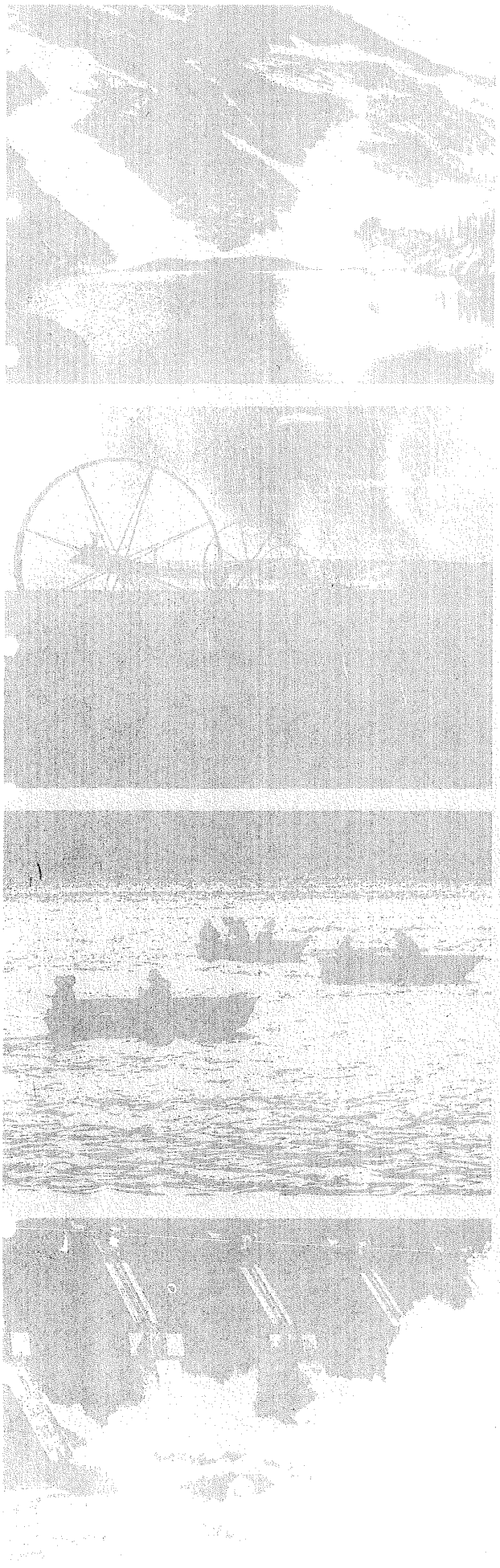

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by
William H. Funk, Harry L. Gibbons,
Robert M. Duffner, Terri Notestine
and Thomas Nielsen

STATE OF WASHINGTON
WATER RESEARCH CENTER

WASHINGTON STATE UNIVERSITY AND
THE UNIVERSITY OF WASHINGTON

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College of Engineering
Civil and Environmental Engineering
Washington State University
Pullman, Washington 99164-3002

Research Project Technical Completion Report

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Washington State Water Research Center
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ABSTRACT

This investigation reviews the present state of water quality at ten stations on the Spokane River from the Washington - Idaho Stateline, River Kilometer 153 to the entry of Hangman Creek River Kilometer 117 below the City of Spokane. A major objective of the study was to supply water quality management information in the critical recharge area of the Spokane River. Other objectives were to develop and refine methodologies for obtaining representative periphyton and macroinvertebrate samples and to investigate the effectiveness of several substrates for *in situ* river use for long term water quality indication.

Nearly all physicochemical water quality indicators showed a measurable increase due to the addition of aquifer waters during the low flow period of the study. There was also a rise in dissolved constituents as the waters moved downstream, most likely as a result of urban runoff and increased human activities along the river. Metal content was relatively low considering mining activities in the headwater regions. An exception was zinc which ranged from 5 to 225 μg/ℓ.

Artificial and natural substrates are compared in periphyton studies. Optimum colonization periods are discussed. Sampling design deficiencies are reviewed and recommendations made. Certain aspects of direct sampling by suction sampler are discussed as well as bias introduced by the utilization of natural and artificial samplers for long term investigations. Placement of samplers and the use of basket and multiplate samplers are also discussed in the case of macroinvertebrate studies.

INTRODUCTION

There have been many studies describing the beneficial aspects of establishing sewage treatment plants after raw effluent has damaged a river. Relatively few investigations have been made upon rivers or streams where the effect of a high level treated effluent has been studied from onset.

The area encompassed in this study was in the upper portion of the Spokane Valley (Figure 1). Water quality of the Spokane River from the Idaho-Washington stateline, River kilometer 156 (River mile 97) downstream past Harvard road to just below the study site at RK 145 (RM 90) approximates other area streams not receiving waste discharge. There are, however, some exceptions, such as metal content, nitrogen supersaturation during high flow, dissolved oxygen less than saturation during low flow, and higher temperatures (U.S. Environmental Protection Agency, 1973). The stream at this point seems to have assimilated treated domestic and light industrial effluents from the cities of Coeur d'Alene and Post Falls, Idaho. Initial results of the present study indicate that nutrients (N and P) are at limiting levels by RK 145 (RM 90).

Considerable controversy over pollutants added to the river has occurred over a lengthy period of time beginning in 1936 when several papers were presented to Northwest Scientific Association concerning the relationship between Spokane River raw sewage pollution and health (Brice, 1936), "The Sanitary Significance of the Spokane River" (Butler, 1936) and "Natural Purification Processes in Water Courses" (Harris, 1936). The city of Coeur d'Alene and several other communities were sewered shortly after that time. The major contributor of raw wastes to the river was the City of Spokane, which did not treat its effluent until 1948 when a primary plant was completed. In 1970, largely through the efforts of businessmen, environmentalists and several political figures, a 1974 World's Fair was proposed on the theme of "Progress Without Pollution." The resulting publicity campaign stimulated the upgrading of the Spokane Treatment facilities as did legal and financial support of the Clean Waters Act of the 1970's.

In 1977, Spokane completed an advanced waste treatment plant with phosphorus removal. There now exists within the Spokane community and surrounding area a strong common desire not to add additional pollutants in any form to any water course without having some knowledge of the consequences of the addition (Public Hearing, Liberty Lake, 1979). Fortunately, in the region of the new Liberty Lake sewage treatment plant (STP) outfall, there are some limited background data. During a 1975 Office of Research and Technology (OWRT) investigation of the river, a water quality and macroinvertebrate station was established at that location. We also have some data from the U.S. Geological Survey (USGS) taken at Liberty Lake Bridge or Harvard Road, the results of several surveys by the U.S. Environmental Protection Agency and its precursor, the Federal Water Quality Administration (FWQA), as well as state agency data (Cunningham and Pine, 1969). Most of these data are of value in determining water quality trends.

Concern also has been recently expressed over the growth of human populations in the study area and the possibility of contamination of the groundwater. The old Liberty Lake sewage treatment plant was overloaded and discharged almost directly into the aquifer. The construction of the new sewage treatment plant and sewer was completed in late 1982. Ironically, the reduction in nutrient input to Liberty Lake and the aquifer as the result of the sewer system will increase the nutrient loading to another aquatic environment, the Spokane River.

The impacts of raw and poorly treated wastes upon a stream environment have been well documented (Gaufin and Tarzwell, 1952, 1956; Gaufin, 1973; Hynes, 1960, 1970; USHEW, 1961; Jones, 1964; Mackenthun and Ingram, 1967; Mackenthun, 1969; Cairns and Dickson, 1970; Cairns et al., 1976; Funk et al., 1973, 1975; Soltero et al., 1974; Miller et al., 1974; Cunningham and Pine, 1969). Most studies have dealt with the effluent already in the receiving stream and then with restoration to some postulated previous community structure after a period of time. This study was directed toward observing the subtle changes taking place, either beneficial or detrimental.

The Liberty Lake sewage district plant will discharge approximately 3785 m^3/day ($\cong 1 \times 10^6$ gal/day). If higher discharges are allowed, lime coagulation is proposed for removal of phosphorus. Plans include effluent disinfection with chlorine at all operation levels followed by dechlorination before release (M. Kennedy Engineers, 1978). The 40 year mean flow of the Spokane River near the proposed discharge point is 171.1 m^3/s (6,258 cfs). The 1976 maximum was 847 m^3/s (29,000 cfs). The minimum that year was 28.9 m^3/s (1020 cfs).

SPECIFIC OBJECTIVES

The specific objectives of this research were: (1) to aid in establishing information for water quality management of the Spokane River in the critical recharge area of the sole source Spokane Aquifer; (2) to develop and refine methodologies for obtaining representative periphyton and macroinvertebrate samples; and (3) to assess the effect of secondary treated sewage upon periphyton and macroinvertebrates in the Upper Spokane River.

Unfortunately, the last objective was not achieved. Construction delays resulted in completion of the sewage treatment plant after the record period designated by the sponsors of this research grant. However, plans are being formulated to conduct a limited study of the periphyton after effluent discharge.

Substrate Selection for Periphyton Studies

The majority of quantitative studies on periphyton utilize some form of artificial substrate (Nelson et al., 1973). Substrates used include glass slides, plexiglass plates, concrete blocks or cylinders, slate tiles, and mylar. Glass slides are the most commonly used artificial substrate (Sladeckova, 1962). Natural substrates generally are limited to macrophytes or river rocks gathered on site.

Artificial substrates are more widely used than natural substrates in studies of attached algal communities for several reasons. Artificial substrates provide a uniform texture, chemical composition, and surface area (Wetzel, 1975; Grzenda and Brehmer, 1960). These qualities tend to minimize differences in the nature of the surface available for colonization. In contrast, natural substrates tend to be heterogeneous in surface texture and chemical composition. An additional disadvantage of natural substrates is that they require specialized removal techniques due to their nonuniform surface area (Nelson et al., 1973). Transparent artificial substrates may offer some advantage over natural substrates in that direct microscopic examination of the periphyton assemblage may be possible (Nelson et al., 1973; Sladeckova, 1962).

Several studies have compared periphyton colonizing artificial and natural substrates. Patrick et al. (1954) and Peters et al. (1968) have reported that artificial substrates (glass and plexiglass, respectively) in rivers were nonselective for the dominant periphytic organisms. Kevern et al. (1966) observed that the instantaneous growth rate of periphyton colonizing plexiglass was comparable to the rate of periphyton colonizing natural stream bottom substrates. Castenholz (1960) concluded in a study on periphyton in several lakes that glass appeared to be nonselective. He did note, however, an absence of blue-green algae on the artificial substrate as compared to the natural substrate; the lack of blue-green algae was attributed to the relatively short colonization periods (2 to 4 weeks) used in the experiment.

Many other comparative studies have reported that artificial substrates are selective. Two investigations that compared attached algae colonizing glass and other types of artificial substrates (styrofoam and aluminum, respectively) have reported significant differences in species composition and abundance (Hohn and Hellerman, 1963; Tuchman and Blinn, 1979). Tuchman and Blinn (1979) also noted a difference in the rates of diatom colonization on the two substrates. Another investigation comparing artificial substrates showed similarities in predominant genera but differences in the relative abundances of diatoms colonizing glass, slate, and acrylic plates (Lowe and Gale, 1980).

Attached algae colonizing artificial and natural substrates (macrophytes) have been compared. Tippet (1970), Siver (1977), and Foerster and Schlichting (1965) all noted the absence of certain genera of diatoms on glass substrates when compared with diatoms colonizing glass often have been representative of the periphytic community in terms of abundance or species composition.

Both qualitative and quantitative differences in periphyton colonizing artificial and natural (rock) substrates have been observed. Yong (1945) reported differences in the species composition and abundance of periphyton on glass and stone substrates. Differences in species composition included the absence on glass slides of a blue-green filamentous algae growing abundantly on the natural substrate. Albin (1965) noted a lack of filamentous algae and quantitative differences in diatoms colonizing glass plates and natural rocks. Pieczynska and Spodniewska (1963) found that diatoms colonizing glass and rocks were similar (although not identical);

however, they reported large quantitative differences in periphyton on the two substrates. Young (1945), Albin (1965), and Piczynska and Spodniewska (1963) all conducted their comparative studies in lentic ecosystems. There is an apparent lack of quantitative investigations comparing periphyton on glass and rock substrates in lotic ecosystems.

Some comparative investigations of periphyton on natural and artificial substrates have apparent deficiencies in sampling design. Brown (1976) noted that attached algae colonizing artificial substrates exposed for a known length of time often have been compared to attached algae colonizing natural substrates exposed for an unknown length of time (i.e., cumulative growth). Additionally, in some comparative investigations, artificial and natural substrates have not been exposed to the same environmental factors, such as light and current. For example, some studies have compared attached algae colonizing artificial substrates in floating-type sampling devices with periphyton colonizing benthic natural substrates (Patrick et al., 1954; Hohn and Hellerman, 1963; Peters et al., 1968). Periphytic growth on mid-channel natural substrates also has been compared to growth on near-shore artificial substrates (Lowe and Gale, 1980). In studies where substrates have not been exposed equally in time and/or space, it is difficult to determine whether differences observed resulted from an effect of substrate or were artifacts of the sampling design.

If the primary objective of a comparative investigation is to evaluate the effect of substrate type on the quantity and quality of periphyton, the sampling design should provide a means whereby both substrate types are exposed for the same length of time to the same environmental factors. By minimizing differences in these factors, the effect of substrate type (if any) on the periphytic community should be reflected. In addition, in situations where the naturally-occurring periphytic organisms are to be characterized, intuitively the sampling methodology should simulate natural environmental conditions as much as possible.

Substrate Selection for Macroinvertebrate Studies

It is appropriate at this point to discuss some of the difficulties involved in getting a representative macroinvertebrate sample from a river system like the Upper Spokane River. Physical conditions of the river often hinder the collection of macroinvertebrate samples because high velocities, depth of water and rocky bottoms make sampling techniques laborious and inefficient. Another problem in taking a representative sample is the fact that aquatic invertebrates often are distributed contagiously, not randomly (Wene and Wickliff, 1940; Minshall and Minshall, 1977). The dramatic influence of substrate type on the distribution of aquatic organisms was shown by Linduska (1942).

To reduce the problems of sampling and organisms distribution, artificial substrates for the colonization of macroinvertebrates have been used. Materials and designs have varied from concrete slabs used by Moon (1935), hardware cloth brush boxes introduced by Wene and Wickliff (1940), multiple-plate hardboard samples of Hester and Dendy (1962) and rock filled baskets used by Mason et al. (1967). Advantages of these artificial

substrates samplers are the simplicity of design and construction, ease of use in a variety of aquatic environments, and uniform substrate allowing for standardized sampling (Crossman and Cairns, 1974).

Although artificial substrates offer a standardized means to sample macroinvertebrates under otherwise difficult conditions, species may show preference for certain substrates, making comparisons between studies using different techniques and substrates inappropriate. In the case of multiple-plate samplers, the tempered hardboard plates used in construction vary in grade and texture depending on manufacturer and contain binding oils, which may inhibit certain species (Mason et al., 1973). In a study conducted in the Ohio River comparing basket and multiplate samplers, Mason et al. (1973) verified Fullner's (1971) findings that the total number of organisms collected by each sampler was generally the same. However, some species selection occurred among the chironomids and mayflies colonizing the two types of samplers. An additional finding of Mason et al. (1973) was that incubation time and depth were very important factors in the basket sampler's performance. Length of incubation was found to be best at 4 to 6 weeks in summer and at least 8 weeks in winter. Sampler depth of 0.3 m below the water surface produced the maximum number and highest diversity of organisms.

METHODS AND MATERIALS

WATER QUALITY STUDIES

Sampling Stations

Ten water sampling stations established along the Upper Spokane River from the Washington/Idaho Stateline, RK 153.2 (RM 95.2) to the entry of Hangman Creek, RK 116.9 (RM 72.6). Sampling at Stateline, RK 153.2 (RM 95.2) was stopped in March 1980 in order to add station Harvard II, RK 149.4 (RM 92.8), approximately 75 m downstream from the proposed Liberty Lake sewage outfall. The location of the Upper Spokane River and the sampling stations are shown in Figure 1. The site descriptions for water sampling stations are given in Table 1 and the river flow in Figure 2.

Physicochemical Methods

Conductivity, pH, dissolved oxygen, CO_2, HCO_3^-, $CO_3^=$, and temperature were measured on site in accordance with the American Public Health Association (APHA) Standard Methods for the Examination of Water and Wastewater, 14th ed. (APHA, 1975). Heavy metal (Cu, Pb, Zn, Hg, Ni, Cd) determinations were made by atomic absorption methods also described in Standard Methods (APHA, 1975). Total Kjeldahl-nitrogen, ammonia-nitrogen, nitrate-nitrogen, nitrite-nitrogen, total phosphorus, total soluble phosphorus, soluble reactive phosphorus, chlorides, and chemical oxygen demand were determined using a Technicon II Autoanalyzer following Technicon II Methods (1971-77) and EPA Methods for Chemical Analysis of Water and Wastes (EPA, 1977). Suspended solids and BOD were performed following Standard Methods (APHA, 1975). These analyses were performed on water samples from every station described above.

Biological Methods

Phytoplankton

Phytoplankton samples were collected biweekly during the bio-reactive period (June through September) and monthly for the rest of the year. Chlorophyll a concentrations were determined by techniques modified from Standard Methods (APHA, 1975). Sonification procedures were added to insure complete disruption of the cells for chlorophyll a extraction. Enumeration and identification were determined following methods described by Jackson and Williams (1962). These data are on computer file at Environmental Engineering laboratories.

PERIPHYTON INVESTIGATION

Description of the Study Area

The study was conducted approximately 24 km east of Spokane, Washington in the Spokane River at RK 148.3 (RM 92.8).

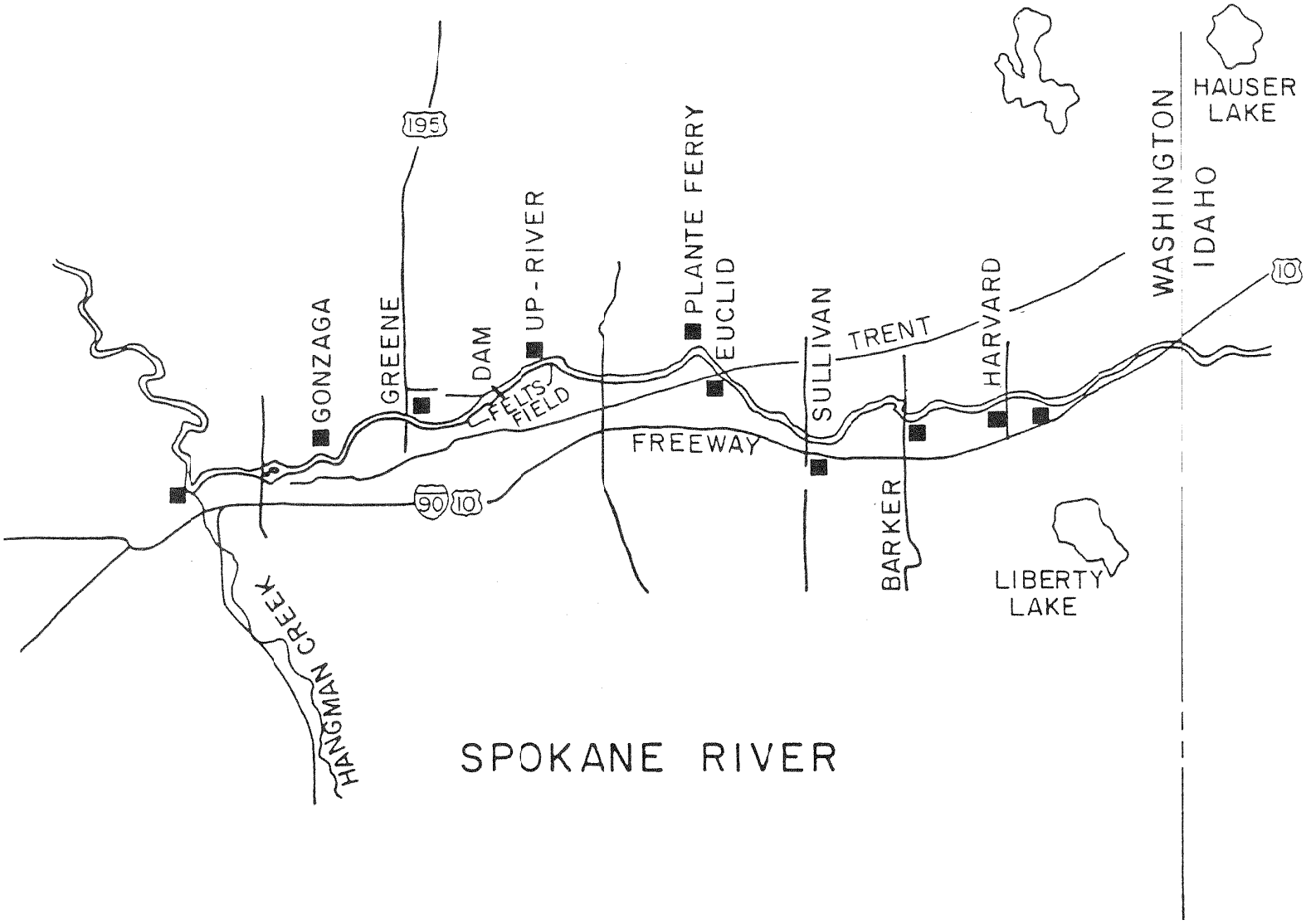

Figure 1. Upper Spokane River, from Washington-Idaho Stateline to Hangman Creek.

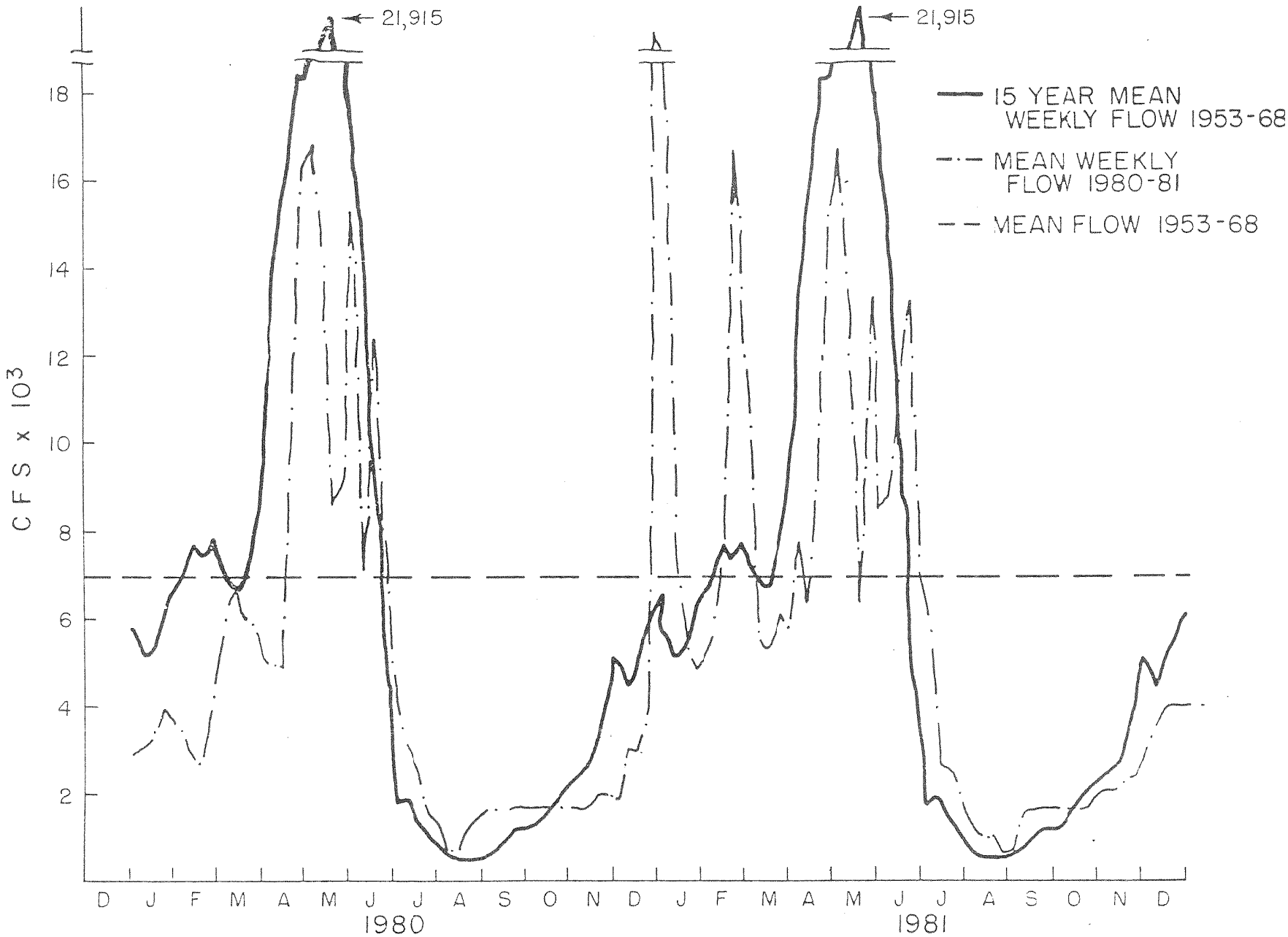

Figure 2. Spokane River flow below Post Falls

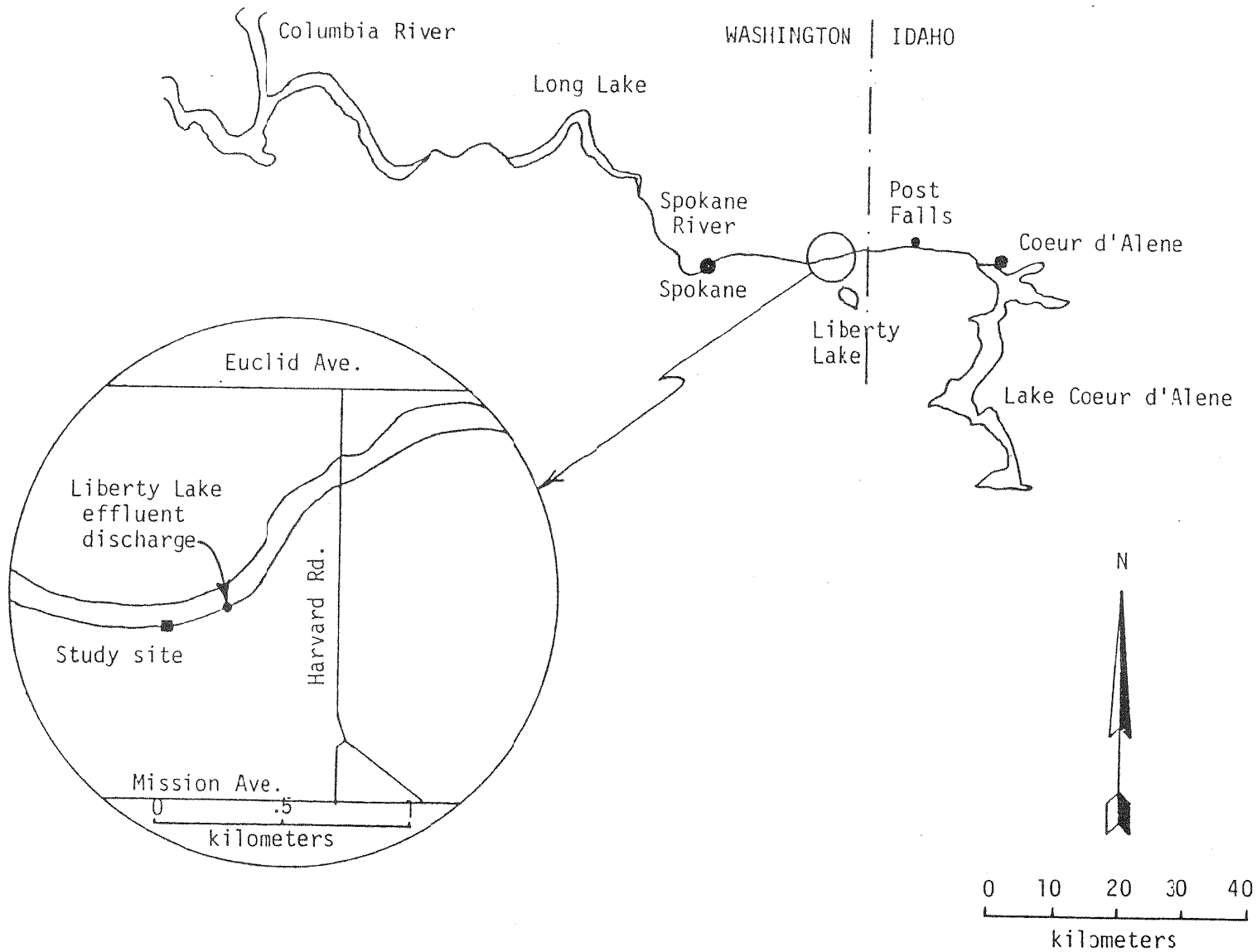

Figure 3. The study area.

Table 1. Description Of sampling sites.

Station	River Mile/km	Width (minimum) (m)	Depth (m)	Relative Velocity (low flow)	Substrate (cm/m in diameter)
Stateline	95.2/153.2	40	1	Moderate	Gravel (5-15 cm)
Harvard I	94.1/151.5	25	1.5	Fast	Rocky and Boulders (15-20 cm; 0.5-1 m)
Harvard II	92.8/148.3	40	1.5	Moderate	Rocky and Boulders (15-20 cm; 0.5-1 m)
Barker	90.4/145.5	50	1	Fast	Gravel to Rocky (10-20 cm)
Sullivan	87.9/141.5	25	2	Very Fast	Boulders (1-3.5 m)
Euclid	138.1	25	3	Fast	Rocky & Boulders (30-50 cm; 0.5 m)
Plantes Ferry	85.8/135.5	50	3.5	Moderate	Gravel to Rocky (10-30 cm)
Upriver Reservoir	84.2/132.6			Very Slow	Detritus, Sand, Gravel
Greene Street	78.2/125.8	50	10	Slow	Gravel and Rocky (5-500 cm)
Gonzaga	75.5/121.5	55	10	Slow	Gravel and Rocky (5-500 cm)
Hangman	72.6/116.9	75	1.5	Fast	Rocky and Boulders (30-50 cm; 0.5-7 m)

The site is approximately 0.23 km downstream of the Liberty Lake wastewater treatment plant outfall (Figure 3). Funk et al. (1975) have described basin geology and details of water quality characteristics presented in a later section of this report.

During the July through November study period, river flow averaged 45 m^3/sec. Maximum and minimum flows of 77 m^3/sec and 18 m^3/sec occurred in July and August respectively (United States Geological Survey, 1981). Flows throughout the investigation were consistent with low flow data for the previous 10 years reported by the United States Geological Survey (1970-1981).

Water temperatures were variable during the study. Temperatures ranged from a maximum of 23°C to a minimum 11°C.

Substrate Methodology

In order to assess the effects of the future sewage effluent upon the periphyton and to better estimate the quantity and community structure of the periphyton, both artificial and natural substrates were employed.

The artificial substrate used was developed in our recent river investigations (Funk, Rabe, Filby et al., 1975). Three equal sections of glass tubing (each section 8.0 cm in length, surface area = 25.3 cm^2) were held in placed by a center cord. The cord and tubing were enclosed within a barbecue basket placed in the river at a depth of one meter for three to six weeks (depending upon the season) to allow for colonization. Upon recovery, one section of tubing was scraped for chlorophyll a extraction. Another tube was scraped for ash-free dry weight. The third tube was scraped and the periphyton used in identification and enumeration. Figure 4 shows the glass tube substrate.

Rocks are the predominant natural substrate in the Spokane River. Hence, rocks from the Spokane River bed at the sampling locations were used for the natural substrate after being collected and cleaned. The rocks were placed in barbecue baskets similar to those containing the glass tubing. After the three to six week colonization period, the periphyton was scraped by a nylon brush from a known area of rock surface delineated by a plexiglass ring (either 2.5 or 3.8 cm id). A watertight seal was provided by a thin layer of foam rubber attached to the rim of the ring and pressed against the surface of the rock, thus allowing the aspiration of the periphyton with the aspirating device shown in Figure 5. The procedure was repeated three times and the resulting samples were randomly selected for chlorophyll a analysis, ash-free dry weight determination, identification and enumeration.

Ash-free dry weight measurements were made by methods outlined in Standard Methods (APHA, 1975). Chlorophyll a procedures modified by sonification followed Standard Methods (APHA, 1975). Enumeration methods followed those of Jackson and Williams (1962).

Experimental Design

The study was conducted as a three factor split plot design experiment with nine observations per treatment unit (substrate/location/colonization period). The treatments under investigation were substrate type and location each at two levels and colonization period at four levels. The two levels of substrate type were artificial (glass) and natural (rock) substrates. The two levels of location were locations 1 and 2 at the Harvard Road sampling station (Figure 3). The four levels of colonization period were colonization period 1 through 4.

The study was conducted over a consecutive 16 week period from July to November, 1980. Artificial and natural substrates at both locations were exposed for four equally long colonization periods. Each colonization period was 4 weeks in length based on the recommendations of Collins and Weber (1978). Optimum length of substrate exposure depends upon the trophic state and velocity of the river being sampled and the type of algae (diatoms only vs. all types) being studied (Collins & Weber, 1978).

Sampling devices were retrieved upon completion of each colonization period. The attached organisms were removed from both substrate types in the field. Nine periphyton samples were removed from each substrate type (at both locations) upon completion of each colonization period. Each of

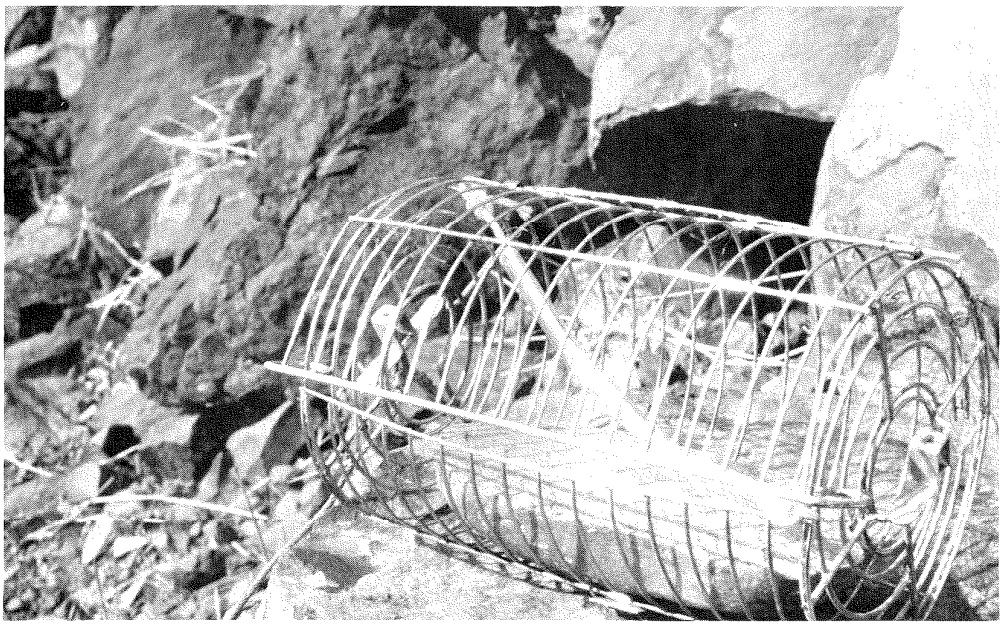

Figure 4. Glass Tube Substrate (enclosed in barbeque basket).

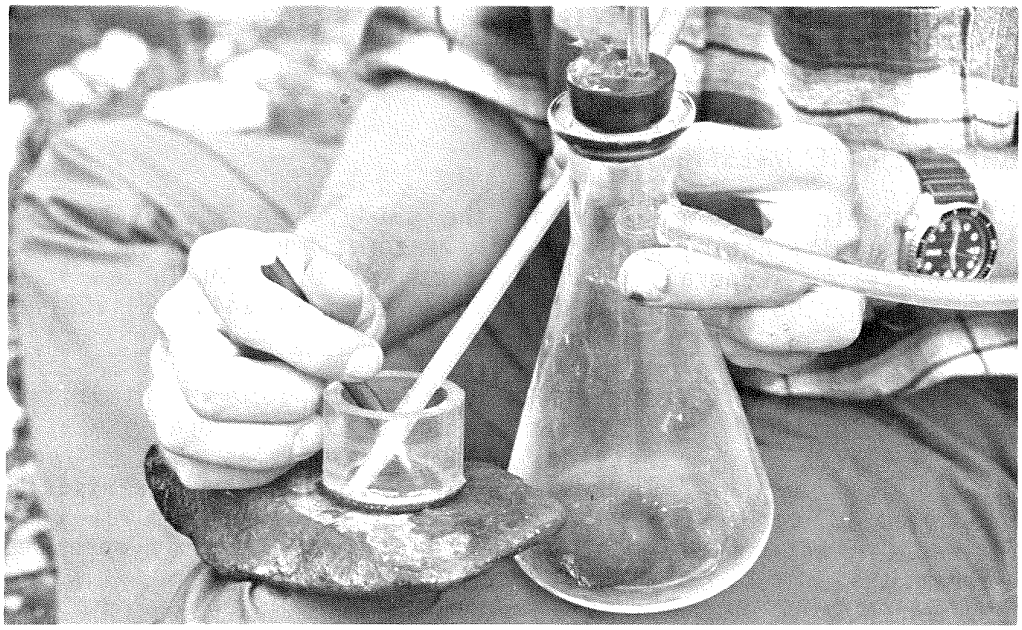

Figure 5. Aspirating device to remove periphyton from rock substance.

the nine samples was randomly assigned to one of three methods of measuring biomass (described later) for each substrate/location treatment combination. Three samples were assigned per biomass method.

Three methods of measuring standing crop (biomass) were ash-free dry weight, chlorophyll a, and direct enumeration. Community structure on both substrate types was characterized by percentage of organic content, calculation of a nondiatom/diatom ratio, and identification of the predominant genera of algae. Percentage of organic content was used as an indicator of community structure, because periphytic communities dominated by diatoms have been shown to have a lower percentage of organic contents than communities dominated by other types of algae (McIntire, 1975). The experimental design is shown in Figure 6.

Statistical Analysis

An analysis of variance for a three factor split plot experimental design was utilized to analyze standing crop and community structure data. Separate analysis of variance was performed for each of the standing crop and community structure parameters. All data were logarithmically (lnx) transformed prior to application of the analysis of variance procedure.

Effects of substrate type, colonization period, and location on standing crop and community structure were tested for statistical significance. Differences in standing crop and community structure parameters were considered statistically significant for levels of P 0.10 and highly significant for levels of P 0.05. Three null hypotheses were tested in each analysis of variance. Each hypothesis corresponded to one treatment factor, i.e., substrate type, colonization period, or location. The null hypotheses of no difference in standing crop were tested on ash-free dry weights, chlorophyll a values, and total cell numbers. The null hypotheses of no difference in community structure were tested on percentage of organic contents and community structure ratios.

MACROINVERTEBRATE INVESTIGATION

This stretch of the river in the study area is relatively fast flowing, with alternating pool and riffle zones and a seasonally scoured bottom substrate. General characteristics are shown in Tables 1 and 2. Flow rates reported upstream at Post Falls Dam, RK 164, (RM 102) ranged from 620 to 1880 cfs during the study period.

Three stations were chosen at RK 153, 148 and 135 (RM 95, 92, and 85) (Figure 7). Station 1 (RK 153) was located in a pool zone with a maximum depth of 4 meters during the study period. Velocities of 8 cm^3/sec were measured 6 cm above the river bottom using a pygmy meter. The river bottom was composed of cobblestones (7 to 15 cm dia.), with gravel and sand intermixed. A noticable amount of periphyton and detritus were seen at mid-stream.

The maximum depth decreased to 2.5 m during the study at Station 2, RK 148. Increased velocities of 19 cm^3/sec at mid-stream created an erosional environment, such that only slight periphyton growth accumulated on the 3

COLONIZATION PERIOD (1-4)																																									
LOCATION 1																																									
NATURAL SUBSTRATE										ARTIFICIAL SUBSTRATE									LOCATION 2																					
																			NATURAL SUBSTRATE									ARTIFICIAL SUBSTRATE												
s_1	s_2	s_3	s_1	s_2	s_3	s_1	s_2	s_3	s_1	s_2	s_3	s_1	s_2	s_3	s_1	s_2	s_3	s_1	s_2	s_3	s_1	s_2	s_3	s_1	s_2	s_3	s_1	s_2	s_3	s_1	s_2	s_3	s_1	s_2	s_3	s_1	s_2	s_3	s_1	s_2	s_3
Ash-Free Dry Weight			Chloro-phyll a			Total Count			Ash-Free Dry Weight			Chloro-phyll a			Total Count			Ash-Free Dry Weight			Chloro-phyll a			Total Count			Ash-Free Dry Weight			Chloro-phyll a			Total Count					
% Organic Content						Comm. Struct. Ratio			% Organic Content						Comm. Struct. Ratio			% Organic Content						Comm. Struct. Ratio			% Organic Content						Comm. Struct. Ratio					

Figure 6. Experimental Design.

