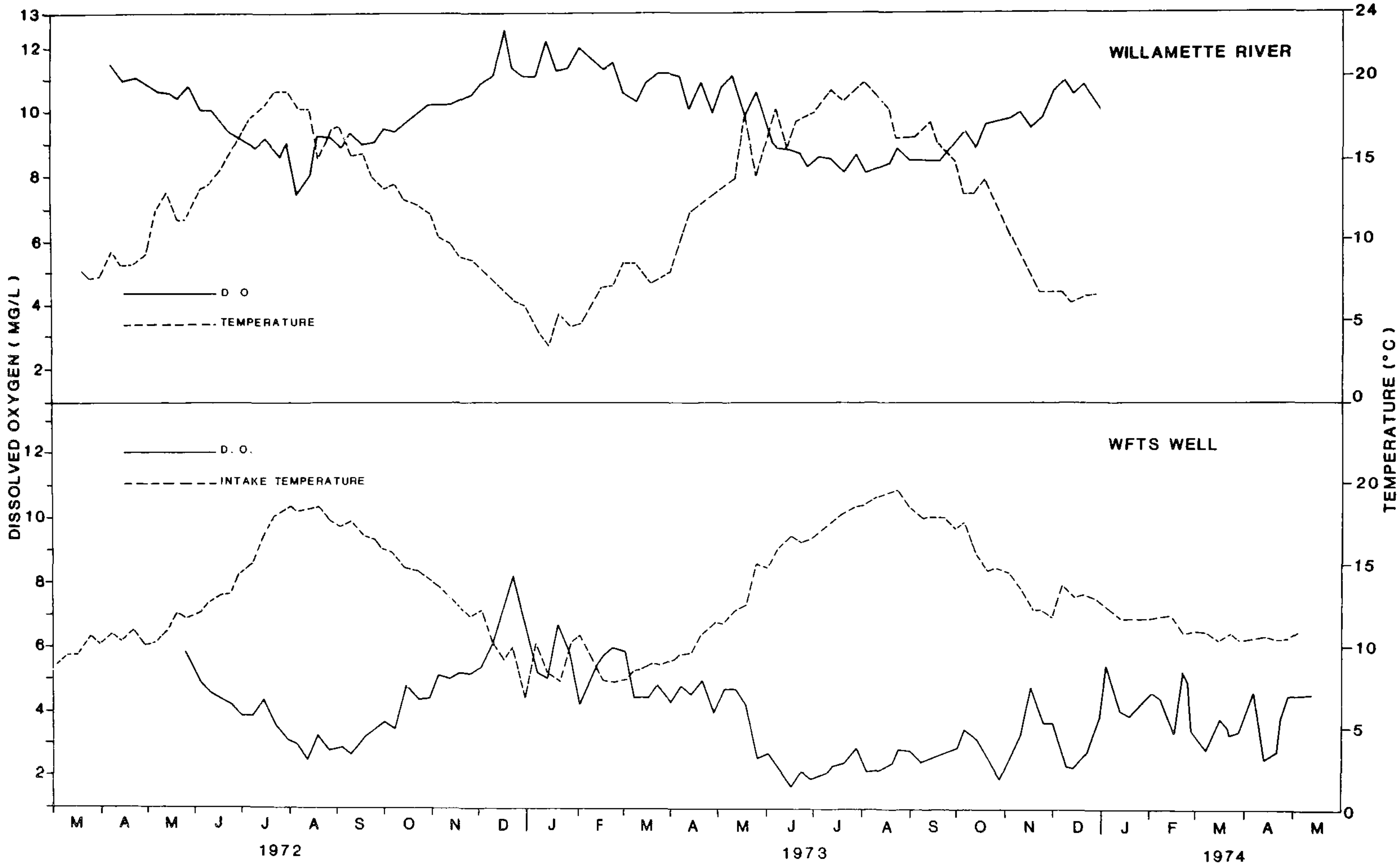


Figure 8. Comparison of dissolved oxygen (mg/l) and water temperature (°C) for the Willamette River and Western Fish Toxicology Station well from March 1972 thru April 1974.

Daily total alkalinity and total hardness values are plotted for the river and well against river discharge (Figure 9). River alkalinity and hardness remained relatively constant throughout the reporting period (1972-1974); however, well alkalinity and hardness varied with river discharge and followed a general seasonal trend. There was a 7-10 day lag period between high discharge in the river and subsequent peaks of alkalinity and hardness in the well.

River water was considered to be soft with an annual hardness range between 16-27 mg/l; mean, 22 mg/l. Well hardness ranged between "soft to moderately hard" with a range of 21-81 mg/l; mean, 34 mg/l. The annual range of alkalinity for the river was 17-30 mg/l, with a mean of 23 mg/l, while that of the well was 18-73 mg/l; mean, 31 mg/l. Bicarbonate alkalinity (as $CaCO_3$) was the major contributor to total alkalinity (nearly 100%) as determined by the phenolphthalein titration test (Section 102.4-5b, APHA Standard Methods, 13th Ed.).

This close, but indirect, relationship between river discharge and well alkalinity and hardness was explained as follows: As ground water infiltrated upward into the water table aquifer during high discharge periods, major anions and cations were leached from the subsurface layers. When the river stage returned to its normal level, water rich in Ca^{++}, Mg^{++}, Na^{+} and the corresponding $SO_4^{=}$, HCO_3^{-}, NO_3^{-} and Cl^{-} ions were carried back to the well. This explains the 7-10 day lag period between high discharges in the river and subsequent sharp peaks of alkalinity and hardness in the well.

While carbon dioxide itself was not monitored routinely, it was considered to be present since pH values for the well were consistently lower (more acidic) than those of the river (Figure 10). The hydrogen ion concentration of the well had an annual pH range of between 6.56-6.98, median 6.80, while the river ranged between 7.00-7.80; a median of 7.4. Low well pH most likely enhanced the solubilizing and leaching of minerals and their salts from the surrounding stratum.

MAJOR CATIONS

Dissolved calcium and magnesium for the WFTS well, while relatively low in concentration, showed a high degree of variability compared to the Willamette River (Figure 11). The well water values ranged from lows of 5.5 Ca^{++} and 1.5 Mg^{++} (mg/l) in November 1973 to highs of 28.3 Ca^{++} and 4.8 Mg^{++} (mg/l) in March 1974, while the river remained constant (4.0-6.5 Ca^{++}, 1.5-2.0 Mg^{++} mg/l) during the entire reporting period. These data also indicated that a majority of the cationic contribution to total hardness was due to the Ca^{++} ions. Well water calcium and magnesium concentrations both showed definite seasonal trends

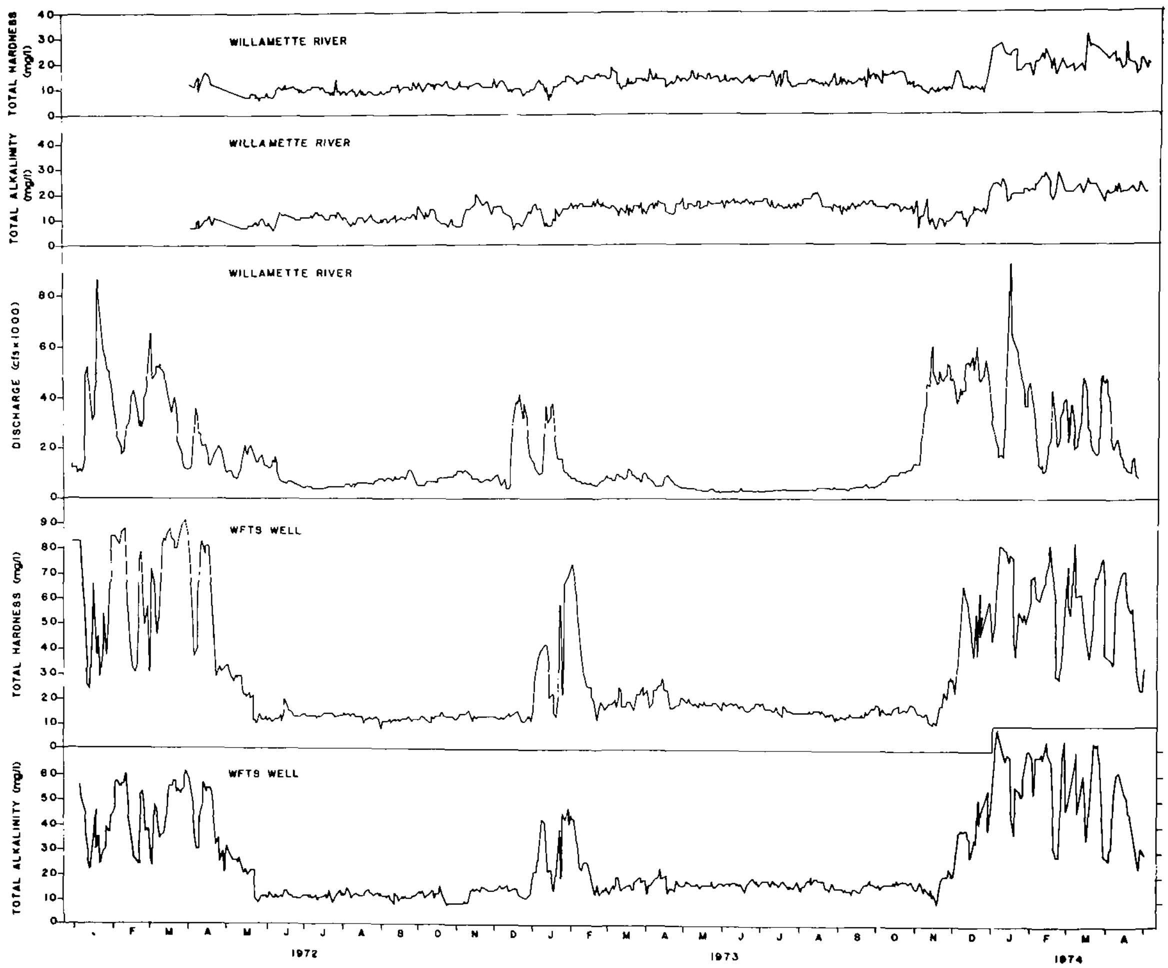


Figure 9. Relationship between daily total alkalinity (mg/l as $CaCO_3$), total hardness (mg/l as $CaCO_3$) and river discharge (cfs X 10000) for the Willamette River and WFTS well from January 1972 thru April 1974.

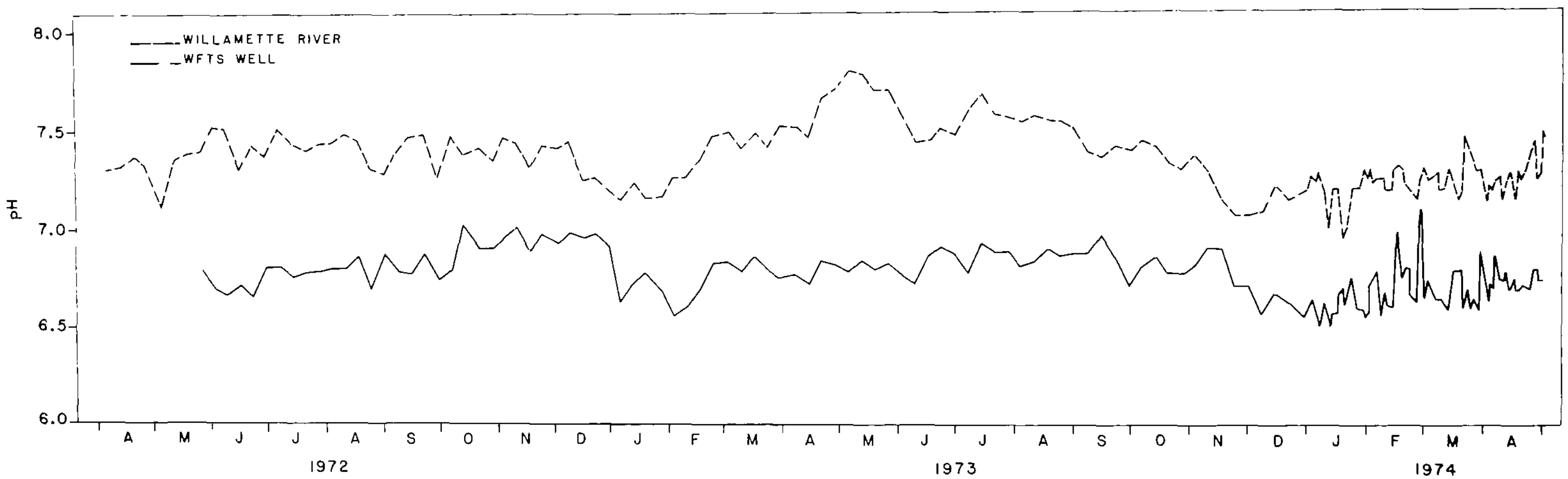


Figure 10. Comparison of hydrogen ion concentration (pH) between the Willamette River and WFTS well from April 1972 thru April 1974.