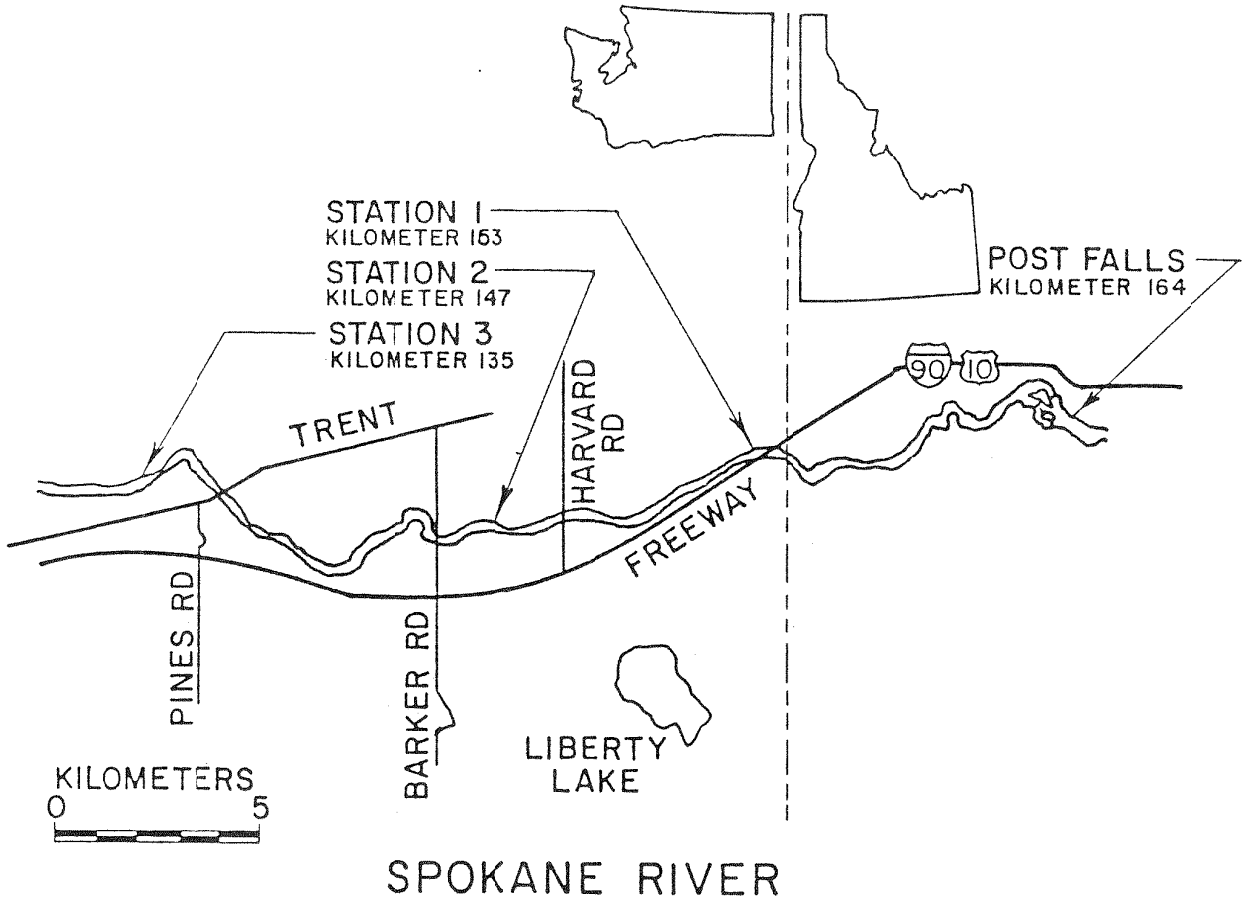

Figure 7. Upper Spokane River showing macroinvertebrate sampling stations.

to 10 cm diameter cobblestone bottom. Closer to shore, velocities decreased to 6 cm^3/sec, allowing detritus deposition and heavier periphyton growth on rocks ranging from 15 to 80 cm in diameter.

Velocities increased to 29 cm^3/sec at Station 3, RK 135. Seven to 15 cm diameter rocks were well scoured with little periphyton growth at mid-stream. The maximum stream depth during the sampling period was 3 m. Velocities were 16 cm^3/sec close to shore. Bottom substrate near shore was composed of 15 to 50 cm diameter rocks lightly covered with periphyton.

A summary of the physical characteristics of each sampling site, including depth, current velocity, and substrate type is given in Table 2.

The basket sampler (Mason et al, 1967) used in this study, consisted of commercially available "Bar-B-Q" baskets filled with rocks obtained from the sampling site (Figure 8). Total colonizable area per basket was calculated by estimating the surface area of the rocks in each basket. Due to their eroded nature, the rocks used were elliposidal in shape, allowing estimation of surface area by measuring the major and minor axes. The mean surface area for basket samplers was 0.11 m^2 (s.d. = 0.005 m^2).

The multiple-plate sampler consists of 0.32 cm (1/8 in) thick tempered hardboard plates, cut into eight 7.6 cm (3 in) square plates (Figure 9). Holes were drilled through the centers of each, along with seven 0.32 cm (1/8 in) thick spacers, and place on a threaded rod. Plates were secured to the rod by two nuts. Total surface area was 0.093 m^2 (1 ft^2).

The suction sampler was based on a design by Gale and Thompson (1975) (Figure 10). The body of the sampler consists of a 18 cm (7.1 in) high metal band, 37 cm (14.5 in) in diameter and a 0.63 cm (1/4 in) thick plexiglass top. Two 34 cm (13.4 in) diameter brass screens, with 250 micron openings, were fastened to holes in the plexiglass top to allow refilling as water was pumped out. Opposing arm ports (14 cm dia., 5.5 in) were cut in the metal band for access into the sampler during operation. The collection system was found inadequate due to operational problems. Small rock and pebbles would often be sucked up into hose and pump, clogging both. These problems were alleviated by installing a new collection system prior to the bilge pump. The new collection system consisted of a series of four sieves arranged in decreasing mesh size. The sieves were constructed of 0.63 cm (0.25 in) plexiglass tubing (i.d. = 10 cm, 3.9 in), cut into 7 cm (2.8 in) lengths and nylon plankton netting with openings of 6380, 3190, 750 and 500 microns (Figure 11).

The basket, multiple-plate and suction samplers were tested at each mid-stream and near-shore location per station. Three replicates of each sampler were taken per location during each sampling period. All sampler placement and retrieval was performed by Scuba diver, ensuring uniformity in sampler placement, homogeneity of the underlying substrate and providing valuable field observations. Basket and multiple-plate samplers were set out in late July after spring flood waters subsided. A colonization period of one month was used throughout the study. The diver retrieved the artificial substrate samplers by approaching from downstream and enclosing each in a nylon bag, thus avoiding loss of dislodged organisms (Gale and Thompson; Rabeni and Gibbs, 1977).

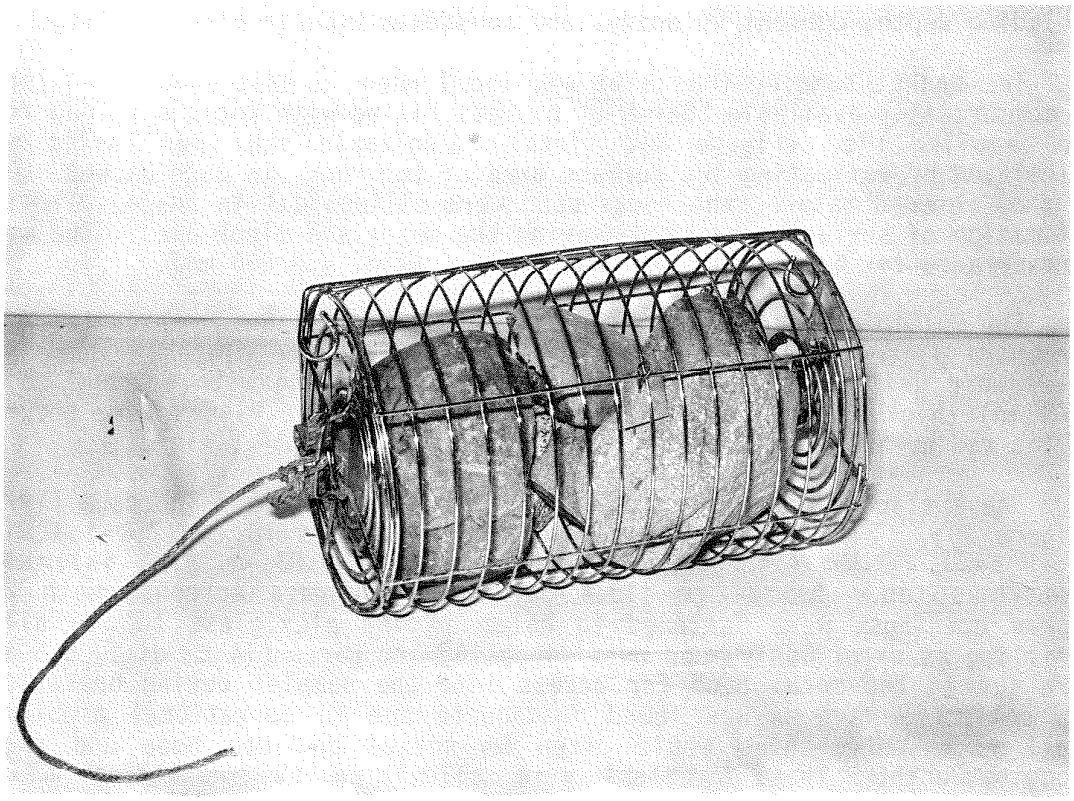

Figure 8. Basket sampler.

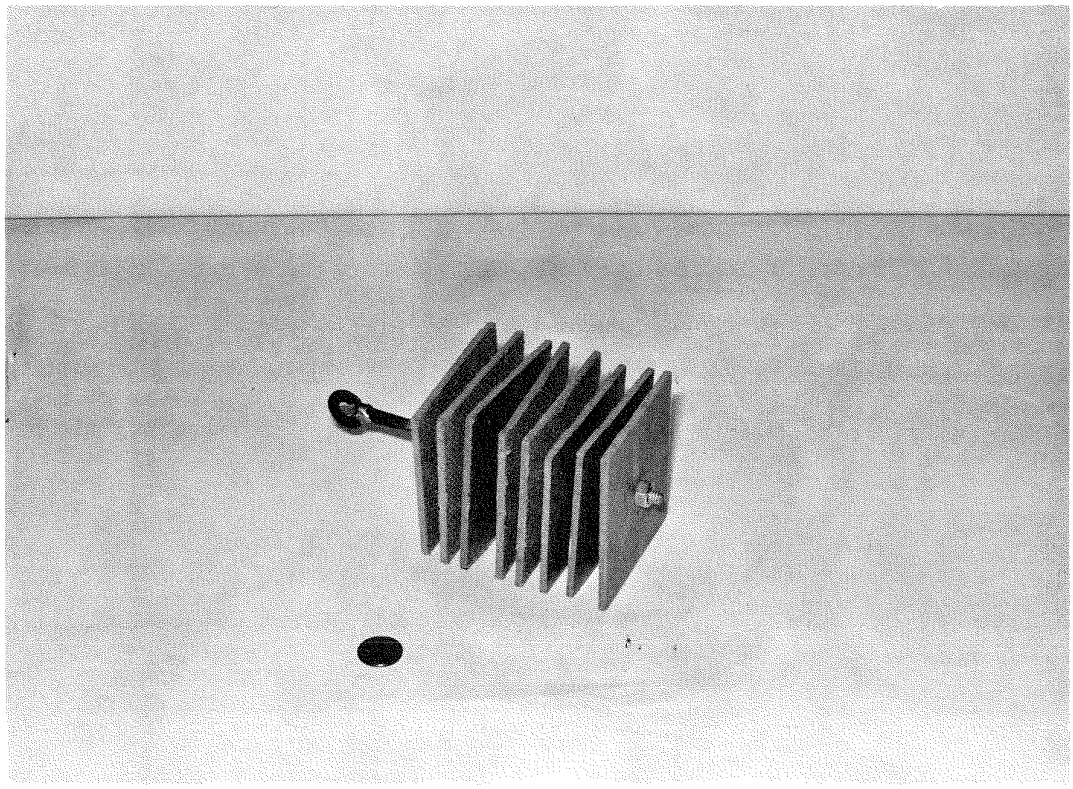

Figure 9. Multiple-plate sampler.

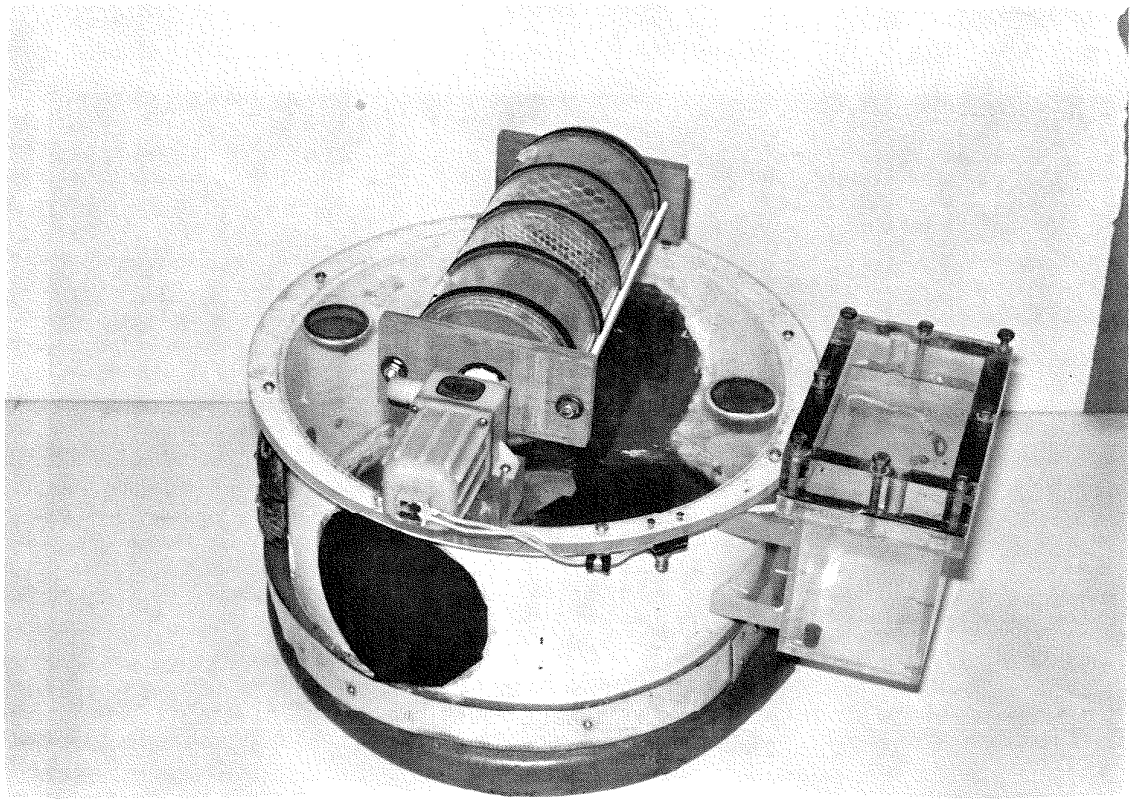

Figure 10. Suction sampler.

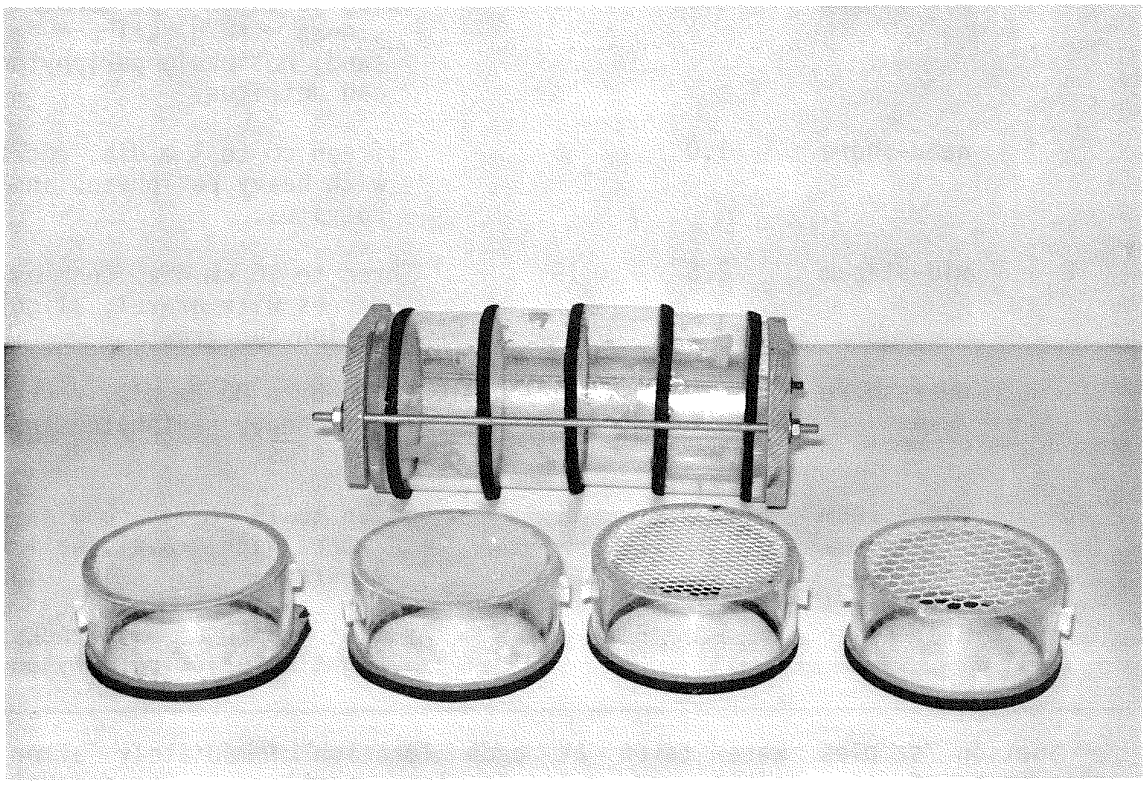

Figure 11. Collection unit for suction sampler.

Table 2. Descriptive summary of stations

Station	Location	Depth (m)	Velocity (cm/sec)	Substrate
1	mid-stream	4.0	8	Seven to 15 cm dia. cobblestones with gravel and sand; noticable periphyton and detritus.
	near-shore	1.0	6	Fifteen cm to 1 m dia. rocks with heavy periphyton and detritus.
2	mid-stream	2.5	19	Three to 10 cm dia. cobblestones with gravel; slight periphyton growth.
	near-shore	1.0	6	Fifteen to 80 cm dia. rocks with heavy periphyton and detritus.
3	mid-stream	3.0	29	Seven to 15 cm dia. cobblestones with gravel; well scoured.
	near-shore	1.0	16	Fifteen to 50 cm dia. rocks; light cover of periphyton.

Suction samples were taken at each location immediately after replacement of the basket and multiple-plate samplers. Operational procedures followed those outlined by Gale and Thompson (1974).

All samples were screened through a 0.59 mm mesh sieve in the field. Retained material was preserved in 90% ethanol and returned to the laboratory for identification and dry weight analysis. Organisms were identified to the generic level. Taxonomic keys used included Merrit and Cummins (1978), Usinger (1956), Wiggins, (1977), Edmunds et al. (1976) and Oliver et al. (1978).

Most sampler comparison studies have based their analysis on total number of organisms, relative abundance of major groups, and community indices (Dickson et al., 1971; Benfield et al., 1974; Crossman and Cairns, 1974). Shannon-Weaver diversity indices (d), calculated by Gibbons et al. (1982) on the Spokane River benthic populations ranged from 0.0 to 2.8, with a mean of 1.5. These low values were primarily due to the low number of species present, coupled with high numbers of chironomids. For this reason it was felt that diversity indices would be sensitive to sampler bias towards chironomids only, and not other less abundant, but equally important, species.

Analysis, therefore, was conducted on total number of organisms, individual organisms with abundance consistently greater than 5% of the total population, and any others that showed indications of sampler or location preference. Due to the inability to identify immature hydropsychids below the family level, and the consistent reaction of species within this family to both sampler type and location, Cheumatopsyche spp., Hydropsyche spp. and immature hydropsychids were analyzed together as the family Hydropsychidae. Other organisms analyzed were Baetis sp., Ceraclea sp., Cricotopus spp. and Microtendipes pendellus.

Three methods were used to analyze the organisms or groups of organisms listed above. Mean, standard deviation and range of number of organisms collected from replicate samples were compared. For further investigation of sampler preference, analysis of variance using a randomized complete block design, followed by Duncan's multiple range test was performed on each organism per station and location. In the block design, each date was used as the replication term, with date-sampler interaction as the error term (Federer, 1955). Initially, location effect on sampler performance was tested using analysis of variance on a randomized complete block, with date as the replication term and date-location interaction as the error term. Problems arose in that only one degree of freedom was available for location effect and two for the error term. Many near-shore basket and multiple-plate samplers were not retrieved for analysis due to loss as the result of vandalism. Any missing data in the block design would reduce the error term's degrees of freedom to zero or one, nullifying the test or making it extremely weak. As an alternative, a more conservative pooled "t" test was used. By doing this, variations between dates were combined into the location term, apparently abating its effect, but increasing the degrees of freedom.

All statistical tests were performed by the Statistical Analysis System (1979). The level of significance was set at 0.05. Values were logarithmically transformed due to the macroinvertebrate population's contagious distribution.

RESULTS

PHYSICOCHEMICAL CONDITIONS

Thirty-one physicochemical parameters were monitored at the ten stations previously described. Sampling was carried out bi-weekly throughout the more biologically active (growth) period from June to September and monthly during the late fall, winter and early spring, or mostly biologically quiescent period.

Several considerations were made in regard to the sampling regimes. Of prime consideration was the establishment of water quality conditions at two stations above the proposed outfall, one at the outfall and four below. For the baseline study, this essentially allowed four stations representative of presently stabilized conditions at Stateline; Harvard I, above proposed outfall; Harvard II, at the outfall; and Barker, below the outfall. The next three stations, Sullivan, Euclid and Plantes Ferry, were in the recharge area of the Spokane aquifer. The Upriver station was downstream of the domestic sewage of the community of Millwood and some industrial effluent. Greene Street, Gonzaga and Hangman stations received some light industrial input and localized runoff from the City of Spokane. The following narrative describes certain perturbations with brief causal explanation included. Data from stations representative of the areas described are presented in a series of graphs (Figures 12 to 23). Extensive biweekly sampling data are available from computer file at Environmental Engineering, Washington State University. These data provide baseline information from which present and future comparisons can be made as development along the river proceeds.

Temperature

The temperature of the waters in the Spokane River ranged from 2.0 to 23.5°C during the study (Appendix A, Table A-1). The Spokane Aquifer has a considerable impact on the temperature of the river. Where the aquifer waters recharge the river, there is a dramatic decrease in temperature during the summer months. The change can be seen by comparing the mean temperatures for May through September at Sullivan with the means from Euclid. Mean temperatures at Sullivan were 16.6°C and in 1981, and 16.8°C in 1980, while the mean temperature at Euclid was 15.3°C for both years. There was as much as a 3°C difference between the maximum temperature attained during the summer above the aquifer recharge in comparison to those below. The upper portions of the river reached a high temperature of 23.5°C, since its waters are directly derived from surface waters of Coeur d'Alene Lake. The highest temperature recorded at Euclid was 19.5°C.

pH

The pH in the Upper Spokane River ranged from a low of 5.4 to a high of 8.5 (Appendix A, Table A-1). The highest pH values occurred during the summer, and corresponded to the peak photosynthetic activity within the river. The pH along the ten river stations occasionally varied as much as

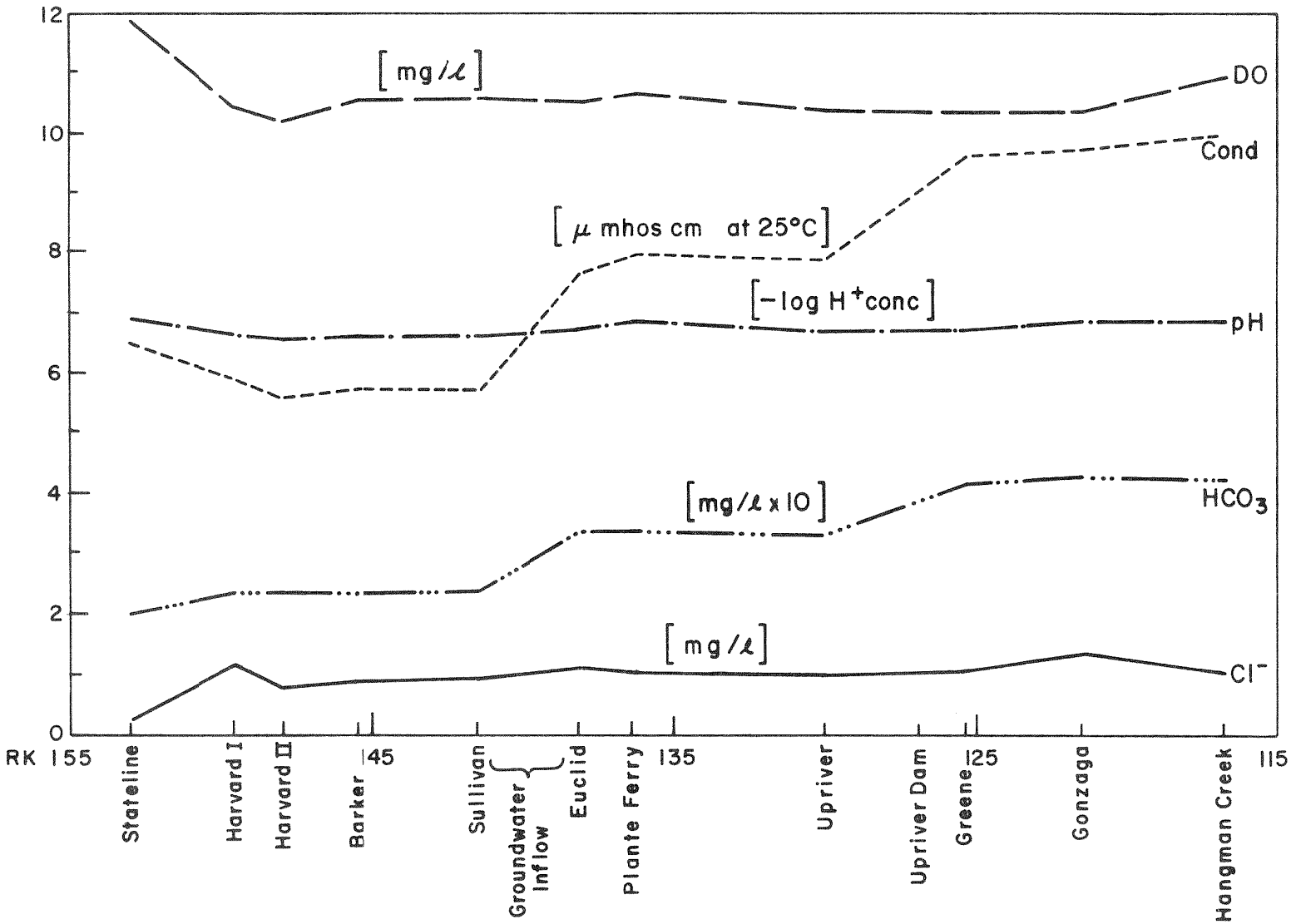

FIGURE 12. PHYSICOCHEMICAL MEASUREMENT MEANS BY RIVER KILOMETER. NOVEMBER 1979 TO OCTOBER 1981. (Sample number at each station ≈ 38)

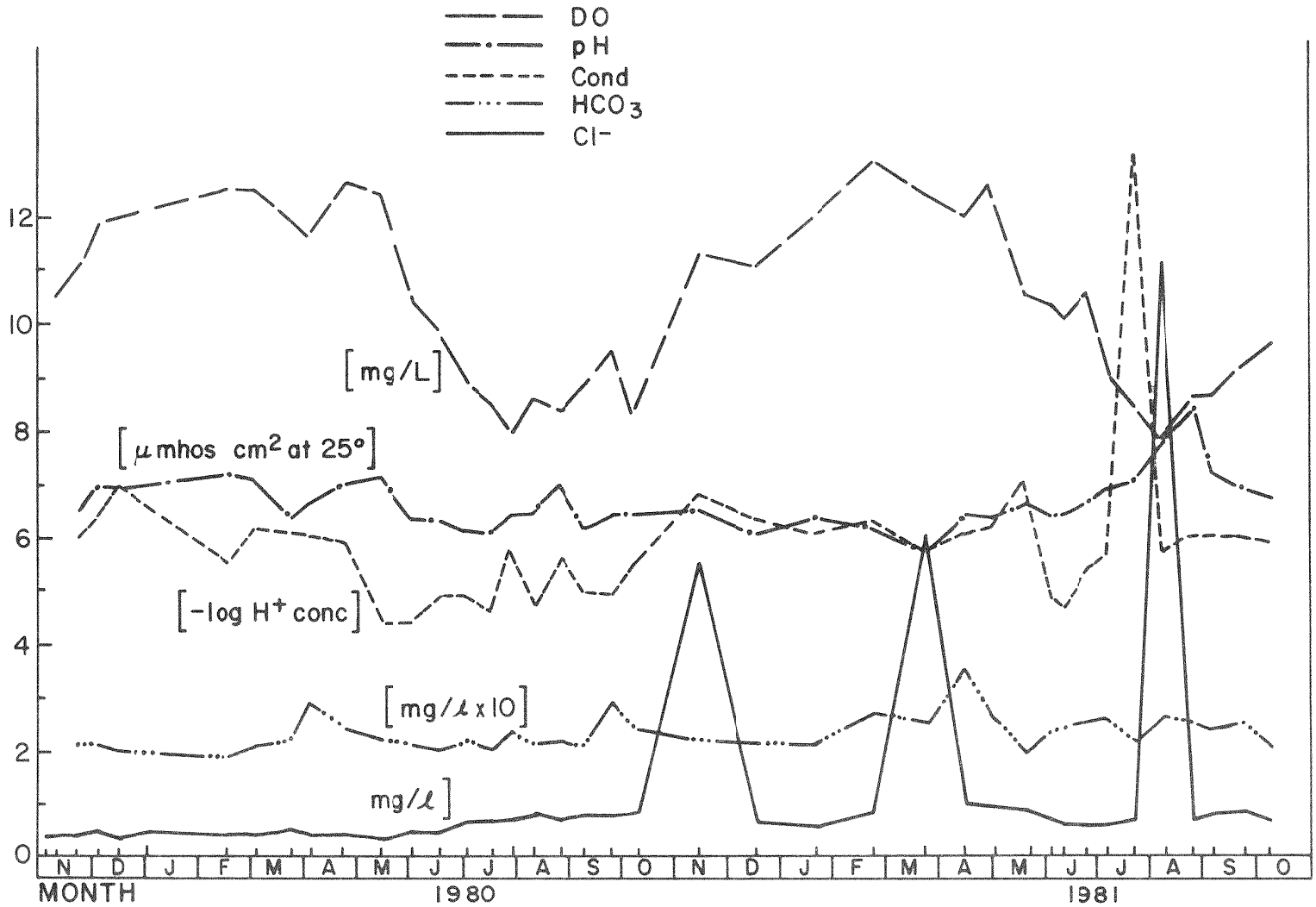

FIGURE 13. PHYSICOCHEMICAL MEASUREMENTS BY DATE AT HARVARD I

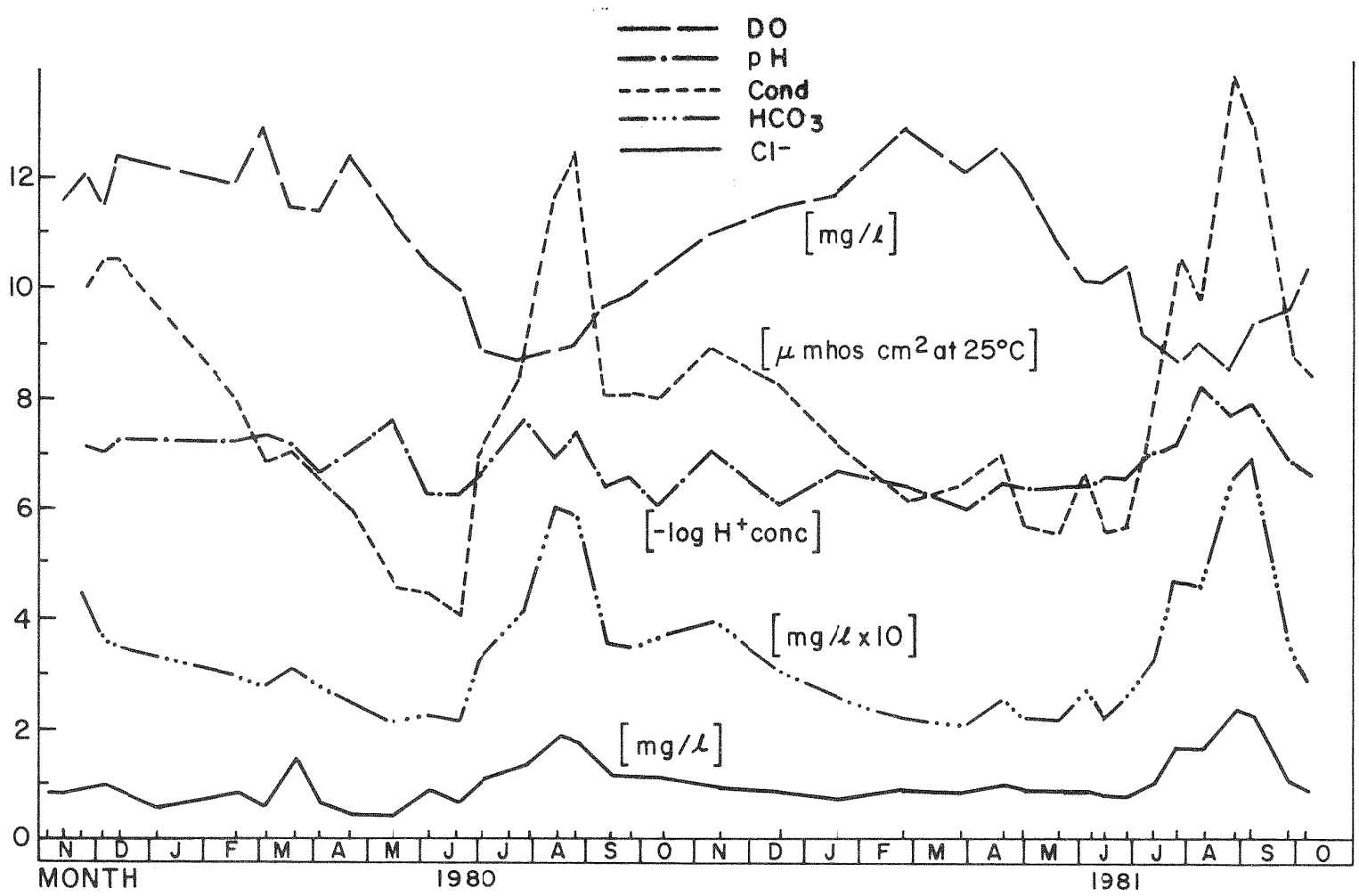

FIGURE 14. PHYSICOCHEMICAL MEASUREMENTS BY DATE AT PLANTES FERRY

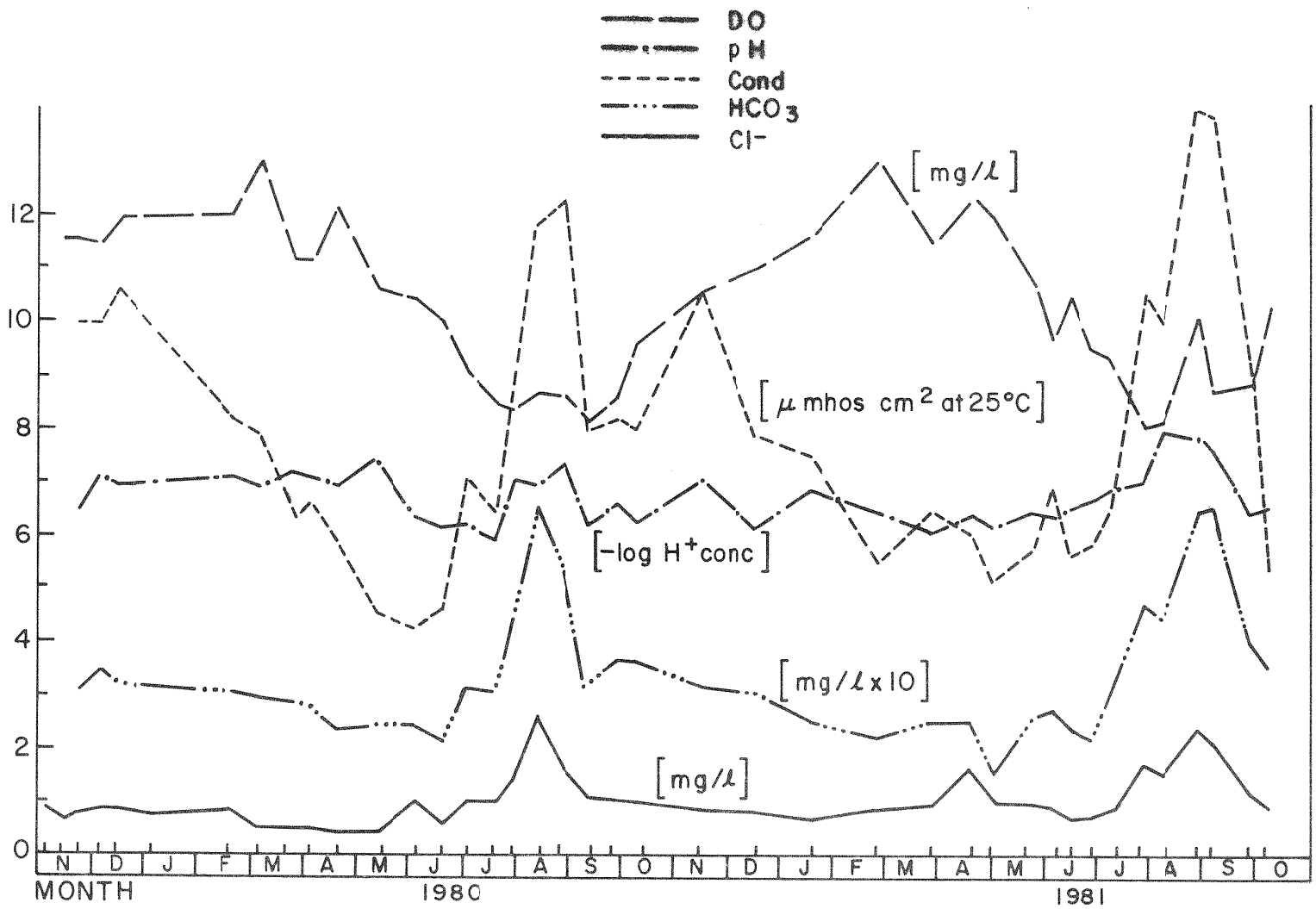

FIGURE 15. PHYSICOCHEMICAL MEASUREMENTS BY DATE AT UPRIVER

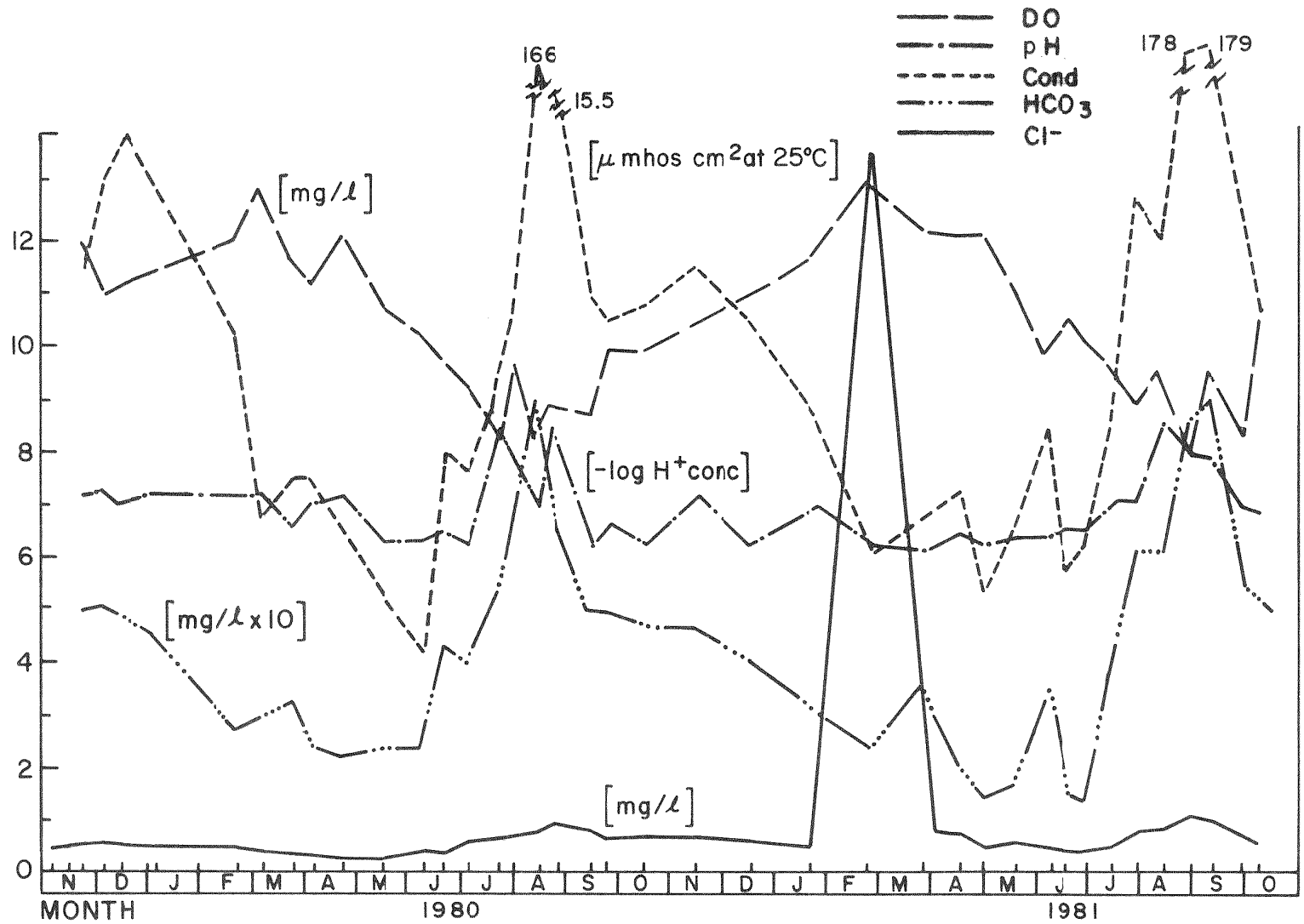

FIGURE 16. PHYSICOCHEMICAL MEASUREMENTS BY DATE AT GONZAGA

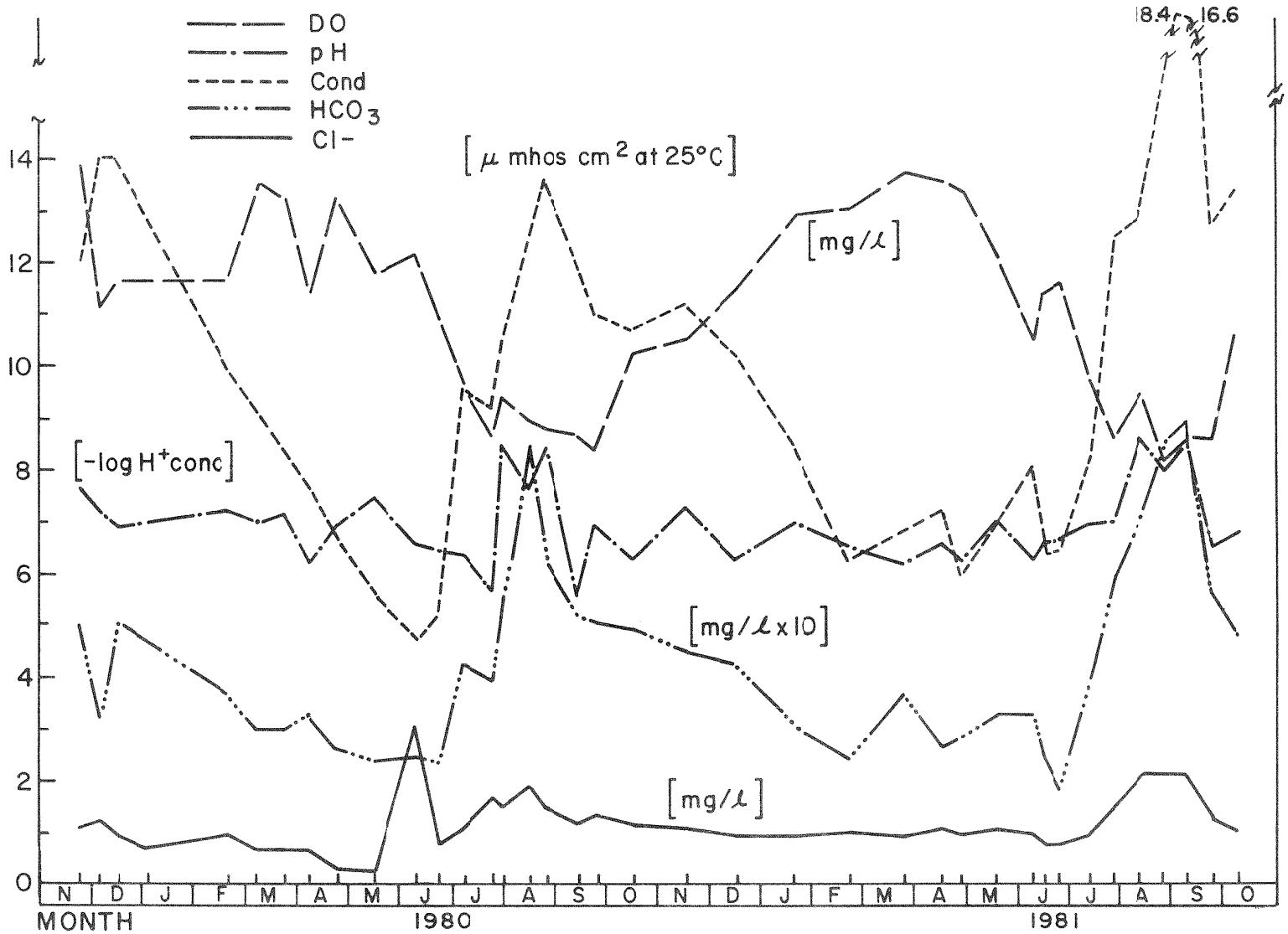

FIGURE 17. PHYSICOCHEMICAL MEASUREMENTS BY DATE AT HANGMAN CREEK

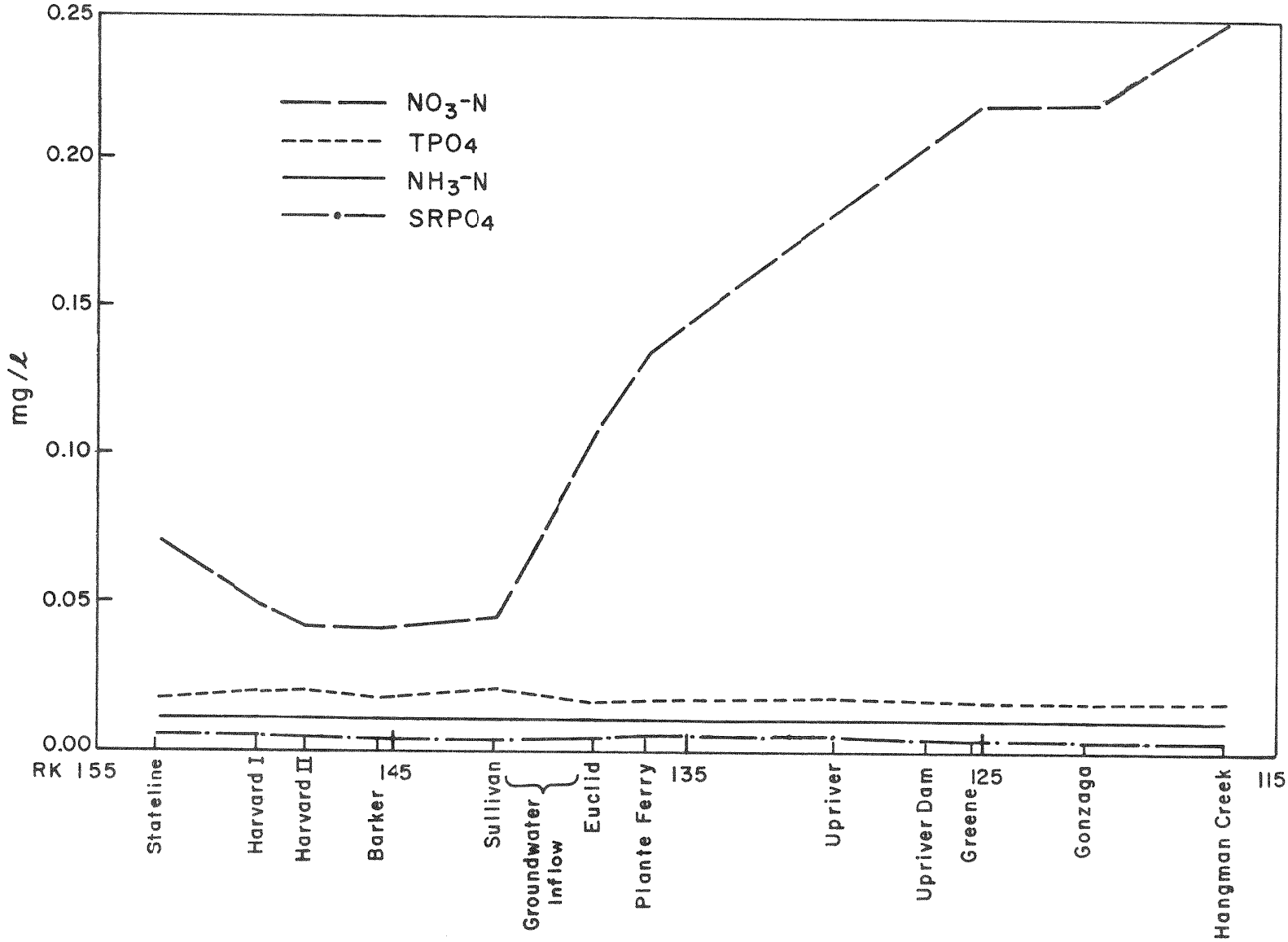

FIGURE 18. MEAN CONCENTRATION OF NUTRIENTS BY RIVER KILOMETER.

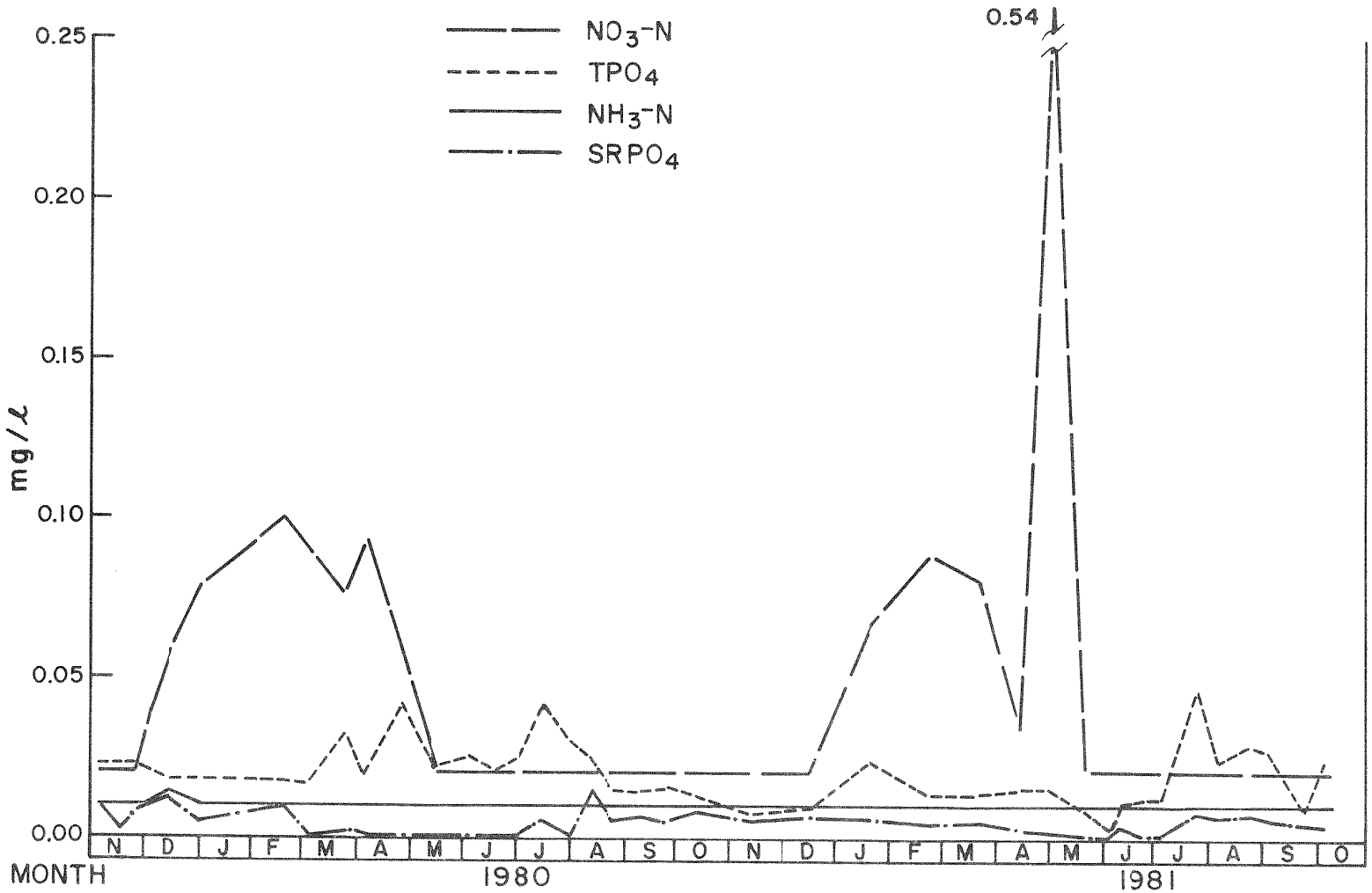

FIGURE 19. CONCENTRATION OF NUTRIENTS BY DATE AT HARVARD I .

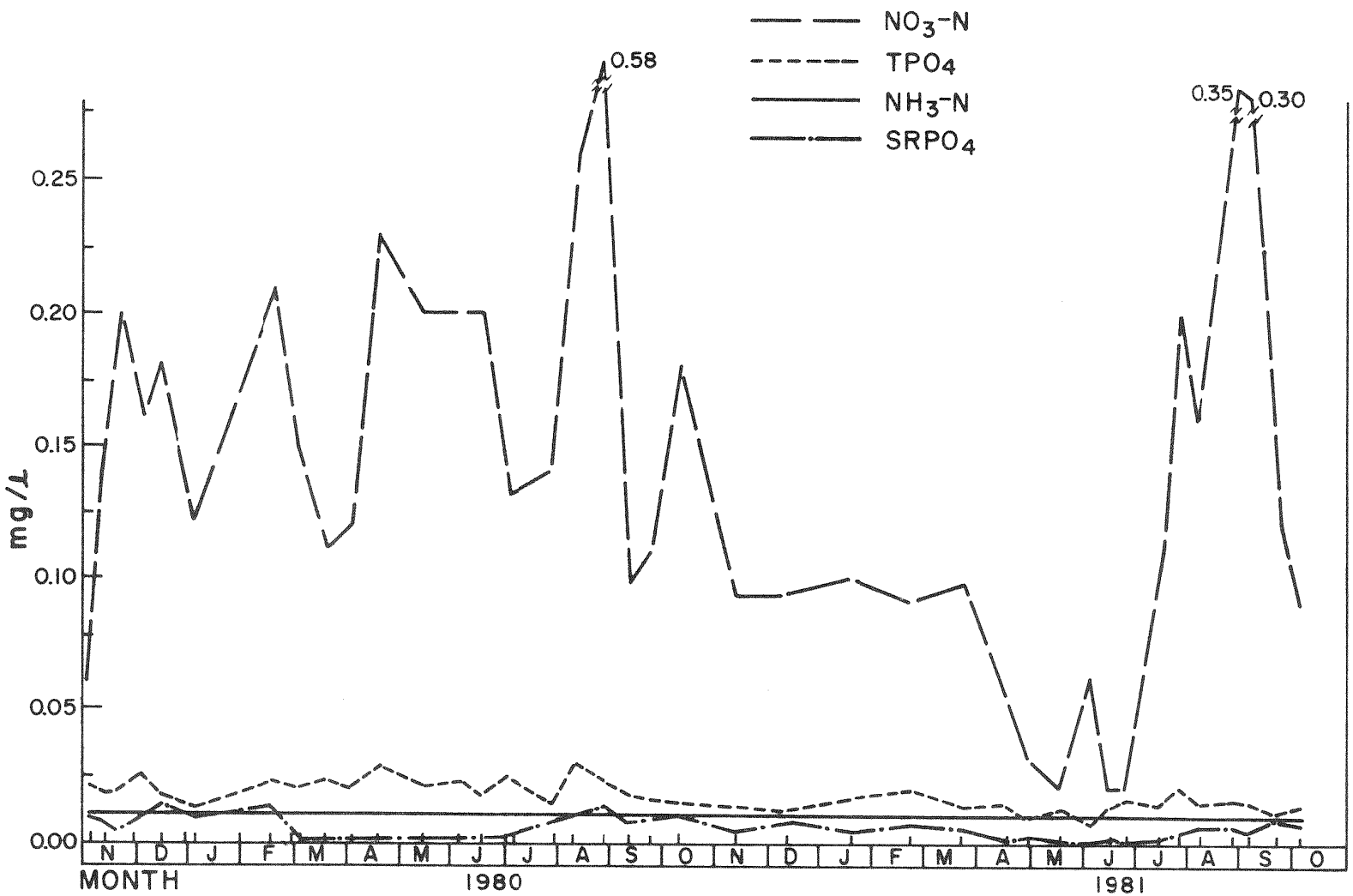

FIGURE 20. NUTRIENT CONCENTRATION BY DATE AT PLANTES FERRY

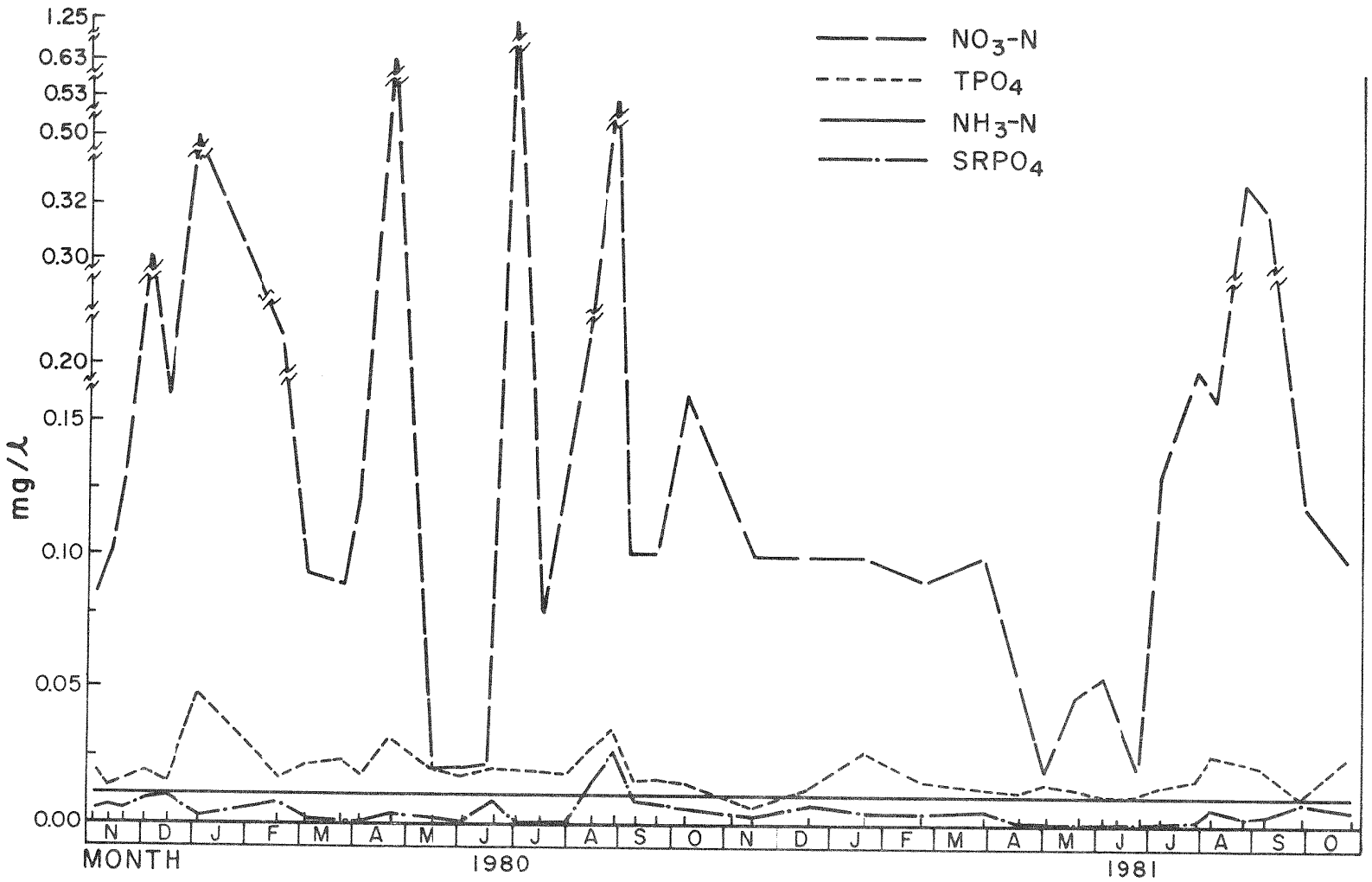

FIGURE 21. NUTRIENT CONCENTRATION BY DATE AT UPRIVER

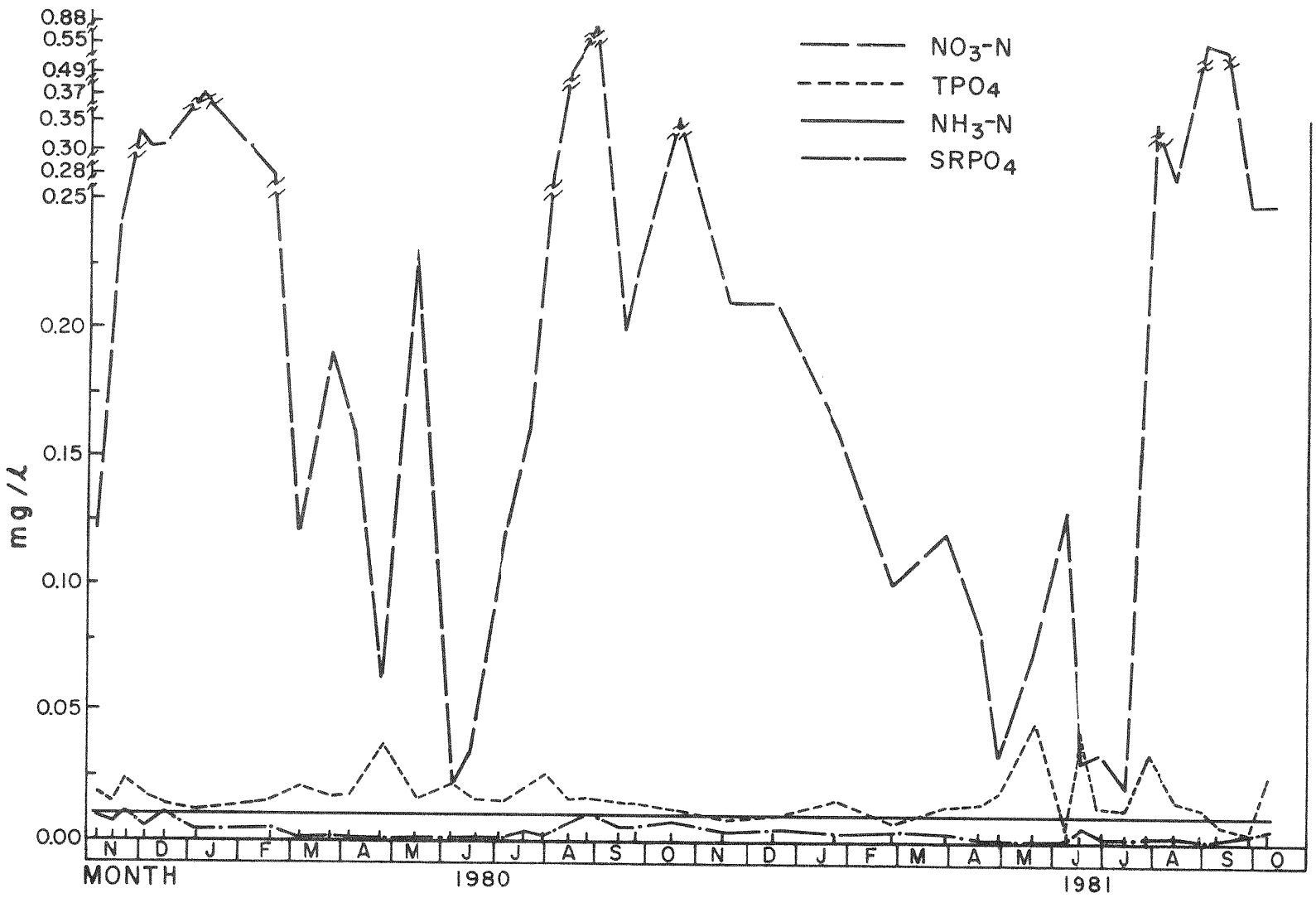

FIGURE 22. NUTRIENT CONCENTRATION BY DATE AT GONZAGA

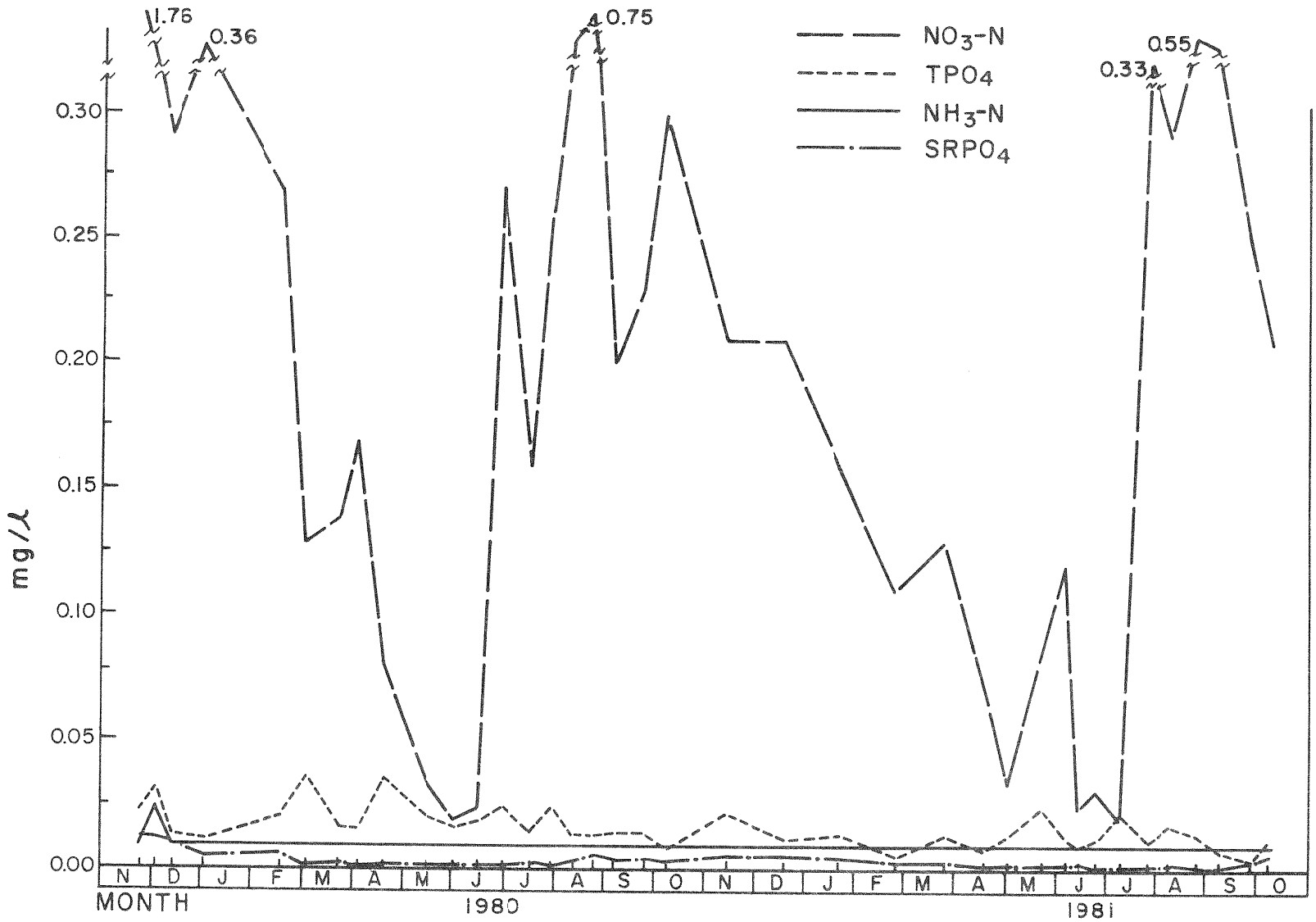

FIGURE 23. NUTRIENT CONCENTRATION BY DATE AT HANGMAN CREEK

1.4 units on the same day. The pH of the Spokane River is relatively low, usually between 6.0 and 7.5, largely due to the acidic nature of its headwaters, low alkalinity buffering capacity and the addition of industrial wastes (Funk, Rabe, Filby et al., 1975).

Dissolved Oxygen

Dissolved oxygen (DO) ranged from 7.5 to 13.9 mg/ℓ in the Upper Spokane River (Appendix A, Table A-1). Low DO occurred in the summer months. Although 7.5 mg/ℓ of DO is high enough to support aquatic organisms, the DO should be prevented from dropping below that level. The high DO occurred during spring runoff and corresponded to high flows.

Carbonates, Bicarbonates and Carbon Dioxides

The concentration of inorganic carbon in the river is relatively low (16 to 90 mg/ℓ shown as $CaCO_3$), and, as previously mentioned, is characteristic of the water in the drainage area (Appendix A, Table A-1). The carbon dioxide concentration ranged from 0 to 3 mg/ℓ. Four times during the study, carbonates were present at two stations in late July and August of both 1980 and 1981. The appearance of carbonates was probably related to algal photosynthetic activity at Gonzaga and Hangman Creek. Alkalinity in the form of bicarbonates ranged from 15 to 89 mg/ℓ as $CaCO_3$. Under low flow conditions, the alkalinity of the river at Euclid and below is influenced by the Spokane Aquifer waters and is appreciably higher than upstream. The upstream stations above Euclid had bicarbonate concentrations in the 20s to low 30s mg/ℓ as $CaCO_3$ for most the year.

Conductivity

Conductivity increases rapidly after the intrusion of aquifer water below Sullivan and continues to increase as domestic and industrial effluent are added. Conductivity rises from a mean value of ≅ 65 μmhos at Stateline to 95 μmhos at Gonzaga. The conductivity of the river, when not impacted by the entry of aquifer waters, was in the range of 40 to 70 $\mu mhos/cm^2$.

Biochemical and Chemical Oxygen Demand

The five-day biochemical oxygen demand (BOD_5) ranged from less than one to 4.8 mg/ℓ O_2 with the majority of the measurements ranging from <1 to 1.0 mg/ℓ O_2 (Appendix A, Table A-2). In this respect, the river has relatively good water quality, in agreement with the DO measurements.

The chemical oxygen (COD) demand was somewhat higher than the BOD_5 (Appendix A, Table A-2). Due to relatively low oxygen-consuming constituents in the upper river and the high flows (aeration and dilution) in the river, the impact on the DO of the Upper Spokane River is minimal. However, that may not be true of the impact of COD on DO in the Lower Spokane River where the effect is cumulative because of dams and quiescent waters.

Suspended Solids

The solids carried by the Upper Spokane River are not deposited on the river bed due to the high velocities during the spring. Some deposition

may occur during low flow periods but it is carried downstream during high flow periods. Our earlier studies (Funk, Rabe, Filby et al., 1975) confirmed that the river bottom, almost without exception, is well scoured to heavy shingle, boulders or basalt bedrock. However, the solids may play an important role in the bioavailability of certain metals, such as zinc, as the water moves downstream. This was demonstrated earlier by bioconcentrations of metals in algae and, to some extent, in macroinvertrates and fishes (Funk, Rabe, Filby et al., 1973, 1975). The data for total and volatile suspended solids are given in Appendix A, Table A-2.

Chlorides

The chloride concentration in the upper Spokane River was low except for a few isolated observations (Appendix A, Table A-2). During low flow, the Spokane Aquifer increased the chloride concentration in the river at and below Euclid. Although the concentration of chloride was doubled, it usually was below 2.0 mg/ℓ. Most of the time, the concentration of chloride was less than 1.0 mg/ℓ.

Several physicochemical indicators (DO, pH, Conductivity, HCO_3, Cl) are summarized by station in Figure 11. Representative stations are summarized by date in Figures 12-17.

Nitrogen and Phosphorus

Nutrient content of the river during the study is shown by station in Figure 18. Representative stations are summarized by date in Figures 19-23.

Phosphorus is considered to be the most limiting of the two prime nutrients (nitrogen and phosphorus) in the Upper Spokane River. That statement can be made with confidence because the N:P ratio is rarely less than 10:1 (Appendix A, Table A-2). In fact, most of the time the N:P ratio is much greater than 10:1. This is due to the relatively high concentration of nitrate-nitrogen present in the river. The Spokane Aquifer is probably a major contributor of nitrate-nitrogen to the river, especially at and below Euclid during summer and fall.

Phosphorus is mainly in the organic form or absorbed to particles while a high percentage of nitrogen is in a readily available form (NO_3-N) and can move rapidly through soils and ground water. It is very important that the amount of phosphorus loading to the river be closely regulated. The impact of increased phosphorus additions in the upper Spokane River could have considerable effect on the primary production in the river. That impact would be particularly important in the reservoir area below the City of Spokane. The term "increased phosphorus" is considered to be relative since 0.01 mg/ℓ soluble phosphorus is recognized by many authorities to be enough to produce algal bloom conditions under quiescent conditions (Sawyer, 1947; MacKenthun, 1969). MacKenthun (1969) also has stated that 1 lb (0.45 kg) of phosphorus theoretically can produce 1000 lb (454 kg) of algae. The level of phosphorus in the river approaches the amount necessary for bloom conditions. Large populations of diatoms are supported throughout the year (especially Asterionella formosa)

and on occasion the nuisance algae (blue-greens) achieve bloom proportions in the summer period especially at the lower river stations Plantes Ferry to Hangman Creek.

Metals

During the study, the concentrations of copper, nickel, cadmium, lead and mercury in the upper Spokane River were relatively low at the ten stations sampled (Appendix A, Table A-3). Copper concentrations ranged from less than 1 to 8.0 μg/ℓ. Nickel concentrations were slightly higher varying from less than 5 to 22 μg/ℓ. Cadmium concentrations ranged from less than 1 to 7 μg/ℓ, and lead ranged from less than 1 to 8 μg/ℓ. Mercury concentrations were most often less than 5 μg/ℓ although the mercury concentration at one station did reach 70 μg/ℓ on one occasion. During the study, copper, cadmium, and lead concentrations were less than 1 μg/ℓ most of the time, whereas nickel concentration was less than 5 μg/ℓ most of the time.

Unlike other metals measured, the level of zinc in the Upper Spokane River was high (Appendix A, Table A-3). The zinc concentrations ranged from 5 to 225 μg/ℓ during the study. It is significant that most of the total zinc concentrations were in a filterable fraction (zinc that passes through a 0.45 μm pore filter membrane). The zinc concentrations in the river were highest during January through June, corresponding to the higher flows of that time of year (Figure 2). As the flows decreased (July through November), the zinc was two to three times less than during the early winter months of 1980 and 1981. As the flow in the river increased in December of 1979 and 1980, the zinc concentrations also increased. Hence, there is a correlation between flow and zinc concentrations in the river.

BIOLOGICAL INDICATORS OF WATER QUALITY

Fecal Coliforms

Initially fecal coliforms were enumerated on m-FC agar (Difco) according to Standard Methods (APHA, 1975). Because of the presence of stressed organisms, presumably due to high zinc concentrations in the river, the MPN Method was employed to increase recovery. The MPN method allowed attenuated organisms to survive, thus consistently having a higher percentage recovery than the MF Method.

The range of fecal coliforms in the upper Spokane River during the study varied from less than 1 to approximately 840 bacteria per 100 ml. The summary of the fecal coliform data are presented in Appendix B, Table B-1. The main trend that was observed is that the downstream stations had significantly higher counts than those in the upper river. Often in the summer of 1980 and 1981, the fecal coliform density exceeded Class A standards for the river, especially at Greene Street, Gonzaga, and Hangman Creek stations. The sources of fecal coliforms were not identified in this study. However, as the river traverses more densely inhabited areas, the fecal coliform load carried by the river increased. According to

Washington State standards the river can be classified as follows: from Stateline to Gonzaga, the Spokane River qualifies as Class A (excellent). From Stateline to Barker the water meets Class AA (extraordinary) except during the months of August and September when the dissolved oxygen level drops below 9.5 mg/ℓ (fecal coliform concentrations meet Class AA standards). The Spokane River at Hangman Creek fails to meet Class A standards because of fecal coliform levels and is classified as Class B (good).

RESULTS

PERIPHYTON INVESTIGATIONS

Standing crop and community structure raw data are presented in Appendix C, Tables C-1 to C-5. Complete analysis of variance results are presented in Tables C-6 to C-10. A summary of analysis of variance results for all standing crop and community structure parameters is presented in Table 3.

Standing Crop

Ash-free dry (organic) weight values for artificial and natural substrates are presented by colonization period and location in Figures 24 and 25 respectively. A highly significant difference between substrates was found. Mean ash-free dry weights on natural substrate were consistently greater than mean ash-free dry weights on artificial substrate. Organic weights differed significantly between colonization periods. Organic weights declined from colonization period one (CP1) to colonization period two (CP2), increased from CP2 to colonization period three (CP3), and remained relatively constant from CP3 to colonization period four (CP4). Ash-free dry weights at the two locations (L1 and L2) did not differ significantly.

Chlorophyll a values for artificial and natural substrates are shown in Figure 26 and 27 by colonization period and location respectively. A highly significant difference was found between colonization periods. A seasonal trend similar to that observed for ash-free dry weights was observed. No significant differences were found between substrate types or locations.

Total cell numbers of attached algae on artificial and natural substrates are presented by colonization period and location in Figures 28 and 29, respectively. Differences in total counts between the two types of substrate were not statistically significant. However, Figures 28 and 29 show differences between substrates in two colonization periods at location 2 (CP2, CP4). Total cell counts on artificial substrates were greater than counts on natural substrates in these cases. Cell numbers apparently followed a seasonal trend similar to trends observed for organic weights and chlorophyll a values, although differences between colonization periods were not statistically significant. Differences in total counts between locations were not statistically significant.

Linear correlation coefficients for standing crop parameters were calculated by the least squares method. Separate coefficients were calculated for artificial and natural substrates. Substrate values were paired by like locations and colonization periods. Correlation coefficients are summarized in Table 4. Natural substrate correlation coefficients were consistently greater than artificial substrate coefficients for like standing crop parameters.

Table 3. Summary of analysis of variance results

Parameter	Substrate	Colonization period	Location
Standing Crop			
Ash-free dry weight	*	**	ns†
Chlorophyll *a*	ns	*	ns
Total cell numbers	ns	ns	ns
Community Structure			
Percent organic content	*	*	ns
Community structure ratio	ns	**	**

* Significant at $P \leq 0.05$.
** Significant at $P \leq 0.10$.
† Not significant.