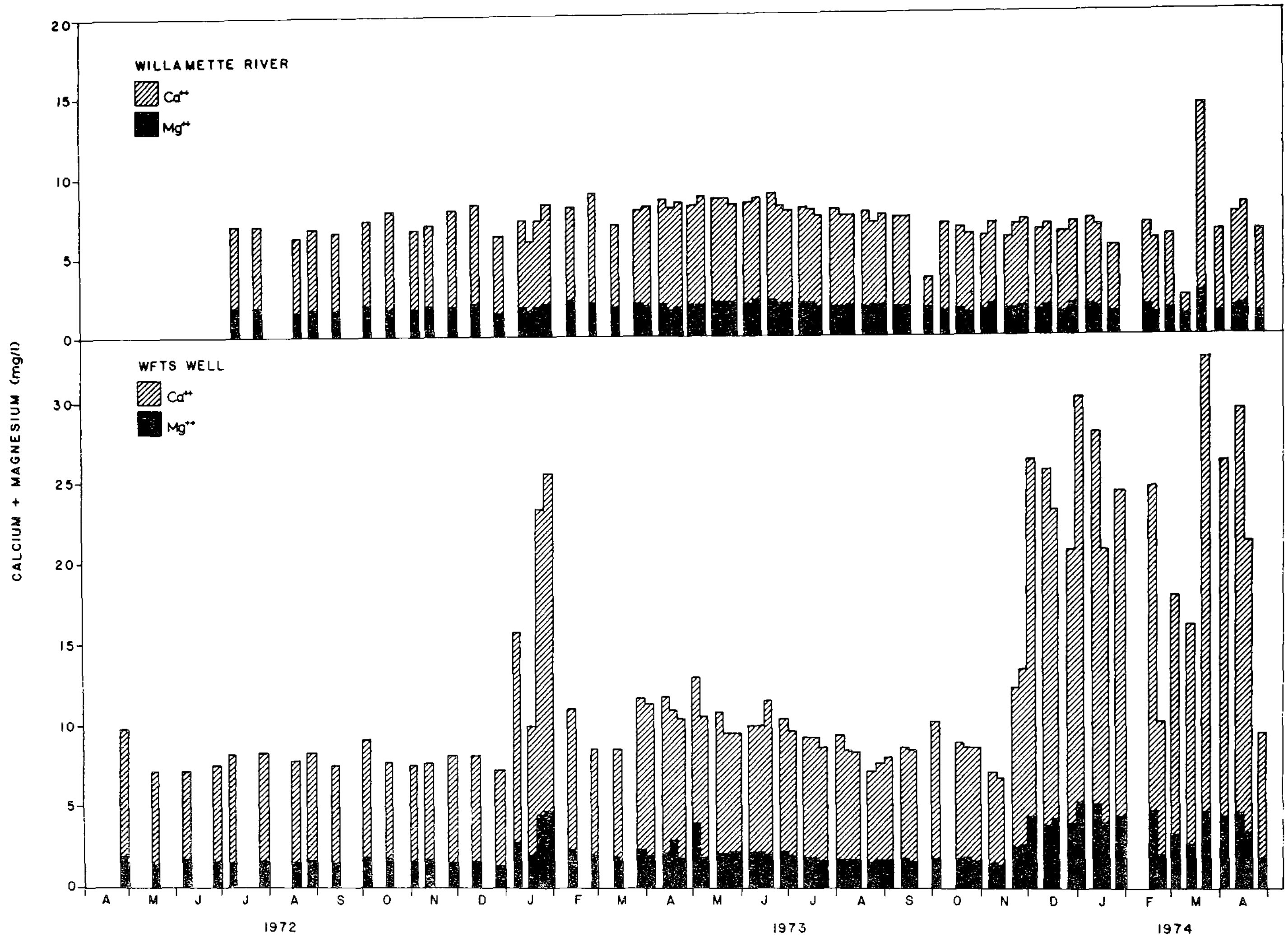


Figure 11. Seasonal variation of mean monthly calcium and magnesium concentrations (mg/l) for the Willamette River and WFTS well from April 1972 thru April 1974.

Sodium and potassium concentrations were stable in the river water but sodium levels in the well water increased following high river discharge in December 1973 thru March 1974 (Figure 12). These low levels of sodium and potassium for the well (Na^+ 3.0-10.0, mean 5.6 mg/l; K^+ 0.5-1.1, mean 0.7 mg/l) and the river (Na^+ 2.30-5.9, mean 4.2 mg/l; K^+ 0.6-1.2, mean 0.8 mg/l) are characteristic of Pacific Northwest waters (Ground Water and Wells, 1966, 1st Ed.).

ANIONS

Moderate seasonal trends were observed in dissolved chloride concentrations which ranged from 3.0-21.0, mean 7.2 mg/l, in the well and 2.0-13.0, mean 4.0 mg/l, in the river (Figure 13).

Nitrates, nitrites and ammonia concentrations are plotted in Figure 14. Nitrates in both the well and river fluctuated seasonally, ranging from 0.138-0.640, mean 0.257 mg/l in the well and 0.004-0.430, mean 0.112 mg/l in the river. The slightly higher nitrate concentration in the well during the summer months of 1973 (as compared to summer 1972), was probably due to the greater amount of rainfall preceeding the 1973 summer season. It was presumed that nitrates entered the river through land surface runoff. Nitrates entered the well either via leaching or direct percolation of nitrate rich water into the aquifer through upstream and overlying soil zones.

Ammonia, to a lesser extent, showed the same trend while nitrites were found to be virtually absent in the well and only in trace amounts in the river.

Dissolved sulfate values for the well and river indicated seasonal variation (Figure 15). Well water sulfates followed a trend similar to hardness in well water; however, during the two-year reporting period, detection limits of the analytical method varied, prohibiting more conclusive results. Nevertheless, during 1973 and 1974, sulfate concentrations ranged from 1.2-27.0, mean 7.3 mg/l in the well and 2.0-20.0, mean 7.0 mg/l in the river.

SOLIDS

Dissolved solids, in both the river and well, were the major contributors toward total solids (Figure 16). The only exception was during the high runoff months (November 1973-May 1974) when suspended and dissolved solids appeared in near equal concentrations in the river.

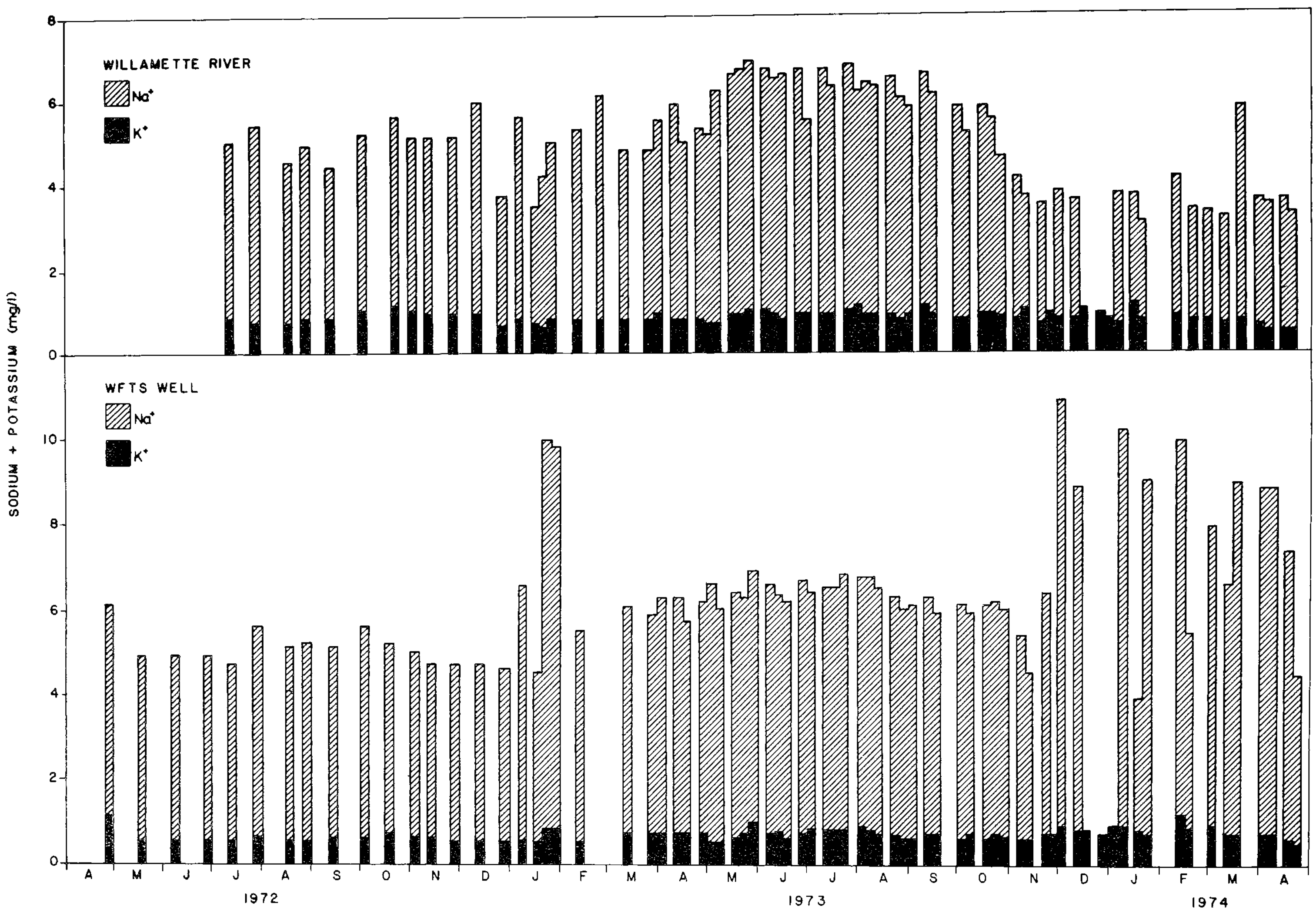


Figure 12. Monthly average sodium and potassium concentrations (mg/l) for the Willamette River and WFTS well from April 1972 thru April 1974.

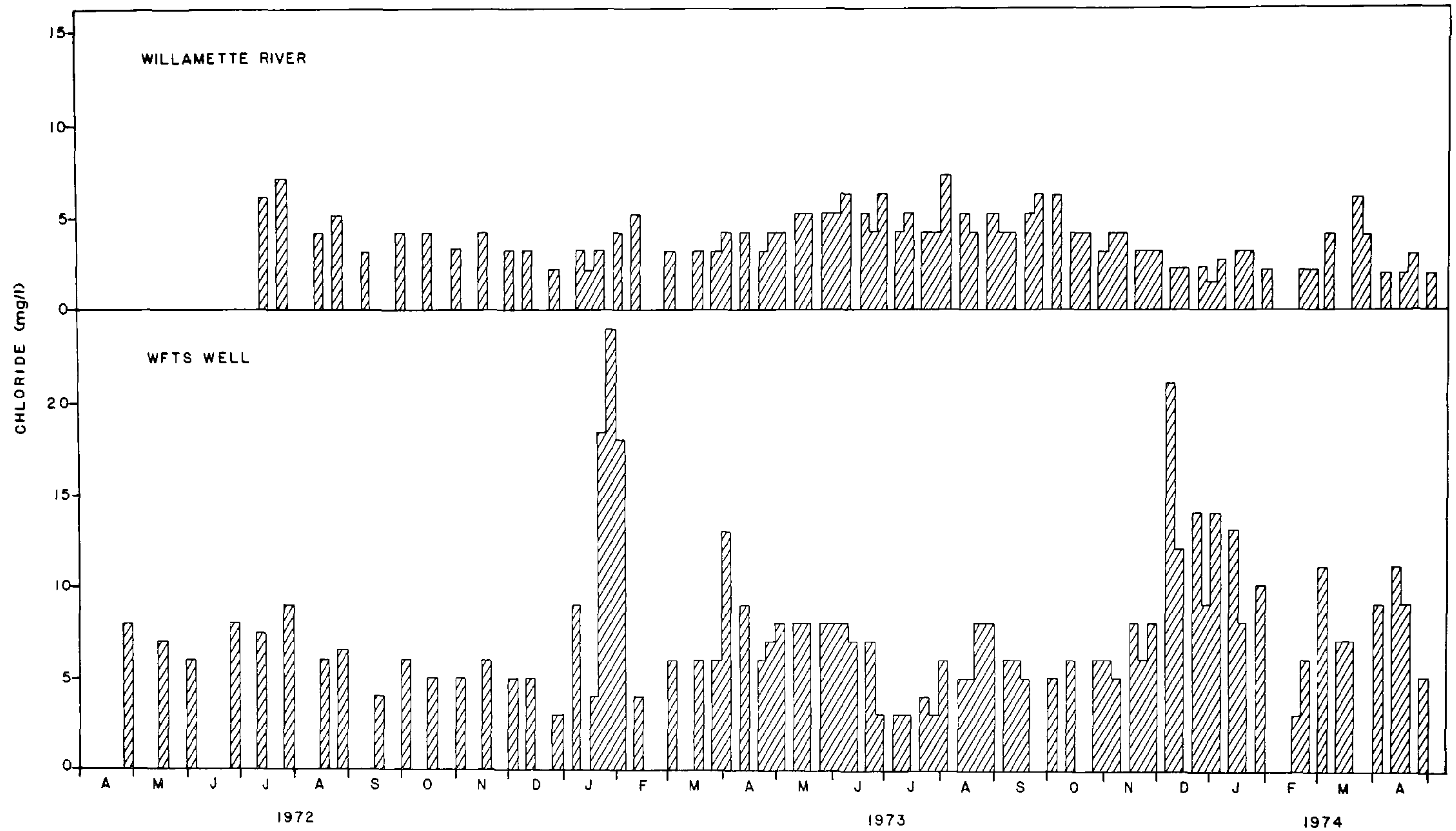


Figure 13. Annual fluctuation of mean dissolved chloride (mg/l) for the Willamette River and the WFTS well from April 1972 thru April 1974.

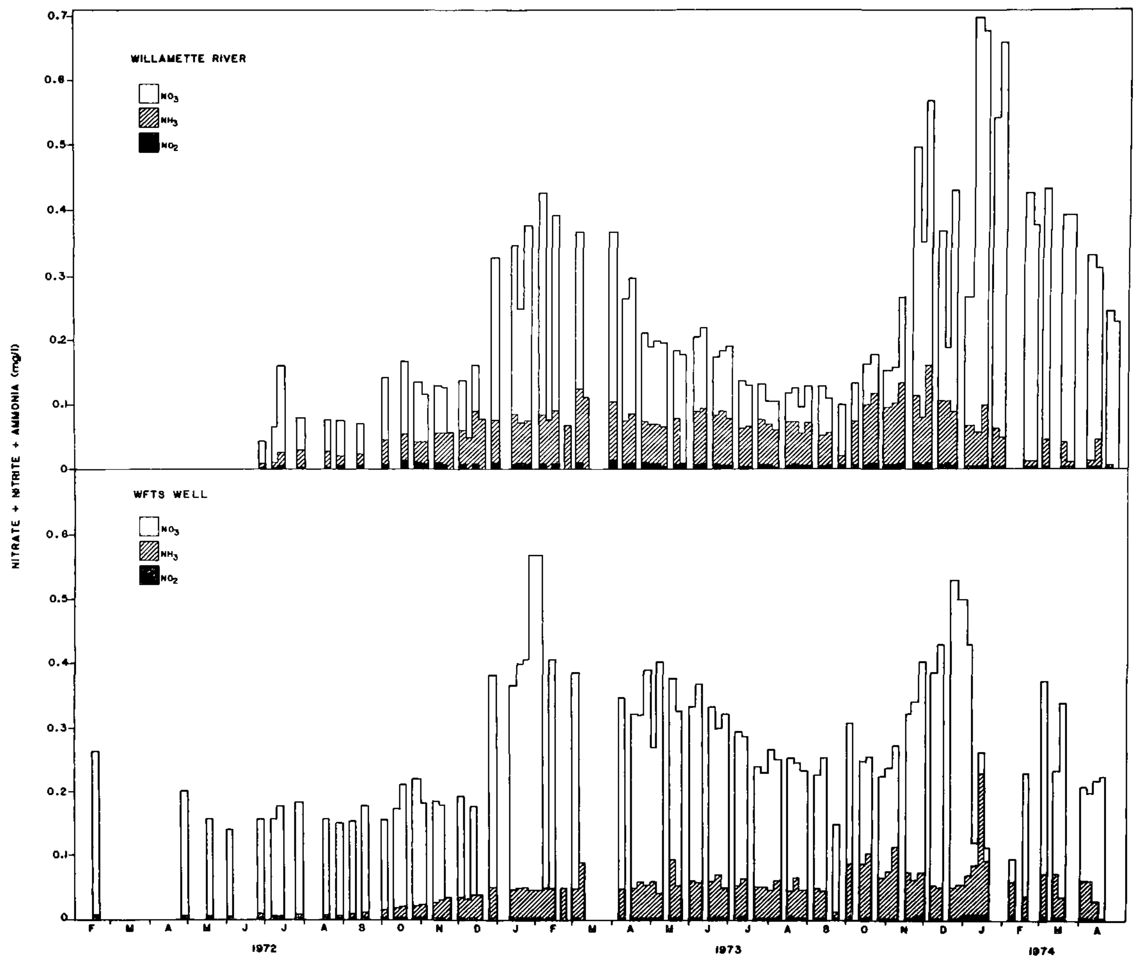


Figure 14. Seasonal comparison of monthly mean nitrate, nitrite, and ammonia concentrations (mg/l) for the Willamette River and WFTS well from February 1972 thru April 1974.

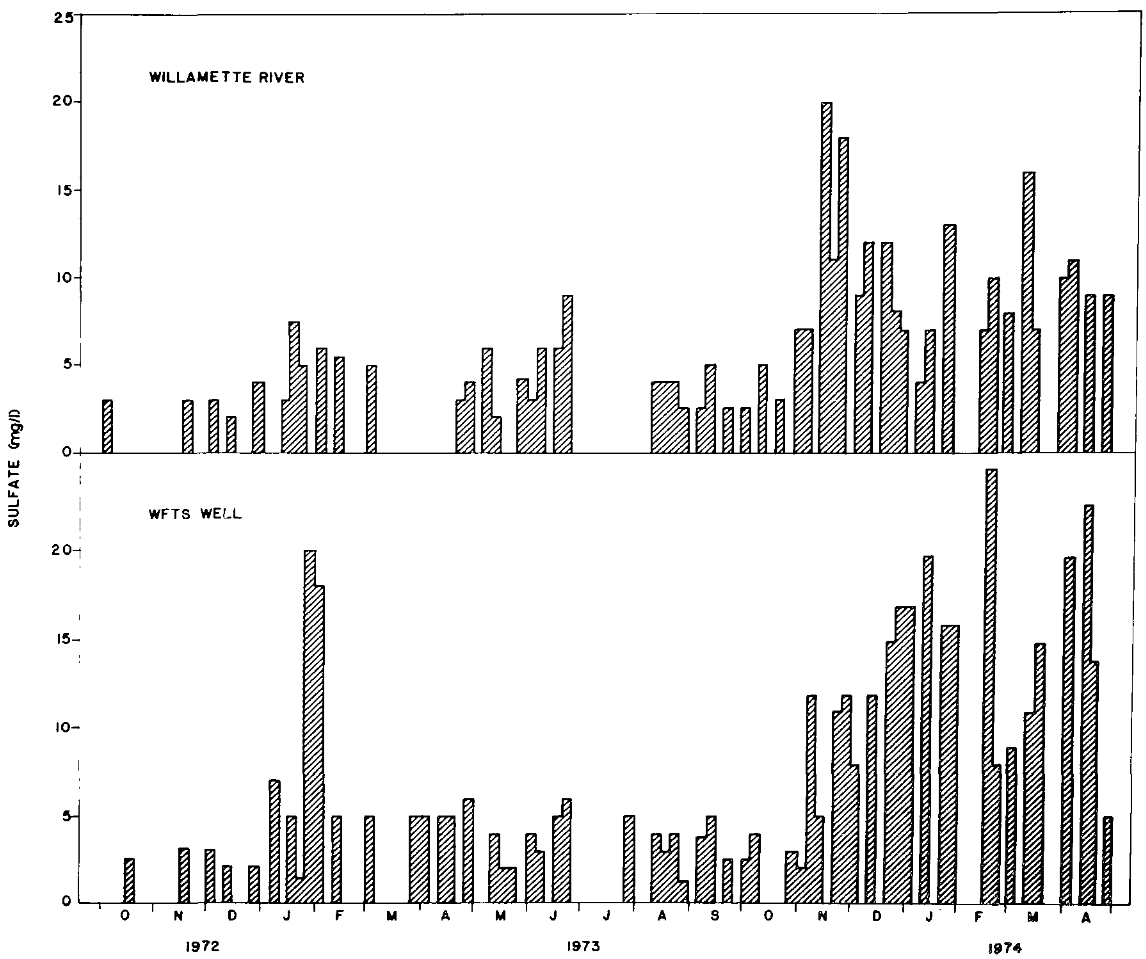


Figure 15. Dissolved sulfate (mg/l) for the Willamette River and WFTS well from October 1972 thru April 1974.

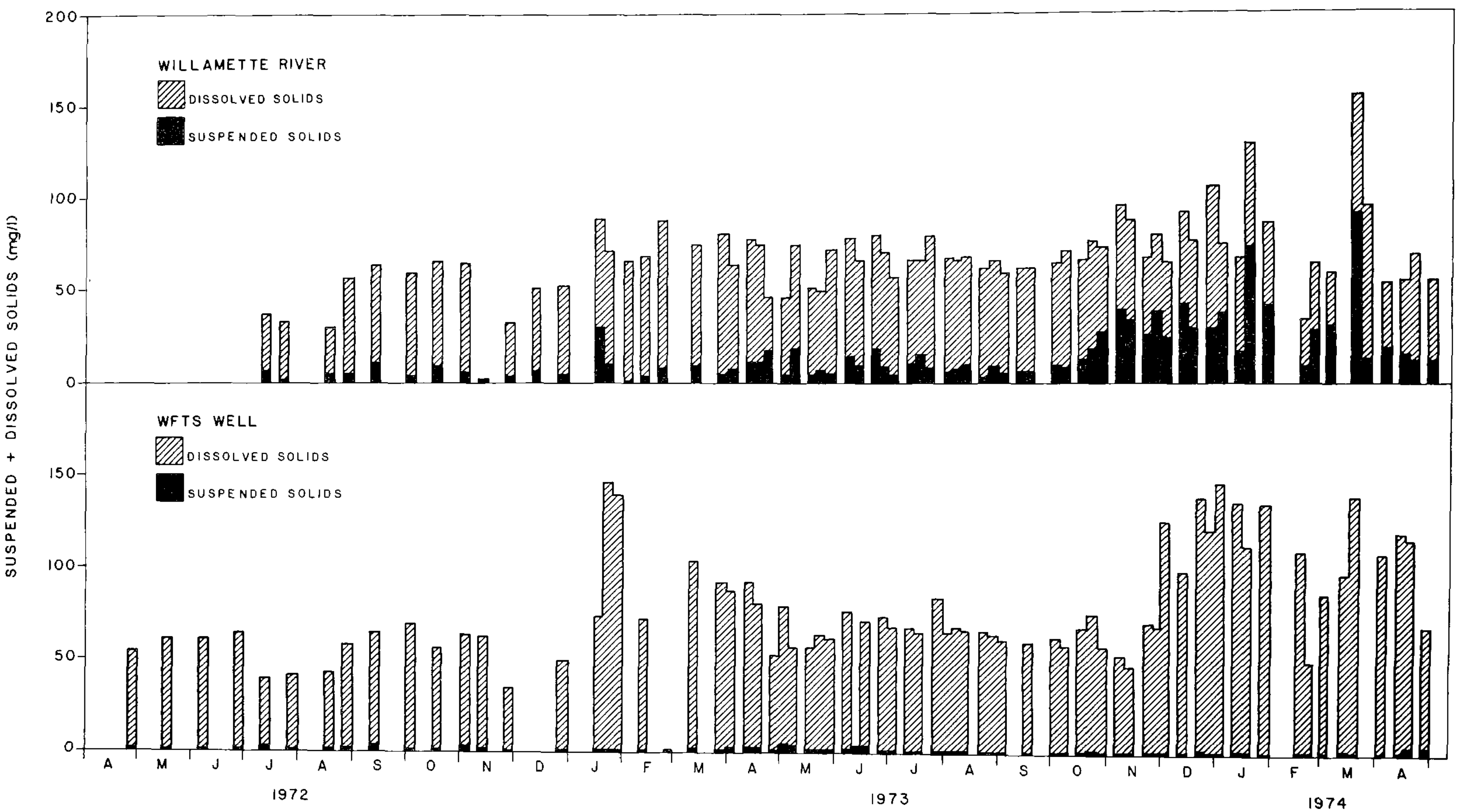


Figure 16. Suspended plus dissolved solids (mg/l) for the Willamette River and WFTS well from April 1972 thru April 1974.