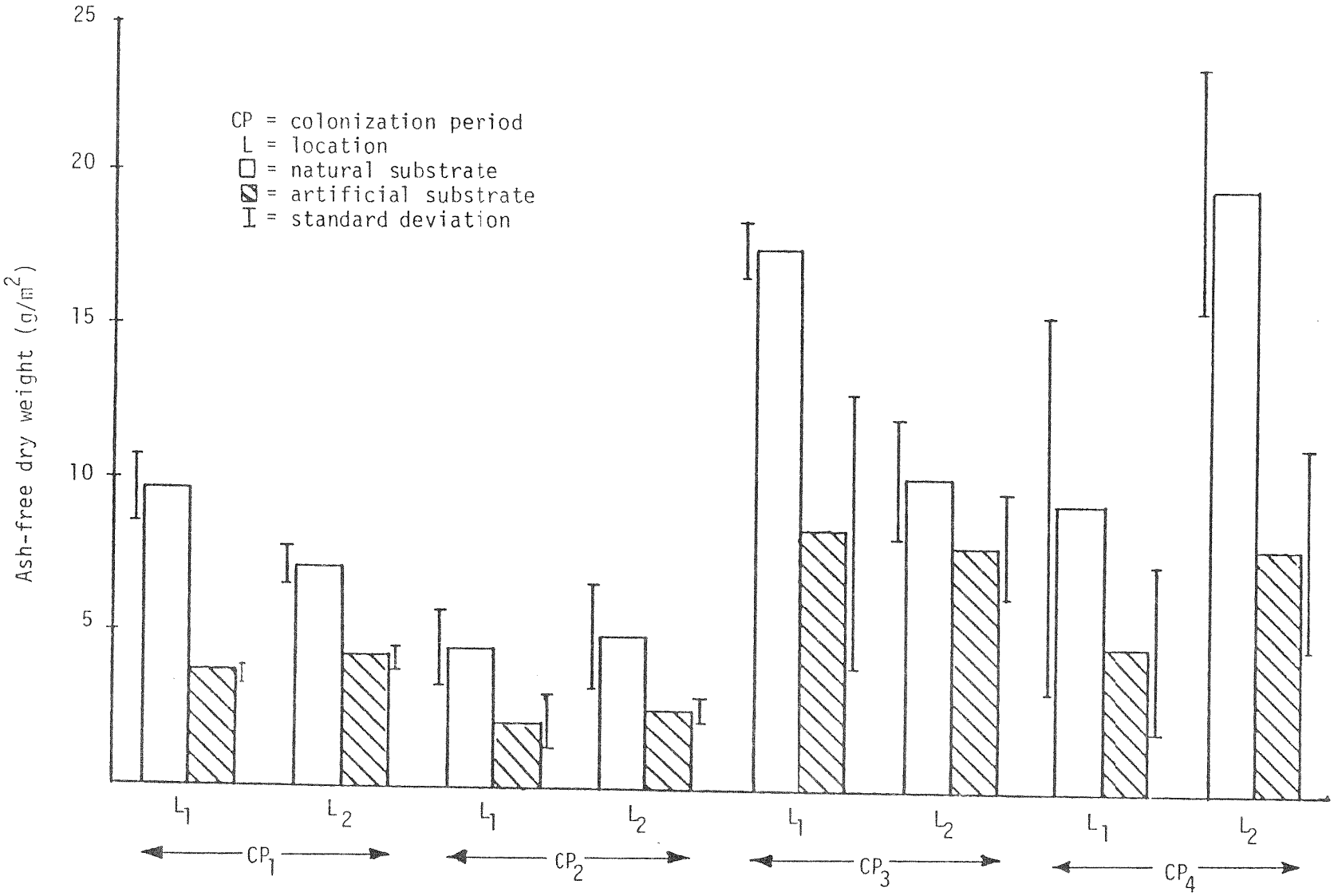

Figure 24. Standing crops of periphyton on artificial and natural substrates as ash-free dry weight by colonization period.

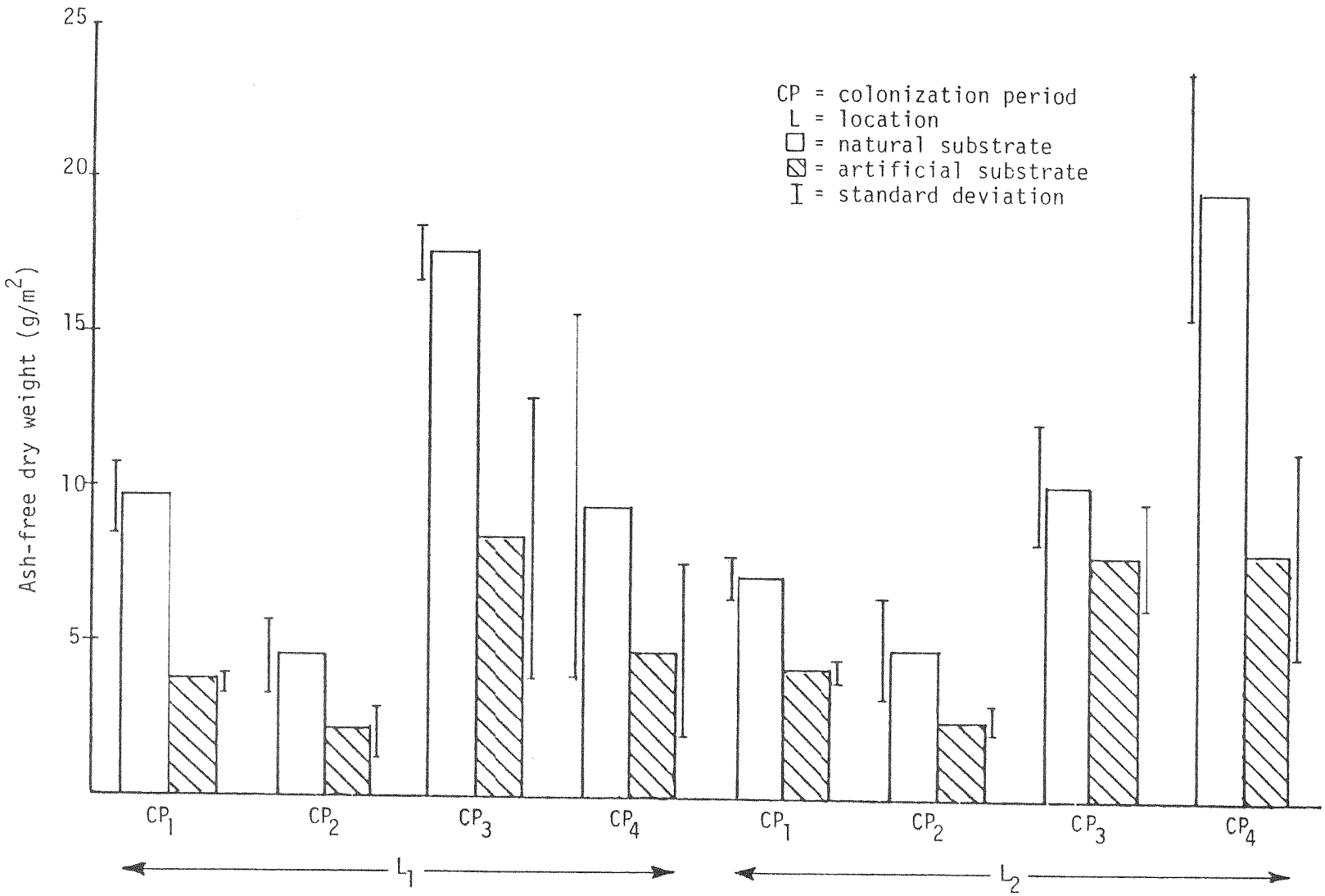

Figure 25. Standing crops of periphyton on artificial and natural substrates as ash-free dry weight by location.

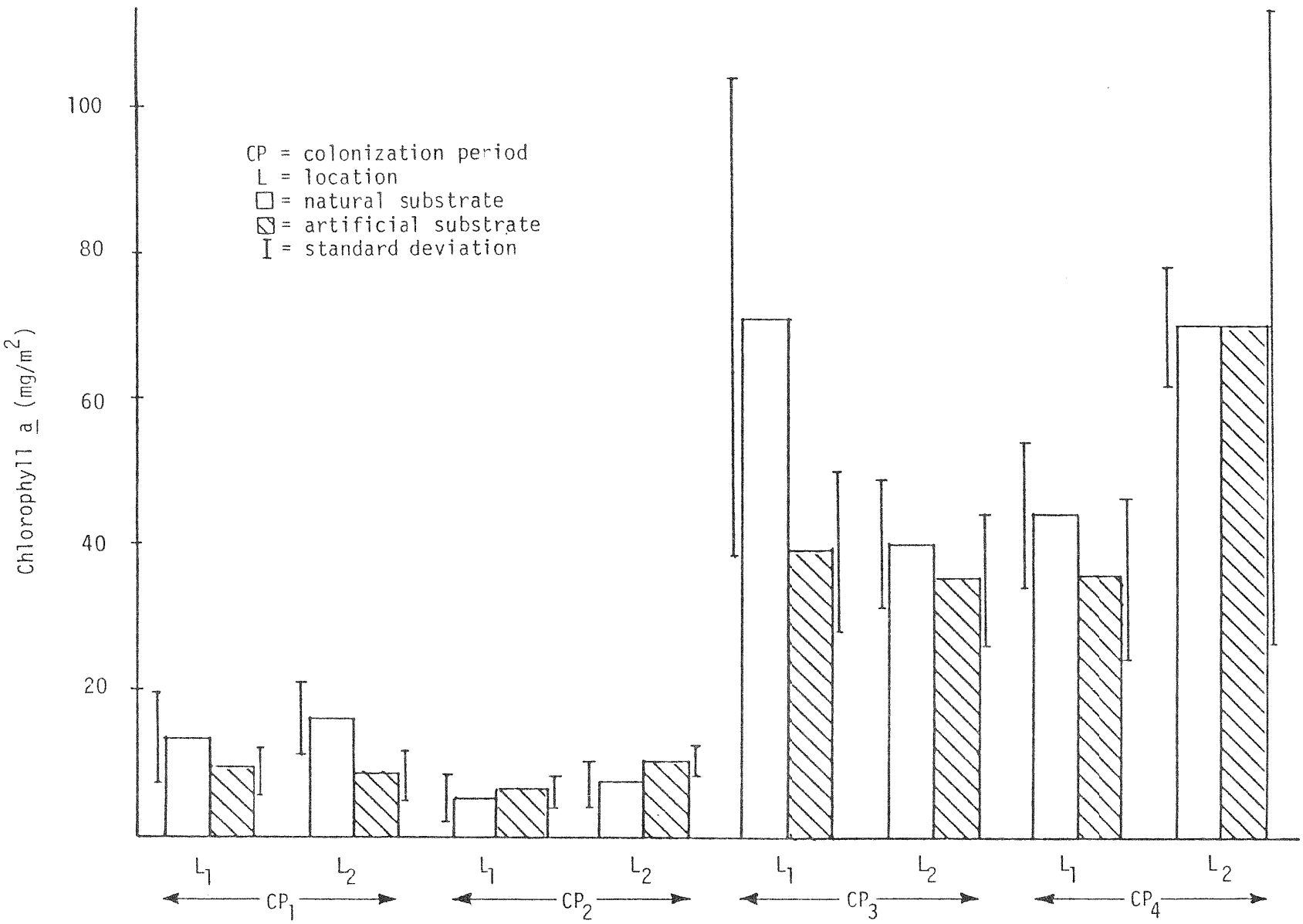

Figure 26. Standing crops of periphyton on artificial and natural substrates as chlorophyll a by colonization period.

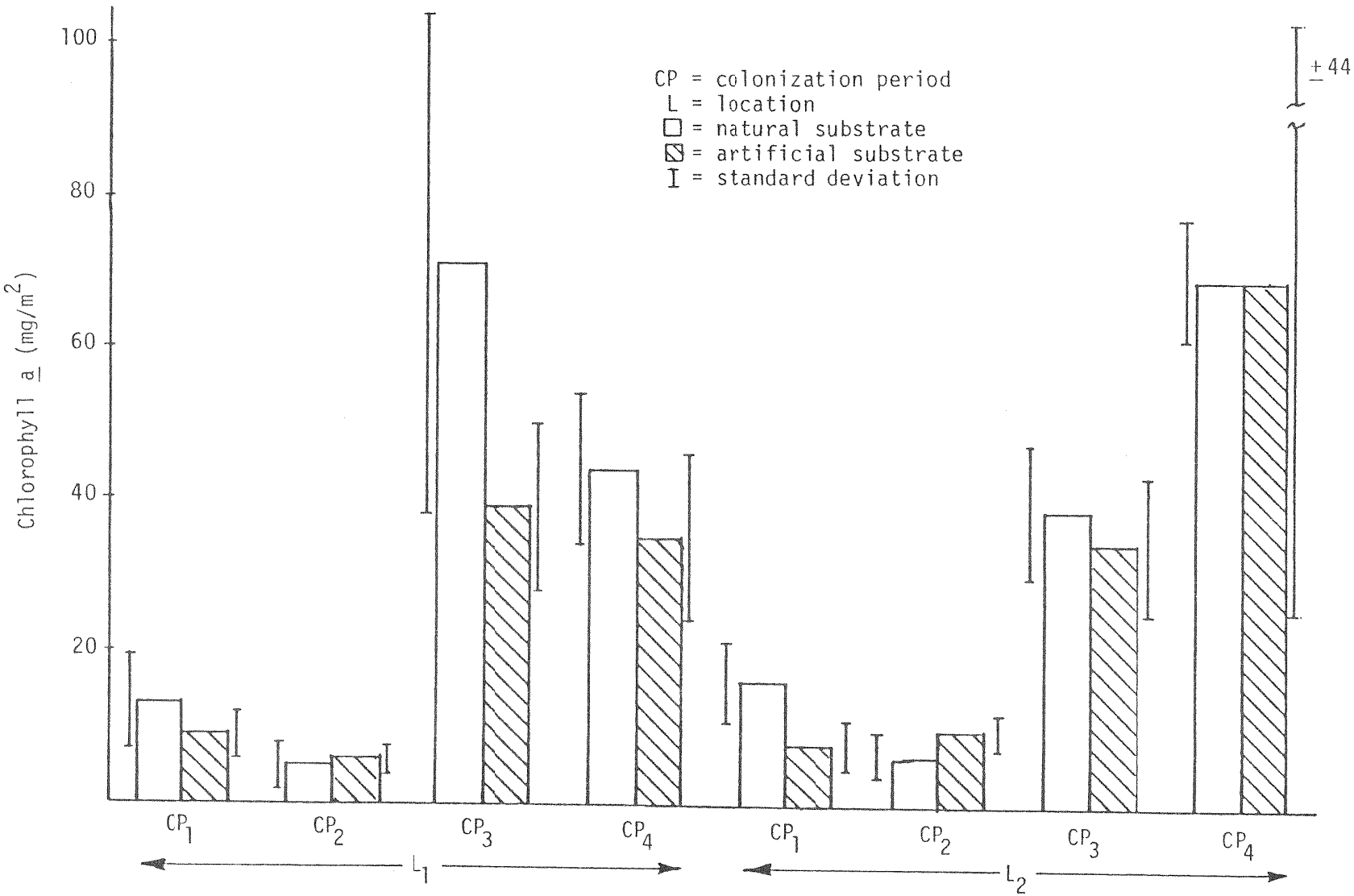

Figure 27. Standing crops of periphyton on artificial and natural substrates as chlorophyll a by location.

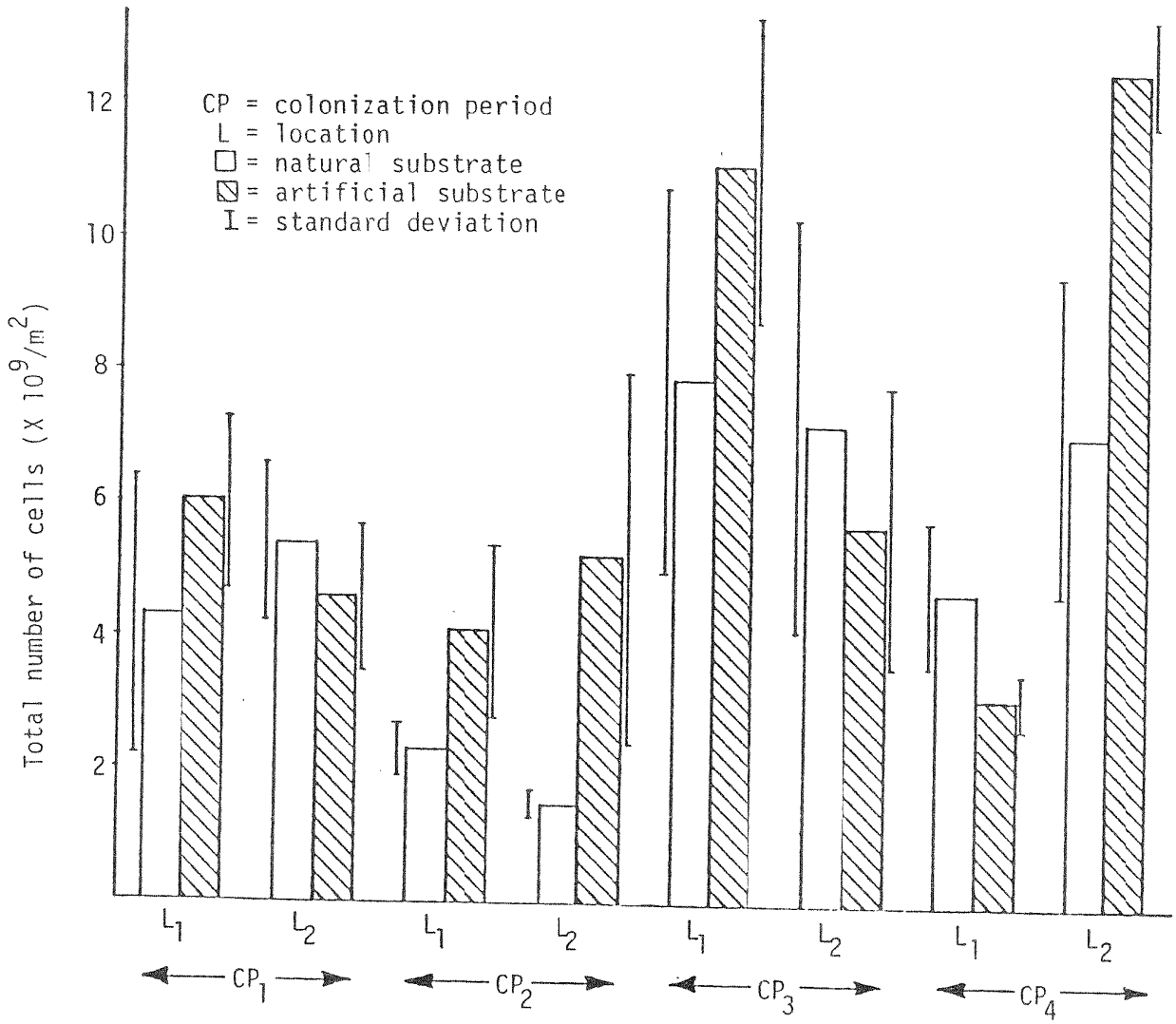

Figure 28. Standing crops of periphyton on artificial and natural substrates as total cell numbers by colonization period.

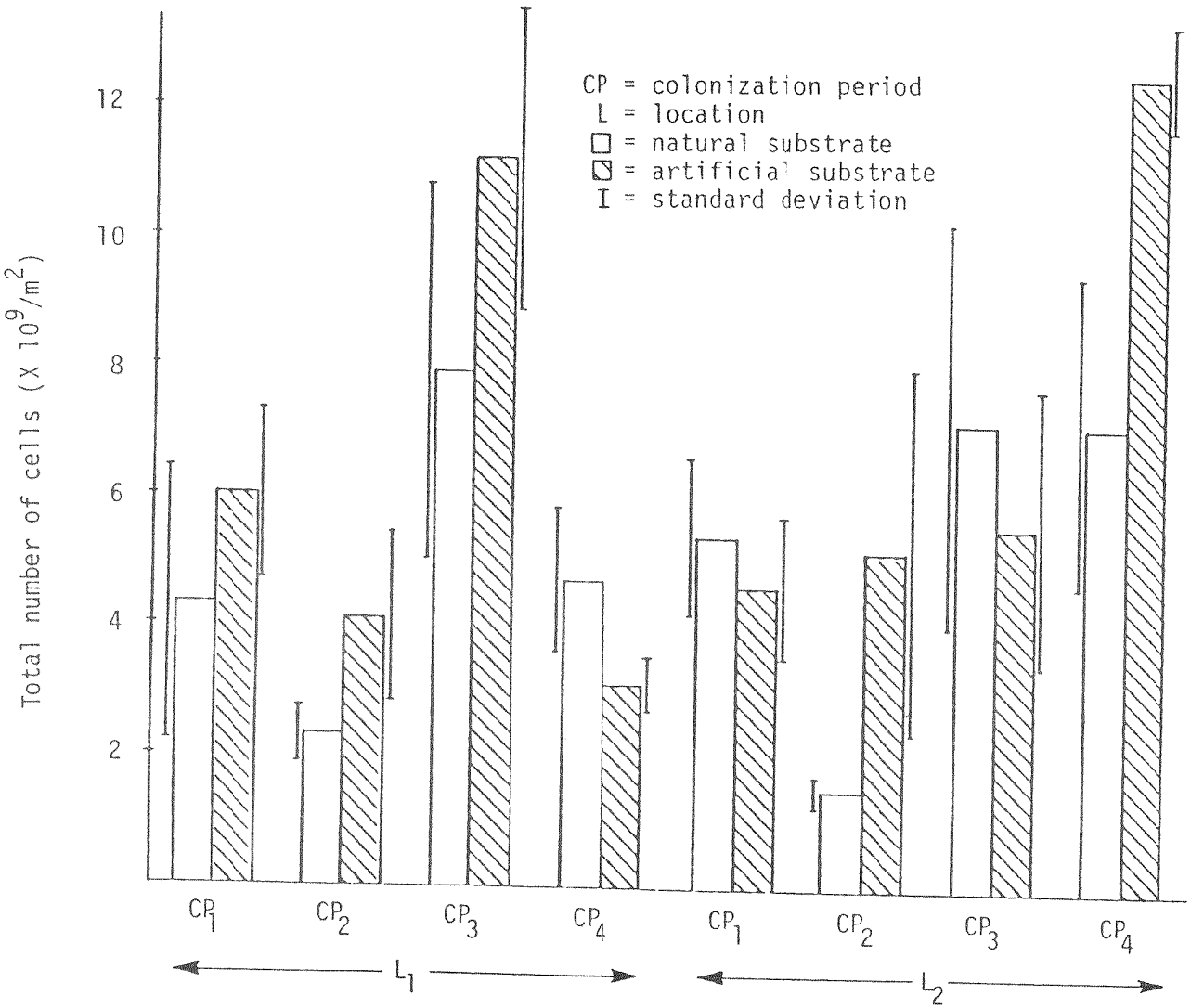

Figure 29. Standing crops of periphyton on artificial and natural substrates as total cell numbers by location.

Table 4. Summary of linear correlation coefficients for artificial and natural substrates*

y variable	x variable	Correlation coefficient	
		natural substrate	artificial substrate
Standing Crop			
Chlorophyll *a*	Ash-free dry weight	0.94	0.75
Total cell numbers	Ash-free dry weight	0.83	0.53
Total cell numbers	Chlorophyll *a*	0.85	0.75
Community Structure			
Percent organic content	Community structure ratio	0.54	0.52

* d.f. = 7.

Variability in standing crop parameters was observed within triplicate samples from artificial and natural substrates. Variability within triplicate samples from artificial substrates was in most cases somewhat less than the variability within triplicate samples from natural substrates. However, artificial substrate variability was at times comparable to or greater than natural substrate variability.

Collins and Weber (1978) have suggested that more precise data are collected when artificial (vs. natural) substrates are used. To determine whether apparent differences in sample variability between artificial and natural substrates were statistically significant, three paired t-tests performed on the standard deviations of artificial substrates and natural substrates were statistically significant, three paired t-tests were performed on the standard deviations of artificial substrate and natural substrate standing crop data. Each paired t-test corresponded to one standing crop parameter. Standard deviations for the two substrate types were paired by like locations and colonization periods. The null hypothesis of equal standard deviations was tested. No statistically significant differences in standard deviations were found between artificial and natural substrates.

Community Structure

The percentages of organic content values for artificial and natural substrates are presented in Figures 30 and 31 by colonization period and location, respectively. A highly significant difference between substrates was determined by the analysis of variance procedure. Differences between the two substrate types were apparent for four treatment combinations (CP1-L1, CP1-L2, CP2-L2, CP4-L2). The artificial substrate consistently yielded a greater percentage of organic contents than the natural substrate in these cases. A highly significant difference between colonization periods was found. Percentage of organic contents in CP1 and CP2 and in CP3 and CP4 apparently were equivalent. A decrease of approximately 40% occurred, however, from CP1-CP2 to EP3-CP4. Percentage of organic contents at the two locations did not differ significantly.

Community structure nondiatom/diatom ratios for artificial and natural substrates are shown by location and colonization period in Figures 32 and 33, respectively. Differences between artificial and natural substrate ratios were not statistically significant. However, differences in community structure between substrates were observed from some treatment combinations (CP1-L1, CP2-L2, CPE3-L2, CP4-L2). Neither type of substrate consistently yielded greater (or lower) community structure ratios. Significant differences in community structure were found between colonization periods and locations. Ratios in CP1 and CP3 were approximately the same (1.0, 1.1); ratios of approximately 3.2 and 0.6 were found in CP2 and CP4, respectively. The overall L2 community structure ratio was approximately twice as large as the L1 ratio.

Linear correlation coefficients for community structure parameters were calculated by the least squares method. Separate values were calculated for artificial and natural substrates. Substrate values were

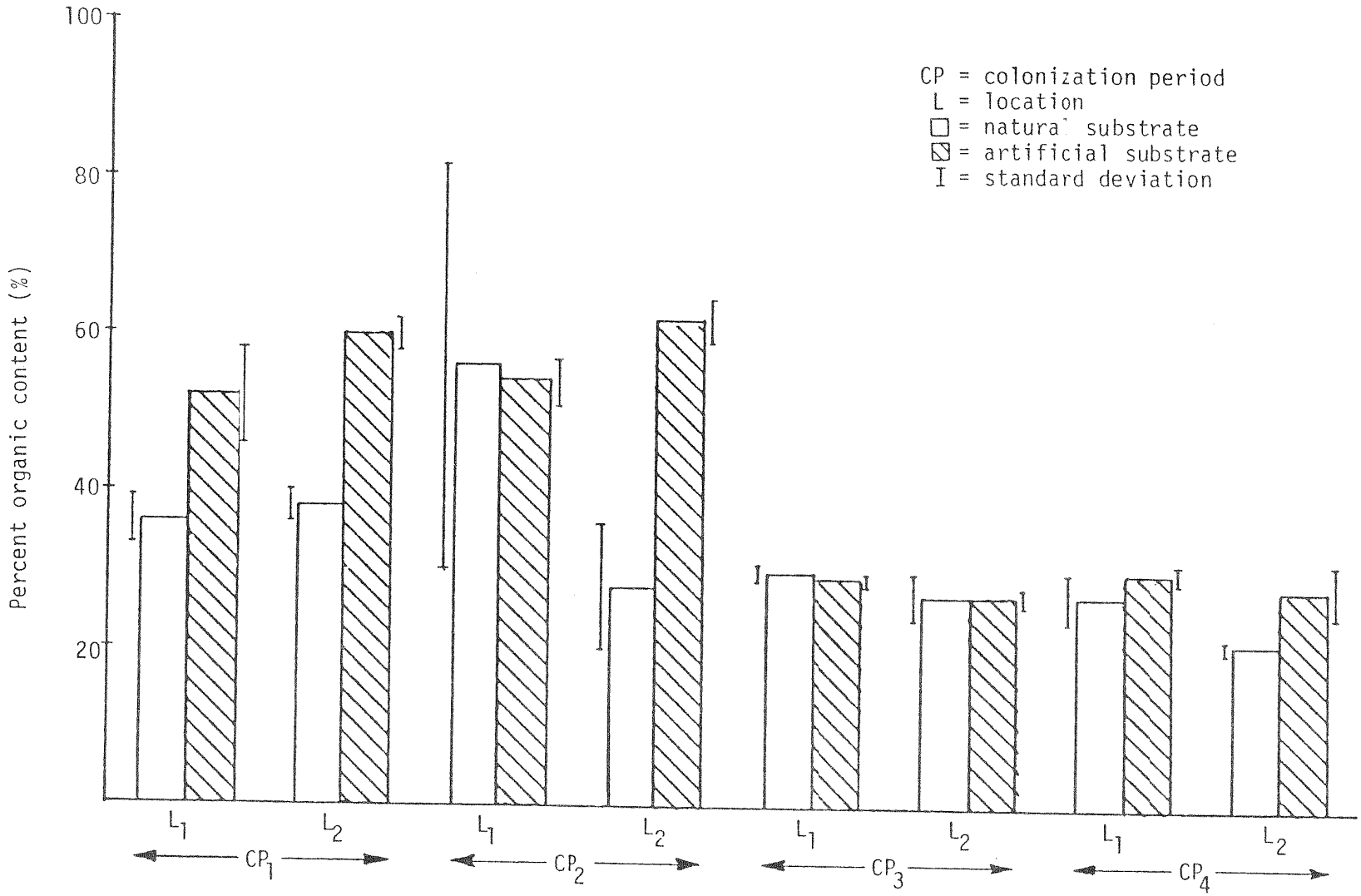

Figure 30. Community structures of periphyton on artificial and natural substrates as percent organic content by colonization period.

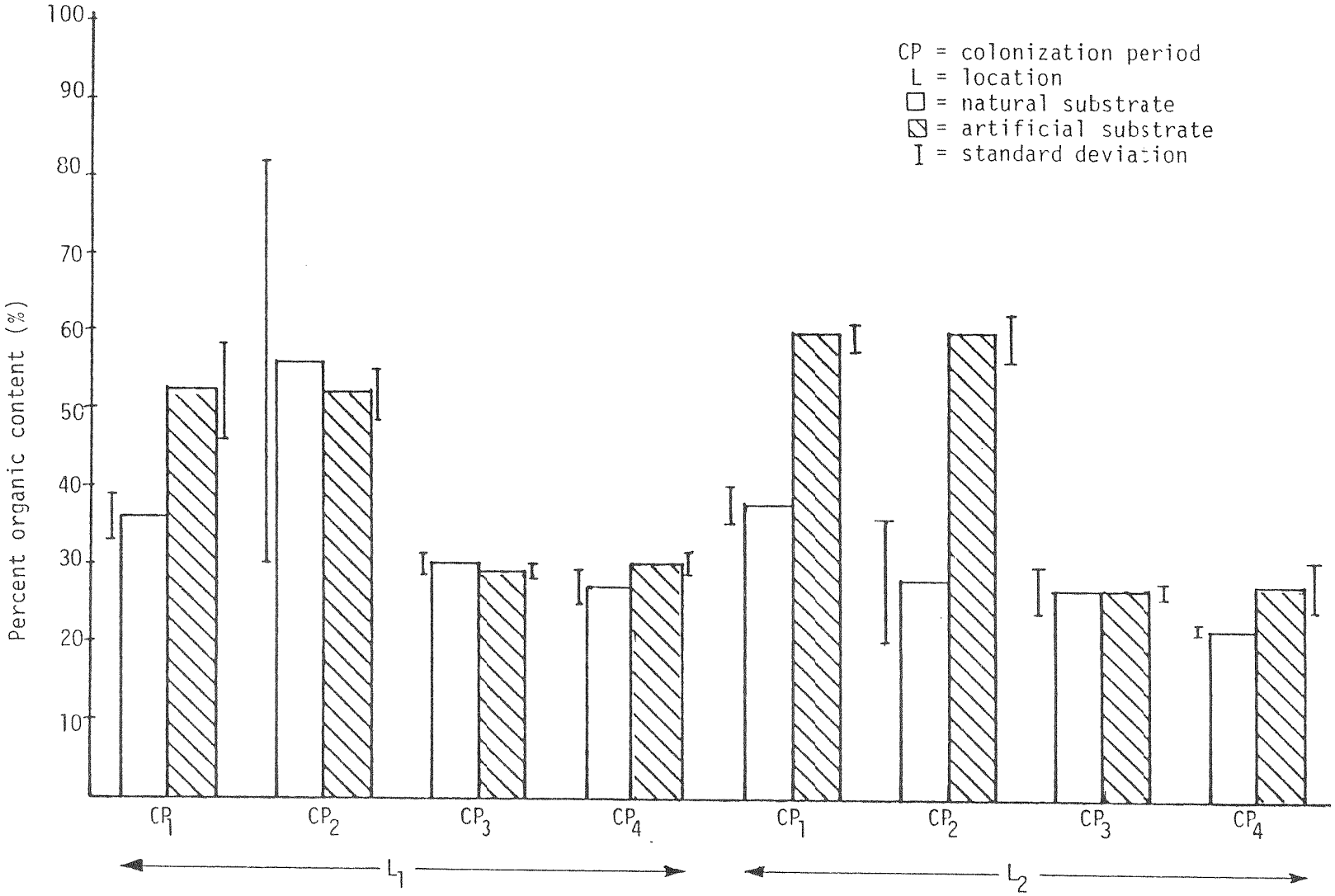

Figure 31. Community structures of periphyton on artificial and natural substrates as percent organic content by location.

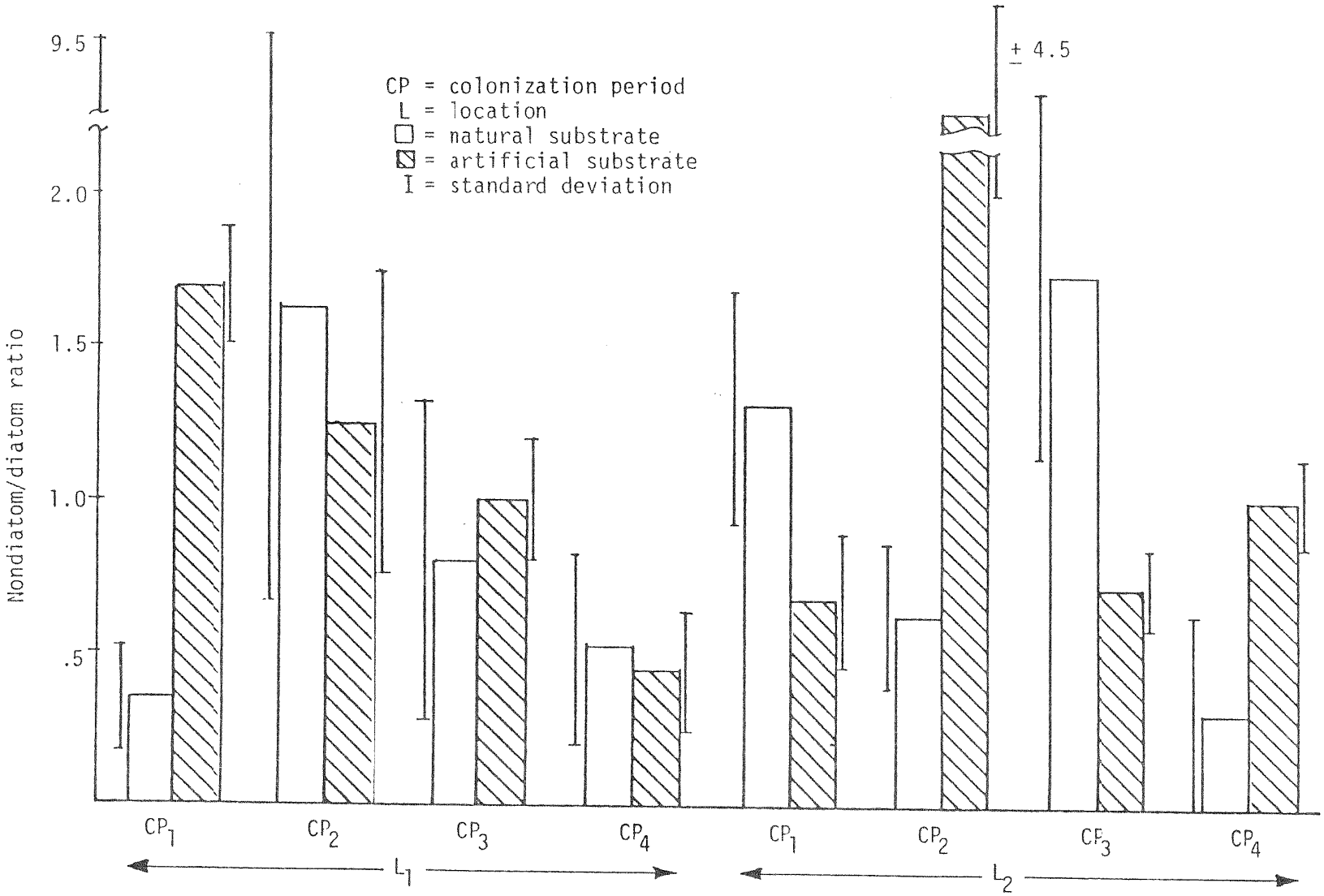

Figure 32. Community structures of periphyton on artificial and natural substrates as nondiatom/diatom ratio by location.

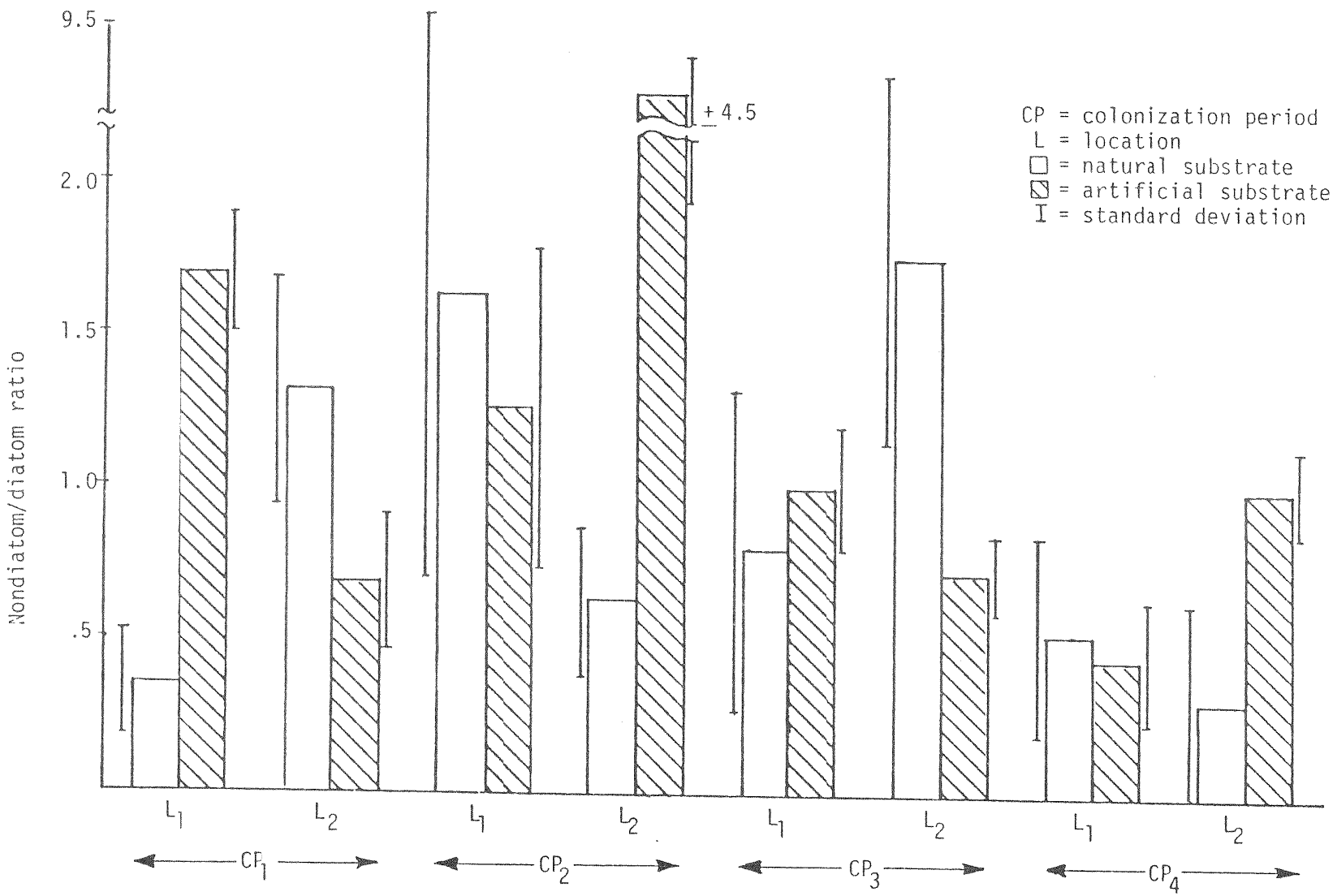

Figure 33. Community structures of periphyton on artificial and natural substrates as nondiatom/diatom ratio by colonization period.

paired by like locations and colonization periods. The correlation coefficients are presented in Table 4. Correlation coefficients for both artificial and natural substrates were approximately 0.5 indicating a low degree of linear association between percentage of organic content and community structure.

Differences in sample variability between artificial and natural substrates were apparent for community structure parameters. Variability within artificial substrate triplicate samples were generally less than variability within natural substrate triplicate samples. However, artificial substrate sample variability was sometimes equivalent to or greater than natural substrate sample variability. To determine whether the apparent differences were statistically significant, paired t-tests were performed on the standard deviations of artificial and natural substrate community structure data. The procedure used for standing crop data was repeated. No statistically significant difference in sample variability was found between artificial and natural substrates.