Suspended solids ranged between 1.0-92.0, mean 15.0 mg/l for the river and 0.8-5.0, mean 1.8 mg/l for the well during the two-year reporting period. Corresponding dissolved solids ranged from 25.0-81.0, mean 52.0 mg/l for the river and 34.0-146.0, mean 73.3 mg/l for the well.

TRACE ELEMENTS

Trace elements (cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel and zinc) were compared for the Willamette River and WFTS well (Table 2). With the exception of iron, manganese and zinc, mean trace metal concentrations for the well and river were in close agreement. River iron and manganese concentrations were approximately ten times greater than those found in the well; while river zinc exceeded the well by a factor of two. River iron displayed a definite seasonal trend ranging from a low of 214 μg/l in July 1973 to a high of 2,535 μg/l in March 1974. River chromium, copper, manganese and nickel displayed only moderate seasonal variation having slightly higher concentrations between November and March. There was no indication of a seasonal trend in trace elements found in well water.

FIELD SAMPLES (MAJOR WESTERN OREGON STREAMS)

Figure 17 is a map of Oregon showing the sites where quarterly water quality data were obtained during the reporting period. Station numbers on the map correspond to stations listed in the data section (Tables 11 thru 13).

Quarterly mean temperatures and dissolved oxygen values for all streams sampled during 1972-1973 are as follows:

	Dec. 72	Mar. 73	Jun. 73	Sep. 73
Temp (°C)	6.4	7.8	19.2	14.8
D.O. (mg/l)	12.0	11.7	9.4	10.0

Temperature and dissolved oxygen varied inversely and followed a seasonal trend.

Table 2. Summary of heavy metal data for the Willamette River and Western Fish Toxicology Station from January 1972 through April 1974.

		WILLAMETTE RIVER					WFTS WELL				
Metal	Detection Limit (µg/l)[1/]	No. of Samples	No. of Positive Occurances	Conc. (µg/l) Min.	Max.	Mean	No. of Samples	No. of Positive Occurances	Conc. (µg/l) Min.	Max.	Mean
Cadmium	0.2-1.0	68	1	1.0	1.0	1.0	75	6	0.2	1.0	0.9
Chromium	0.4-1.0	69	41	1.0	6.0	2.4	77	27	0.4	17.0	2.5
Cobalt	0.5-2.0	65	17	1.0	3.0	1.6	70	26	0.5	3.0	1.5
Copper	0.2-1.0	71	71	0.5	8.0	3.3	75	73	1.0	27.0	3.0
Iron	2.0-40.0	70	70	100.	4300	736	75	75	18	290	82
Lead	2.0-5.0	70	29	2.0	15.0	5.8	76	34	2.0	10.0	5.2
Manganese	1.0	70	70	12.5	100	30.7	76	73	1.0	32.0	3.0
Mercury	0.5	62	27	0.5	11.0	1.8	70	37	0.5	4.0	1.3
Nickel	1.0-2.0	69	51	1.0	8.0	2.6	73	50	1.0	6.0	2.3
Zinc	1.0	70	70	1.0	52.0	9.4	75	71	1.0	29.5	5.1

1/ Detection limits established by Consolidated Laboratory Services, National Environmental Research Center, Corvallis, Oregon.

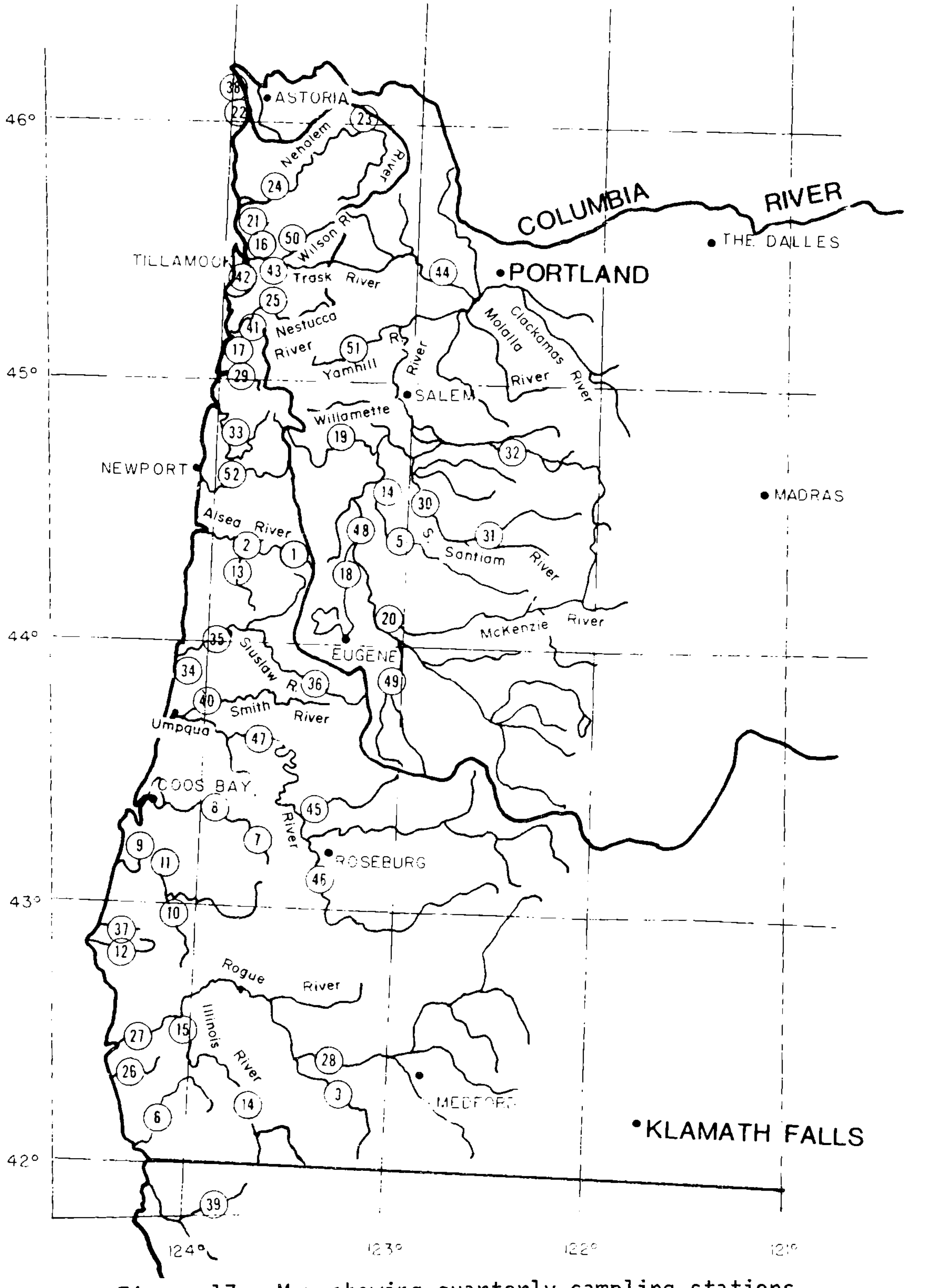


Figure 17. Map showing quarterly sampling stations on major western Oregon rivers.

Figure 18 contains a quarterly summary of pH, total alkalinity and total hardness data obtained and gives the percentage of streams sampled which had values within the indicated concentration ranges. Southwestern Oregon streams (Umpqua River and southward) were known to have a somewhat higher pH, alkalinity and hardness than northwestern Oregon streams (determined by a preliminary review of U.S. EPA Storage and Retrieval Data for Western Oregon). Alkalinity and hardness concentrations showed no seasonal trends but confirmed the north-south geographical effect. Approximately eighty percent of the rivers had an alkalinity and hardness between 10-30 mg/l. All of these were northwestern streams. The remaining 20 percent were essentially southwestern streams, with a range of 31-80 mg/l. Hydrogen ion concentration (pH) showed a moderate seasonal trend, being somewhat more acidic (pH 6.5-7.0) during late fall and winter.

Figure 19 is a summary of basic chemical characteristics including the trace metals (Cd, Cu and Zn) for all four quarters. Trace metals did not reflect a seasonal trend. Seventy-five percent of the streams sampled had a cadmium concentration less than 0.01 μg/l (17 positive occurances in a total of 106 samples). The highest Cd concentration found was 0.2 μg/l. Of the 46 positive occurances for copper (N = 108), the range was 0.2-5.0, mean 1.8 μg/l. Zinc had the highest number of positive occurances (76 of 110 total samples with a range of 0.1-11.0, mean 2.4 μg/l).

It was difficult to compare these trace metal concentrations with similar data collected from other sources since reliable analytical techniques for analyzing trace metals at these low detection levels have only recently become available.