Predominant genera of attached algae on artificial and natural substrates were quite similar, although not identical. Communities on both substrate types in CP1 were dominated by *Anabaena* sp. and *Fragilaria* sp. Artificial substrate samples also contained substantial numbers of *Stigeoclonium* sp. *Stigeoclonium* sp. was rarely observed in the natural substrate samples.

Fragilaria sp., *Tabellaria* sp., *Anabaena* sp., and *Stigeoclonium* sp. were the predominant genera of periphyton on artificial and natural substrates in CP2. *Tabellaria* sp., *Anabaena* sp., *Rhizoclonium* sp., and *Ulothrix* sp. were predominant in CP3 and CP4. Artificial substrate samples in CP4 also contained substantial numbers of *Pleurodicus* sp. The conspicuous presence or absence of specific genera of algae on the artificial substrates were not apparent in CP3.

Discussion of Periphyton Results

Standing Crop

The effect of artificial substrate on standing crop apparently was negligible. Standing crops of periphyton on natural and artificial substrates did not generally differ based on total count and chlorophyll *a* results. Counts and chlorophyll *a* data were weighted more heavily than ash-free dry weight data in the interpretation of results, because gravimetric methods do not distinguish between autotrophic growth, heterotrophic growth, and detritus (Wetzel and Westlake, 1969). Thus, differences in ash-free dry weights on artificial and natural substrates were considered an indication of differences in heterotrophic growth or detrital accumulation (discussed later) rather than differences in standing crops of attached algae.

The sigmoid model generally describes the shape of periphyton growth curves (Kevern *et al.*, 1966). Cooper and Wilhm (1970) have suggested that the sigmoid curve can be divided into three linear phases of periphyton growth. These correspond to initial colonization and lag phase, maximum instantaneous growth rate phase (inflection point), and equilibrium growth phase (upper asymptote of the sigmoid curve). The growth rate in the final phase approaches zero and reflects a net balance between new growth of periphyton and losses of periphyton due to sloughing and grazing. Maximum standing crops of periphyton occur in the equilibrium phase.

The optimum length of substrate exposure in periphyton sampling should provide an estimate of maximum standing crop before substantial losses due to sloughing, etc. occur (Weber, 1973; Collins and Weber, 1978). The four week colonization period used in this investigation (based on trophic conditions, river velocity, and type of algae under study) was assumed to meet the maximum standing crop criterion. Thus, periphyton samples were probably removed during the equilibrium phase of the sigmoid production curve.

The four week exposure period apparently provided sufficient time for similar periphyton assemblages to become established on artificial and natural substrates. Previous comparative studies reporting quantitative differences between artificial (glass) and natural (rock) substrates may have sampled periphyton in other portions of the sigmoidal growth curve. Differences in those cases may reflect differential rates of initial colonization and maximum instantaneous growth on artificial and natural substrates.

Colonization period had a significant effect on two of the three standing crop parameters (ash-free dry weight, chlorophyll *a*). Significant differences between colonization periods indicate that blocking (grouping) samples by like environmental factors was an effective means of reducing error variance (Steel and Torrie, 1980). Differences between colonization periods were anticipated, because seasonal fluctuations in flow, temperature, day length, and other environmental factors are known sources of variability in periphyton standing crops.

That total cell numbers did not statistically differ between colonization periods may be accounted for in several ways. Similar counts throughout a study could be an indication of a level of population saturation (Waters, 1961) or equilibrium density (Tuchman and Blinn, 1979) that is not seasonally dependent. Seasonal fluctuations in periphyton, however, have been commonly reported (especially for diatoms) (Hynes, 1970; Patrick and Reimer, 1966). A more plausible explanation, therefore, is that the variability within replicate samples and inconsistencies in at the two sampling locations prevented any apparent differences between colonization periods from being statistically significant.

The effect of location on standing crop was apparently negligible in this investigation. Values obtained at the two locations were generally quite similar. Any appreciable differences between locations are probably a result of differences in microhabitat. Duplicate samplers apparently can be expected to yield comparable standing crops as long as differences in environmental conditions between locations are minimized as much as possible.

Linear correlation coefficients for chlorophyll a vs. ash-free dry weights are in good agreement with values of 0.93 and 0.72 reported by Peters et al. (1968) and Cushing (1967) respectively. Peters et al. (1968) and Nelson et al. (1973) reported ranges of linear correlation coefficients for total counts vs. chlorophyll a of 0.75 - 0.90 and 0.82 - 0.88, respectively. Correlation coefficients in the present study fell within the reported ranges of values. The linear correlation coefficients for counts vs. organic weights fell within the range of values (0.49 - 0.78) reported by Fox et al. (1979), but were lower than the value of 0.93 reported by Peters et al. (1968).

Community Structure

The effects of artificial substrate on the community structure of periphyton in the investigation are difficult to ascertain. Community structure ratios between artificial and natural substrates were not statistically different, yet apparent differences occurred for 50% of the treatment combinations. Neither substrate consistently yielded higher community structure ratios, however. Percentages of organic contents on artificial and natural substrates were statistically different, but differences were apparent only for 50% of the treatment combinations. The artificial substrate consistently yielded a greater percentage organic contents where differences were apparent. Predominant genera of algae were similar (but not identical).

If percentage of organic content is a reliable indicator of community structure (McIntire, 1975), differences in percentage of organic content and community structure ratios between substrates should occur for the same treatment combinations. An examination of treatment combinations in the study suggests that percentages of organic contents and community structure ratios were not consistently in agreement (only agreed for three of the five treatment combinations where differences were apparent). Poor agreement between percentage of organic contents and community structure ratios suggests that percentage of organic content may not be a reliable

indicator of Upper Spokane River periphyton community structure. Poor agreement between the two community structure parameters is apparently another indication of differential accumulation of inorganic and organic colloidal and/or particulate matter settling from the water column or differences in heterotrophic growth on the two types of substrate.

Qualitative differences in periphyton colonizing artificial and natural substrates were apparent for approximately 50% of the treatment combinations. Thus, attached algal organisms colonizing artificial substrates were not consistently representative of the attached algae colonizing natural substrates. It is interesting to note that the artificial substrate did not appear to prohibit the growth of filamentous green or blue-green algae as observed in other comparative investigations. The four week colonization period apparently provided sufficient time for attachment and growth of those types of algae.

Deficiencies in Sampling Design

An apparent deficiency in sampling design in the investigation is that the artificial and natural substrates were dissimilar in shape and size. The dissimilarities in shape and size most likely produced different patterns of current flow about the two substrate types. Hynes (1970) reported that zonation of attached algae (by species) as a function of current flow often is observed. Beers and Neuhold (1968) suggested that variable chlorophyll a contents on quadrants of a substrate were related to boundary layer and shear force phenomena. Tuchman and Stevenson (1980) reported that a difference in fluid flow about dissimilarly-shaped natural substrates was a major source of variability within replicate samples.

Another apparent deficiency in sampling design with respect to dissimilarities in shape and size is concerned with accumulation of inorganic and organic particulate and/or colloidal matter. The broad, flat surface of the natural substrates probably provided a greater surface area for settlement and accumulation of particulate and/or suspended matter than the short, curved surface of the artificial substrates. Both apparent differences in fluid dynamics and the greater tendency of flat surfaces (vs. curved) to accumulate and retain settling organic and inorganic matter probably account for differences in ash-free dry weights and percent organic content between the two types of substrate. The deficiency in sampling design could be minimized by using artificial and natural substrates of similar shapes and sizes in future comparative investigations.

Another possible deficiency in sampling design is the length of colonization period used in the study. A shorter period of substrate exposure might have detected greater differences between the two types of substrate. For example, differences in initial attachment and colonization of periphyton (lag phase) and differences in maximum growth rates (instantaneous) between artificial and natural substrates might have been observed with a shorter colonization period. A four week colonization period was assumed to meet the maximum standing crop criterion recommended for periphyton sampling by Weber (1973) based on trophic conditions, etc. However, the validity of the assumption is unknown, because the production curve for Upper Spokane River periphyton has not been established. The

apparent deficiency in sampling design with respect to colonization period length could be overcome by sampling artificial and natural substrates over a series of successively increasing exposure periods (e.g. 3, 7, 9, ... days). Production curves generated for both types of substrates could then be compared to determine differences between periphyton growth rates on artificial and natural substrates.

Sample Variability

Substantial sample variability within replicate samples is apparently a problem inherent to periphyton field studies. Butcher (1940) noted that the distribution of attached algae over small surface areas is often heterogeneous despite seemingly constant environmental factors. The variability within triplicate samples observed in the present study is most likely an indication of the heterorgeneous distribution referred to by Butcher.

Several factors affecting microhabitat apparently contribute to sample variability. Zonation in relation to current flow (Hynes, 1970) is a known source of variability in the distribution of attached algae over the surface of a substrate. Zonation may be a function of microhabitat differences in fluid dynamics (Hynes, 1970). Beers and Neuhold (1968) suggested that differences in fluid dynamics, boundary layer and shear force phenomena, were major sources of variability within replicate samples removed from single substrate.

The heterogeneous distribution of periphyton on a substrate due to microhabitat differences has several implications for periphyton sampling. Replicate samples should be incorporated into quantitative sampling designs whenever possible. Replicate samples would intuitively provide a better representation of periphyton standing crops and community structures than single samples. In addition, random selection of areas to be scraped or random assignment of samples to biomass procedures when replicate samples are removed from natural substrates is important. Conclusions concerning substrate selectivity based on single sample results may be oversimplified and/or erroneous.

Implications of Results

Quantitative differences in periphyton colonizing artificial and natural substrates were apparently negligible (based on standing crop results). However, qualitative differences in periphyton colonizing the two types of substrate were observed. Thus, periphyton colonizing artificial substrates did not consistently represent periphyton colonizing natural substrates in the Upper Spokane River.

Several observations concerning sampling methodology were made during the investigation. The use of artificial substrates did not significantly reduce sample variability when compared to natural substrates. Also, direct microscopic observation of periphyton colonizing the transparent artificial substrates was not possible, because periphyton growth was so dense. Finally, the sampling procedure (removal method) used for periphyton on natural substrates provided a simple, efficient means of

quantitatively sampling naturally-occurring attached algae. Thus, the use of artificial substrates presented no apparent advantage over the use of natural substrates in the study.

The major implication of these results for future periphyton studies is that natural substrates should be used for characterization and monitoring of lotic periphyton whenever possible. Utilization of natural substrates for periphyton colonization is particularly important in water quality monitoring when detection of changes in naturally-occurring biological communities is an ultimate goal. Changes in naturally-occurring periphyton may not be reflected by periphyton colonizing artificial substrates.

Periphyton Study Conclusions

Natural substrates should be utilized for determination and monitoring of lotic periphyton standing crops and community structures whenever possible. This recommendation is based upon the following:

1. periphytic algae colonizing artificial substrates were not consistently representative of periphytic algae colonizing natural substrates in the Upper Spokane River,

2. the use of artificial substrates did not significantly reduce sample variability when compared to natural substrates and

3. the use of artificial substrates presented no advantage over the use of natural substrates.

MACROINVERTEBRATE INVESTIGATION

Throughout the study, the dipteran family Chironomidae was the dominant organism in the Spokane River, with the more abundant species being *Cricotopus* spp., *Microtendipes pendellus*, *Dicrotendipes* sp. and *Thienemannimyia* sp. Significant numbers of Trichoptera, predominated by *Ceraclea* sp., *Hydropsyche* sp. and *Cheumatopsyche* sp. were found. The third dominant group was presented by a single species, *Baetis* sp., from the order Ephemeroptera. Other organisms frequently found included various oligochaetes, the snail *Pysa* sp., the Dipterans *Simulium* sp. and *Antocha* sp., and water mites from the order hydracarina. Complete species lists, along with mean and standard deviations of number of organisms collected from replicate samples, are presented in Appendix C.

A comparison of each station, with reference to the effects of physical habitat on the distribution of the dominant organisms, followed by the response of *Baetis* sp., Hydropsychidae, *Ceraclea* sp., *Cricotopus* spp., *Microtendipes pendellus* and total number of organisms to sampler type and sampler location are presented.

Station Comparison

The relative distributions of the dominant groups, as indicated by mean values from replicated suction, basket and multiple-plate samplers taken in late September, 1980, are shown in Figure 34.

Organisms collected at Station 1 were predominately chironomids, comprising 82 to 93% of the total population. Mean number of chironomids from replicated samples ranged from 10,888 to 2,683/m² in the mid-stream suction and multiple-plate samplers, respectively. Of these, Microtendipes pendellus, followed by Cricotopus spp., were most abundant. Three to 12% of the populations were trichopterans, with mean numbers ranging from 69 to 370/m² in the respective mid-stream multiple-plate and suction samples. The only mayflies collected at Station 1 on this date were in the mid-stream basket and near shore multiple-plate with mean values of 6 and 9 organisms/m², comprising less than 1% of the samples.

The chironomid populations from samples at Station 2 made up 79, 38 and 85% of the populations in the mid-stream suction, basket and multiple-plate samplers, respectively. A greater proportion of the near shore samples were chironomids, comprising 99, 89 and 95% of the suction basket and multiple-plate, respectively. The maximum number found was in the near-shore suction sample with 7,254 chironomids/m². Mid-stream samples had greater numbers of trichopterans than were found at Station 1, with 20, 58 and 8% of the populations from the respective suction, basket and multiple-plate samplers. The basket contained the greatest percent of trichopterans with 3,370/m². Less than 10% of any near-shore sample was made up of trichopterans. The Ephemeroptera, Baetis sp., was found in significant numbers in the mid-stream basket and multiple-plate samples with 4 and 6% of the total, respectively.

A striking similarity is noted in Figure 34 between samples collected at Station 1, both mid-stream and near-shore, and the near-shore samples of Station 2. In each case, Chironomidae are by far the dominant organism, but a general decrease in those collected by the basket and multiple-plate samplers is evident.

The description of these sampling sites in Table 5 shows each to have low current velocities and heavy periphyton and detritus accumulation on the natural substrate, indicating a correlation between number of chironomids and these physical habitat chracteristics. Minshall and Minshall (1977) found a similar correlation in a study of a Rocky Mountain stream, that indicated detritus is a key factor in the control of chironomid distributions.

Along with the correlation between number of chironomids and physical characteristics of the sampling sites, a consistant decrease in the numbers of chironomids collected by the basket and multiple-plate samplers, as compared to the suction sampler, is shown. Mason et al. (1973) found the multiple-plate sampler to be biased against certain chironomid species, possibly explaining the low numbers recovered by that sampler in the present study. Additional explanation lies in the relative positioning of the basket and multiple-plate samplers.

In their placement the diver noted that the artificial substrate samplers sat above the natural substrate in a higher current velocity, due to the decreasing velocity gradient towards the river bottom. Rabeni and Marshall (1977) found in a fast flowing stream, a mean free water velocity of 50 cm/sec, 3 cm above the natural substrate. At the substrate surface, the velocity decreased to 12 cm/sec. Although current velocity itself was not found to directly affect colonization, it was related to detritus deposition. Due to the relative position of the basket and multiple-plate on the river bottom, we can expect a decrease in detrital deposition, which as Minshall and Minshall (1977) point out, will limit chironomid colonization. Since the suction sampler collects organisms directly off the river bottom, we would expect these samples to contain more detritus, and thus a larger number of chironomids.

The descriptive characteristics presented in Table 1 demonstrates that Station 3 had higher velocities with a well scoured bottom. Figure 34 indicates chironomids as the dominant group in all samples, but a shift in the most abundant species had taken place. Cricotopus spp. was by far abundant, comprising 62 to 83% of the total population, the maximum of 6,879/m^2 having been collected by the basket sampler. The dominant species in previous samples were Microtendipes pendellus. Preference by Cricotopus spp. for the erosional environmentals of Station 3 is supported by Merrit and Cummins (1978) habitat classification as "lotic-erosional and deposition," whereas Microtendipes spp. is classified as "lentic-littoral, lotic-depositional."

Figure 34 shows a large increase in number of chironomids collected by the basket sampler as compared to the suction and multiple-plate. Environmental conditions at Station 3 may be such that the basket sampler becomes bias for these organisms.

Other characteristics of Station 3 samples include the significant numbers of Ephemeroptera found in the basket and multiple-plate samples, totaling 251 and 316/m^2, respectively. These numbers accounted for 3% of the population in the basket and 10% in the multiple-plate. Twenty-three percent of the near-shore suction sample was comprised of miscellaneous organisms, most of which were oligocheates totaling 324/m^2.

A comparison of stations and samplers (Figure 34) indicates sampler bias. Performance of individual samplers was shown to be effected by current velocities and detritus-periphyton accumulation. In order to investigate these points further, analysis is carried out on selected organisms or groups of organisms.

Baetis sp.

Figure 35 shows little colonization had taken place at Station 1. Nine of the 15 replicated sampling sets collected were void of the mayfly, Baetis sp. Of the samples that did contain baetids, a mid-stream sample taken on 9/26/81 had the most, with 38/m^2. As indicated in Figure 35, baetids were more prevalent at Stations 2 and 3, enabling comparative analysis.

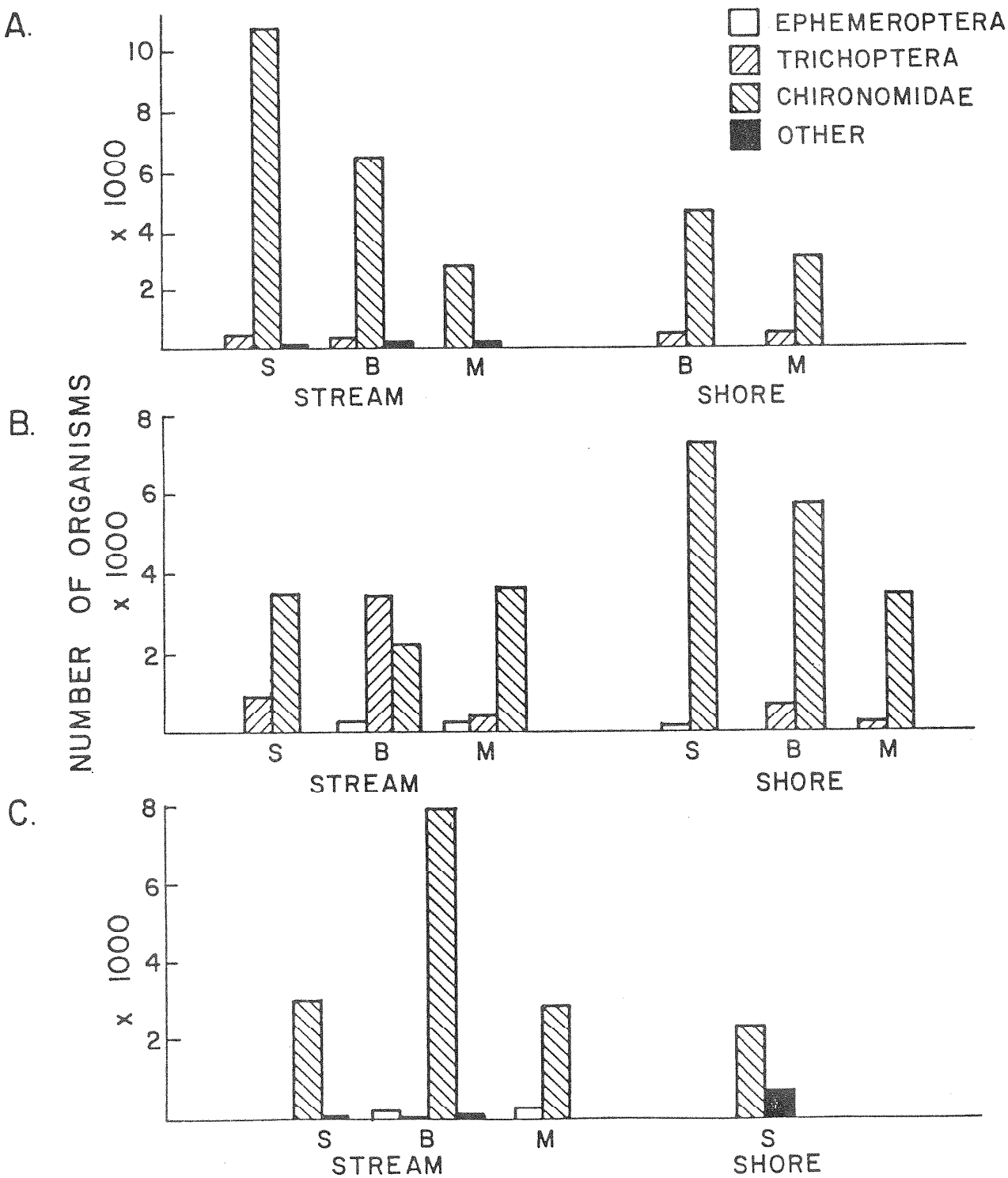

Figure 34. Relative distribution of dominant organisms per m^2 from the suction (S), basket (B) and multiple-plate (M) samplers collected on 9/26/80 through 9/28/80.
A: Station 1, B: Station 2, C: Station 3

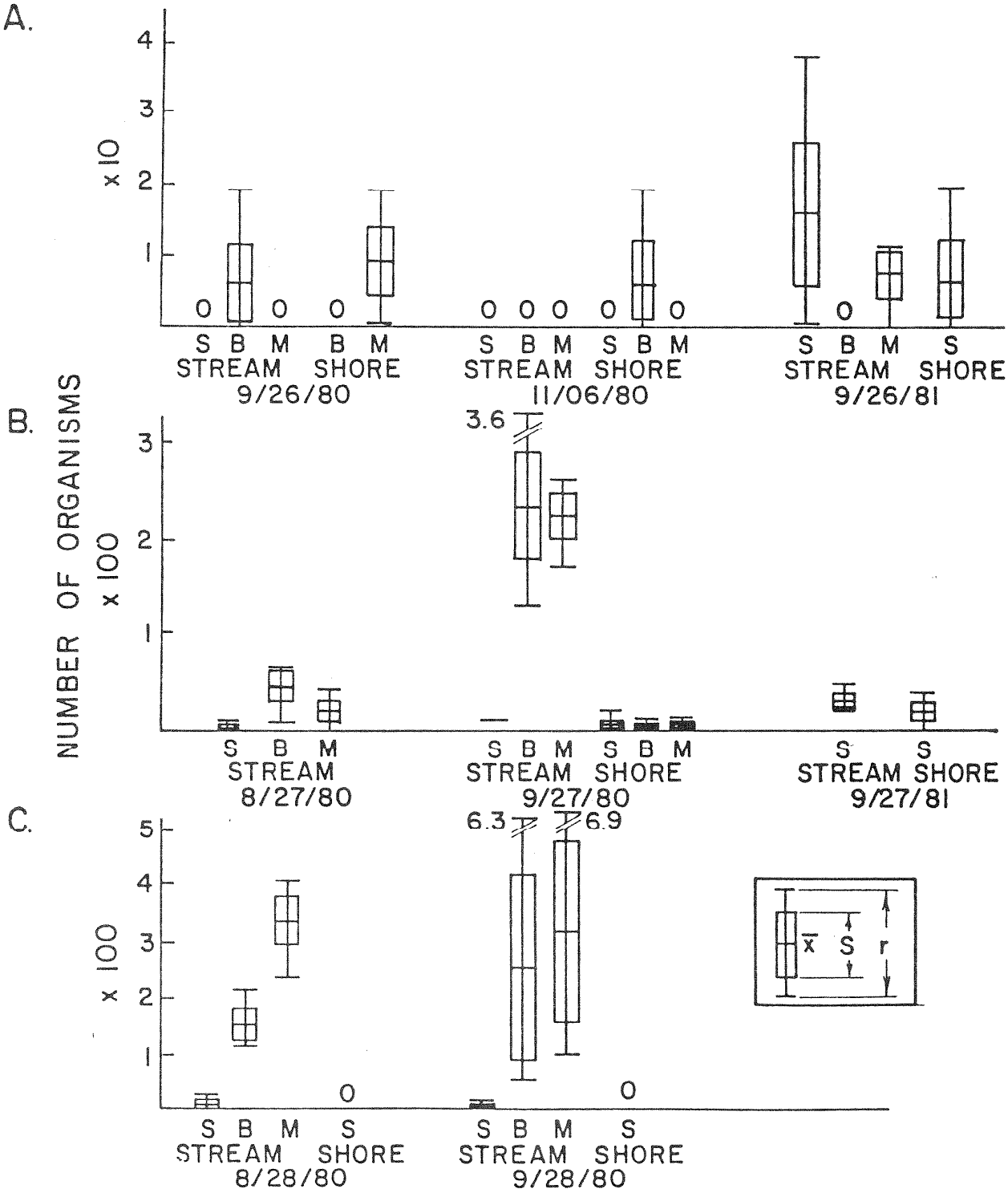

Figure 35. Mean ($\bar{x}$), standard deviation (s) and range (r) of Baetis sp. per m^2 collected from the suction (S), basket (B) and multiple-plate (M) samplers. A: Station 1, B: Station 2, C: Station 3

Observations of mid-stream samples indicated that heavier colonization occurred on the basket and multiple plate than on the natural substrate, as indicated by the suction sampler. The overall mean value for baetids collected at Station 2 by the suction sampler was 13.4/m². The basket and multiple-plate samplers collected 142.5 and 125.5/m², respectively. Analysis of variance results, summarized in Table 5, show the basket and multiple-plate collections equal, with both differing significantly from that of the suction sampler. Mean number of baetids collected at Station 3 by the suction, basket and multiple plate samplers were 6.2, 201.5 and 326.5/m², respectively. Each collection differed significantly from the others.

Although sufficient data were not available for statistical comparison of near-shore samples at Station 2 and 3, Figure 36 shows no difference between the three samplers. This is particularly evident in samples taken on 9/27/80 at Station 2. Mean number of Baetis sp. collected from replicated suction, basket and multiple-plate samplers were 6.3, 3.0 and 3.7/m², respectively.

Comparison of these same near-shore samples to the mid-stream collections, show considerable variation due to sampler location. Mid-stream basket samplers had a mean number of 142.5 baetids/m², compared to 3.0/m² for the near-shore samples. Similarly, the multiple-plate samples contained 125.5/m² at the mid-stream location and 3.7/m² at the near-shore location. Results of pooled t-tests for sampler location variation in Table 6 confirms these differences as significant. Location had no effect on baetid populations from the suction sampler.

Studies on factors influencing the distribution of benthic macroinvertebrates have indicated that current is a primary controlling parameter for the mayfly Baetis sp. (Corkum et al., 1977; Minshall and Minshall, 1977; Rabeni and Marshall, 1977). In a study of substrate and current effects on mayfly drift, Corkum et al. (1977) found current to be the dominating factor in the redistribution of individuals from undesirable habitats. Drift of Baetis vagans was found greatest at 10 cm/sec, the lowest velocity tested. Increased colonization occurred at higher velocities. Rabeni and Minshall (1977) found Baetis tricaudatus to prefer faster currents. This was attributed to the organisms' greater oxygen requirements.

Low current velocities can account for the relative absence of Baetis sp. at Station 1, where the mid-stream velocity was 8 cm/sec. With Station 2 near-shore and mid-stream velocities of 6 and 19 cm/sec, respectively, it is not surprising that sampler location had such a significiant effect on the basket and multiple-plate collections. What is surprising is the consistently low numbers of Baetis sp. found in the suction samples, regardless of location.

Direct bottom samplers, such as the suction sampler, should provide the best estimate of the true benthic populations (Gale and Thompson, 1975; Rabeni and Gibbs, 1978). It seems, in the case of Baetis sp., that this is not true. In efficiency tests by Gale and Thompson (1975), only 43% of the baetids released inside the suction sampler were recovered.

Table 5. Analysis of Variance (ANOVA) and Duncan's multiple range test results for sampler type differences using date as the replication term and sampler-date interaction as the error term. Overall mean number of organisms per m^2 collected by the suction (S), basket (B) and multiple-plate (M) samplers are given. Means with the same superscript letters are equal at the 0.05 level of significance.

Location:	MID-STREAM				NEAR-SHORE			
Sampler:	S	B	M	ANOVA	S	B	M	ANOVA
STATION 1								
Baetis sp.	5.2^a	2.1^a	2.4^a		3.2^a	3.2^a	4.7^a	
Hydropsychidae	43.9^a	390.7^b	33.9^a	***	3.2^a	261.5^a	186.7^a	
Ceraclea sp.	281.0^a	191.3^a	110.0^a		23.3^a	60.0^a	99.3^a	
Cricotopus spp.	528.4^a	1366.1^b	719.8^b	***	419.7^a	5674.5^a	1171.5^a	
Microtendipes sp.	7679.6^a	1207.0^b	698.2^b	***	536.2	1054.0^a	451.3^a	
Total Numbers	9456.6^a	5899.8^{ab}	2826.3^b	***	2237.5^a	6272.8^b	3152.8^c	***
STATION 2								
Baetis sp.	13.4^a	142.5^b	125.5^b	***	12.5	3.0	3.7	#
Hydropsychidea	269.3^a	2066.0	297.7^a		18.7	505.3	29.0	#
Ceraclea sp.	125.7^a	54.3^a	113.0^a		17.2	90.0	118.7	#
Cricotopus spp.	1952.2^a	5080.7^a	3376.8^a		1356.7	1791.6	972.0	#
Microtendipes sp.	2403.9^a	34.2^b	0.0^b	***	3106.7	1066.7	157.7	#
Total Numbers	5098.1^a	8467.5^a	4301.0^a		6708.5	6385.7	3670.0	#
STATION 3								
Baetis sp.	6.2^a	201.5^b	326.5^c	***	0.0	--	--	#
Hydropsychidae	10.7^a	62.3^b	32.7^b	***	1.8	--	--	#
Ceraclea sp.	15.7^a	10.8^b	9.0^a		11.2	--	--	#
Cricotopus spp.	1889.5^a	8825.7	5763.7		2146.8	--	--	#
Microtendipes sp.	18.8^a	93.0^a	0.0^a		0.0	--	--	#
Total Numbers	2559.3^a	10243.8^a	6469.7^a		2881.0	--	--	#

(*** indicates significant differences)
(# indicates insufficient data for statistical analysis)

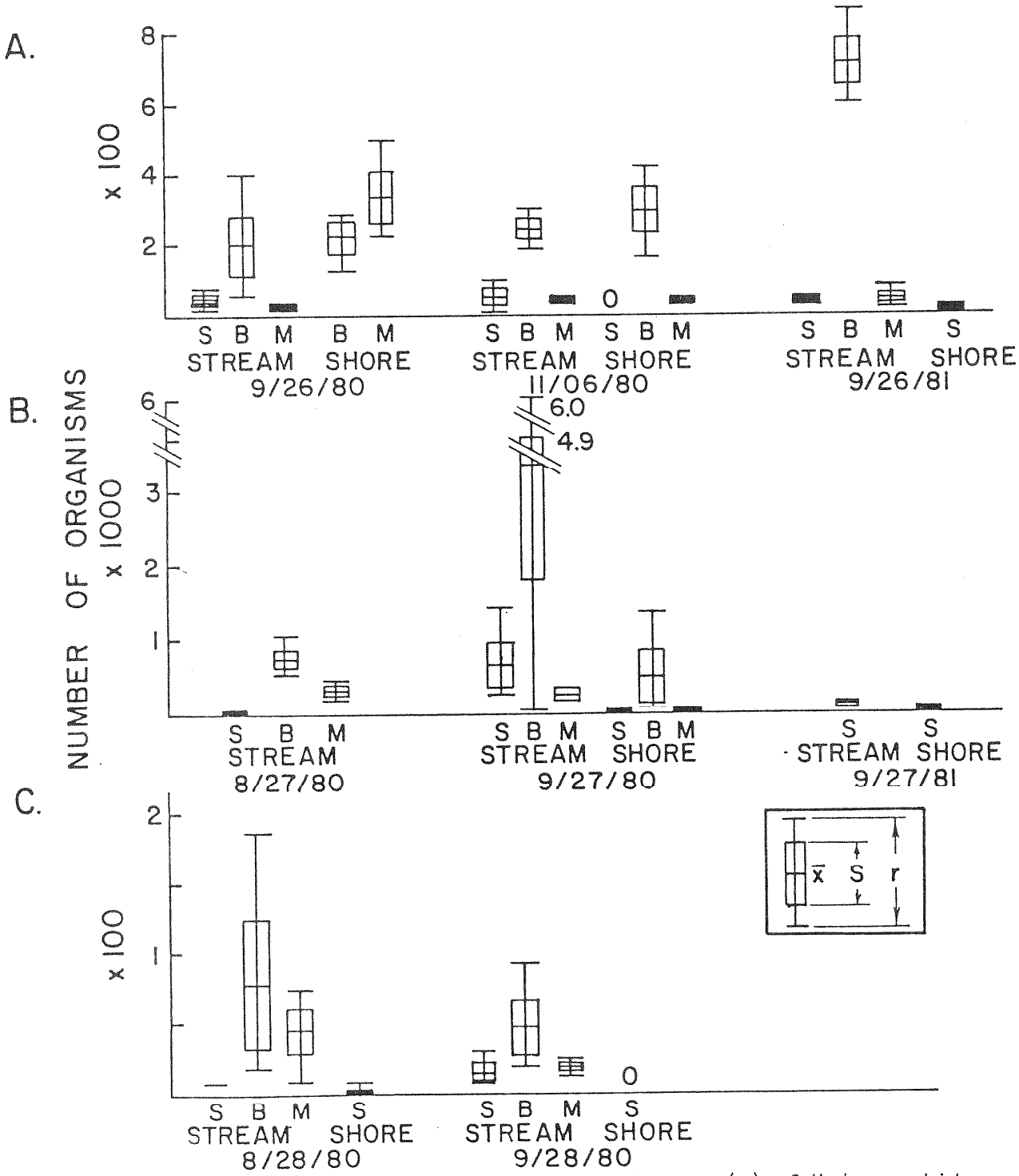

Figure 36. Mean ($\bar{x}$), standard deviation (s) and range (r) of Hydropsychidae per m^2 collected from the suction (S), basket (B) and multiple-plate (M) samplers. A: Station 1, B: Station 2, C: Station 3

Table 6. Pooled 't' test results for sampler location differences. Overall mean number of organisms per m² collected by the suction (S), basket (B) and multiple-plate (M) samplers at mid-stream (STR) and near-shore (SHO) locations are given. Tests were conducted at the 0.05 level of significance.

Sampler:	Suction			Basket			Multiple-Plate		
Location:	STR	SHO	ANOVA	STR	SHO	ANOVA	STR	SHO	ANOVA
STATION 1									
Baetis sp.	5.2	3.2		2.1	3.2		2.4	4.7	
Hydropsychidae	43.9	3.2	***	390.7	261.5		33.9	186.7	***
Ceraclea sp.	281.0	23.3	***	191.3	60.0		110.0	99.3	
Cricotopus spp.	528.4	419.7		1366.1	5674.5		719.8	1171.5	
Microterdipes sp.	7679.6	536.2	***	1207.0	1054.0		698.2	451.3	
Total Numbers	9456.6	2237.2	***	5899.8	6272.8		2826.3	3152.8	
STATION 2									
Baetis sp.	13.4	12.5		142.5	3.0	***	125.5	3.7	***
Hydropsychidae	269.3	18.7	***	2066.0	505.3		297.7	29.0	***
Ceraclea sp.	125.7	17.2	***	54.3	90.0		113.0	118.7	
Cricotopus spp.	1952.2	1356.7		5080.7	1791.6		3376.8	972.0	***
Microtendipes sp.	2403.9	3106.7		34.2	1066.7	***	0.0	157.7	***
Total Numbers	5098.1	6708.5		8467.5	6385.7		4301.0	3670.0	
STATION 3									
Baetis sp.	6.2	0.0		201.5		#	326.5		#
Hydropsychidae	10.7	1.8	***	62.3		#	32.7		#
Ceraclea sp.	15.7	11.2		10.8		#	9.0		#
Cricotopus spp.	1889.5	2146.8		8825.7		#	5763.7		#
Microtendipes sp.	18.8	0.0		93.0		#	0.0		#
Total Numbers	2559.3	2881.0		10243.7		#	6469.7		#

(*** indicates significant differences)
(# indicates insufficient data for statistical analysis)

The speed of the organism, allowing it to avoid the intake nozzle, was given as explanation for that bias.

Due to the bias apparent against mayflies by the suction sampler, no standard is available to measure the performance of the artificial substrate samplers for accurate collection of Baetis sp. The positive response by the basket and multiple-plate samplers to current velocity does indicate that reasonable estimates of the true baetid population were made. It is clearly pointed out, that in choosing sampling sites where mid-stream velocities exceed 10 cm/sec, placement of artificial substrate samplers is extremely important. Near-shore sampling, where velocities may be decreased, will provide a distorted view of the mayfly population in the river.

Hydropsychidae

Two characteristics are seen in the graphical discription of the hydropsychid populations in Figure 36. First is the greater number of Hydropsychidae collected by the basket samplers. Second, the suction and multiple-plate samplers show consistent equality in numbers collected.

These relationships were typified in the mid-stream Station 1 samplers, where the suction and multiple-plate overall mean counts were 43.9 and 33.9/m^2, compared to 390.7/m2 in the basket samplers. The suction and multiple-plate counts are indicated as being significantly different than the basket in Table 5. The same relationship was evident in mid-stream Station 2 samples, but no statistically significant difference was shown. Although the basket samplers mean count of 2066.0 hydropsychids/m^2 was much greater than the suction and multiple-plate's counts of 269.3 and 297.7/ m^2, the difference was not significant due to the wide range of numbers found in the basket samplers which were as low as 28/m^2. Fewer hydropsychids were collected at Station 3, with the greatest mean value of 62.3/m^2 in the basket sampler. This value was significantly greater than 10.7 and 32.7/m^2 from the suction and multiple-plate, respectively.

Table 6 indicates that population estimates obtained from the suction sampler were quite sensitive to location variability. Mid-stream suction samples were significiantly greater than the corresponding near-shore samples. This is illustrated at Station 2, where the mid-stream value of 269.3/m^2 is compared to 18.7/m^2 from the near-shore samples. The multiple-plate samplers differed significantly due to location at Stations 1 and 2, but as shown in Table 6, locations with greater numbers alternated at each station. Therefore, conclusions could not be drawn as to the effect of location on the multiple-plate hydropsychid populations. No difference due to basket location was shown.

Variations in hydropsychid distributions have been well researched. Williams and Hynes (1973) studied the microdistribution and feeding habits of two hydropsychid caddisflies and identified a preference for the largest available substrate and strongest current. The study area's substrate ranged for 10 to 15 cm in diameter, with current velocities of 10 to 50 cm/sec. Edington (1969) tested current preference by altering

the flow regime of an area colonized by hydrospychids. The organisms actively recolonized areas of higher flow and abandoned sites where velocity decreased. Edington (1969) believes that velocity preference may in part be due to optimal operation of the caddisfly's feeding nets. The hydropsychids utilize silken capture nets for straining food particles from the current (Wiggins, 1977).

Substrate preference has also been related to the net structures. Mason et al. (1973) discusses the caddisfly's utilization of the junction between two spheres or crevices for net attachment. By stacking rocks inside a basket, more junction sites are provided per area samples. Rabeni and Gibbs (1978) found the basket to accumulate less organic matter on the more numerous rock intrices, thus providing an ideal site for net attachment.

Results from the present study reflect the observations of these researchers. The baskets were found to collect more hydropsychids than the other samplers. Observations by the Scuba diver verify the estimates provided by the suction and multiple-plate samplers. Hydropsychids were seen on the river bottom, but not in the proportions suggested by the basket sampler.

As in the case with Baetis sp., samples taken near-shore from a fast flowing river can be expected to underestimate the overall hydropsychid population when using the suction sampler. Evidence would indicate the same may be true for the multiple-plate, although more samples were required for statistical confirmation. The basket sampler populations were not effect by sampler location.

Ceraclea sp.

Ceraclea sp. was the dominant Trichoptera during the study. Ceraclea sp. is a caddisfly from the family Leptoceridae. The organism is easily identified by its long antenna, stout body and characteristic sand grain case. Unlike the sessile, filter feeding hydropsychids, Ceraclaea sp. is a more transient, collector-gatherer (Merrit and Cummins, 1978). Because of these differences, expected response to sampler type and location would differ from the hydropsychids. As can be seen in Figure 37, this is the case.

Graphical analysis in Figure 37 of the mid-stream samples indicate that the suction sampler collected greater numbers of Ceraclea sp. than did the basket or multiple-plate. Representative of this trend are the samples collected on 11/06/80 at Station 1 (Figure 37A). The suction samples contained the greatest number of Ceraclea sp. with a mean of 501.7/m^2 and a range of 320 to 649/m^2. The mean number of Ceraclea sp. in the basket samplers was less, but within the above range, with 375.3/m^2. The multiple plate collected 254.7/m^2. Although Figure 37 shows similar trends in most other sampler sets, the range (r) of numbers from each sampler overlap. Analysis of variance results in Table 5 reflect that relationship by indicating no difference in Ceraclea sp. populations based on sampler type due to large variation within samples. Near-shore samples also revealed no difference due sampler type.

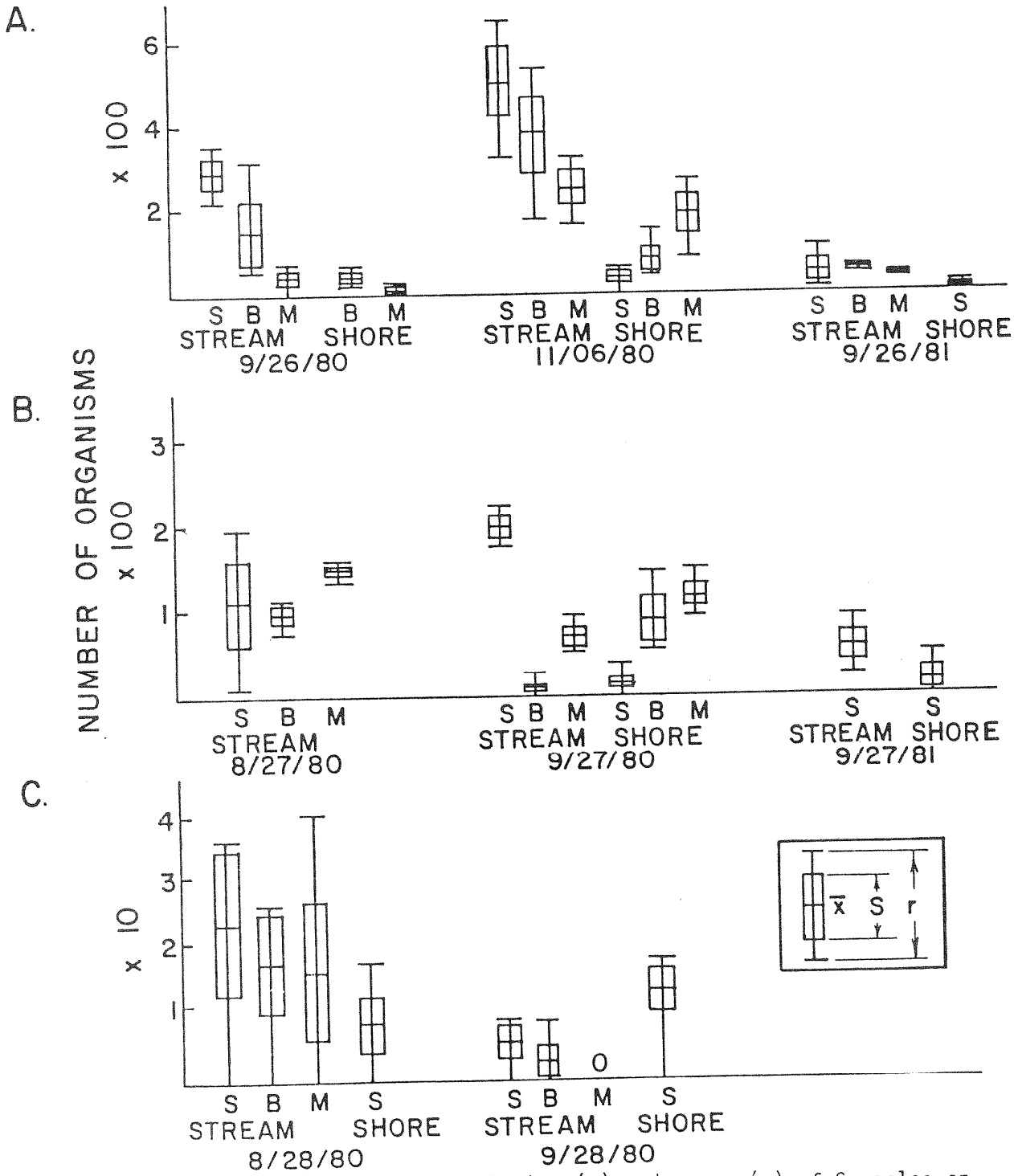

Figure 37. Mean ($\bar{x}$), standard deviation (s) and range (r) of Ceraclea sp. per m^2 collected from the suction (S), basket (B) and multiple-plate (M) samplers. A: Station 1, B: Station 2, C: Station 3

Location effect was evident in the suction samplers at Stations 1 and 2. Respective overall mean values for mid-stream and near-shore suction samples were 281.3 and 23.3/m² at Station 1 and 125.7 and 17.2/m² at Station 2. These values are different at the 0.05 level of significance (Table 6). Baskets had the same relationship at Station 1, but not at a significant level. Location had no effect on the multiple-plate sampler.

No information could be found concerning the effect of sampler type or location on the leptocerid caddisflies. The greatest numbers of Ceraclea sp. were from the suction samples taken at mid-stream, Station 1. The overall mean was 281.0/m², as compared to 125.7 and 15.7/m² at Stations 2 and 3, respectively. Increasing velocity measurements at these stations were seen to correlate with these decreasing numbers (Table 4). Contradicting that relationship is the preference for mid-stream locations at Stations 1 and 2. In that case it is difficult to determine factors influencing the organisms relative distribution.

The results do indicate that the basket and multiple-plate samplers provide reasonably accurate estimates of the Ceraclea sp. populations based on collections from the suction sampler. The suction sampler does show decreased populations close to shore, but such decreases are not detected by the basket or multiple-plate samplers.

Criptopus spp.

Cricotopus spp. are chironomids in the tribe Orthocladiini. Merrit and Cummins (1978) classify the organism's habitat as "lotic-erosional and depositional" and trophic relation as "collector-gatherers (detritus and algae)." Cricotopus spp. was by far the dominant organism in Station 2 and 3 mid-stream and Station 3 near-shore samples. A maximum of 15,094 Cricotopus spp./m² were collected by the basket sampler at Station 1.

Figure 38 indicates greater numbers of Cricotopus spp. had been collected by the basket sampler as compared to the suction sampler. Mid-stream samples in Figure 36A representing Station 1, showed significant differences based on sampler type. Overall mean number of Cricotopus spp. found in the basket, multiple-plate and suction samplers were 1366.1, 719.8 and 528.4/m² respectively. Values for the basket and multiple-plate samplers were equally greater at a significant level than the suction sampler (Table 5).

Similar results were obtained at Stations 2 and 3 as shown in Figure 36B and C. The overall mean number of Cricotopus spp. found in the basket sampler at Station 2 was 5080.7/m², with 3376.8 and 1952.2/m² in the multiple-plate and suction samplers, respectively. Large variation within samplers made these values equal according to the analysis of variance test results shown in Table 5. Station 3 samplers were related as above with 8825.7, 5763.7 and 1889.5 Cricotopus spp./m² in the respective basket, multiple-plate and suction samplers. From Figure 36 we would expect these mean values to be significantly different, but as indicated in Table 5, they were statistically equal. With only 2 sampling dates at Station 3, lack of sufficient data may account for this discrepancy. Pooled t-tests for location effect indicate that Cricotopus spp. population estimates are not affected by sampler location. Multiple-plate samplers at Station 2

were the only sets to show a difference due to the location at significant levels (Table 6). The mid-stream mean value of 3376.8/m² was significantly greater than the near-shore value of 972.0/m². Location had no effect on the Cricotopus spp. populations obtained from the basket or suction samplers.

When using artificial substrate samplers, particularly the basket type, inflated Cricotopus populations can be expected. Although not reflected in analysis of variance results, this is clearly indicated in Figure 37. Mason et al (1973) also found artificial substrate samplers to be bias for certain Cricotopus species. C. bicinctus and C. attenuatus selectively colonized the multiple-plate sampler, whereas C. exilus preferred the basket. Preference for the artificial substrate samplers can significantly effect the interpretation of the benthic community, especially when the organism is the dominant species. At Stations 2 and 3 8/27-28/80 samples, Cricotopus spp. comprised 83 and 95% of the basket populations compared to 62 and 81% on the natural substrate as indicated by the suction sampler. The basket samples over estimated the importance of Cricotopus spp. in the river.

Microtendipes pendellus

Microtendipes pendellus is a chironomid of the Chironomini tribe. Its habitat is classified as "lentic-littoral, lotic-depositional" and trophic relationship as "collector-filterers and gatherers" (Merrit and Cummins, 1978). M. pendellus was an important component of the Spokane River's benthic macroinvertebrate population, especially in the pool environment of Station 1. The organism made up as much as 86% of the suction sampled population on 9/26/80 at Station 1, with a mean of 9662/m² from replicated samples.

The dominance of Microtendipes pendellus was not shown in the basket or multiple-plate samplers, as evident in Figure 39. On the same date and station mentioned above, M. pendellus comprised 34 and 28% of the respective basket and multiple-plate populations, with a mean of 2,347 and 810 organisms/m² from replicated samples. Numbers of M. pendellus on the natural substrate, as indicated by suction samples, were significantly greater than those of the basket and multiple-plate samples at Station 1 and 2 mid-stream locations (Table 5). Near-shore populations were not effect by sampler type.

In Minshall and Minshall's (1977) study of the microdistribution of benthic organisms, a positive relationship was drawn between chironomids and detritus. Habitat characteristics by Merrit and Cummins (1978) indicate that M. pendellus prefers depositional environments where detrital accumulation is prevalent. Table 5 indicates that Station 1 and near-shore Station 2 offer such an environment, contrasted by the scouring environment at Station 3 where little colonization occurred. It seems the artificial substrate samplers did not supply this preferred habitat.

Low numbers in the basket and multiple-plate may have been due to their positioning. The multiple-plate sampler's hardboard plates were placed vertically on the river bottom, limiting detrital accumulation. By stacking rocks in the basket, a large portion of the available colonizable

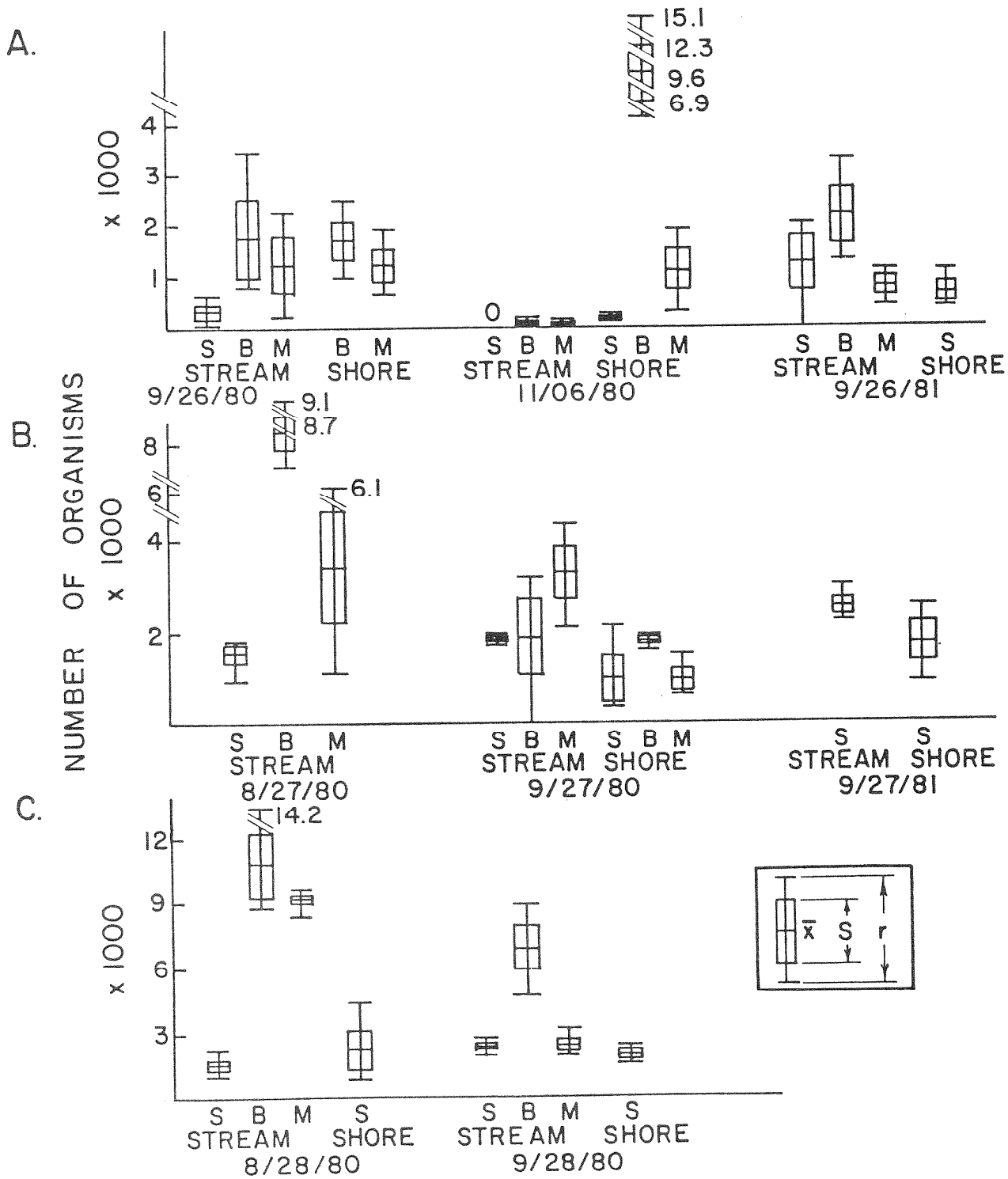

Figure 38. Mean ($\bar{x}$), standard deviation (s) and range (r) of *Cricotopus spp.* per m^2 collected from the suction (S), basket (B) and multiple-plate samplers. A: Station 1, B: Station 2, C: Station 3

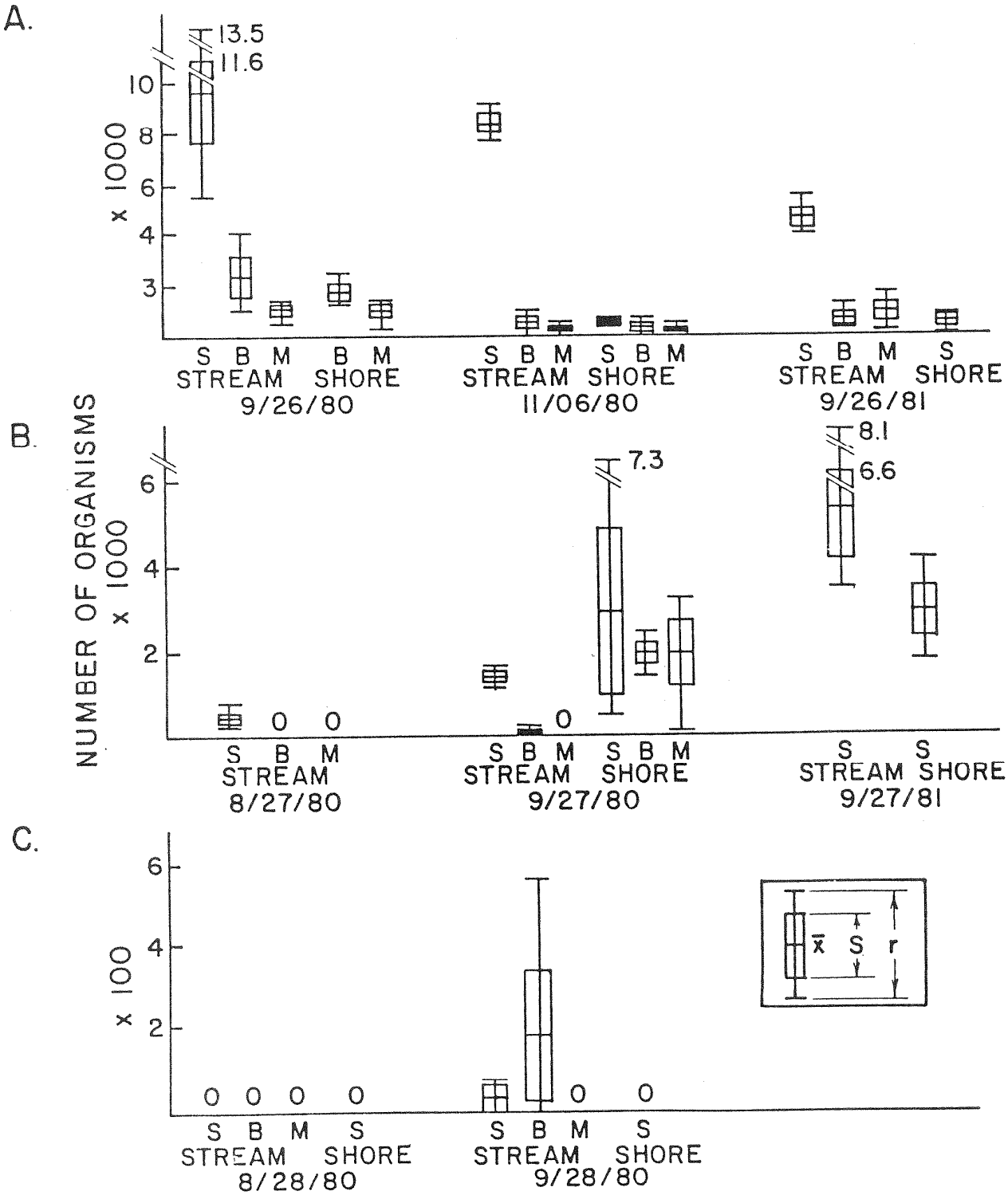

Figure 39. Mean (x̄), standard deviation (s) and range (r) of Microtendipes pendellus per m^2 collected from the suction (S), basket (B) and multiple-plate (M) samplers. A: Station 1. B: Station 2, C: Station 3

area is shielded from deposition by overlying rocks. Also, by placing the artificial substrates on top of the natural substrate, the samplers sat higher, exposed to increase velocities, thus limiting deposition.

M. pendellus populations from the suction sampler varied due to sampler location at Station 1. Table 6 shows the mid-stream overall mean of 7,679.6/m² was significantly greater than 536.2/m², the near-shore value. Other variations due to location were found in the basket and multiple-plate samples at Station 2. Mid-stream overall mean of 34.2/m² was significantly less than the near-shore mean of 1066.7/m² for the basket sampler. Mid-stream and near-shore multiple-plate values of 0.0 and 157.7/m² also differed significantly.

Total Number of Organisms

The relative response to total number of organisms to sampler type varied with station. At mid-stream Station 1, represented in Figure 40A, shows the suction sampler as having contained greater number of organisms. The overall means for total numbers in the suction sampler are 9456.6/m² significantly greater than 5899.8 and 2826.3/m² in the respective basket and multiple-plate samplers as shown in Table 5. At Station 2 mid-stream, the basket samples collected more individuals than the suction or multiple-plate sampler. The overall mean number of organisms in the basket was 8467.5 per m² compared to 5098.1 and 4301.0 for the suction and multiple-plate, although not at a statistically significant level. A similar preference for the basket sampler occurred at Station 3, but again was not shown statistically significant.

The response of total number of organisms was not greatly affected by sampler location. The suction sampler at Station 1 collect significantly greater numbers at mid-stream than near-shore, with 9456.6 and 2237.2/m², respectively. No other samples differed due to location. Other authors have found variable response to sampler type as indicated by total numbers. Wene and Wickliff (1940) found the basket sampler to be a more productive habitat compared to the natural substrate. Mason et al. (1973), comparing the multiple-plate to the basket sampler, also showed that the basket collected more organisms. The total number of organisms in the present study's samples were largely dictated by the dominant chironomid population. Comparing Figures 39 to 40A, it can be seen that M. pendellus was responsible for the greater numbers found in the suction sampler. Similarly, large Cricotopus spp. populations in basket samples at Stations 2 and 3 shown in Figures 38B and 38C are reflected in corresponding total numbers shown in Figures 40B and 40C. True differences in each sampler's respective population therefore is masked when analyzing total number of organisms only.

Macroinvertebrate Study Conclusions

The results of this study indicate that differences in sampler type and sampler location may create modified microhabitats available for colonization by the benthic macroinvertebrates, producing variations in the estimated populations in the Spokane River. The number of various

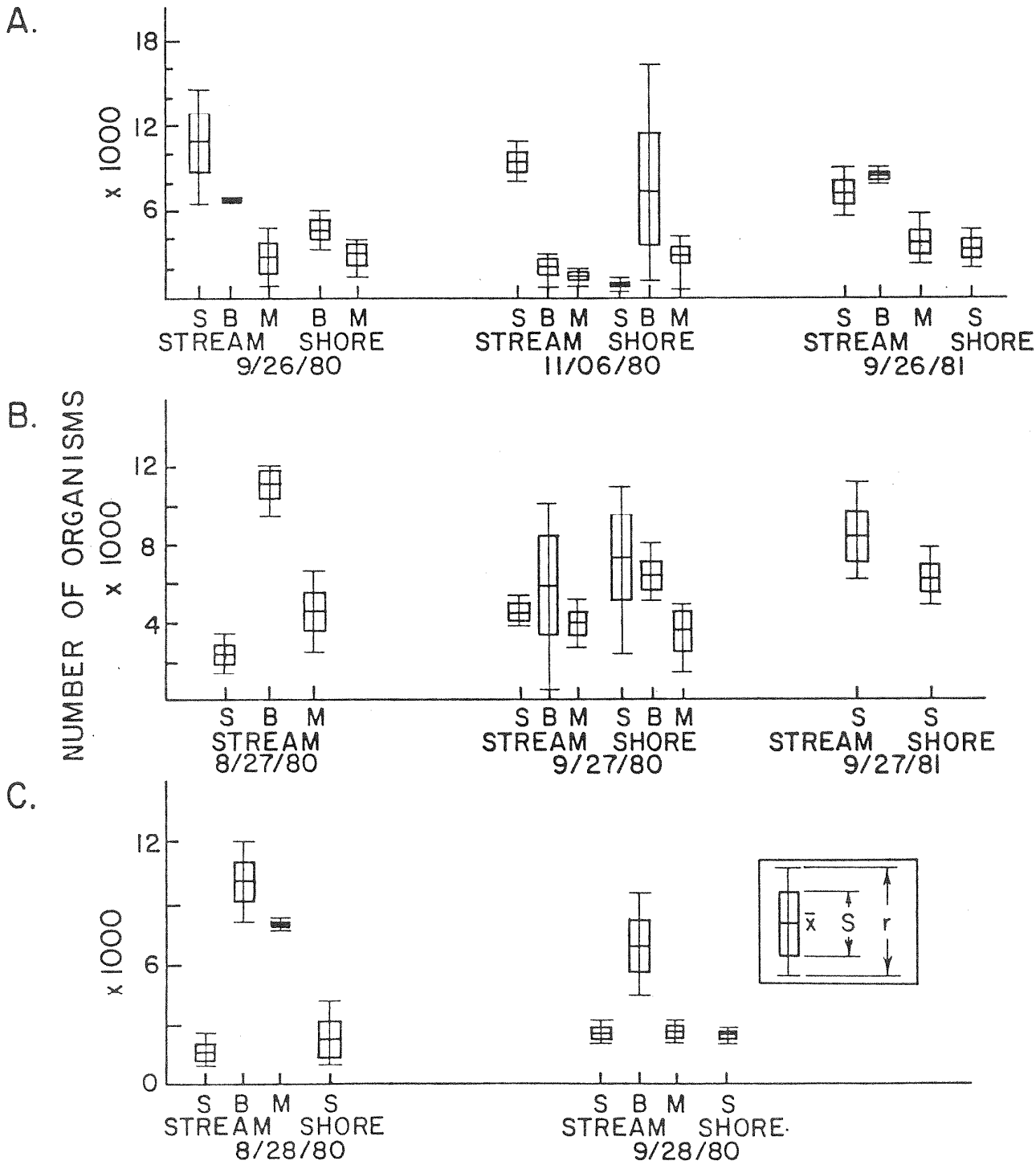

Figure 40. Mean ($\bar{x}$), standard deviation (s) and range (r) of total number of organisms per m^2 collected from the suction (S), basket (B) and multiple-plate (M) samplers. A: Station 1, B: Station 2, C: Station 3

organisms collected by the suction, basket and multiple-plate samplers were primarily determined by the ability of each sampler to provide the habitat preferred by the organisms. The rocks stacked in the basket sampler provided numerous attachment sites for the hydropsychid caddisflies as compared to the natural substrate, therefore enhancing colonization. Hydropsychids collected from the multiple-plate samplers more adequately represented the true population. The number of Ceraclea sp. found in both artificial substrate samplers corresponded well to those in the suction samplers. Chironomid populations were also affected by sampler type. Inflated Cricotopus spp. populations were found in the artificial substrate samplers, particularly the basket type. In depositional environments Microtendipes pendellus showed avoidance toward both the basket and multiple-plate samplers. Conflicting estimates of total number of organisms from the samplers were primarily due to fluctuations in the chironomid populations. The mayflies, represented by Baetis sp., showed avoidance toward the suction sampler. The correlation between number of organisms collected and the preference for higher velocities suggests that the basket and multiple-plate samples more closely represented the true baetid population.

In general, benthic macroinvertebrate populations decreased in the near-shore locations as compared to mid-stream. The best example of the shore effect was provided at Station 2 where velocity, detritus deposition and substrate size differential between near-shore and mid-stream was greatest. At this station, numbers of Baetis sp., Hydropsychidae and Cricotopus spp. were significantly greater in mid-stream samples than those near-shore. Microtendipes pendellus, was shown to prefer near-shore locations in all samplers.

As indicated, various estimates of the true benthic macroinvertebrate will be obtained, depending on sampler type and habitat. This is particularly true in a fast flowing river such as the Spokane River, where the rigorous sampling conditions limit the sampling methods available.

In studies where an estimation of the true population is required, a direct bottom sampler such as the suction sampler is required. Due to the avoidance of Baetis sp. to the intake nozzle the efficiency of the suction sampler should be tested before use in rivers with an abundance of mayflies. If artificial substrate samplers are to be used in such studies, it should be recognized the basket type sampler will inflate the importance of the hydropsychid population, and both the basket and multiple-plate may distort the chironomid population, depending upon localized environmental conditions.

Although the basket and multiple-plate samplers have been shown to contain bias for certain organisms, once recognized, these samplers are appropriate for other studies such as continuous monitoring, baseline and fisheries-related studies.

It is recommended that the investigator pay close attention to sampler placement. As shown here samples take at near-shore locations may provide a distorted view of the overall population in the river. In large rivers, where mid-stream placement of samplers by a Scuba diver is not feasible,

near-shore locations should be chosen such that velocity, detrital deposition and substrate size closely approximate that of the majority of the river.

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APPENDIX A

Table A-1. Spokane River Field Data. Expressed in mg/l; except Temp (°C) pH Cond (μMHOS CM^2 at 25°C) CO_2, CO_3 and HCO_3 (mg/l as $CaCO_3$)

STATIONS: ST=Stateline, HA=Harvard Above, HB=Harvard Below, BA=Barker, SU=Sullivan, EU=Euclid, PF= Plantes Ferry, UP=Upriver Drive, GR=Greene Street, GO=Gonzaga, HC=Hangman Creek.

DATE	STA	TEMP	PH	DO	CO_2	CO_3	HCO_3	COND
11/12/79	ST	7.5		11.1				
	HA	8.0		10.5				
	BA	8.2		11.1				
	SU	6.0		11.8				
	EU	7.0		11.4				
	PF	6.5		11.5				
	UP	6.5		11.5				
	GR	6.5		10.5				
	GO	6.0						
11/20/79	ST	6.0	6.6	11.3	2.0		22	70
	HA	6.2	6.5	11.3	2.0		21	60
	BA	6.0	6.4	12.1	1.0		21	65
	SU	6.0	6.4	11.8	2.0		21	60
	EU	6.0	6.8	11.5	1.0		33	90
	PF	6.0	7.1	12.0	2.5		44	100
	UP	6.0	6.4	11.5	2.5		35	100
	GR	6.5	6.8	11.2	2.5		48	115
	GO	6.2	7.1	11.8	0.5		49	115
	HC	5.5	7.7	13.9	0.5		49	120
12/04/79	ST	6.0	6.9	11.9	1.5		21	70
	HA	6.0	6.9	11.8	1.5		22	64
	BA	6.0	6.8	12.1	2.0		22	72
	SU	6.0	6.9	11.7	2.0		23	71
	EU	6.2	7.2	11.4	2.0		32	88
	PF	6.0	7.0	11.4	1.5		35	105
	UP	6.0	7.1	11.4	2.0		34	100
	GR	6.5	7.2	11.4	1.5		48	135
	GO	6.5	7.2	10.9	3.0		50	130
	HC	7.0	7.2	11.1	2.0		32	140

Table A-1. Spokane River Field Data - continued

DATE	STA	TEMP	PH	DO	CO_2	CO_3	HCO_3	COND
12/16/79	ST	2.0	6.7	12.1	2.0		20	65
	HA	2.0	6.9	12.0	1.0		20	70
	BA	2.5	6.7	12.6	1.0		21	70
	SU	2.5	7.0	12.6	1.5		19	75
	EU	4.0	7.2	12.2	2.0		30	100
	PF	3.5	7.2	12.3	1.5		34	105
	UP	3.5	6.9	11.9	1.0		32	105
	GR	4.0	7.2	11.1	1.5		49	140
	GO	4.5	6.9	11.2	1.0		49	140
	HC	4.5	6.8	11.6	1.0		50	140
01/04/80	ST	3.0	6.5	11.5	1.0		20	66
	HA	3.0	6.5	11.6	1.0		20	65
	BA	4.0	6.4	11.6	1.0		20	70
	SU	4.0	6.8	11.9	0.5		22	80
	EU	4.0	6.7	11.9	1.0		25	85
	PF	4.5	6.8	11.6	1.0		27	90
	UP	4.5	6.8	11.4	1.0		26	88
	GR	4.5	6.9	11.7	1.0		42	110
	GO	4.5	7.0	11.2	1.0		46	108
	HC	4.0	6.8	11.8	1.5		47	119
02/18/80	ST	3.0	7.2	12.5	1.0		19	56
	HA	3.0	7.2	12.5	1.0		18	55
	BA	3.5	7.1	12.7	1.0		19	54
	SU	4.0	7.0	12.2	1.0		22	58
	EU	4.5	7.0	12.0	1.0		31	77
	PF	4.2	7.2	11.9	1.0		29	78
	UP	4.0	7.1	11.9	1.0		30	82
	GR	4.0	7.1	11.7	1.0		39	98
	GO	3.5	7.1	11.8	1.0		43	101
	HC	2.8	7.1	11.8	1.0		45	98
03/05/80	ST	2.0	7.2	12.5	1.0		17	62
	HA	2.0	7.1	12.5	1.0		21	62
	BA	2.0	7.0	12.6	1.0		22	61
	SU	2.0	7.3	12.7	1.0		23	62
	EU	2.0	7.1	13.0	1.0		29	65
	PF	2.0	7.3	12.9	1.0		27	68
	UP	2.0	6.8	13.0	2.0		28	78
	GR	2.5	6.9	13.1	2.0		25	68
	GO	2.5	7.0	12.9	1.0		27	66
	HC	3.0	6.9	13.5	1.0		29	70

Table A-1. Spokane River Field Data - continued

DATE	STA	TEMP	PH	DO	CO_2	CO_3	HCO_3	COND
03/22/80	HA	4.5	6.3	11.9	1.0		22	61
	HB	4.5	6.6	11.6	1.0		22	60
	BA	4.5	7.1	11.7	1.0		27	62
	SU	4.5	6.7	11.7	1.0		25	60
	EU	4.5	6.7	11.6	1.0		29	71
	PF	4.5	7.1	11.4	2.0		30	70
	UP	4.5	7.2	11.2	1.0		28	63
	GR	4.5	7.1	12.5	1.0		31	72
	GO	4.0	7.1	11.6	1.0		29	78
	HC	4.0	7.1	13.2	1.0		29	72
04/04/80	HA	4.5	6.6	11.6	1.0		28	61
	HB	4.5	6.5	11.6	1.0		28	60
	BA	4.5	6.6	11.8	1.0		27	59
	SU	4.5	6.6	11.9	1.0		23	58
	EU	5.0	6.7	11.3	1.0		29	62
	PF	5.5	6.6	11.3	1.0		27	65
	UP	5.5	6.6	11.2	1.0		27	66
	GR	5.5	6.8	11.2	1.0		32	80
	GO	5.2	6.5	11.1	1.0		32	78
	HC	5.2	6.2	11.3	1.0		32	76
04/21/80	HA	6.0	7.0	12.7	1.0		24	58
	HB	6.0	7.1	12.9	1.0		22	58
	BA	6.0	7.0	12.3	1.0		23	59
	SU	6.0	6.9	12.7	1.0		23	54
	EU	6.5	7.1	12.5	1.0		24	55
	PF	6.0	7.0	12.4	1.0		24	59
	UP	6.0	6.9	12.2	1.0		23	58
	GR	6.5	6.9	12.1	1.0		24	58
	GO	6.5	6.9	12.0	1.0		24	63
	HC	7.0	6.8	13.2	1.0		25	62
05/14/80	HA	12.0	7.2	12.4	2.0		22	44
	HB	12.0	7.4	11.5	1.0		22	56
	BA	12.0	7.6	11.0	1.0		21	49
	SU	12.0	7.6	11.2	1.0		21	48
	EU	12.0	7.6	11.0	1.0		21	46
	PF	13.0	7.6	11.1	1.0		21	45
	UP	13.0	7.4	10.6	0.5		24	45
	GR	12.5	6.9	10.7	1.0		23	51
	GO	13.0	7.0	10.7	1.0		22	52
	HC	13.0	7.4	11.7	1.0		23	55

Table A-1. Spokane River Field Data - continued

DATE	STA	TEMP	PH	DO	CO_2	CO_3	HCO_3	COND
06/03/80	HA	12.5	6.3	10.4	1.0		21	44
	HB	12.5	6.5	10.6	1.0		22	44
	BA	12.0	6.5	10.2	1.0		23	44
	SU	12.0	6.3	10.5	1.0		22	43
	EU	12.0	6.2	10.3	1.0		21	43
	PF	12.0	6.2	10.4	1.0		22	44
	UP	12.0	6.3	10.4	1.0		24	42
	GR	12.0	6.1	10.3	1.0		24	45
	GO	12.0	6.2	10.2	1.0		23	40
	HC	12.0	6.5	12.1	1.0		24	47
06/18/80	HA	15.5	6.3	9.7	1.5		20	49
	HB	15.5	6.2	10.0	1.0		20	44
	BA	15.5	6.1	10.0	1.5		22	42
	SU	16.0	6.4	9.8	1.0		25	44
	EU	16.0	6.3	9.9	1.0		21	47
	PF	16.0	6.2	9.9	1.0		21	40
	UP	16.0	6.2	10.0	1.0		22	46
	GR	16.0	6.2	9.8	1.0		22	47
	GO	16.0	6.2	9.6	1.0		23	78
	HC	16.0	6.4	10.8	1.0		23	52
07/02/80	HA	19.0	6.1	8.9	1.0		22	48
	HB	19.0	6.1	8.8	1.0		22	47
	BA	19.0	6.3	8.9	1.0		21	81
	SU	19.0	6.1	8.8	1.0		23	55
	EU	18.0	6.2	8.8	1.5		30	69
	PF	18.0	6.6	8.9	1.0		32	69
	UP	18.0	6.2	9.0	1.0		31	70
	GR	18.0	6.0	9.0	0.5		40	75
	GO	18.0	6.4	9.2	0.5		42	75
	HC	18.0	6.3	9.5	1.0		42	95
07/16/80	HA	20.0	6.1	8.5	0.5		20	43
	HB	20.0	5.8	8.5	0.5		21	42
	BA	20.0	5.9	8.6	0.5		21	47
	SU	20.0	5.7	8.5	0.5		21	45
	EU	18.5	6.1	8.5	1.0		33	69
	PF							
	UP	18.0	5.9	8.4	1.0		30	64
	GR	18.0	6.0	8.0	0.5		39	84
	GO	18.0	6.2	8.1	1.0		38	88
	HC	18.0	5.6	8.5	1.0		38	92

Table A-1. Spokane River Field Data - continued

DATE	STA	TEMP	PH	DO	CO_2	CO_3	HCO_3	COND
07/29/80	HA	23.0	6.4	7.9	0.5		23	57
	HB	23.0	6.4	8.2	0.5		23	57
	BA	23.0	6.9	8.0	0.5		22	55
	SU	23.0	6.9	8.3	0.5		23	50
	EU	22.0	7.2	8.3	0.5		39	70
	PF	22.0	7.6	8.7	0.5		42	83
	UP	22.5	7.0	8.3	0.5		43	89
	GR	22.5	7.8	8.3	0.5		55	100
	GO	22.0	8.4	9.6		5.0	54	105
	HC	22.5	8.4	9.3		6.0	54	105
08/12/80	HA	23.0	6.9	8.6	1.0		21	47
	HB	23.0	6.9	8.7	1.0		25	49
	BA	23.0	6.9	8.6	1.0		23	51
	SU	22.0	7.2	8.8	1.0		29	47
	EU	18.0	6.6	8.9	1.0		62	119
	PF	18.0	6.8	8.8	1.0		58	116
	UP	19.0	6.9	8.7	1.0		65	117
	GR	16.5	6.7	8.6	1.0		87	163
	GO	16.0	6.9	8.2	1.0		89	166
	HC	16.0	7.5	8.9	1.0		85	163
08/26/80	HA	18.5	7.0	8.4	1.0		22	56
	HB	18.5	6.8	7.8	1.0		23	57
	BA	19.0	7.0	8.0	1.0		23	59
	SU	18.5	7.1	8.1	1.0		24	54
	EU	16.0	7.1	8.5	1.0		56	115
	PF	16.5	7.3	8.9	1.0		57	125
	UP	17.0	7.3	8.6	1.0		55	122
	GR	17.0	7.2	8.5	1.0		65	145
	GO	16.5	8.4	8.7		4.0	65	155
	HC	16.5	8.4	8.7		7.0	62	135
09/09/80	HA	18.5	6.2	8.8	0.5		21	49
	HB	18.5	6.0	9.2	1.0		24	49
	BA	18.0	6.2	9.1	1.0		24	49
	SU	17.5	6.3	8.9	1.0		23	52
	EU	15.0	5.6	9.3	1.0		34	74
	PF	16.0	6.3	9.6	0.5		35	80
	UP	16.5	6.2	8.2	1.0		31	79
	GR	16.5	6.3	9.4	1.0		49	102
	GO	15.5	6.1	8.6	1.0		49	109
	HC	15.5	5.4	8.6	1.0		51	120

Table A-1. Spokane River Field Data - continued

DATE	STA	TEMP	PH	DO	CO_2	CO_3	HCO_3	COND
09/24/80	HA	16.0	6.4	9.5	1.0		28	48
	HB	16.0	6.3	9.8	1.0		23	51
	BA	15.0	6.7	9.5	1.5		24	45
	SU	14.5	6.2	9.8	1.0		24	46
	EU	14.0	6.3	9.8	1.0		34	73
	PF	15.0	6.5	9.8	0.5		34	80
	UP	15.0	6.6	8.6	0.5		36	82
	GR	13.0	6.4	9.5	1.0		49	105
	GO	12.5	6.6	9.8	1.0		49	106
	HC	12.5	6.8	8.3	1.0		50	110
10/10/80	HA	11.0	5.5	8.3	1.0		23	55
	HB	11.5	5.6	9.1	0.5		19	52
	BA	13.0	5.9	9.3	1.0		20	55
	SU	12.5	5.5	9.3	1.5		17	52
	EU	12.5	6.0	9.5	1.0		31	78
	PF	13.0	6.0	10.2	1.0		36	79
	UP	13.0	6.2	9.6	1.0		36	79
	GR	12.5	6.2	9.5	0.5		49	105
	GO	12.5	6.2	9.8	1.0		47	107
	HC	12.5	6.2	10.2	1.0		48	106
11/14/80	HA	7.5	6.5	11.3	0.5		22	67
	HB	7.5	7.1	11.4	0.5		24	66
	BA	7.5	7.0	11.5	1.0		24	64
	SU	7.5	7.1	11.3	1.0		24	67
	EU	7.0	7.1	11.0	1.0		31	84
	PF	7.0	7.0	10.9	1.0		39	88
	UP	7.0	7.0	10.6	1.0		32	106
	GR	7.0	6.9	10.5	1.0		43	117
	GO	7.0	7.2	10.4	1.0		45	114
	HC	7.0	7.2	10.4	1.5		44	112
12/17/80	HA	5.0	6.0	11.1	1.5		22	63
	HB	5.0	6.0	11.0	1.5		22	61
	BA	5.0	6.0	11.2	1.0		23	61
	SU	5.0	6.0	11.6	1.0		24	66
	EU	5.0	6.0	11.4	1.0		27	79
	PF	5.0	6.0	11.4	1.0		30	82
	UP	5.0	6.1	11.0	1.0		30	78
	GR	5.0	6.1	10.8	1.0		34	101
	GO	5.0	6.1	10.8	1.0		39	105
	HC	5.0	6.1	11.4	1.0		42	101