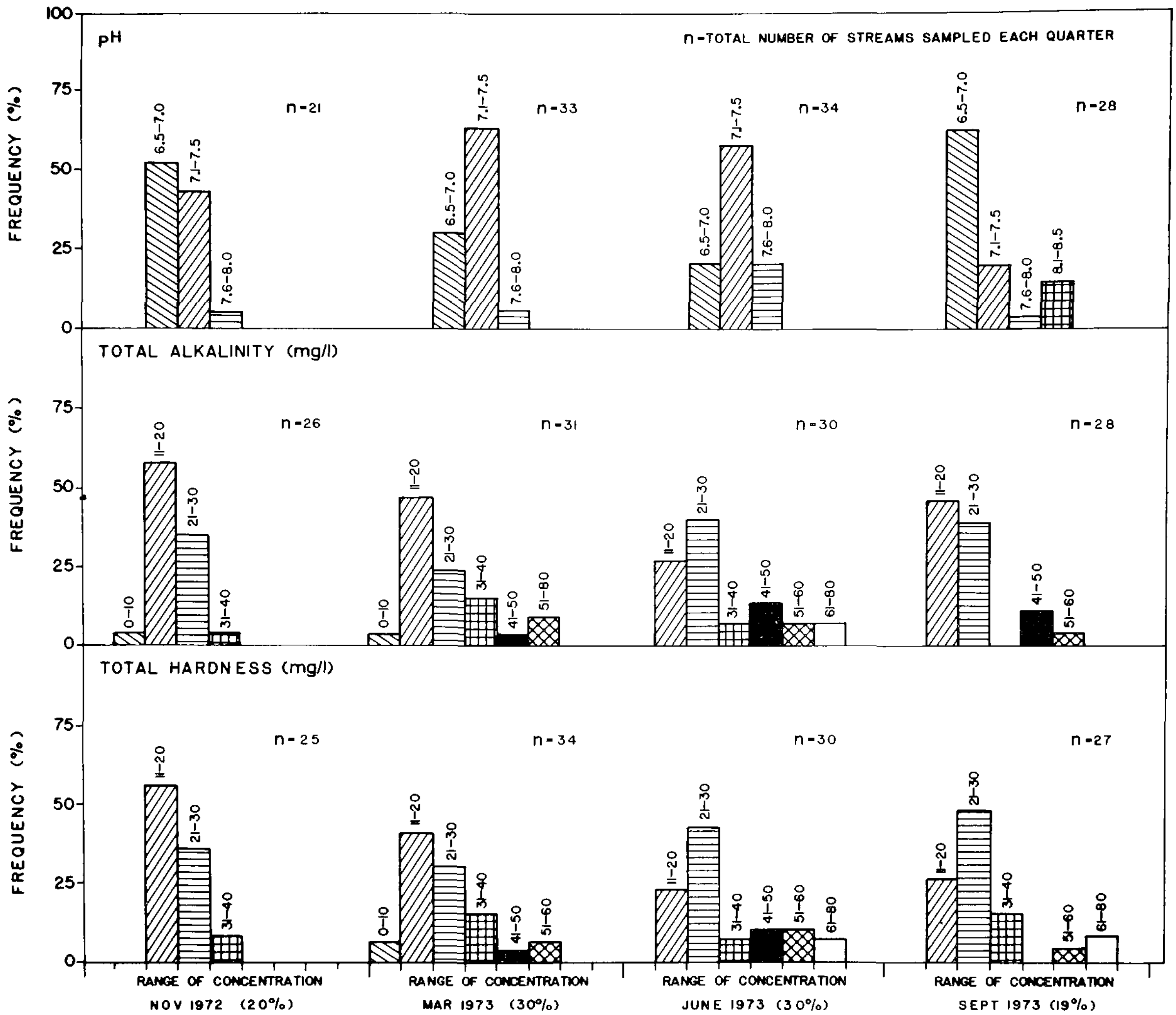


Figure 18. Quarterly summary of pH, total alkalinity (mg/l as $CaCO_3$) and total hardness (mg/l as $CaCO_3$) for major western Oregon streams (1972-1973). The percentage of streams is indicated in parentheses following collection date.

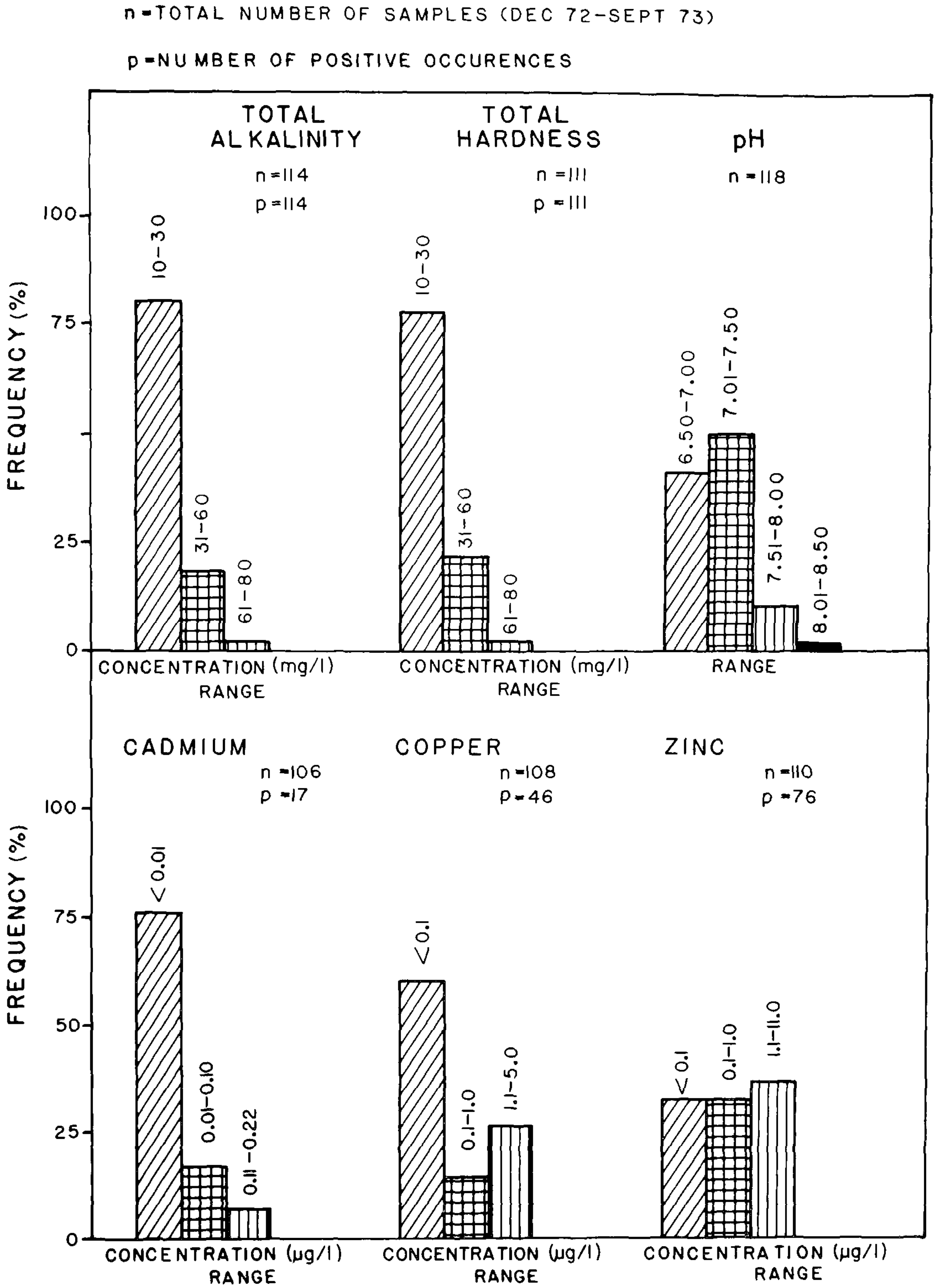


Figure 19. Annual summary of basic chemical and trace element concentrations and their relative frequencies for western Oregon streams from December 1972 thru September 1973.

Comparable levels for unpolluted lake and river water from a single study (Burrell, 1974) using anodic stripping voltammetry are as follows:

Cadmium, Copper and Zinc Values for Uncontaminated Natural Waters (μg/l)

	Cd	Cu	Zn
Trinity River, Shasta-Trinity National Forest, California	0.2	2.2	0.3
Sulphur Springs, Kittitas County, Washington			3.2
Park Lake, Kittitas County, Washington	1.0	0.2	4.3
Rachel Lake, Kittitas County, Washington	0.2	0.6	0.4
Roosevelt Lake, Okanogan County, Washington	0.3	1.3	1.6

The heated graphite tube method used in the present study must still be considered an experimental, non-routine technique. Certain analytical problems involving its use must still be solved. But due to the relatively pure nature of the bulk of our samples, we consider the heavy metal values to be quite acceptable and interferences, including matrix effects, have been found to be minimal.

SECTION VI

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SECTION VII
APPENDIX

TABLE A-1. KEY TO CHEMICAL ABBREVIATIONS

Ca	Calcium (mg/l)
Cd	Cadmium (μg/l)
Cl	Chloride (mg/l)
Co	Cobalt (μg/l)
Cr	Chromium (μg/l)
Cu	Copper (μg/l)
D O	Dissolved Oxygen concentration (mg/l)
D S	Dissolved Solids (mg/l)
Fe	Iron (μg/l)
Hg	Mercury (μg/l)
K	Potassium (mg/l)
Mg	Magnesium (mg/l)
Mn	Manganese (μg/l)
Na	Sodium (mg/l)
NH_3	Ammonia (mg/l)
Ni	Nickel (μg/l)
NO_2	Nitrite (mg/l)
NO_3	Nitrate (mg/l)
Pb	Lead (μg/l)
pH	Hydrogen ion concentration
Precip.	Precipitation (inches)
SO	Sulfate (mg/l)
S S	Suspended Solids (mg/l)
T	Turbidity (JTU, Jackson Turbidity Units)
Temp.	Temperature (degrees centigrade)
TA	Total Alkalinity (mg/l as $CaCO_3$)
TH	Total Hardness (mg/l as $CaCO_3$)
ZN	Zinc (μg/l)

Table A-2. Mean monthly physical and chemical data for the Willamette River from March, 1972 thru April, 1974.

Month	Water Temperature °C Min.	Max.	Mean	Precip. (inches)	River Height (ft. above mean sea level)	Discharge (cfsX1000)	T (JTU)	D S (mg/l)	S S (mg/l)
March (1972)	7.6	8.2	8.0	0.21	208.4	41.29	---	---	---
April	8.4	9.3	8.8	0.14	203.8	17.36	---	---	---
May	11.5	12.8	12.1	0.08	202.8	14.78	3	---	---
June	14.3	16.1	15.2	0.03	201.9	9.90	---	---	---
July	17.4	19.2	18.6	0.00	200.7	4.57	---	31.5	3.5
August	16.3	18.1	17.1	0.01	200.9	5.97	---	37.5	5.5
September	13.9	15.1	14.5	0.08	201.4	8.68	2	52.0	11.0
October	12.2	12.8	12.5	0.03	201.0	7.06	---	56.5	5.5
November	9.2	9.8	9.5	0.16	201.4	9.26	---	43.7	3.5
December	5.8	6.3	6.0	0.64	203.8	20.61	52	46.2	5.2
January (1973)	4.3	4.9	4.6	0.18	204.4	18.59	---	60.8	14.5
February	6.8	7.6	7.2	0.06	200.9	6.83	---	72.5	5.5
March	7.9	7.9	7.9	0.18	201.2	8.83	---	71.0	7.0
April	10.7	12.7	11.5	0.06	200.9	7.15	---	55.0	10.8
May	14.4	16.0	14.7	0.03	199.9	3.76	3	52.1	7.8
June	16.3	18.1	17.2	0.05	199.7	3.26	---	61.0	12.8
July	17.9	19.9	18.9	0.00	199.7	3.34	2	57.0	9.7
August	17.0	18.7	17.9	0.02	200.0	3.94	4	58.0	7.6
September	15.4	16.8	16.1	0.08	199.5	4.34	2	54.0	5.8
October	12.2	13.1	12.6	0.08	201.5	8.84	8	55.2	14.8
November	7.2	7.7	7.4	0.61	208.6	43.04	22	44.0	34.5
December	6.4	6.7	6.5	0.40	209.7	48.08	24	44.5	33.5
January (1974)	---	---	---	0.37	208.2	43.95	26	46.5	42.8
February	---	---	---	0.27	204.9	27.14	27	29.7	22.7
March	---	---	---	0.29	208.2	43.95	26	72.0	52.5
April	---	---	---	0.08	204.7	24.31	14	43.3	14.5

Table A-3. Mean monthly chemical data (DO, pH, TA, TH, NO_2, NO_3, NH_3) for the Willamette River from April 1972 thru April 1974.

Month	DO	pH *	TA	TH	NO_2	NO_3	NH_3
			(mg/l except pH)				
April (1972)	11.3	7.35	19	23	----	----	----
May	10.7	7.40	20	19	----	----	----
June	9.8	7.40	20	20	0.002	0.004	0.007
July	9.2	7.47	22	20	0.003	0.083	0.017
August	8.8	7.40	20	19	0.005	0.053	0.019
September	9.4	7.45	20	20	0.004	0.048	0.018
October	10.0	7.40	21	22	0.009	0.100	0.036
November	10.6	7.41	23	21	0.007	0.074	0.045
December	11.8	7.20	21	20	0.007	0.166	0.076
January (1973)	11.8	7.18	22	21	0.006	0.269	0.072
February	11.3	7.36	26	24	0.007	0.270	0.085
March	11.1	7.48	24	24	0.120	0.260	0.101
April	10.8	7.54	24	24	0.006	0.165	0.068
May	10.5	7.72	26	25	0.005	0.130	0.056
June	8.9	7.47	26	24	0.005	0.105	0.080
July	8.7	7.60	26	24	0.003	0.056	0.065
August	8.6	7.55	27	22	0.002	0.048	0.063
September	8.8	7.40	25	23	0.003	0.071	0.038
October	9.6	7.39	25	25	0.005	0.059	0.092
November	10.1	7.12	20	20	0.006	0.302	0.115
December	10.8	7.13	22	22	0.005	0.220	0.086
January (1974)	11.2	7.20	21	21	0.007	0.337	0.121
February	12.0	7.25	23	19	0.015	0.167	0.047
March	11.8	7.24	23	22	0.009	0.215	0.052
April	12.2	7.25	21	19	0.003	0.179	0.048

*Median value.