Table A-1. Spokane River Field Data - continued

DATE	STA	TEMP	PH	DO	CO_2	CO_3	HCO_3	COND
01/20/81	HA	4.0	6.3	12.0	1.0		21	61
	HB	4.0	6.3	11.8	1.0		21	61
	BA	4.0	6.5	11.9	1.0		23	62
	SU	4.0	6.5	12.0	1.0		24	65
	EU	4.0	6.7	11.7	1.0		25	71
	PF	4.0	6.7	11.6	1.0		25	71
	UP	4.0	6.8	11.6	1.5		25	75
	GR	4.0	6.9	11.5	1.0		28	86
	GO	4.0	6.9	11.6	1.0		30	86
	HC	4.0	6.9	12.8	1.0		30	84
02/26/81	HA	4.0	6.2	13.1	2.0		27	63
	HB	4.0	6.3	13.1	1.5		22	64
	BA	4.0	6.3	12.9	1.5		21	59
	SU	4.0	6.4	13.1	1.5		23	63
	EU	4.0	6.2	13.0	1.5		23	65
	PF	4.0	6.3	12.9	1.5		22	60
	UP	4.0	6.3	13.0	1.5		22	55
	GR	4.0	6.4	13.0	1.0		22	62
	GO	4.0	6.2	13.0	1.0		23	60
	HC	4.0	6.4	13.0	1.0		23	61
03/27/81	HA	5.5	5.7	12.4	1.0		25	57
	HB	5.5	5.8	12.4	1.0		20	61
	BA	5.5	5.8	12.6	1.5		35	58
	SU	5.5	5.8	12.5	1.0		25	62
	EU	5.5	5.8	11.7	1.0		20	62
	PF	5.5	5.9	12.1	1.0		20	63
	UP	5.0	6.0	11.5	1.0		25	64
	GR	5.5	6.1	12.1	0.5		25	72
	GO	5.5	6.0	12.1	1.5		40	67
	HC	5.0	6.1	13.7	1.5		35	67
04/16/81	HA	6.0	6.4	12.0	1.0		35	61
	HB	6.0	6.4	12.4	0.5		35	61
	BA	6.0	6.4	12.0	1.0		25	55
	SU	6.5	6.4	12.1	1.0		30	60
	EU	6.5	6.4	12.0	1.0		25	61
	PF	6.0	6.4	12.5	1.0		25	68
	UP	6.0	6.4	12.3	1.0		25	60
	GR	6.5	6.4	12.0	1.0		30	62
	GO	6.0	6.4	12.0	1.0		30	71
	HC	6.0	6.4	13.5	1.0		25	71

Table A-1. Spokane River Field Data - continued

DATE	STA	TEMP	PH	DO	CO_2	CO_3	HCO_3	COND
04/30/81	HA	7.0	6.3	12.6	1.0		26	62
	HB	7.0	6.2	12.6	1.0		24	60
	BA	7.0	6.2	12.4	1.0		24	56
	SU	7.0	6.4	12.6	1.0		21	60
	EU	7.0	6.3	12.6	1.0		26	60
	PF	7.0	6.3	12.0	1.0		23	56
	UP	7.0	6.1	12.0	1.0		15	52
	GR	6.0	6.2	12.0	1.0		22	64
	GO	6.0	6.2	12.0	1.0		23	52
	HC	6.0	6.2	13.3	1.0		27	59
05/19/81	HA	11.0	6.6	10.5	1.5		19	70
	HB	11.0	6.5	10.8	1.0		21	67
	BA	11.0	6.3	11.0	1.0		20	53
	SU	11.0	6.4	10.5	1.0		21	53
	EU	11.0	6.3	10.8	1.0		22	53
	PF	11.0	6.3	10.9	1.0		22	55
	UP	11.5	6.4	10.7	1.0		25	57
	GR	10.5	6.3	10.7	1.0		26	77
	GO	11.0	6.3	10.8	1.0		26	65
	HC	10.5	6.9	12.0	1.0		32	68
06/05/81	HA	15.5	6.4	9.8	1.0		23	49
	HB	15.0	6.3	10.0	1.0		21	54
	BA	15.0	6.3	9.7	1.0		23	50
	SU	15.5	6.2	9.8	1.0		23	50
	EU	14.5	6.2	9.8	1.0		26	59
	PF	14.5	6.3	10.1	1.0		27	66
	UP	14.0	6.3	9.7	1.0		27	68
	GR	14.5	6.4	9.7	1.0		34	79
	GO	14.5	6.3	9.8	1.5		35	83
	HC	14.5	6.2	10.3	1.0		32	80
06/11/81	HA	13.5	6.4	10.1	1.5		24	47
	HB	13.0	6.5	10.4	1.5		21	50
	BA	13.0	6.5	9.9	1.5		19	51
	SU	13.5	6.6	10.1	1.5		24	53
	EU	13.5	6.4	10.6	1.5		26	56
	PF	13.5	6.5	10.1	1.0		22	55
	UP	13.5	6.5	10.5	1.0		23	56
	GR	14.0	6.5	10.3	1.0		24	60
	GO	14.0	6.5	10.5	1.0		24	56
	HC	13.5	6.5	11.3	1.5		24	63

Table A-1. Spokane River Field Data - continued

DATE	STA	TEMP	PH	DO	CO_2	CO_3	HCO_3	COND
06/25/81	HA	15.0	6.6	10.5	1.5		25	54
	HB	15.0	6.6	10.3	2.0		24	54
	BA	15.0	6.4	10.5	1.5		24	54
	SU	14.5	6.5	11.0	1.0		21	52
	EU	14.0	6.6	10.4	1.5		24	55
	PF	14.0	6.5	10.4	1.5		25	56
	UP	14.0	6.6	9.5	1.5		21	58
	GR	13.5	6.5	9.8	1.5		25	58
	GO	13.5	6.5	10.0	1.5		22	61
	HC	13.5	6.5	11.5	1.5		17	64
07/09/81	HA	17.0	6.8	9.0	1.5		26	56
	HB	17.0	6.9	8.8	1.5		26	56
	BA	17.0	6.9	9.0	2.0		26	57
	SU	17.0	6.8	8.8	1.5		26	55
	EU	16.5	6.9	8.7	2.0		39	97
	PF	16.5	6.9	9.2	2.0		32	70
	UP	16.0	6.9	9.3	1.5		29	64
	GR	16.5	7.0	9.2	1.0		35	84
	GO	16.5	7.0	9.6	1.5		37	83
	HC	16.5	6.8	9.7	0.6		39	82
07/24/81	HA	20.0	7.0	8.4	1.5		22	132
	HB	20.0	6.8	8.3	1.0		22	57
	BA	20.0	6.9	8.8	2.0		22	52
	SU	20.0	6.9	8.5	1.5		27	57
	EU	17.5	7.0	8.4	1.5		44	97
	PF	18.0	7.1	8.6	1.0		46	105
	UP	18.0	7.0	8.0	1.5		47	105
	GR	17.5	7.1	8.5	1.5		55	124
	GO	17.5	7.0	8.8	1.5		60	127
	HC	18.0	6.9	8.5	1.0		58	124
08/06/81	HA	22.0	7.7	7.7	1.5		26	57
	HB	21.5	7.7	8.5	1.5		27	56
	BA	22.0	7.8	8.1	1.5		26	60
	SU	22.0	7.9	8.6	1.5		29	59
	EU	20.0	8.1	8.2	1.5		45	85
	PF	20.0	8.2	9.0	1.5		45	98
	UP	20.0	7.9	8.1	1.0		44	100
	GR	20.0	8.3	8.4	1.0		65	120
	GO	19.0	8.5	9.5		1.5	60	120
	HC	19.0	8.5	9.4		1.5	70	128

Table A-1. Spokane River Field Data - continued

DATE	STA	TEMP	PH	DO	CO_2	CO_3	HCO_3	COND
08/25/81	HA	23.0	8.4	8.6		0.5	25	60
	HB	23.5	8.4	8.7		0.5	26	57
	BA	23.0	8.0	7.5	1.0		30	49
	SU	22.0	7.7	7.5	1.0		25	64
	EU	17.0	7.9	8.6	2.0		71	138
	PF	18.0	7.7	8.5	2.0		65	144
	UP	19.0	7.8	10.1	1.0		64	142
	GR	16.0	7.9	8.5	1.5		87	178
	GO	16.0	7.8	7.8	2.0		85	178
	HC	16.0	7.9	8.1	1.0		84	184
09/03/81	HA	19.0	7.2	8.7	1.5		23	60
	HB	18.5	7.2	8.4	1.5		21	62
	BA	19.0	7.1	8.8	1.5		25	58
	SU	19.0	7.0	8.5	1.0		25	60
	EU	16.0	7.3	8.7	1.5		66	130
	PF	17.5	7.8	9.3	1.0		68	139
	UP	18.5	7.6	8.7	0.5		65	138
	GR	15.0	7.5	8.8	0.5		94	180
	GO	16.0	7.7	9.5	1.0		89	179
	HC	16.0	8.4	8.5		1.0	88	166
09/24/81	HA	16.5	6.9	9.2	1.0		25	60
	HB	16.5	6.6	9.5	1.0		25	60
	BA	16.5	6.7	9.5	1.0		25	58
	SU	15.5	6.5	9.0	0.5		26	65
	EU	14.5	6.9	9.0	1.0		37	84
	PF	14.5	6.8	9.6	1.0		36	87
	UP	15.5	6.4	8.8	1.5		40	91
	GR	14.0	6.8	9.0	1.5		52	117
	GO	14.0	6.8	8.2	1.5		54	126
	HC	14.0	6.4	8.5	1.0		55	126
11/03/81	HA	9.5	6.7	9.7	1.0		20	59
	HB	9.5	6.7	10.2	2.2		24	52
	BA	9.5	6.7	10.2	1.0		21	66
	SU	10.0	6.4	10.5	1.5		23	54
	EU	9.5	6.5	10.3	1.5		30	72
	PF	10.0	6.6	10.3	1.5		28	83
	UP	10.0	6.5	10.3	1.5		35	53
	GR	10.0	6.6	10.0	1.5		41	94
	GO	10.0	6.7	10.5	1.5		50	107
	HC	9.5	6.7	10.5	1.5		46	134

Table A-2. Spokane River Chemistry Data. Expressed in mg/l.

STATIONS: ST=Stateline, HA=Harvard Above, HB=Harvard Below, BA=Barker, SU=Sullivan, EU=Euclid, PF=Plantes Ferry, UP=Upriver Drive, GR=Greene Street, GO=Gonzaga, HC=Hangman Creek.

DATE	ST	TP	TSP	SRP	NH3-N	NO3-N	NO2-N	TKN	CL	COD	BOD	TSS	VSS
11/06/79	ST	.021	.007	.007	<0.01	<0.02	<0.01	0.12	0.4	4.0		4.0	1.2
	HA	.022	.007	.007	<0.01	<0.02	<0.01	0.14	0.4	4.2		7.1	1.8
	BA	.010	.009	.008	<0.01	<0.02	<0.01	0.11	0.4	4.5		3.1	2.4
	SU	.018	.006	.006	<0.01	<0.02	<0.01	0.11	0.4	4.3		4.0	1.2
	EU												
	PF	.020	.011	.009	<0.01	0.060	<0.01	0.13	0.7	4.0		2.9	1.0
	UP	.018	.006	.004	<0.01	0.085	<0.01	0.18	0.8	4.3		5.5	1.2
	GR	.018	.006	.006	<0.01	0.120	<0.01	0.10	0.8	3.2		4.8	1.7
	GO	.017	.011	.008	<0.01	0.120	<0.01	0.10	0.8	3.2		4.3	1.2
	HC												
11/12/79	ST	.019	.017	.001	<0.01	<0.02	<0.01	0.12	0.4	3.8		2.9	0.7
	HA	.022	.021	.002	<0.01	<0.02	<0.01	0.11	0.4	4.0		5.4	2.0
	BA	.019	.017	.006	<0.01	<0.02	<0.01	0.14	0.4	4.0		5.4	2.7
	SU	.018	.017	.002	<0.01	<0.02	<0.01	0.11	0.4	4.0		5.4	1.8
	EU	.018	.016	.001	<0.01	0.090	<0.01	0.12	0.6	3.5		5.4	1.8
	PF	.018	.017	.007	<0.01	0.140	<0.01	0.12	0.7	4.0		5.7	2.1
	UP	.013	.012	.006	<0.01	0.100	<0.01	0.12	0.6	4.2		5.7	2.1
	GR	.017	.012	.006	<0.01	0.230	<0.01	0.18	0.8	3.8		6.8	3.6
	GO	.014	.012	.007	<0.01	0.240	<0.01	0.17	0.8	3.8		5.9	1.6
	HC												
11/20/79	ST	.017	.003	.002	<0.01	<0.02	<0.01	0.13	0.4	4.8	0.9	2.6	2.1
	HA	.022	.004	.004	<0.01	<0.02	<0.01	0.11	0.4	4.3	1.1	2.1	1.6
	BA	.017	.007	.002	<0.01	0.034	<0.01	0.13	0.4	4.5	1.3	1.6	1.4
	SU	.016	.004	<.001	<0.01	0.024	<0.01	0.11	0.4	4.3	1.0	2.1	1.3
	EU	.021	.008	<.001	<0.01	0.11	<0.01	0.13	0.7	4.0	2.5	2.1	1.3
	PF	.019	.008	.003	<0.01	0.20	<0.01	0.14	0.8	4.2	3.1	3.0	2.5
	UP	.016	.008	.004	<0.01	0.13	<0.01	0.12	0.7	4.2	2.9	1.0	0.4
	GR	.036	.012	.001	<0.01	0.35	<0.01	0.15	0.9	3.7	1.9	0.9	0.4
	GO	.024	.016	.010	<0.01	0.31	<0.01	0.13	0.9	3.5	1.4	1.1	1.0
	HC	.024	.017	.012	<0.01	1.76	<0.01	0.11	1.0	4.2	2.4	2.5	2.0
12/04/79	ST	.023	.009	.009	<0.01	0.069	<0.01	0.11	0.5	5.3	1.1	2.7	1.4
	HA				<0.01	0.039	<0.01	0.11	0.5	5.4	1.3	2.7	1.8
	BA	.025	.008	.007	<0.01	0.062	<0.01	0.11	0.6	6.1	1.3	2.7	1.3
	SU	.052	.020	.007	<0.01	0.23	<0.01	0.12	0.5	5.6	0.9	3.6	0.9
	EU	.018	.008	.008	<0.01	0.19	<0.01	0.10	0.7	4.5	1.0	2.7	1.8
	PF	.025	.009	.009	<0.01	0.16	<0.01	0.12	0.9	4.6	1.5	2.5	2.1
	UP	.019	.008	.008	<0.01	0.30	<0.01	0.11	0.8	5.4	1.3	2.9	0.7
	GR	.020	.008	.008	<0.01	0.62	<0.01	0.09	0.9	4.6	1.6	1.4	1.3
	GO	.018	.006	.005	<0.01	0.30	<0.01	0.11	1.0	4.6	1.7	3.6	1.3
	HC	.033	.013	.012	0.026	0.32	<0.01	0.16	1.2	4.7	1.3	2.4	2.3

Table A-2. Spokane River Chemistry Data - continued

DATE	ST	TP	TSP	SRP	NH3-N	NO3-N	NO2-N	TKN	CL	COD	BOD	TSS	VSS
12/16/79	ST	.015	.012	.010	0.014	0.059	<0.01	0.14	0.4	4.1	0.6	3.1	0.7
	HA	.017	.013	.011	0.011	0.058	<0.01	0.13	0.4	4.0	1.3	2.1	0.2
	BA	.014	.013	.010	0.010	0.052	<0.01	0.11	0.4	3.8	1.4	2.6	1.3
	SU	.016	.015	.009	<0.01	0.053	<0.01	0.16	0.4	3.8	1.5	4.8	4.3
	EU	.014	.014	.011	<0.01	0.14	<0.01	0.16	0.7	3.3	0.5	2.1	0.2
	PF	.018	.016	.015	0.010	0.18	<0.01	0.15	0.8	3.8	0.9	1.5	0.6
	UP	.014	.013	.010	<0.01	0.16	<0.01	0.15	0.8	2.9	1.4	4.8	0.2
	GR	.013	.012	.011	<0.01	0.29	<0.01	0.15	0.9	3.0	0.9	1.2	0.2
	GO	.013	.012	.010	<0.01	0.30	<0.01	0.15	0.9	2.2	0.4	2.9	1.1
	HC	.014	.012	.011	<0.01	0.29	<0.01	0.17	0.9	2.2	0.9	5.5	1.2
01/04/80	ST	.011	.010	.005	0.010	0.17	<0.01	0.10	0.7	3.0	1.4	1.8	1.6
	HA	.018	.010	.004	0.010	0.078	<0.01	0.11	0.5	3.0	1.2	3.8	1.9
	BA	.023	.008	.006	<0.01	0.070	<0.01	0.11	0.4	3.4	0.6	3.3	2.2
	SU	.018	.009	.006	<0.01	0.062	<0.01	0.13	2.4	4.0	0.9	2.9	1.7
	EU	.011	.010	.007	<0.01	0.14	<0.01	0.12	1.1	4.6	0.9	4.1	1.7
	PF	.013	.012	.008	<0.01	0.12	<0.01	0.14	0.5	4.3	0.4	2.9	2.6
	UP	.048	.021	.003	<0.01	0.50	<0.01	0.12	0.7	4.5	1.6	4.0	2.9
	GR	.011	.010	.002	<0.01	0.24	<0.01	0.14	0.9	4.5	1.1	2.9	2.7
	GO	.011	.010	.003	<0.01	0.37	<0.01	0.15	0.8	3.8	0.7	2.7	2.3
	HC	.011	.010	.005	<0.01	0.36	<0.01	0.10	0.6	3.3	1.0	6.1	2.9
02/18/80	ST	.015	.009	.007	<0.01	0.12	<0.01	0.11	0.4	4.1	0.7	0.9	0.4
	HA	.018	.017	.009	<0.01	0.10	<0.01	0.09	0.4	6.4	0.5	1.2	0.5
	BA	.025	.012	.009	<0.01	0.10	<0.01	0.11	0.4	3.8	0.7	0.5	0.4
	SU	.018	.012	.009	<0.01	0.12	<0.01	0.10	0.4	3.8	0.4	2.4	1.0
	EU	.017	.012	.009	0.016	0.12	<0.01	0.17	0.7	4.0	0.8	1.1	0.7
	PF	.023	.017	.013	<0.01	0.21	<0.01	0.10	0.8	4.1	0.3	1.3	0.9
	UP	.017	.009	.008	<0.01	0.21	<0.01	0.13	0.8	4.8	2.3	0.5	0.4
	GR	.023	.013	.009	<0.01	0.26	<0.01	0.11	0.9	4.6	0.8	0.7	0.5
	GO	.015	.010	.004	<0.01	0.28	<0.01	0.08	0.9	3.8	0.6	2.4	1.0
	HC	.021	.011	.008	<0.01	0.27	<0.01	0.10	0.9	4.0	0.5	0.5	0.2
03/05 80	ST	.018	.004	<.001	<0.01	0.090	<0.01	0.10	0.4	4.6	0.9	3.3	1.6
	HA	.017	.003	<.001	<0.01	0.11	<0.01	0.10	0.4	4.5	1.0	2.9	1.2
	BA	.017	.004	<.001	<0.01	0.11	<0.01	0.10	0.5	4.6	0.7	0.5	0.2
	SU	.021	.004	<.001	<0.01	0.20	<0.01	0.11	0.5	4.3	1.3	3.6	1.2
	EU	.017	.013	<.001	<0.01	0.090	<0.01	0.09	0.5	4.0	1.5	0.5	0.2
	PF	.020	.005	<.001	<0.01	0.15	0.016	0.09	0.5	4.6	1.2	2.4	0.7
	UP	.022	.006	.002	<0.01	0.092	<0.01	0.10	0.5	3.7	1.9	0.5	0.2
	GR	.019	.006	.002	<0.01	0.12	<0.01	0.13	1.0	4.5	1.7	2.4	1.2
	GO	.021	.004	.001	<0.01	0.12	<0.01	0.10	0.7	4.1	1.3	2.7	1.1
	HC	.037	.006	.001	<0.01	0.13	<0.01	0.13	0.6	4.0	2.0	0.5	0.2
03/22/80	HA	.033	.008	.002	<0.01	0.076	<0.01	0.14	0.5	4.8	0.3	2.9	1.9
	HB	.014	.013	.002	<0.01	0.071	<0.01	0.11	0.5	4.3	0.1	1.9	1.8
	BA	.016	.006	.003	<0.01	0.077	<0.01	0.12	0.5	4.6	0.1	1.4	1.2
	SU	.017	.008	<.001	<0.01	0.063	<0.01	0.12	0.5	4.8	0.1	2.7	1.1
	EU	.014	.008	.001	<0.01	0.13	<0.01	0.12	0.5	4.3	0.1	4.6	3.6
	PF	.023	.005	<.001	<0.01	0.11	<0.01	0.13	1.4	4.5	0.0	2.5	1.2
	UP	.023	.006	.001	<0.01	0.089	<0.01	0.13	0.5	4.5	0.6	2.2	2.3
	GR	.016	.005	<.001	<0.01	0.42	<0.01	0.13	0.6	4.3	1.1	3.9	2.0
	GO	.017	.009	.002	<0.01	0.19	<0.01	0.13	0.6	4.3	0.1	1.7	1.5
	HC	.017	.005	.002	<0.01	0.14	<0.01	0.13	0.6	4.1	1.5	6.0	3.7

Table A-2. Spokane River Chemistry Data - continued

DATE	ST	TP	TSP	SRP	NH3-N	NO3-N	NO2-N	TKN	CL	COD	BOD	TSS	VSS
04/04/80	HA	.019	.002	.001	<0.01	0.093	<0.01	0.13	0.4	4.1	0.4	0.0	0.0
	HB	.020	.002	.001	<0.01	0.091	<0.01	0.17	0.4	4.5	0.3	1.0	0.4
	BA	.016	.003	.001	<0.01	0.10	<0.01	0.14	0.4	4.3	0.5	1.0	0.7
	SU	.021	.003	.002	<0.01	0.089	<0.01	0.15	0.4	4.5	0.8	1.4	0.3
	EU	.022	.004	.003	<0.01	0.12	<0.01	0.14	0.5	4.5	0.3	1.5	0.1
	PF	.020	.003	.001	<0.01	0.12	<0.01	0.14	0.6	4.6	0.5	0.3	0.1
	UP	.018	.001	.001	<0.01	0.12	<0.01	0.14	0.5	4.6	0.9	0.9	0.8
	GR	.017	.003	001	<0.01	0.16	<0.01	0.13	0.6	5.0	0.2	0.7	0.2
	GO	.018	.002	.001	<0.01	0.16	<0.01	0.19	0.6	5.0	0.6	0.4	0.2
	HC	.017	.001	.001	<0.01	0.17	<0.01	0.14	0.6	5.1	0.0	1.6	0.6
04/21/80	HA	.042	.001	.001	<0.01	0.063	<0.01	0.19	0.4	5.3	1.5	4.4	1.2
	HB	.029	.002	.001	<0.01	0.055	<0.01	0.20	0.4	5.6	1.4	4.7	3.0
	BA	.043	.002	.001	0.015	0.037	<0.01	0.20	0.4	4.8	0.7	7.8	2.5
	SU	.036	.001	.001	<0.01	0.058	<0.01	0.20	0.4	4.8	1.3	6.5	1.7
	EU	.033	.003	.003	<0.01	0.070	<0.01	0.19	0.4	5.3	1.1	6.5	2.0
	PF	.028	.002	.001	<0.01	0.230	<0.01	0.19	0.4	5.3	1.2	4.8	1.2
	UP	.032	.004	.001	<0.01	0.630	<0.01	0.19	0.4	4.8	1.1	3.4	1.4
	GR	.032	.001	.001	<0.01	0.060	<0.01	0.18	0.4	5.1	1.2	6.5	2.8
	GO	.038	.003	.001	<0.01	0.062	<0.01	0.18	0.4	5.3	1.1	5.2	2.4
	HC	.038	.001	.001	<0.01	0.082	<0.01	0.21	0.4	4.6	1.8	6.9	2.3
05/14 80	HA	.022	.002	.001	<0.01	<0.02	<0.01	0.09	0.3	4.3	3.1	3.7	1.0
	HB	.019	<.001	<.001	<0.01	<0.02	<0.01	0.13	0.3	4.8	2.1	2.0	0.5
	BA	.021	<.001	<.001	<0.01	<0.02	<0.01	0.12	0.3	4.3	1.2	3.2	1.4
	SU	.018	<.001	<.001	<0.01	0.027	<0.01	0.13	0.3	4.6	1.6	2.1	1.6
	EU	.017	.008	.001	<0.01	<0.02	<0.01	0.12	0.3	4.5	1.6	2.6	1.7
	PF	.021	<.001	<.001	<0.01	<0.02	<0.01	0.10	0.4	4.3	1.5	3.4	1.4
	UP	.020	.003	<.001	<0.01	<0.02	<0.01	0.11	0.4	4.1	1.4	0.0	0.0
	GR	.021	<.001	<.001	<0.01	<0.02	<0.01	0.10	0.4	3.7	1.5	5.1	1.8
	GO	.017	<.001	<.001	<0.01	0.230	<0.01	0.13	0.4	3.7	1.4	2.6	2.1
	HC	.021	<.001	<.001	<0.01	0.036	<0.01	0.14	0.4	4.0	1.5	3.6	0.2
06/03/80	HA	.025	.006	<.001	<0.01	<0.02	<0.01	0.08	0.5	2.9	0.6	9.3	3.6
	HB	.026	.009	.001	<0.01	0.027	<0.01	0.11	0.5	4.8	0.8	4.4	0.9
	BA	.016	.001	<.001	<0.01	<0.02	<0.01	0.09	0.7	4.5	0.4	5.1	1.7
	SU	.017	.003	<.001	<0.01	<0.02	<0.01	0.09	0.7	4.5	0.9	8.4	1.6
	EU	.017	.004	<.001	<0.01	<0.02	<0.01	0.10	0.7	3.2	0.7	6.6	1.4
	PF	.023	.003	<.001	<0.01	<0.02	<0.01	0.09	0.8	7.0	0.5	5.6	1.0
	UP	.017	.007	<.001	<0.01	<0.02	<0.01	0.09	1.0	5.1	0.8	4.2	3.8
	GR	.033	.003	.001	<0.01	0.022	<0.01	0.10	0.9	4.3	0.7	17.2	2.1
	GO	.021	.002	<.001	<0.01	<0.02	<0.01	0.09	0.8	4.3	0.7	6.5	2.2
	HC	.018	.002	<.001	<0.01	<0.02	<0.01	0.09	3.0	4.5	1.3	10.6	2.0
06/18/80	HA	.020	.007	<.001	<0.01	<0.02	<0.01	0.10	0.5	3.3	0.4	2.2	1.7
	HB	.023	.011	.001	<0.01	<0.02	<0.01	0.10	0.5	2.5	0.8		
	BA	.020	.008	.001	<0.01	0.03	<0.01	0.11	0.6	2.4	1.2		
	SU	.015	.010	.001	<0.01	<0.02	<0.01	0.11	0.6	2.1	0.8		
	EU		.010	<.001	<0.01	0.02	<0.01	0.11	0.6	1.1	1.0		
	PF	.018	.006	.001	<0.01	0.02	<0.01	0.10	0.6	1.1	0.7		
	UP	.020	.009	.001	<0.01	0.021	<0.01	0.11	0.6	1.2	1.2		
	GR	.022	.009	.001	<0.01	0.030	<0.01	0.10	0.6	1.9	1.0	6.7	2.2
	GO	.016	.006	<.001	<0.01	0.033	<0.01	0.10	0.6	1.9	1.1		
	HC	.020	.009	.001	<0.01	0.026	<0.01	0.12	0.7	2.4	1.0		

Table A-2. Spokane River Chemistry Data - continued

DATE	ST	TP	TSP	SRP	NH3-N	NO3-N	NO2-N	TKN	CL	COD	BOD	TSS	VSS
07/02/80	HA	.024	.003	.001	<0.01	<0.02	<0.01	0.11	0.7	2.5	0.6	2.0	0.6
	HB	.018	.008	.001	<0.01	0.29	<0.01	0.11	0.7	2.7	0.5	2.0	0.1
	BA	.033	.005	<.001	<0.01	0.020	<0.01	0.12	0.7	3.2	0.6	4.0	1.0
	SU	.040	.010	.001	<0.01	0.021	<0.01	0.12	0.7	3.3	0.4	3.6	1.0
	EU	.020	.007	.001	<0.01	0.26	<0.01	0.14	0.9	3.2	0.7	1.9	0.7
	PF	.024	.020	.001	<0.01	0.13	<0.01	0.13	1.0	3.3	0.8	2.5	1.4
	UP		.009	.001	<0.01	1.25	<0.01	0.14	1.0	3.7	1.2	2.0	
	GR	.018	.006	.001	<0.01	0.15	<0.01	0.12	1.0	3.7	1.0	1.5	1.5
	GO	.015	.005	<.001	<0.01	0.12	<0.01	0.19	1.0	3.7	0.9	3.4	0.9
	HC	.026	.007	<.001	<0.01	0.27	<0.01	0.16	1.0	3.7	0.9	2.7	1.1
07/16/80	HA	.041	.010	.004	<0.01	<0.02	<0.01	0.11	0.7	5.3	0.7	2.7	1.3
	HB	.036	.010	.007	<0.01	<0.02	<0.01	0.12	0.7	4.5	0.5	2.1	0.9
	BA	.017	.005	.001	<0.01	<0.02	<0.01	0.11	0.7	4.8	0.6	3.7	0.0
	SU	.051	.019	.002	<0.01	<0.02	<0.01	0.10	0.7	4.5	0.9	3.7	1.3
	EU	.017	.005	.002	<0.01	0.084	<0.01	0.10	1.0	4.0	0.4	2.5	1.6
	PF												
	UP	.019	.005	.001	<0.01	0.078	<0.01	0.11	1.0	4.1	0.6	1.4	0.5
	GR	.022	.005	.002	<0.01	0.15	<0.01	0.11	1.0	3.7	1.0	2.8	1.3
	GO	.020	.005	.003	<0.01	0.16	<0.01	0.09	1.1	4.5	0.8	4.0	2.0
	HC	.016	.005	.002	<0.01	0.16	<0.01	0.10	1.6	4.8	0.4	3.0	1.3
07/29/80	HA	.020	.006	<.001	<0.01	<0.02	<0.01	0.14	0.7	5.1	0.3	1.9	0.8
	HB	.021	.006	<.001	<0.01	<0.02	<0.01	0.16	0.7	5.1	1.0	1.9	0.6
	BA	.022	.006	<.001	<0.01	0.020	<0.01	0.15	0.7	10.4	0.4	2.6	
	SU	.031	.006	<.001	<0.01	<0.02	<0.01	0.16	0.7	5.0	0.6	1.8	0.9
	EU	.013	.007	.004	<0.01	0.13	<0.01	0.17	1.2	5.0	0.4	2.1	1.2
	PF	.014	.013		<0.01	0.14	<0.01	0.15	1.3	4.6	1.0	1.1	0.3
	UP	.018	.008	.001	<0.01	0.13	<0.01	0.19	1.3	4.6	0.8	1.0	0.7
	GR	.026	.008	.001	<0.01	0.29	<0.01	0.15	1.3	3.0	0.6	1.9	1.0
	GO	.026	.010	<.001	<0.01	0.28	<0.01	0.16	1.4	3.0	1.2		
	HC	.026	.007	<.001	<0.01	0.26	<0.01	0.17	1.4	3.2	1.1	1.5	1.5
08/12/80	HA	.026	.020	.015	<0.01	<0.02	<0.01	0.17	0.8	4.3	0.6	0.9	0.1
	HB	.024	.019	.013	<0.01	0.078	0.02	0.20	1.4	5.3	0.3	0.7	0.4
	BA	.022	.018	.014	<0.01	<0.02	<0.01	0.17	0.8	6.2	1.0	3.0	1.0
	SU	.021	.016	.011	<0.01	<0.02	<0.01	0.17	0.8	6.1	1.3	1.1	0.2
	EU	.020	.015	.011	<0.01	0.25	<0.01	0.15	1.6	5.4	0.7	0.9	0.2
	PF	.029	.024		<0.01	0.26	<0.01	0.15	1.8	5.0	0.4	1.7	1.1
	UP	.028	.018	.015	<0.01	0.28	<0.01	0.18	2.6	5.8	0.7	0.2	0.2
	GR	.018	.016	.010	<0.01	0.47	<0.01	0.14	1.7	4.3	0.8	1.4	
	GO	.016	.012	.007	<0.01	0.49	<0.01	0.14	1.7	4.0	0.6	1.9	0.6
	HC	.014	.010	.004	<0.01	0.47	<0.01	0.15	1.8	3.8	1.4	0.7	0.3
08/26/80	HA	.015	.008	.005	<0.01	<0.02	<0.01	0.14	0.7	5.3	2.3	0.3	0.3
	HB	.017	.010	.006	<0.01	<0.02	<0.01	0.15	0.7	5.4	0.2	1.8	1.1
	BA	.015	.008	.005	<0.01	<0.02	<0.01	0.13	0.7	5.6	0.0	1.0	0.2
	SU	.017	.010	.006	<0.01	<0.02	<0.01	0.14	0.7	4.8	0.0	1.1	0.2
	EU	.013	.011	.009	<0.01	0.52	<0.01	0.17	1.5	3.7	0.2	1.0	0.7
	PF	.022	.015	.013	<0.01	0.58	<0.01	0.12	1.7	3.8	0.6	1.2	0.4
	UP	.035	.029	.026	<0.01	0.53	<0.01	0.18	1.7	4.8	0.5	0.3	0.1
	GR	.017	.012	.011	<0.01	0.82	<0.01	0.12	1.5	3.3	0.5	0.6	0.2
	GO	.017	.011	.009	<0.01	0.88	<0.01	0.14	1.5	3.0	0.6	1.4	0.6
	HC	.014	.010	.007	0.01	0.75	<0.01	0.13	1.4	4.0	0.5		

Table A-2. Spokane River Chemistry Data - continued

DATE	ST	TP	TSP	SRP	NH3-N	NO3-N	NO2-N	TKN	CL	COD	BOD	TSS	VSS
09/09/80	HA	.014	.014	.006	<0.01	<0.02	<0.01	0.13	0.8	4.6	1.7		
	HB	.015	.014	.006	<0.01	<0.02	<0.01	0.13	0.7	4.6	0.6		
	BA	.012	.012	.006	<0.01	<0.02	<0.01	0.15	0.8	4.5	0.5		
	SU	.013	.011	.005	<0.01	<0.02	<0.01	0.15	0.7	9.3	0.6		
	EU	.015	.012	.006	<0.01	0.082	<0.01	0.14		5.0	0.8		
	PF	.017	.013	.007	<0.01	0.097	<0.01	0.21	1.1	4.3	0.7		
	UP	.016	.014	.008	<0.01	0.100	<0.01	0.19	1.1	5.0	0.6	1.1	0.4
	GR	.015	.012	.006	<0.01	0.21	<0.01	0.18	1.1	4.0	1.1	3.2	2.0
	GO	.014	.008	.004	<0.01	0.20	<0.01	0.19	1.1	4.2	0.8		
	HC	.015	.008	.003	<0.01	0.20	<0.01	0.18	1.1	4.0	0.5		
09/24/80	HA	.015	.011	.005	<0.01	<0.02	<0.01	0.12	0.8	4.8	0.5	0.8	0.6
	HB	.016	.010	.007	<0.01	<0.02	<0.01	0.16	0.8	5.1	0.6	2.2	0.5
	BA	.017	.012	.008	<0.01	<0.02	<0.01	0.15	0.8	4.8	1.0	1.5	0.6
	SU	.017	.013	.005	<0.01	<0.02	<0.01	0.14	0.7	4.6	0.6		
	EU	.016	.009	.006	<0.01	0.087	<0.01	0.12	1.0	4.0	0.7	1.5	0.9
	PF	.016	.011	.008	<0.01	0.11	<0.01	0.12	1.1	4.2	0.3		
	UP	.017	.007	.007	<0.01	0.10	<0.01	0.13	1.1	4.6	0.7	1.2	0.4
	GR	.016	.009	.005	<0.01	0.20	<0.01	0.12	1.2	4.3	0.4	1.1	0.7
	GO	.015	.009	.004	<0.01	0.22	<0.01	0.13	1.2	4.3	0.2	1.0	0.5
	HC	.015	.007	.005	<0.01	0.23	<0.01	0.12	1.3	5.6	0.7	0.6	0.2
10/10/80	HA	.012	.008	.008	<0.01	<0.02	<0.01	0.12	0.8	3.5	0.3		
	HB	.024	.008	.006	<0.01	<0.02	<0.01	0.10	0.8	4.3	0.6	1.1	0.3
	BA	.012	.008	.008	<0.01	<0.02	<0.01	0.11	0.8	3.7	1.0	0.5	0.2
	SU	.012	.007	.007	<0.01	<0.02	<0.01	0.10	0.8	3.7	1.0	1.2	0.7
	EU	.014	.007	.007	<0.01	0.13	<0.01	0.12	1.0	3.3	1.0	1.5	0.2
	PF	.015	.009	.009	<0.01	0.18	<0.01	0.13	1.0	4.0	1.4		
	UP	.014	.007	.006	<0.01	0.16	<0.01	0.14	1.0	4.2	1.1	0.9	0.2
	GR	.014	.007	.007	<0.01	0.33	<0.01	0.13	1.1	3.7	1.1		
	GO	.011	.007	.007	<0.01	0.32	<0.01	0.11	1.1	4.3	0.2		
	HC	.009	.004	.004	<0.01	0.30	<0.01	0.10	1.1	3.7	0.8	0.2	0.0
11/14/80	HA	.007	.006	.006	<0.01	<0.02	<0.01	0.11	5.5	6.9	1.9		
	HB	.010	.004	.004	<0.01	<0.02	<0.01	0.11	3.1	4.0	0.2		
	BA	.014	.001	.001	<0.01	<0.02	<0.01	0.12	0.7	4.5	0.0		
	SU	.010	.003	.003	<0.01	<0.02	<0.01	0.26	0.7	5.4	0.0		
	EU	.010	.004	.004	<0.01	0.072	<0.01	0.23	0.8	5.4	0.8	10.0	3.5
	PF	.011	.003	.003	<0.01	0.092	<0.01	0.25	0.9	5.4	0.4		
	UP	.006	.003	.003	<0.01	0.10	<0.01	0.11	0.8	5.4	1.3		
	GR	.007	.004	.004	<0.01	0.21	<0.01	0.18	1.0	4.5	1.3		
	GO	.009	.004	.004	<0.01	0.21	<0.01	0.22	1.0	4.0	1.4		
	HC	.022	.005	.005	<0.01	0.21	<0.01	0.17	1.0	3.8	1.1		
12/17/80	HA	.009	.007	.007	<0.01	<0.02	<0.01	0.14	0.7	4.0	1.4	2.4	1.8
	HB	.023	.012	.006	<0.01	<0.02	<0.01	0.14	0.7	3.8	0.9	3.7	1.7
	BA	.016	.005	.005	<0.01	<0.02	<0.01	0.18	0.7	3.7	0.5	2.9	2.1
	SU	.009	.008	.008	<0.01	<0.02	0.01	0.16	0.7	3.7	0.7	2.4	1.7
	EU	.012	.006	.006	<0.01	0.072	<0.01	0.15	0.7	2.9	0.7	3.3	1.9
	PF	.012	.007	.007	<0.01	0.092	0.01	0.17	0.8	3.0	0.4	2.6	1.9
	UP	.012	.009	.007	<0.01	0.10	<0.01	0.18	0.8	3.5	0.8	2.0	0.8
	GR	.010	.008	.003	<0.01	0.21	0.015	0.15	0.8	3.0	0.5	1.2	0.8
	GO	.010	.005	.005	<0.01	0.21	<0.01	0.12	0.8	3.2	0.4	1.8	1.0
	HC	.012	.005	.005	<0.01	0.21	<0.01	0.11	0.8	3.0	1.0	2.2	1.3