Table A-4. Mean monthly chemical data (Ca, Mg, Na, K, SO_4, CL) for the Willamette River from April 1972 thru April 197

	(mg/l)					
Month	Ca	Mg	Na	K	SO_4	Cl
April (1972)	---	---	---	---	---	---
May	---	---	---	---	---	---
June	---	---	---	---	---	---
July	5.1	1.9	4.5	0.8	<1.0	6.5
August	4.8	1.6	3.9	0.8	<10.0	4.5
September	4.9	1.6	3.6	0.8	<10.0	3.0
October	5.9	1.8	4.4	1.1	2.8	4.0
November	5.3	1.8	4.2	0.9	3.8	3.3
December	5.5	1.7	4.1	0.8	8.0	2.5
January (1973)	5.3	1.8	3.9	0.7	5.6	3.0
February	6.3	2.2	4.9	0.8	5.0	4.0
March	5.5	1.9	4.0	0.8	<5.0	3.0
April	6.4	1.8	4.6	0.8	4.3	3.8
May	6.4	2.0	5.5	0.8	3.8	4.8
June	6.3	2.1	5.7	0.9	6.2	5.2
July	5.9	2.0	5.4	0.9	<5.0	4.2
August	5.7	1.8	5.2	0.9	3.9	5.0
September	5.6	1.8	5.1	1.0	3.3	4.8
October	5.0	1.7	4.5	0.8	4.4	4.2
November	4.8	1.8	2.9	0.8	14.0	3.2
December	5.1	1.7	2.9	0.9	10.2	2.4
January (1974)	4.8	1.8	2.6	0.9	7.8	2.6
February	4.7	1.6	2.8	0.8	8.3	6.3
March	5.7	1.9	3.5	0.7	10.4	5.0
April	5.4	1.7	3.0	0.6	9.8	2.3

Table A-5. Mean monthly heavy metal data for the Willamette River from April 1972 thru April 1974.

	(μg/l)									
Month	Cd	Cr	Co	Cu	Fe	Pb	Mn	Ni	Zn	Hg
April (1972)	---	---	---	---	---	---	---	---	---	---
May	---	---	---	---	---	---	---	---	---	---
June	---	---	---	---	---	---	---	---	---	---
July	<1.0	1.5	1.5	4.2	320	5.0	19.5	2.0	5.2	0.8
August	<1.0	2.5	<2.0	3.5	450	<5.0	18.5	2.5	8.0	0.5
September	<1.0	5.0	3.0	3.0	360	<5.0	22.0	2.0	5.0	2.0
October	<1.0	1.5	1.0	6.0	245	6.0	17.0	1.0	6.0	1.8
November	<1.0	1.3	1.0	2.8	255	<5.0	20.0	1.9	4.5	6.0
December	<1.0	3.5	1.0	4.5	1225	<5.0	39.5	4.0	5.5	2.0
January (1973)	1.8	3.8	<1.0	2.8	668	6.2	31.3	4.0	8.8	0.8
February	<1.0	1.8	<1.0	3.0	323	4.5	16.5	1.8	6.8	0.6
March	<1.0	2.0	<1.0	5.5	330	4.0	16.0	<1.0	8.5	<0.5
April	<1.0	<1.0	<1.0	2.8	388	7.3	16.5	2.0	8.8	0.6
May	<1.0	<1.0	<1.0	2.2	236	5.0	22.4	3.8	8.0	1.2
June	<1.0	<1.0	1.3	2.8	233	3.7	23.3	3.0	12.3	0.7
July	<1.0	<1.0	<1.0	3.5	214	2.0	18.8	2.0	13.8	3.3
August	<1.0	1.5	1.2	2.8	290	5.4	18.3	1.9	18.3	0.7
September	<1.0	<1.3	<1.0	1.8	242	5.0	16.0	1.6	15.0	<0.5
October	<1.0	1.2	1.0	2.2	524	<5.0	31.0	1.0	6.2	<0.5
November	<1.0	1.8	---	4.5	1660	<5.0	62.3	3.5	13.5	<0.5
December	<1.0	2.0	2.0	4.3	1198	6.3	51.3	3.7	10.5	<0.5
January (1974)	<1.0	3.3	2.0	5.0	1877	1.25	63.5	2.0	9.5	<0.5
February	<1.0	1.7	<1.0	3.3	1420	<5.0	43.0	0.7	6.3	<0.5
March	<1.0	3.0	<2.0	4.0	2535	6.5	62.0	1.5	9.0	<0.5
April	<1.0	1.5	<2.0	3.0	897	6.5	25.8	<2.0	4.75	---

Table A-6. Mean monthly physical and chemical data for the Western Fish Toxicology Station well from April 1972 thru April 1974.

Month	Air Temp °C		Temp °C	T	D S	S S	Cl
	Wet Bulb	Dry Bulb	Intake	(JTU)	(mg/l)	(mg/l)	(mg/l)
April (1972)	----	12.9	10.5	---	55.0	<1.0	8.0
May	----	15.3	11.3	---	61.0	<1.0	7.0
June	----	18.0	13.4	---	62.5	<1.0	7.0
July	----	20.0	17.1	---	39.0	1.8	8.3
August	----	18.5	18.1	---	49.0	1.8	6.3
September	----	11.7	19.7	---	61.0	4.0	4.0
October	----	9.8	14.8	---	61.8	1.0	5.5
November	----	9.2	12.5	---	51.2	2.2	5.3
December	---	3.1	9.0	---	48.0	<1.0	4.0
January (1973)	----	6.2	9.4	---	119.0	<1.0	12.4
February	----	9.1	8.2	---	72.0	<1.0	5.0
March	----	9.5	8.8	---	96.0	2.0	6.0
April	----	12.9	10.3	---	75.0	2.5	8.8
May	----	18.8	13.1	---	61.0	2.4	8.0
June	----	16.0	16.3	1.5	71.0	2.8	7.5
July	----	17.8	18.1	3.3	70.0	1.0	6.8
August	12.0	15.3	20.0	6.4	64.0	<1.0	5.8
September	12.3	13.6	17.7	5.3	60.5	<1.0	5.3
October	8.1	9.2	15.4	5.8	62.0	1.2	5.4
November	6.0	6.7	12.4	6.8	58.0	1.0	6.8
December	6.0	6.7	12.2	7.8	110.0	<1.0	14.0
January (1974)	4.9	5.9	11.7	7.3	130.0	1.3	11.3
February	6.2	7.6	11.3	10.7	80.5	0.8	6.7
March	9.4	8.6	10.8	5.0	115.0	1.5	7.0
April	8.8	11.0	10.5	3.8	100.0	2.0	8.5

Table A-7. Mean monthly chemical data (Da, pH, TA, TH, NO_2, NO_3, NH_3) for the Western Fish Toxicology Station well from April 1972 thru April 1974.

Month	DO	pH*	TA	TH	NO_2	NO_3	NH_3
	(mg/l except pH)						
April (1972)	---	---	---	---	<0.001	0.200	<0.001
May	5.6	6.8	20	22	<0.001	0.154	<0.001
June	4.5	6.7	21	24	<0.001	0.144	0.003
July	4.0	6.8	20	23	<0.001	0.176	0.002
August	3.1	6.8	22	23	0.001	0.151	0.002
September	3.6	6.8	20	22	<0.001	0.158	0.006
October	4.5	6.8	21	22	<0.001	0.164	0.013
November	5.4	6.9	21	23	<0.001	0.160	0.026
December	7.2	6.8	23	23	<0.001	0.240	0.036
January (1973)	5.6	6.7	39	52	<0.001	0.390	0.047
February	5.8	6.7	28	33	<0.001	0.350	0.048
March	4.7	6.8	26	30	----	----	0.090
April	4.8	6.8	27	31	0.001	0.293	0.051
May	3.9	6.8	26	28	<0.001	0.281	0.062
June	2.2	6.9	27	28	0.001	0.271	0.059
July	2.7	6.8	27	26	0.001	0.208	0.054
August	2.7	6.9	27	25	0.002	0.198	0.051
September	2.9	6.8	25	25	<0.001	0.172	0.035
October	3.0	6.8	27	27	<0.001	0.177	0.076
November	4.0	6.8	25	28	0.002	0.261	0.074
December	3.0	6.6	50	62	<0.001	0.414	0.052
January (1974)	4.6	6.6	63	67	0.001	0.578	0.061
February	4.1	6.7	51	58	<0.001	0.389	0.019
March	3.8	6.7	54	53	<0.001	0.368	0.021
April	3.5	6.7	43	51	<0.001	0.262	0.192

*Median value

Table A-8. Mean monthly chemical data (Ca, Mg, Na, K, SO_4) for the Western Fish Toxicology Station well from April 1972 thru April 1974.

Month	Ca	Mg	Na	K	SO_4
	(mg/l)				
April (1972)	7.9	2.0	5.0	1.1	<10.0
May	5.8	1.4	4.4	0.5	<5.0
June	5.8	1.6	4.4	0.5	3.0
July	6.7	1.6	4.6	0.5	<1.0
August	6.5	1.7	4.7	0.5	<10.0
September	6.0	1.6	4.5	0.6	<10.0
October	6.7	1.9	4.7	0.6	5.0
November	6.2	1.6	4.2	0.6	3.7
December	6.2	1.5	4.2	0.5	3.0
January (1973)	15.3	3.5	7.1	0.7	7.8
February	7.7	2.1	5.0	0.5	5.0
March	8.0	2.1	5.3	0.7	5.0
April	8.9	2.3	5.4	0.7	5.3
May	8.3	2.4	5.8	0.7	3.0
June	8.4	2.2	5.8	0.7	4.8
July	7.4	1.9	5.8	0.8	<5.0
August	6.5	1.7	5.7	0.7	3.1
September	6.7	1.7	5.4	0.7	3.1
October	7.0	1.8	5.4	0.7	2.9
November	7.9	2.1	4.8	0.7	10.0
December	20.3	4.2	9.0	0.8	13.0
January (1974)	21.3	4.8	7.0	0.8	17.3
February	14.3	3.4	6.9	0.9	14.7
March	20.8	3.8	7.2	0.7	13.0
April	18.2	3.7	6.8	0.6	15.5

Table A-9. Mean monthly heavy metal data for the Western Fish Toxicology Station well from April 1972 thru April 1974.

	(μg/l)									
Month	Cd	Cr	Co	Cu	Fe	Pb	Mn	Ni	Zn	Hg
April (1972)	<0.2	0.4	0.9	27.0	98	4.0	2.0	4.0	24.0	<0.5
May	<0.2	1.0	0.8	6.6	108	5.0	1.6	1.0	7.4	1.0
June	<0.4	0.7	1.2	4.6	99	3.0	1.9	2.4	4.9	<0.5
July	<1.0	1.0	1.5	5.0	105	5.0	1.3	2.0	4.0	1.5
August	<1.0	1.5	<2.0	7.0	150	<5.0	2.0	2.5	5.0	1.3
September	1.0	0.9	2.0	3.0	102	5.0	2.0	1.0	1.0	2.5
October	1.0	1.0	2.0	3.0	79	6.0	1.5	1.0	2.0	2.3
November	<1.0	1.5	<1.0	2.0	83	<5.0	2.0	1.0	1.5	3.0
December	<1.0	2.5	<1.0	3.0	177	<5.0	15.5	2.5	9.5	1.0
January (1973)	<1.0	3.0	1.0	2.3	107	<5.0	3.4	4.5	3.8	1.1
February	<1.0	1.0	<1.0	7.3	48	4.0	1.0	2.5	9.3	0.6
March	<1.0	<1.0	<1.0	3.0	33	4.0	1.5	1.0	11.0	0.8
April	<1.0	<1.0	<1.0	1.8	123	6.9	3.3	1.8	4.8	0.5
May	<1.0	<1.0	<1.2	1.6	128	<5.0	6.4	3.2	11.3	0.8
June	<1.0	<1.0	1.3	1.8	66	4.3	9.0	3.0	7.3	1.2
July	<1.0	<1.0	<1.0	1.8	70	3.8	2.1	1.5	5.5	1.1
August	<1.0	<1.0	<1.0	2.8	60	5.0	1.8	1.9	5.3	0.7
September	<1.0	<1.0	<1.0	1.0	81	5.0	1.3	1.7	3.0	0.7
October	<1.0	1.2	<1.0	1.6	64	<5.0	1.6	1.0	2.0	0.6
November	<1.0	1.0	---	1.8	95	5.0	1.8	2.0	2.6	<0.5
December	<1.0	5.5	2.0	2.3	52	5.0	2.0	1.5	3.0	<0.5
January (1974)	<1.0	.67	1.75	3.0	50	2.5	2.0	2.0	5.3	0.3
February	<1.0	<1.0	<1.0	2.3	72	1.7	2.7	<1.0	2.0	<0.5
March	<1.0	0.5	<2.0	1.0	59	6.5	2.5	2.0	2.0	<0.5
April	<1.0	<1.0	<2.0	1.5	48	5.8	2.0	<2.0	<1.0	1.5

Table A-10. Physical and chemical data (Temp., DO, pH) for major western Oregon rivers for collection dates from December 1972 thru September 1973.

Station Number River and Location	TEMP °C				D O (mg/l)				pH			
	12/72	03/73	06/73	09/73	12/72	03/73	06/73	09/73	12/72	03/73	06/73	09/73
1. ALSEA, N. Fk below Mill Cr.	1.0	----	----	----	13.5	----	----	----	7.28	----	----	----
2. ALSEA, Hwy 34 @ Mike Bauer	1.0	----	----	12.0	13.5	----	----	10.0	6.80	----	----	6.88
3. APPLEGATE, near Applegate	----	7.0	23.0	----	----	12.2	9.6	----	----	7.53	7.90	----
4. CALAPOOIA, Hwy 34	----	----	17.8	----	----	----	8.6	----	----	----	7.16	----
5. CALAPOOIA, @ Brownsville	10.0	7.2	----	----	10.9	11.3	----	----	6.80	7.08	----	----
6. CHETCO, 7 mi. above tidewater	----	6.8	17.5	----	----	12.2	8.6	----	----	7.18	7.30	----
7 COOS, So. Fk. @ Dielwood	5.5	----	----	17.5	12.6	----	----	9.8	6.75	----	----	6.75
8. COOS, 3 mi. above tidewater	----	8.0	21.0	----	----	11.0	9.9	----	----	6.65	7.29	6.61
9. COQUILLE, W. Fk. on Hwy. 42	----	----		18.5	----	----	----	8.6	----	----	----	6.82
10. COQUILLE, S. Fk. @ Myrtle Point	5.5	----	----	----	12.6	----	----	----	7.00	----	----	----
11. COQUILLE, @ Coquille	----	8.5	22.0	18.6	----	11.3	9.6	8.6	----	6.99	7.45	6.80
12. ELK, head of tidewater	----	7.5	21.0	17.0	----	11.9	10.4	9.8	----	7.16	7.70	6.72
13. FIVE, @ Five Rivers	----	----	21.0	11.0	----	----	9.4	10.4	----	----	----	7.23
14. ILLINOIS, E. Fk, @ Hwy 20	----	9.2	24.0	----	----	11.4	9.0	----	----	7.59	7.60	----
15. ILLINOIS, W. Fk. @ Agness	----	8.3	24.0	18.0	----	11.8	8.6	11.4	----	7.43	7.70	7.45
16. KILCHES, @ Kilches R. Park	----	----	16.5	10.5	----	----	10.9	----	----	7.24	6.92	6.96
17. LITTLE NESTUCCA, @ Hwy 18	----	----	----	10.0	----	----	----	9.4	----	----	----	6.75
18. LONG TOM, @ Monroe	8.3	10.0	----	18.5	10.5	11.2	----	9.6	7.09	7.20	----	7.51
19. LUCKIAMUTE, @ Hwy 99	----	----	----	----	----	----	----	----	6.78	7.04	----	----
20. McKENZIE, I-5 nr. Eugene	8.5	7.0	14.3	15.5	11.2	11.8	10.2	11.6	7.62	7.11	7.25	7.00
21. MIAMI, head of tidewater	----	----	13.2	10.5	----	----	10.2	----	----	6.83	6.89	6.72
22. NECANICUM, @ Seaside	---	----	----	----	----	----	----	----	----	6.79	----	----
23. NEHALEM, N. Fk. nr. Salmonberry	----	----	----	----	----	----	----	----	----	----	6.81	----
24. NEHALEM, Hwy 101 at bridge	----	----	18.6	11.0	----	----	9.5	----	----	7.07	7.15	6.78
25. NESTUCCA, @ Cloverdale	----	----	17.0	11.7	----	----	8.8	9.1	7.10	7.15	7.10	6.85
26. PISTOL, 5 mi. above tidewater	----	6.2	17.2	----	----	12.4	9.2	----	----	7.19	7.33	----

Table A-10. (Cont'd) Physical and chemical data (Temp., DO, pH) for major western Oregon rivers for collection dates from December 1972 thru September 1973.

	Station Number River and Location	TEMP °C 12/72	TEMP °C 03/73	TEMP °C 06/73	TEMP °C 09/73	D O (mg/l) 12/72	D O (mg/l) 03/73	D O (mg/l) 06/73	D O (mg/l) 09/73	pH 12/72	pH 03/73	pH 06/73	pH 09/73
27.	ROGUE, 5 mi. above tidewater	5.9	7.8	21.0	20.0	12.4	11.8	9.1	11.6	7.10	7.49	7.77	8.05
28.	ROGUE, I-5 @ Rogue R.	----	7.0	22.0	----	----	12.7	11.5	----	----	7.32	7.94	----
29.	SALMON, head of tidewater	----	----	16.5	----	----	----	9.0	----	----	----	7.12	----
30.	SANTIAM, I-5 nr. Albany	8.1	----	----	----	11.2	----	----	----	6.90	----	----	----
31.	SANTIAM, M. Fk. B. Green Peter Dam	10.8	----	----	----	11.0	----	----	----	6.80	----	----	----
32.	SANTIAM, N. Fk. @ Mill City	----	----	----	13.5	----	----	----	----	----	----	----	7.01
33.	SILETZ, Hwy 229	1.3	----	18.5	11.0	13.8	----	9.4	10.0	6.95	----	6.99	6.89
34.	SILTCOOS, Hwy 101 State Pk.	----	8.5	22.0	----	----	11.8	9.2	----	----	6.90	6.98	----
35.	SIUSLAW, head of tidewater	----	9.0	20.3	17.2	----	12.0	10.6	10.6	----	6.85	7.45	7.30
36.	SIUSLAW, Hwy 126 @ Swisshome	9.0	----	24.0	----	11.5	----	9.1	----	7.08	----	7.26	----
37	SIXES, head of tidewater	5.8	8.0	21.0	18.5	12.5	11.2	9.0	9.8	6.91	7.33	7.29	7.40
38.	SKIPANNON, Hwy 101 @ Seaside	----	----	----	----	----	----	----	----	----	6.66	----	----
39.	SMITH, M. Fk. (Calif.) Hwy 199	----	7.1	20.0	----	----	11.8	9.4	----	----	7.31	7.21	----
40.	SMITH, (Ore.) head of tidewater	----	9.8	22.5	19.5	----	10.8	9.5	8.6	----	6.75	7.10	6.82
41.	THREE, Hwy 101 @ Hebo	----	----	12.5	11.2	----	----	10.5	----	6.91	6.98	6.87	6.70
42.	TILLAMOOK, Hwy 101 @ Tillamook	----	----	19.5	10.2	----	----	8.8	----	----	7.14	7.01	6.93
43.	TRASK, Hwy 101 @ bridge	----	----	16.0	12.0	----	----	9.4	9.1	----	7.29	7.26	7.03
44.	TUALATIN,Hwy 205	----	----	----	15.5	----	----	----	----	----	----	----	8.25
45.	UMPQUAH,N. Fk. I-5 @ Winchester	----	7.2	18.9	----	----	12.3	8.4	----	----	7.11	7.25	----
46.	UMPQUAH,S. Fk. I-5 Nr Canyonville	10.0	7.2	22.0	22.0	11.3	11.8	9.2	12.2	7.12	7.48	7.87	8.30
47.	UMPQUAH,Hwy 38 above tidewater	9.5	----	----	----	10.9	----	----	----	7.10	----	----	----
48.	WILLAMETTE, Hwy 99 nr. Corvallis	4.1	----	17.2	----	12.0	----	9.0	----	7.16	----	7.38	----
49.	WILLAMETTE, C. Fk. I-5 @ Saginaw	9.8	7.3	15.9	20.0	11.0	11.6	9.6	10.0	7.20	7.22	7.21	6.79
50.	WILSON, Hwy 101	----	----	16.5	10.2	----	----	9.5	----	----	7.15	7.12	6.95
51.	YAMHILL, Hwy 18	----	----	19.5	----	----	----	8.4	----	----	6.88	6.99	----
52.	YAQUINA, Hwy 20 @ Eddyville	1.3	----	----	----	14.2	----	----	----	6.84	----	----	----

Table A-11. Physical and chemical data (TA, TH) for major western Oregon river for collection dates from December 1972 thru September 1973.

	Station Number River and Location	T A (mg/l)				T H (mg/l)			
		12/72	03/73	06/73	09/73	12/72	03/73	06/73	09/73
1.	ALSEA, N. Fk. below Mill Cr.	26	----	----	----	24	----	----	----
2.	ALSEA, Hwy 34 @ Mike Bauer	18	----	----	29	17	----	----	27
3.	APPLEGATE, nr. Applegate	----	61	76	----	----	60	76	----
4.	CALAPOOIA, Hwy 34	----	----	21	----	----	----	20	----
5.	CALAPOOIA, @ Brownsville	23	10	----	----	20	23	----	----
6.	CHETCO, 7 mi above tidewater	----	20	42	----	----	23	47	----
7.	COOS, So. Fk. @ Dielwood	13	----	----	18	16	----	----	21
8.	COOS, 3 mi. above tidewater	----	14	----	15	----	14	----	24
9.	COQUILLE, W. Fk. on Hwy 42	----	----	----	30	----	----	----	30
10.	COQUILLE, S. Fk. @ Myrtle Point	19	----	----	----	25	----	----	----
11.	COQUILLE, @ Coquille	----	22	----	28	----	25	----	34
12.	ELK, head of tidewater	----	20	26	25	----	23	27	28
13.	FIVE, @ Five Rivers	----	----	----	19	----	----	----	16
14.	ILLINOIS, E. Fk. @ Hwy 20	----	53	58	----	----	52	59	----
15.	ILLINOIS, W. Fk. @ Agness	----	52	61	54	----	50	62	61
16.	KILCHES, @ Kilches R. Park	----	11	16	15	----	12	21	16
17.	LITTLE NESTUCCA, @ Hwy 18	----	----	----	15	----	----	----	17
18.	LONG TOM, @ Monroe	26	28	----	25	28	33	----	27
19.	LUCKIAMUTE, @ Hwy 99	13	14	----	----	13	15	----	----
20.	McKENZIE, I-5 nr. Eugene	24	21	25	22	18	18	18	23
21.	MIAMI, head of tidewater	----	13	16	16	----	14	22	19
22.	NECANICUM, @ Seaside	----	7	----	----	----	10	----	----
23.	NEHALEM, N. Fk. nr. Salmonberry	----	12	12	----	----	12	13	----
24.	NEHALEM, Hwy 101 at bridge	----	----	28	23	----	----	----	26
25.	NESTUCCA, @ Cloverdale	14	16	26	29	16	18	25	25
26.	PISTOL, 5 mi. above tidewater	----	23	49	----	----	22	58	----

Table A-11. (Cont'd) Physical and chemical data(TA, TH) for major western Oregon rivers for collection dates from December 1972 thru September 1973.

Station Number River and Location	T A (mg/l) 12/72	03/73	06/73	09/73	T H (mg/l) 12/72	03/73	06/73	09/73
27. ROGUE, 5 mi. above tidewater	24	41	48	42	33	39	46	39
28. ROGUE, I-5 @ Rogue R.	----	37	38	----	----	33	32	----
29. SALMON, head of tidewater	----	----	23	----	----	----	29	----
30. SANTIAM, I-5 nr Albany	15	----	----	----	14	----	----	----
31. SANTIAM, M. Fk. B. Green Peter Dam	15	----	----	----	14	----	----	----
32. SANTIAM, N. Fk. @ Mill City	----	----	----	19	----	----	----	16
33. SILETZ, Hwy 229	14	----	16	17	16	----	16	17
34. SILTCOOS, Hwy 101 State Pk.	----	12	18	----	----	12	15	----
35. SIUSLAW, head of tidewater	----	13	----	18	----	10	----	18
36. SIUSLAW, Hwy 126 @ Swisshome	17	----	16	----	18	----	14	----
37. SIXES, head of tidewater	19	21	32	29	26	24	34	35
38. SKIPANNON, Hwy 101 @ Seaside	----	16	----	----	----	23	----	----
39. SMITH, M. Fk. (Calif.) Hwy 199	----	36	44	----	----	36	42	----
40. SMITH, (Ore.) head of tidewater	----	13	----	17	----	13	----	----
41. THREE, Hwy 101 @ bridge	10	11	14	18	12	16	26	24
42. TILLAMOOK, Hwy 101 @ Tillamook	----	21	30	30	----	21	28	31
43. TRASK, Hwy 101 @ bridge	----	----	28	27	----	21	27	28
44. TUALATIN,Hwy 205	----	----	----	48	----	----	----	52
45. UMPQUAH,N. Fk. I-5 @ Winchester	----	26	28	----	----	23	22	----
46. UMPQUAH,S. Fk. I-5 nr. Canyonville	29	33	51	49	27	34	54	63
47. UMPQUAH,Hwy 38 above tidewater	29	----	----	----	27	----	----	----
48. WILLAMETTE, Hwy 99 nr. Corvallis	25	----	26	----	20	----	24	----
49. WILLAMETTE, C. Fk. I-5 @ Saginaw	40	21	24	20	34	19	22	22
50. WILSON, Hwy 101	----	18	24	20	----	16	21	22
51. YAMHILL, Hwy 18	----	11	17	----	----	14	16	----
52. YAQUINA, Hwy 20 @ Eddyville	16	----	----	----	22	----	----	----

Table A-12. Heavy metals data for major western Oregon rivers for collection dates from December 1972 thru September 1973.

Station Number River and Location	Cd (µg/l) 12/72	03/73	06/73	09/73	Cu (µg/l) 12/72	03/73	06/73	09/73	Zn (µg/l) 12/72	03/73	06/73	09/73
1. ALSEA, N. Fk. below Mill Cr	0.1	----	----	----	1.3	----	----	----	0.0	----	----	----
2. ALSEA, Hwy 34 @ Mike Bauer	0.0	----	----	0.0	1.8	----	----	0.0	3.0	----	----	0.0
3. APPLEGATE, nr Applegate	----	0.1	0.0	----	----	2.3	1.6	----	----	3.3	0.0	----
4. CALAPOOIA, Hwy 34	----	----	0.0	----	----	----	0.0	----	----	----	0.1	----
5. CALAPOOIA, @ Brownsville	0.2	0.0	----	----	3.5	0.5	----	----	5.0	0.3	----	----
6. CHETCO, 7 mi. above tidewater	----	0.0	0.0	----	----	0.0	0.0	----	----	0.0	0.0	----
7. COOS, So. Fk. @ Dielwood	0.0	----	----	0.0	1.2	----	----	0.0	3.0	----	----	1.0
8. COOS, 3 mi. above tidewater	----	0.0	----	0.0	----	0.0	----	0.0	----	1.3	----	0.0
9. COQUILLE, W. Fk. on Hwy 42	----	----	----	0.0	----	----	----	0.0	----	----	----	2.0
10. COQUILLE, S. Fk. @ Myrtle Point	0.0	----	----	----	1.0	----	----	----	0.0	----	----	----
11. COQUILLE, @ Coquille	----	0.0	----	0.2	----	0.0	----	5.0	----	0.3	0.5	1.0
12. ELK, head of tidewater	0.1	0.0	0.0	0.0	1.4	0.0	0.0	0.5	4.0	0.3	0.1	1.0
13. FIVE, @ Five Rivers	----	----	----	0.0	----	----	----	0.0	----	----	----	2.0
14. ILLINOIS, E. Fk. @ Hwy 20	----	0.0	0.0	----	----	1.1	----	----	----	1.0	2.2	----
15. ILLINOIS, W. Fk. @ Agness	----	0.0	0.0	0.0	----	0.0	0.0	0.0	----	0.3	0.2	0.0
16. KILCHES, @ Kilches R. Park	----	0.0	0.0	0.0	----	0.0	0.0	2.0	----	0.0	0.1	4.0
17. LITTLE NESTUCCA, @ Hwy 18	----	----	----	0.0	----	----	----	0.0	----	----	----	1.0
18. LONG TOM, @ Monroe	0.0	0.0	----	0.0	4.1	0.5	----	0.5	7.0	0.3	----	6.0
19. LUCKIAMUTE, @ Hwy 99	0.1	0.0	----	----	5.0	0.3	----	----	11.0	0.0	----	----
20. McKENZIE, I-5 nr. Eugene	0.0	0.0	0.1	0.0	1.3	0.0	0.0	0.0	6.0	0.0	0.5	4.0
21. MIAMI, head of tidewater	----	0.0	0.0	0.0	----	0.0	0.0	0.0	----	0.0	0.9	0.0
22. NECANICUM, @ Seaside	----	0.0	----	----	----	0.0	----	----	----	0.3	----	----
23. NEHALEM, N. Frk. nr Salmonberry	----	0.0	0.1	----	----	0.0	0.0	----	----	0.0	0.0	----
24. NEHALEM, Hwy 101 at bridge	----	----	----	0.0	----	----	----	0.0	----	----	----	2.0
25. NESTUCCA, @ Cloverdale	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
26. PISTOL, 5 mi. above tidewater	----	0.0	0.0	----	----	1.0	0.0	----	----	0.0	0.1	----

Table A-12. (Cont'd) Heavy metals data for major Western Oregon rivers for collection dates from December 1972 thru September 1973.

	Station Number River and Location	Cd (μg/l) 12/72	03/73	06/73	09/73	Cu (μg/l) 12/72	03/73	06/73	09/73	Zn (μg/l) 12/72	03/73	06/73	09/73
27.	ROGUE, 5 mi. above tidewater	0.0	0.0	0.0	0.0	4.2	0.0	0.5	0.0	7.0	0.0	1.2	6.0
28.	ROGUE, I-5 @ Rogue R.	----	0.0	0.1	----	1.1	----	0.5	----	0.3	----	1.6	----
29.	SALMON, head of tidewater	----	----	0.0	----	----	----	0.0	----	----	----	0.1	----
30.	SANTIAM, I-5 nr Albany	0.0	----	----	----	2.4	----	----	----	1.0	----	----	----
31.	SANTIAM, M. Fk. B. Green Peter Dam	0.1	----	----	----	2.2	----	----	----	0.0	----	----	----
32.	SANTIAM, N. Fk. @ Mill City	----	----	----	0.0	----	----	----	0.5	----	----	----	2.0
33.	SILETZ, Hwy 229	0.0	----	0.2	0.0	2.3	----	0.0	0.0	0.0	----	3.5	0.0
34.	SILTCOOS, Hwy 101 State Pk.	----	0.0	0.0	----	----	0.0	0.2	----	----	0.3	----	----
35.	SIUSLAW, head of tidewater	----	0.0	----	0.0	----	0.0	----	0.0	----	11.0	----	3.0
36.	SIUSLAW, Hwy 126 @ Swisshome	0.0	----	0.2	----	4.5	----	0.0	----	3.0	----	2.7	----
37.	SIXES, head of tidewater	0.1	0.0	0.0	0.0	1.8	0.0	0.0	0.0	3.0	0.0	2.0	1.0
38.	SKIPANNON, Hwy 101 @ Seaside	----	0.0	----	----	----	2.5	----	----	----	0.7	----	----
39.	SMITH, M. Fk. (Calif.) Hwy 199	----	0.0	0.0	----	----	0.0	0.0	----	----	0.3	0.0	----
40.	SMITH, (Ore.) head of tidewater	----	0.0	----	----	----	0.0	----	0.5	----	0.0	----	2.0
41.	THREE, Hwy 101 @ Hebo	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	2.8	0.9	0.0
42.	TILLAMOOK, Hwy 101 @ Tillamook	----	0.0	0.0	0.0	----	0.0	0.0	0.5	----	1.0	0.6	0.0
43.	TRASK, Hwy 101 @ bridge	----	0.0	0.0	0.0	----	0.0	0.0	1.5	----	0.0	0.7	2.0
44.	TUALATIN,Hwy 205	----	----	----	0.0	----	----	----	1.8	----	----	----	3.0
45.	UMPQUAH,N. Fk. I-5 @ Winchester	----	0.0	0.0	----	----	0.0	0.0	----	----	0.0	2.7	----
46.	UMPQUAH,S. Fk. I-5 nr. Canyonville	0.2	0.0	0.0	0.2	4.7	1.1	1.5	0.0	5.0	0.3	0.0	8.0
47	UMPQUAH,Hwy 38 above tidewater	0.2	----	----	----	4.7	----	----	----	5.0	----	----	----
48.	WILLAMETTE, Hwy 99 nr. Corvallis	----	----	0.0	----	1.3	----	0.0	----	----	0.1	----	----
49.	WILLAMETTE, C. Fk. I-5 @ Saginaw	0.1	0.0	0.0	0.0	3.1	0.5	0.0	0.0	8.0	0.6	0.0	2.0
50.	WILSON, Hwy 101	----	0.0	0.0	0.0	----	0.0	0.0	0.5	----	0.0	0.1	6.0
51.	YAMHILL, Hwy 18	----	0.0	0.0	----	----	0.0	0.0	----	----	0.0	0.2	----
52.	YAQUINA, Hwy 20 @ Eddyville	0.0	----	----	----	1.2	----	----	----	3.0	----	----	----

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

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*Western Fish Toxicology Station now is attached to the Corvallis Environmental Research Laboratory, Corvallis, OR 97330

16. ABSTRACT

Seasonal variation in water quality was compared for the Western Fish Toxicology Station (WFTS), Corvallis, OR, the adjacent Willamette River and approximately 40 major western Oregon rivers from 1972 through 1974.

Water temperature patterns of the Willamette River and the WFTS well were similar (range, 4.6-20.0C). While both displayed seasonal trends, well water lagged 7-10 days behind the river in both temperature increases and decreases. Dissolved oxygen values in both the river and well water were inversely related to temperature. Average dissolved oxygen concentrations were higher in the river (10.4 mg/l) than in the well water (4.1 mg/l). Hydrogen ion concentration (pH) was low in the well water (range, 6.6-7.0), compared to the river (range, 7.0-7.8). River water had a mean hardness and alkalinity of 22 mg/l and 23 mg/l respectively, while well water ranged between "soft to moderately hard" (mean hardness, 34 mg/l; mean alkalinity, 31 mg/l). High Willamette River discharges (above Corvallis) were followed by a 7-10 day lag in corresponding sharp peaks of total hardness, alkalinity, and certain cations and anions in the well water. Major cation and anion concentrations were low overall. Trace metals were found to be at or near detection limits. River iron and manganese concentrations were approximately 10 times greater than those found in the well. River zinc had a mean of 9.4 ug/l, while the well water mean concentration was 5.1 ug/l.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Water quality Seasonal variations Rivers	Major western Oregon rivers Willamette River Western Fish Toxicology Station	08H

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