Table A-2. Spokane River Chemistry Data - continued

DATE	ST	TP	TSP	SRP	NH3-N	NO3-N	NO2-N	TKN	CL	COD	BOD	TSS	VSS
01/20/81	HA	.024	.005	.005	<0.01	0.066	<0.01	0.08	0.6	4.0	1.3	3.2	1.4
	HB	.018	.010	.003	<0.01	0.063	<0.01	0.09	0.7	3.8	0.7	3.5	0.9
	BA	.018	.012	.002	<0.01	0.062	<0.01	0.08	0.7	3.3	0.4	2.9	0.7
	SU	.028	.009	.004	<0.01	0.065	<0.01	0.09	0.6	4.1	0.8	1.2	0.7
	EU	.016	.006	.003	<0.01	0.088	<0.01	0.08	0.7	3.5	0.7	2.7	1.2
	PF	.016	.005	.003	<0.01	0.10	<0.01	0.09	0.7	3.8	0.9	2.6	0.5
	UP	.027	.004	.004	<0.01	0.10	<0.01	0.08	0.7	3.8	1.1	7.9	1.9
	GR	.017	.018	.004	<0.01	0.16	<0.01	0.09	0.7	3.3	0.6	1.3	0.6
	GO	.017	.013	.003	<0.01	0.16	<0.01	0.11	0.8	3.3	1.1	2.0	0.5
	HC	.014	.007	.005	<0.01	0.16	<0.01	0.08	0.8	3.2	2.5	2.8	1.1
02/26/81	HA	.013	.009	.003	<0.01	0.088	<0.01	0.11	0.8	3.8	2.2	5.3	2.2
	HB	.021	.006	.004	<0.01	0.088	<0.01	0.12	0.8	4.5	2.2	2.9	1.5
	BA	.013	.012	.010	<0.01	0.086	<0.01	0.10	0.8	4.6	1.8	3.0	2.4
	SU	.022	.016	.004	<0.01	0.085	<0.01	0.10	3.3	4.6	2.1	3.1	3.7
	EU	.016	.008	.005	<0.01	0.088	<0.01	0.10	1.1	4.1	2.8	2.5	2.4
	PF	.020	.012	.006	<0.01	0.090	<0.01	0.09	0.9	3.8	1.7	2.8	1.0
	UP	.015	.015	.004	<0.01	0.090	<0.01	0.10	0.8	3.8	2.7	1.4	3.5
	GR	.015	.010	.006	<0.01	0.10	<0.01	0.10	0.9	4.1	2.9	3.4	2.6
	GO	.008	.008	.005	<0.01	0.10	<0.01	0.12	13.7	4.6	1.8	5.1	2.7
	HC	.005	.005	.003	<0.01	0.11	<0.01	0.11	0.9	3.8		3.0	1.8
03/27/81	HA	.013	.008	.004	<0.01	0.079	<0.01	0.16	6.0	5.1	4.8	2.5	1.2
	HB	.012	.008	.004	<0.01	0.077	<0.01	0.16	0.9	4.1	1.5	3.1	1.2
	BA	.012	.011	.004	<0.01	0.078	<0.01	0.16	0.8	5.8	1.7	3.6	2.4
	SU	.032	.008	.002	<0.01	0.079	<0.01	0.15	0.8	5.9	1.3	6.2	3.0
	EU	.012	.010	.005	<0.01	0.090	<0.01	0.16	0.8	6.2	2.4	3.7	2.1
	PF	.013	.008	.005	<0.01	0.098	<0.01	0.15	0.8	5.6	1.0	4.2	2.4
	UP	.012	.009	.005	<0.01	0.10	<0.01	0.17	0.8	5.6	1.0	10.2	2.6
	GR	.013	.007	.004	<0.01	0.12	<0.01	0.16	3.0	5.8	1.1	2.6	1.4
	GO	.013	.008	.004	<0.01	0.12	<0.01	0.17	0.9	5.4	1.2	1.9	0.1
	HC	.013	.008	.004	<0.01	0.13	<0.01	0.13	0.8	5.3	2.3	3.8	0.2
04/16/81	HA	.015	.013	.002	<0.01	0.033	<0.01	0.16	0.9	3.8	1.3	2.9	1.0
	HB	.015	.004	.002	<0.01	0.040	<0.01	0.16	0.9	4.5	1.8	1.2	0.4
	BA	.011	.005	.001	<0.01	0.043	<0.01	0.15	5.6	5.9	3.7	19.5	10.0
	SU	.013	.004	.001	<0.01	0.038	<0.01	0.16	3.1	4.8	0.9	5.2	1.5
	EU	.008	.004	.001	<0.01	0.053	<0.01	0.16	7.6	5.4	1.5	2.7	2.6
	PF	.015	.004	.001	<0.01	0.053	<0.01	0.16	1.0	4.8	2.0	1.1	1.0
	UP	.012	.004	.001	<0.01	0.053	<0.01	0.17	1.6	5.4	1.4	4.0	2.6
	GR	.019	.004	.001	<0.01				1.3	5.3	1.8	2.5	1.6
	GO	.015	.004	.001	<0.01	0.081	<0.01	0.18	1.3	5.1	1.6	1.9	1.9
	HC	.009	.003	.001	<0.01	0.074	<0.01	0.18	1.0	5.1	2.6	3.7	3.0
04/30/81	HA	.016	.002	.002	<0.01	0.54	<0.01	0.19	0.9	4.9	2.8	3.5	2.0
	HB	.007	.001	.001	<0.01	<0.02	<0.01	0.17	0.9	5.4	2.0	3.6	1.7
	BA	.016	.002	.002	<0.01	<0.02	<0.01	0.17	0.9	5.3	1.4	3.5	1.6
	SU	.012	.001	.001	<0.01	<0.02	<0.01	0.17	0.9	5.3	3.2	3.4	0.7
	EU	.007	.001	.001	<0.01	0.022	<0.01	0.19	0.9	5.3	2.5	4.0	1.6
	PF	.010	.011	.002	<0.01	0.032	<0.01	0.17	0.9	5.6	3.3	3.0	1.2
	UP	.016	.007	.001	<0.01	<0.02	<0.01	0.17	0.9	5.6	1.5	3.2	2.0
	GR	.014	.001	.001	<0.01	0.020	<0.01	0.17	0.9	5.6	1.6	4.0	1.9
	GO	.020	.015	.001	0.010	0.032	<0.01	0.20	0.9	5.6	1.4	3.1	1.7
	HC	.014	.004	.001	<0.01	0.034	<0.01	0.17	0.9	5.4	1.7	3.0	1.5

Table A-2. Spokane River Chemistry Data - continued

DATE	ST	TP	TSP	SRP	NH3-N	NO3-N	NO2-N	TKN	CL	COD	BOD	TSS	VSS
05/19/81	HA	.007	.006	<.001	<0.01	<0.02	<0.01	0.13	0.8	5.4	1.9	3.6	1.2
	HB	.020	.006	.001	<0.01	<0.02	<0.01	0.13	0.8	5.1	1.6	3.4	1.1
	BA	.018	.003	.001	<0.01	<0.02	<0.01	0.14	0.8	5.0	1.8	3.8	1.0
	SU	.012	.002	<.001	<0.01	<0.02	<0.01	0.15	0.8	5.6	1.3	3.5	1.5
	EU	.013	.001	<.001	<0.01	<0.02	<0.01	0.14	0.8	5.3	2.7	3.7	1.3
	PF	.013	.002	.001	<0.01	0.020	<0.01	0.14	0.8	5.3	2.8	4.5	2.5
	UP	.013	.003	.001	<0.01	0.049	<0.01	0.12	0.9	5.4	2.7	3.0	1.2
	GR	.012	.002	<.001	<0.01	0.058	<0.01	0.14	1.0	5.1	1.4	3.3	1.7
	GO	.047	.002	<.001	<0.01	0.072	<0.01	0.16	1.0	4.8	1.3	3.0	1.5
	HC	.026	.003	<.001	<0.01	0.087	<0.01	0.15	1.0	4.5	1.0	5.2	1.2
06/05/81	HA	.003	.002	<.001	<0.01	<0.02	<0.01	0.13	0.7	5.0	2.3	2.3	1.0
	HB	.003	.002	<.001	<0.01	<0.02	<0.01	0.13	0.7	4.6	2.6	2.8	1.0
	BA	.003	.003	.001	<0.01	<0.02	<0.01	0.13	0.7	4.8	1.9	1.2	0.5
	SU	.004	.002	<.001	<0.01	<0.02	<0.01	0.12	1.0	5.3	1.9	2.3	0.7
	EU	.008	.002	<.001	<0.01	0.045	<0.01	0.12	0.8	5.3	1.6	2.7	1.1
	PF	.007	.002	<.001	<0.01	0.062	<0.01	0.12	0.8	5.4	1.6	2.5	1.2
	UP	.011	.003	<.001	<0.01	0.054	<0.01	0.12	0.8	5.6	1.5	2.3	0.8
	GR	.003	.003	<.001	<0.01	0.120	<0.01	0.11	0.9	4.5	1.3	2.1	1.0
	GO	.003	.002	<.001	<0.01	0.130	<0.01	0.13	0.9	5.0	1.3	2.5	1.3
	HC	.013	.002	.001	<0.01	0.120	<0.01	0.13	0.9	4.6	1.2	1.1	0.6
06/11/81	HA	.010		.003	<0.01	<0.02	<0.01	0.11	0.6	4.6	1.5	2.5	0.7
	HB	.007		.004	<0.01	<0.02	<0.01	0.12	0.6	4.5	1.4	6.7	1.0
	BA	.007		.003	<0.01	<0.02	<0.01	0.12	0.6	4.5	0.9	2.8	1.2
	SU	.007		.004	<0.01	<0.02	<0.01	0.13	0.6	4.6	1.1	3.7	0.3
	EU	.007		.001	<0.01	<0.02	<0.01	0.12	0.6	4.6	1.5	1.7	0.5
	PF	.012		.002	<0.01	<0.02	<0.01	0.13	0.7	4.5	1.1	2.5	0.7
	UP	.011		.001					0.7	4.6	1.5	6.2	1.3
	GR	.008		.002	<0.01	0.030	<0.01	0.14	0.7	4.8	1.5	3.0	0.8
	GO	.045		.004	<0.01	0.031	<0.01	0.13	0.7	4.8	1.7	2.3	0.7
	HC	.010		.003	<0.01	0.025	<0.01	0.13	0.7	5.8	1.9	2.5	1.0
06/25/81	HA	.012	.003	.001	<0.01	<0.02	<0.01	0.13	0.6	4.3	1.2	5.0	1.7
	HB	.013	.003	<.001	<0.01	<0.02	<0.01	0.12	0.6	4.5	1.1	5.3	1.8
	BA	.011	.003	.001	<0.01	<0.02	<0.01	0.11	0.7	3.7	1.2	3.5	1.7
	SU	.013	.013	.001	<0.01	<0.02	<0.01	0.11	0.7	4.2	2.2	1.8	1.5
	EU	.015	.003	.001	<0.01	<0.02	<0.01	0.12	0.7	4.0	1.2	6.2	4.0
	PF	.016	.004	.001	<0.01	<0.02	<0.01	0.08	0.7	4.5	1.2	2.3	1.7
	UP	.012	.002	.001	<0.01	<0.02	<0.01	0.12	0.7	4.6	0.2	3.0	1.7
	GR	.012	.002	<.001	<0.01	0.032	<0.01	0.11	0.7	4.3	0.3	3.3	0.0
	GO	.013	.003	<.001	<0.01	0.035	<0.01	0.12	0.7	4.3	1.2	3.0	0.8
	HC	.012	.002	.001	<0.01	0.031	<0.01	0.14	0.7	3.8	1.4	3.5	1.0
07/09/81	HA	.011	.004	.001	<0.01	<0.02	<0.01	0.10	0.6	3.8	1.1	4.0	1.3
	HB	.015	<.002	.001	<0.01	<0.02	<0.01	0.11	0.6	3.3	0.4	4.2	1.5
	BA	.013	<.002	.001	<0.01	0.19	<0.01	0.14	0.6	3.5	0.3	3.7	1.0
	SU	.015	.006	<.001	<0.01	0.078	<0.01	0.11	0.6	3.7	0.6	4.2	1.3
	EU	.008	<.002	.001	<0.01	0.043	<0.01	0.12	1.5	2.7	1.5	3.7	1.2
	PF	.015	<.002	.002	<0.01	0.11	<0.01	0.13	1.0	3.5	1.0	2.7	0.8
	UP	.015	<.002	.001	<0.01	0.13	<0.01	0.13	0.8	3.8	0.7	4.0	1.3
	GR	.013	<.002	<.001	<0.01	0.11	<0.01	0.12	0.9	2.9	1.3	6.0	2.0
	GO	.013	<.002	.002	<0.01	<0.02	<0.01	0.12	0.9	2.9	0.8	7.0	2.3
	HC	.022	<.002	.001	<0.01	<0.02	<0.01	0.14	0.9	2.9	0.7	5.3	1.8

Table A-2. Spokane River Chemistry Data - continued

DATE	ST	TP	TSP	SRP	NH3-N	NO3-N	NO2-N	TKN	CL	COD	BOD	TSS	VSS
07/24/81	HA	.047	.009	.007	<0.01	<0.02	<0.01	0.13	0.7	3.3	0.5		
	HB	.047	.007	.005	<0.01	<0.02	<0.01	0.14	0.7	3.3	0.2	13.7	0.3
	BA	.025	.011	.006	<0.01	<0.02	<0.01	0.13	0.7	3.7	1.1	2.0	0.7
	SU	.040	.009	.005	<0.01	<0.02	<0.01	0.13	0.7	4.0	1.5	6.8	1.0
	EU	.064	.016	.005	<0.01	0.18	<0.01	0.13	1.5	3.5	3.0	5.2	1.0
	PF	.020	.014	.004	<0.01	0.20	<0.01	0.12	1.6	3.2	0.6	2.2	1.0
	UP	.018	.014	.002	<0.01	0.20	<0.01	0.13	1.7	3.7	0.9	2.3	0.2
	GR	.018	.005	.003	<0.01	0.29	<0.01	0.11	1.4	3.2	1.0	5.7	0.8
	GO	.033	.022	.002	<0.01	0.32	<0.01	0.14	1.3	3.0	0.7	1.5	0.2
	HC	.011	.002	.001	<0.01	0.33	<0.01	0.11	1.4	2.9	1.0	2.8	0.6
08/06/81	HA	.022	.011	.006	<0.01	<0.02	<0.01	.13	11.2	5.8	1.2	1.5	0.8
	HB	.019	.009	.006	<0.01	<0.02	<0.01	0.12	0.9	4.2	1.2	2.5	1.3
	BA	.019	.011	.005	<0.01	<0.02	<0.01	0.12	2.6	5.3	1.0	1.8	0.8
	SU	.019	.008	.005	<0.01	<0.02	<0.01	0.13	0.7	4.3	1.3	4.0	2.0
	EU	.021	.007	.005	<0.01	0.15	<0.01	0.16	1.6	3.7	0.6	4.8	0.8
	PF	.015	.013	.006	<0.01	0.16	<0.01	0.18	1.6	4.0	0.5	2.3	2.0
	UP	.026	.009	.005	<0.01	0.16	<0.01	0.18	1.5	4.2	0.5	2.8	0.7
	GR	.017	.007	.004	<0.01	0.33	<0.01	0.14	1.6	3.3	0.8	3.0	1.5
	GO	.017	.008	.003	<0.01	0.28	<0.01	0.17	1.5	3.3	1.3	3.0	0.3
	HC	.019	.003	.002	<0.01	0.29	<0.01	0.15	2.0	3.7	0.6	2.8	1.5
08/25/81	HA	.029	.013	.007	<0.01	<0.02	<0.01	0.15	0.7	4.0	1.7	2.7	0.5
	HB	.035	.011	.008	<0.01	<0.02	<0.01	0.14	0.7	4.1	0.2	4.0	2.0
	BA	.022	.011	.003	<0.01	<0.02	<0.01	0.17	0.8	4.0	1.1	2.5	0.3
	SU	.022	.009	.006	<0.01	0.055	<0.01	0.16	0.8	4.1	1.3	3.7	0.8
	EU	.018	.009	.006	<0.01	0.33	<0.01	0.11	2.0	3.2	0.8	3.7	1.2
	PF	.018	.009	.006	<0.01	0.35	<0.01	0.12	2.3	3.2	0.5	1.7	0.5
	UP	.022	.005	.003	<0.01	0.33	<0.01	0.12	2.3	3.5	0.6	1.8	0.2
	GR	.013	.002	.002	<0.01	0.56	<0.01	0.10	2.0	2.2	0.7	2.8	0.2
	GO	.013	.002	<.001	<0.01	0.55	<0.01	0.10	2.0	2.7	0.6	4.2	1.3
	HC	.015	.005	<.001	<0.01	0.55	<0.01	0.12	2.0	2.5	1.0	3.0	1.8
09/03/81	HA	.028	.019	.005	<0.01	<0.02	<0.01	0.16	0.8	4.3	2.2	1.0	0.5
	HB	.034	.033	.006	<0.01	<0.02	<0.01	0.14	0.8	4.3	1.6	1.5	1.0
	BA	.023	.012	.005	<0.01	<0.02	<0.01	0.16	0.8	4.6	1.0	1.7	0.5
	SU	.035	.022	.004	<0.01	<0.02	<0.01	0.15	0.8	4.5	1.0	2.3	1.5
	EU	.022	.012	.005	<0.01	<0.02	<0.01	0.14	1.8	3.2	1.0		
	PF	.018	.007	.005	<0.01	0.30	<0.01	0.14	2.2	3.3	0.5	2.2	1.0
	UP	.021	.011	.004	<0.01	0.32	<0.01	0.24	2.1	4.5	1.1	3.0	2.5
	GR	.009	.007	.002	<0.01			0.18	1.9	2.7	1.0	2.8	1.7
	GO	.007	.006	.002	<0.01	0.54	<0.01	0.14	1.9	3.0	1.7	2.7	0.8
	HC	.008	.008	.001	<0.01	0.53	<0.01	0.17	2.0	3.0	0.0	2.2	0.7
09/24/81	HA	.009	.013	.008	<0.01	<0.02	<0.01	0.15	0.8	4.0	0.7	3.2	1.2
	HB	.012	.016	.011	<0.01	<0.02	<0.01	0.14	0.7	4.3	0.9	2.7	0.5
	BA	.009	.012	.007	<0.01	<0.02	<0.01	0.13	0.7	4.0	0.4	0.6	0.5
	SU	.010	.018	.008	<0.01	<0.02	<0.01	0.13	0.6	4.1	1.0	2.7	1.8
	EU	.008	.018	.008	<0.01	<0.02	<0.01	0.12	0.9	3.7	0.4	2.0	0.7
	PF	.012	.012	.009	<0.01	0.12	<0.01	0.14	1.0	3.8	0.8	6.2	0.7
	UP	.010	.015	.009	<0.01	0.12	<0.01	0.15	1.1	4.5	1.1	5.2	0.8
	GR	.008	.010	.007	<0.01	0.25	<0.01	0.13	1.2	4.6	1.7	2.3	0.3
	GO	.004	.009	.005	<0.01	0.25	<0.01	0.12	1.2	5.1	0.6	3.7	0.5
	HC	.004	.011	.004	<0.01	0.25	<0.01	0.12	1.2	4.3	0.4	1.8	0.8

Table A-2. Spokane River Chemistry Data - continued

DATE	ST	TP	TSP	SRP	NH3-N	NO3-N	NO2-N	TKN	CL	COD	BOD	TSS	VSS
11/03/81	HA	.025	.004	.003	<0.01	<0.02	<0.01	0.16	0.7	3.8	0.4		
	HB	.021	.005	.003	<0.01	<0.02	<0.01	0.12	0.7	3.3	1.0		
	BA	.018	.008	.004	<0.01	<0.02	<0.01	0.13	0.6	2.9	0.6		
	SU	.022	.011	.003	<0.01	<0.02	<0.01	0.16	0.7	3.0	0.8		
	EU	.012	.006	.004	<0.01	0.08	<0.01	0.22	0.7	3.5	1.4		
	PF	.014	.008	.007	<0.01	0.09	<0.01	0.12	0.8	3.3	0.6		
	UP	.022	.010	.006	<0.01	0.09	<0.01	0.13	0.8	3.5	1.4		
	GR	.019	.006	.005	<0.01	0.21	<0.01	0.13	0.9	2.9	1.1		
	GO	.024	.007	.005	<0.01	0.25	<0.01	0.24	1.0	3.2	1.7		
	HC	.012	.007	.006	<0.01	0.21	<0.01	0.12	1.0	3.0	1.7		

Table A-3. Spokane River Metals Data (Copper, Lead, Zinc, Mercury). Expressed in µg/l. T=Total, S=Filterable (through 0.45µm Filter)

STATIONS: ST=Stateline, HA=Harvard Above, HB=Harvard Below, BA=Barker, SU=Sullivan, EU=Euclid, PF=Plantes Ferry, UP=Upriver Drive, GR=Greene Street, GO=Gonzaga, HC=Hangman Creek.

Date	ST	T-Cu	S-Cu	T-Pb	S-Pb	T-Zn	S-Zn	T-Hg
11/20/79	ST	<1.0		<1.0		85		0.6
	HA	<1.0		<1.0		85		1.2
	BA	<1.0		<1.0		90		<0.5
	SU	<1.0		<1.0		80		<0.5
	EU	<1.0		<1.0		85		<0.5
	PF	<1.0		<1.0		70		<0.5
	UP	<1.0		<1.0		75		<0.5
	GR	<1.0		1.4		50		<0.5
	GO	<1.0		1.6		25		16.0
	HC	<1.0		<1.0		50		21.0
12/04/79	ST	<1.0	<1.0	<1.0	<1.0	100	95	<0.5
	HA	<1.0	<1.0	<1.0	<1.0	100	95	<0.5
	BA	<1.0	<1.0	1.4	<1.0	115	85	0.5
	SU	<1.0	<1.0	<1.0	<1.0	115	90	0.5
	EU	<1.0	<1.0	1.1	<1.0	100	90	<0.5
	PF	<1.0	<1.0	<1.0	<1.0	115	100	<0.5
	UP	<1.0	<1.0	1.1	<1.0	90	85	<0.5
	GR	<1.0	<1.0	8.0	1.2	75	55	<0.5
	GO	<1.0	<1.0	2.3	<1.0	90	70	<0.5
	HC	1.7	<1.0	3.6	<1.0	115	85	<0.5
12/16/79	ST	<1.0	<1.0	1.4	<1.0	135	100	<0.5
	HA	<1.0	<1.0	1.8	<1.0	128	100	1.7
	BA	<1.0	<1.0	1.4	<1.0	118	93	<0.5
	SU	<1.0	<1.0	2.4	<1.0	100	95	<0.5
	EU	<1.0	<1.0	1.0	<1.0	110	93	24
	PF	<1.0	<1.0	1.6	<1.0	100	84	<0.5
	UP	<1.0	<1.0	<1.0	<1.0	110	92	<0.5
	GR	<1.0	<1.0	1.4	<1.0	84	58	<0.5
	GO	<1.0	<1.0	1.6	<1.0	75	57	0.5
	HC	<1.0	<1.0	1.4	<1.0	94	58	<0.5

Table A-3. Spokane River Metals Data - continued

Date	ST	T-Cu	S-Cu	T-Pb	S-Pb	T-Zn	S-Zn	T-Hg
01/04/80	ST	2.5	1.9	<1.0	<1.0	117	111	0.6
	HA	4.2	2.4	<1.0	<1.0	118	110	1.2
	BA	8.1	<1.0	<1.0	<1.0	118	110	<0.5
	SU	3.8	<1.0	<1.0	<1.0	115	100	<0.5
	EU	3.9	3.6	<1.0	<1.0	117	102	<0.5
	PF	1.6	1.0	<1.0	<1.0	110	93	<0.5
	UP	3.7	2.5	3.6	<1.0	155	100	<0.5
	GR	3.7	1.3	1.3	1.0	115	110	<0.5
	GO	2.4	1.4	1.4	<1.0	116	108	16
	HC	<1.0	<1.0	4.2	<1.0	137	103	21
02/18/80	ST	3.5		1.1	<0.5	145	127	<0.5
	HA	1.3		0.6	<0.5	127	110	<0.5
	BA	1.5		<0.5	<0.5	93	75	<0.5
	SU	1.4		<0.5	<0.5	110	83	<0.5
	EU	1.9		<0.5	<0.5	110	93	<0.5
	PF	1.4		<0.5	<0.5	110	93	<0.5
	UP	4.0		<0.5	<0.5	127	110	<0.5
	GR	3.5		<0.5	<0.5	93	75	<0.5
	GO	2.0		<0.5	<0.5	95	90	<0.5
	HC	1.5		<0.5	<0.5	100	83	<0.5
03/05/80	ST	1.6		<0.5	<0.5	135	127	<0.5
	HA	1.3		<0.5	<0.5	135	110	<0.5
	BA	1.4		<0.5	<0.5	136	117	<0.5
	SU	2.0		<0.5	<0.5	127	123	<0.5
	EU	1.1		0.8	0.6	128	110	<0.5
	PF	1.6		<0.5	<0.5	117	100	1.5
	UP	1.3		<0.5	<0.5	125	110	<0.5
	GR	1.4		<0.5	<0.5	128	110	<0.5
	GO	1.5		<0.5	<0.5	127	110	<0.5
	HC	1.4		0.6	<0.5	134	117	0.9
03/22/80	HA	1.2		2.2	<0.5	135	118	<0.5
	HB	1.5		1.1	<0.5	134	110	<0.5
	BA	1.2		1.9	<0.5	128	111	<0.5
	SU	1.2		0.8	<0.5	129	112	<0.5
	EU	1.8		1.1	1.0	128	114	<0.5
	PF	1.5		1.1	1.0	127	109	<0.5
	UP	1.5		0.6	<0.5	130	127	<0.5
	GR	1.8		0.6	<0.5	134	119	<0.5
	GO	2.1		1.1	<0.5	142	128	<0.5
	HC	2.7		<0.5	<0.5	140	128	<0.5

Table A-3. Spokane River Metals Data - continued

Date	ST	T-Cu	S-Cu	T-Pb	S-Pb	T-Zn	S-Zn	T-Hg
04/04/80	HA	1.5		<0.5	<0.5	155	136	<0.5
	HB	1.5		<0.5	<0.5	143	129	<0.5
	BA	1.2		<0.5	<0.5	135	128	<0.5
	SU	2.7		<0.5	<0.5	136	129	<0.5
	EU	2.4		<0.5	<0.5	135	108	<0.5
	PF	1.5		<0.5	<0.5	128	107	<0.5
	UP	1.5		<0.5	<0.5	135	118	<0.5
	GR	2.1		<0.5	<0.5	134	116	<0.5
	GO	2.1		<0.5	<0.5	136	128	<0.5
	HC	1.8		<0.5	<0.5	134	126	<0.5
04/21/80	HA	1.8		2.4	1.6	205	135	<0.5
	HB	2.1		3.0	2.7	200	175	<0.5
	BA	2.1		2.7	<0.5	200	145	<0.5
	SU	2.7		3.0	<0.5	195	160	<0.5
	EU	2.1		2.4	<0.5	187	160	<0.5
	PF	2.1		1.9	<0.5	185	135	<0.5
	UP	2.1		1.2	<0.5	185	143	<0.5
	GR	2.4		1.9	<0.5	185	155	<0.5
	GO	2.4		1.9	<0.5	180	160	<0.5
	HC	3.0		2.2	<0.5	180	158	<0.5
05/14/80	HA	2.7		2.4	<0.5	135	114	1.7
	HB	2.1		2.4	<0.5	137	100	<0.5
	BA	2.1		2.4	<0.5	125	100	<0.5
	SU	2.1		2.7	<0.5	128	114	<0.5
	EU	2.1		2.4	<0.5	125	100	<0.5
	PF	7.7		2.0	<0.5	125	80	<0.5
	UP	2.4		2.4	<0.5	135	114	<0.5
	GR	2.4		2.7	<0.5	128	100	<0.5
	GO	2.4		2.4	<0.5	114	80	<0.5
	HC	2.7		2.4	<0.5	125	100	0.6
06/03/80	HA	2.4		0.9	<0.5	114	80	<0.5
	HB	3.3		1.5	<0.5	125	80	<0.5
	BA	2.4		1.0	<0.5	100	80	<0.5
	SU	2.4		1.5	<0.5	114	100	<0.5
	EU	3.0		1.0	<0.5	114	80	<0.5
	PF	3.3		2.0	<0.5	114	80	<0.5
	UP	2.4		1.0	<0.5	114	80	0.5
	GR	3.3		1.0	<0.5	100	95	<0.5
	GO	2.4		0.6	<0.5	125	80	<0.5
	HC	2.4		1.5	0.6	80	75	<0.5

Table A-3. Spokane River Metals Data - continued

Date	ST	T-Cu	S-Cu	T-Pb	S-Pb	T-Zn	S-Zn	T-Hg
06/18/80	HA	1.5	<1.0	<1.0	<1.0	95	65	<0.5
	HB	1.0	<1.0	<1.0	<1.0	95	65	<0.5
	BA	<1.0	<1.0	<1.0	<1.0	95	65	<0.5
	SU	<1.0	<1.0	<1.0	<1.0	78	50	<0.5
	EU	1.8	<1.0	<1.0	<1.0	78	65	<0.5
	PF	<1.0	<1.0	<1.0	<1.0	78	65	<0.5
	UP	<1.0	<1.0	<1.0	<1.0	95	65	<0.5
	GR	1.0	<1.0	<1.0	<1.0	65	50	<0.5
	GO	1.0	<1.0	<1.0	<1.0	65	42	<0.5
	HC	1.2	<1.0	<1.0	<1.0	87	72	<0.5
07/02/80	HA	<1.0	<1.0	<1.0	<1.0	78	65	<0.5
	HB	<1.0	<1.0	<1.0	<1.0	72	50	<0.5
	BA	<1.0	<1.0	<1.0	<1.0	65	50	<0.5
	SU	<1.0	<1.0	<1.0	<1.0	78	75	0.5
	EU	1.0	<1.0	<1.0	<1.0	78	42	<0.5
	PF	1.0	<1.0	<1.0	<1.0	72	50	<0.5
	UP	1.0	<1.0	<1.0	<1.0	107	42	<0.5
	GR	4.0	<1.0	<1.0	<1.0	78	58	23.0
	GO	1.0	<1.0	1.8	<1.0	95	50	<0.5
	HC	<1.0	<1.0	<1.0	<1.0	95	50	<0.5
07/16/80	HA	<1.0	<1.0	<1.0	<1.0	78	50	<0.5
	HB	<1.0	<1.0	<1.0	<1.0	65	50	<0.5
	BA	<1.0	<1.0	<1.0	<1.0	50	33	<0.5
	SU	<1.0	<1.0	<1.0	<1.0	65	42	<0.5
	EU	<1.0	<1.0	<1.0	<1.0	65	50	4.7
	PF							
	UP	<1.0	<1.0	<1.0	<1.0	95	78	<0.5
	GR	<1.0	<1.0	1.7	<1.0	65	42	<0.5
	GO	<1.0	<1.0	<1.0	<1.0	65	42	<0.5
	HC	<1.0	<1.0	<1.0	<1.0	65	50	<0.5
07/29/80	HA	<1.0	<1.0	<1.0	<1.0	86	75	<0.5
	HB	<1.0	<1.0	<1.0	<1.0	86	80	<0.5
	BA	2.0	1.8	<1.0	<1.0	81	64	<0.5
	SU	2.0	1.8	<1.0	<1.0	92	42	<0.5
	EU	2.8	2.4	<1.0	<1.0	81	21	<0.5
	PF	1.0	<1.0	<1.0	<1.0	75	26	<0.5
	UP	1.0	<1.0	<1.0	<1.0	64	31	<0.5
	GR	1.0	<1.0	<1.0	<1.0	42	21	<0.5
	GO	1.0	<1.0	1.2	<1.0	70	48	<0.5
	HC	<1.0	<1.0	<1.0	<1.0	48	22	1.0

Table A-3. Spokane River Metals Data - continued

Date	ST	T-Cu	S-Cu	T-Pb	S-Pb	T-Zn	S-Zn	T-Hg
08/12/80	HA	<1.0	<1.0	<1.0	<1.0	75	26	<0.5
	HB	<1.0	<1.0	<1.0	<1.0	64	40	<0.5
	BA	<1.0	<1.0	<1.0	<1.0	59	16	<0.5
	SU	<1.0	<1.0	<1.0	<1.0	81	50	0.9
	EU	1.0	<1.0	<1.0	<1.0	64	55	<0.5
	PF	<1.0	<1.0	<1.0	<1.0	50	42	<0.5
	UP	1.0	<1.0	<1.0	<1.0	42	21	<0.5
	GR	<1.0	<1.0	<1.0	<1.0	40	26	<0.5
	GO	<1.0	<1.0	<1.0	<1.0	42	26	<0.5
	HC	<1.0	<1.0	<1.0	<1.0	40	31	<0.5
08/26/80	HA	<1.0	<1.0	<1.0	<1.0	106	89	<0.5
	HB	<1.0	<1.0	<1.0	<1.0	111	65	1.0
	BA	<1.0	<1.0	<1.0	<1.0	106	50	<0.5
	SU	<1.0	<1.0	<1.0	<1.0	106	65	<0.5
	EU	2.0	1.7	<1.0	<1.0	65	40	<0.5
	PF	1.0	<1.0	<1.0	<1.0	71	45	<0.5
	UP	<1.0	<1.0	<1.0	<1.0	55	20	<0.5
	GR	<1.0	<1.0	<1.0	<1.0	35	25	<0.5
	GO	<1.0	<1.0	<1.0	<1.0	30	25	<0.5
	HC	<1.0	<1.0	<1.0	<1.0	50	20	0.7
09/09/80	HA	<1.0	<1.0	<1.0	<1.0	60	53	<0.5
	HB	<1.0	<1.0	<1.0	<1.0	60	42	2.4
	BA	<1.0	<1.0	<1.0	<1.0	65	59	<0.5
	SU	<1.0	<1.0	<1.0	<1.0	81	53	<0.5
	EU	<1.0	<1.0	<1.0	<1.0	87	75	<0.5
	PF	<1.0	<1.0	<1.0	<1.0	71	65	<0.5
	UP	<1.0	<1.0	<1.0	<1.0	76	70	<0.5
	GR	<1.0	<1.0	<1.0	<1.0	40	37	<0.5
	GO	<1.0	<1.0	<1.0	<1.0	60	56	<0.5
	HC	<1.0	<1.0	<1.0	<1.0	45	38	<0.5
09/24/80	HA	1.8	<1.0	<1.0	<1.0	75	30	1.4
	HB	<1.0	<1.0	<1.0	<1.0	60	38	8.4
	BA	1.4	<1.0	<1.0	<1.0	75	38	<0.5
	SU	1.8	<1.0	<1.0	<1.0	75	38	8.5
	EU	2.2	<1.0	<1.0	<1.0	75	47	1.0
	PF	1.0	<1.0	<1.0	<1.0	75	47	<0.5
	UP	1.4	1.0	<1.0	<1.0	68	30	28
	GR	2.7	1.0	<1.0	<1.0	47	8	<0.5
	GO	-1	<1.0	<1.0	<1.0	60	20	<0.5
	HC	3.8	<1.0	<1.0	<1.0	68	30	24

Table A-3. Spokane River Metals Data - continued

Date	ST	T-Cu	S-Cu	T-Pb	S-Pb	T-Zn	S-Zn	T-Hg
10/10/80	HA	1.4	<1.0	<1.0	<1.0	83	75	5.6
	HB	1.4	<1.0	1.0	<1.0	92	68	29
	BA	3.3	1.8	<1.0	<1.0	75	60	18
	SU	<1.0	<1.0	<1.0	<1.0	68	47	64
	EU	1.4	<1.0	<1.0	<1.0	60	30	<0.5
	PF	4.4	2.2	<1.0	<1.0	55	38	0.8
	UP	1.4	<1.0	<1.0	<1.0	75	60	22
	GR	2.2	<1.0	<1.0	<1.0	47	5	60
	GO	1.8	<1.0	<1.0	<1.0	30	5	11
	HC	2.2	<1.0	<1.0	<1.0	30	20	8
11/14/80	HA	<1.0	<1.0	<1.0	<1.0	92	83	<0.5
	HB	<1.0	<1.0	<1.0	<1.0	92	60	<0.5
	BA	1.0	<1.0	<1.0	<1.0	83	75	0.6
	SU	1.8	<1.0	<1.0	<1.0	92	83	<0.5
	EU	3.3	<1.0	<1.0	<1.0	102	92	<0.5
	PF	<1.0	<1.0	<1.0	<1.0	120	110	0.6
	UP	2.2	<1.0	<1.0	<1.0	120	92	<0.5
	GR	1.8	<1.0	<1.0	<1.0	60	55	<0.5
	GO	1.0	<1.0	<1.0	<1.0	83	60	4.8
	HC	1.4	<1.0	<1.0	<1.0	75	60	70

Table A-3. Spokane River Metals Data - continued

(Copper,Lead,Zinc,Mercury,Cadmium,Nickel)
(Expressed in µg/l)

STATIONS: ST=Stateline, HA=Harvard Above, HB=Harvard Below, BA=Barker, SU=Sullivan, EU=Euclid, PF=Plantes Ferry, UP=Upriver Drive, GR=Greene Street, GO=Gonzaga, HC=Hangman Creek. (T=Total, S=Filterable through 0.45µm Filter)

Date	STA	T-Cu	S-Cu	T=Pb	S=Pb	T-Zn	S-Zn	T-Hg	T-Cd	S-Cd	T-Ni	S-Ni
12/17/80	HA	<1.0	<1.0	<1.0	<1.0	155	140	<0.5	1.5	<1.0	<5.0	<5.0
	HB	<1.0	<1.0	<1.0	<1.0	140	140	<0.5	<1.0	<1.0	<5.0	<5.0
	BA	<1.0	<1.0	<1.0	<1.0	140	140	<0.5	<1.0	<1.0	<5.0	<5.0
	SU	<1.0	<1.0	<1.0	<1.0	155	145	<0.5	<1.0	<1.0	5.0	<5.0
	EU	1.0	<1.0	1.2	<1.0	140	130	<0.5	<1.0	<1.0	<5.0	<5.0
	PF	<1.0	<1.0	<1.0	<1.0	140	115	<0.5	<1.0	<1.0	8.0	<5.0
	UP	1.0	<1.0	<1.0	<1.0	150	140	<0.5	1.0	<1.0	<5.0	<5.0
	GR	2.5	<1.0	<1.0	<1.0	215	125	1.5	1.0	<1.0	<5.0	<5.0
	GO	4.3	<1.0	<1.0	<1.0	165	125	1.7	<1.0	<1.0	<5.0	<5.0
	HC	3.7	<1.0	<1.0	<1.0	150	125	0.5	<1.0	<1.0	<5.0	<5.0
01/20/81	HA	<1.0	<1.0	5.5		175	165	<0.5	1.5	<1.0	<5.0	<5.0
	HB	<1.0	<1.0	5.5		235	165	<0.5	1.5	<1.0	<5.0	<5.0
	BA	<1.0	<1.0	5.5		165	155	<0.5	1.0	<1.0	<5.0	<5.0
	SU	<1.0	<1.0	5.5		185	165	<0.5	<1.0	<1.0	<5.0	<5.0
	EU	<1.0	<1.0	5.0		195	165	<0.5	<1.0	<1.0	<5.0	<5.0
	PF	1.0	<1.0	5.5		195	165	<0.5	<1.0	<1.0	<5.0	<5.0
	UP	<1.0	<1.0	7.0		195	165	<0.5	<1.0	<1.0	<5.0	<5.0
	GR	<1.0	<1.0	4.5		195	165	<0.5	<1.0	<1.0	<5.0	<5.0
	GO	<1.0	<1.0	5.5		195	155	<0.5	1.0	<1.0	<5.0	<5.0
	HC	<1.0	<1.0	4.5		195	165	<0.5	1.5	<1.0	<5.0	<5.0
02/26/81	HA	<1.0	<1.0	3.5	<1.0	165	155	<0.5	1.0	<1.0	<5.0	<5.0
	HB	<1.0	<1.0	3.5	<1.0	165	155	<0.5	<1.0	<1.0	<5.0	<5.0
	BA	<1.0	<1.0	3.5	<1.0	155	125	<0.5	1.0	<1.0	<5.0	<5.0
	SU	<1.0	<1.0	4.0	<1.0	155	135	<0.5	1.5	<1.0	<5.0	<5.0
	EU	<1.0	<1.0	4.0	<1.0	155	150	<0.5	1.5	<1.0	<5.0	<5.0
	PF	<1.0	<1.0	4.0	<1.0	205		<0.5	1.0	<1.0	<5.0	<5.0
	UP	<1.0	<1.0	4.0	<1.0	200	165	0.5	1.5	<1.0	<5.0	<5.0
	GR	<1.0	<1.0	4.0	<1.0	175	150	5.4	1.5	<1.0	<5.0	<5.0
	GO	<1.0	<1.0	4.5	<1.0	175	150	1.1	1.5	<1.0	<5.0	<5.0
	HC	<1.0	<1.0	4.0	<1.0	175	150	<0.5	1.5	<1.0	<5.0	<5.0
03/27/81	HA	2.0	<1.0	2.0	<1.0	165	110	<0.5	1.0	<1.0	10.0	7.5
	HB	<1.0	<1.0	2.0	<1.0	165	125	<0.5	1.0	<1.0	5.0	<5.0
	BA	1.5	<1.0	1.5	<1.0	165	110	0.9	1.0	<1.0	<5.0	<5.0
	SU	<1.0	<1.0	1.5	<1.0	140	130	0.5	1.0	<1.0	22.0	<5.0
	EU	<1.0	<1.0	3.5	<1.0	140	125	<0.5	1.2	<1.0	7.5	<5.0
	PF	1.0	<1.0	1.8	<1.0	155	125	<0.5	1.0	<1.0	10.0	<5.0
	UP	<1.0	<1.0	1.8	<1.0	165	140	<0.5	1.0	<1.0	5.0	<5.0
	GR	<1.0	<1.0	1.5	<1.0	155	140	<0.5	1.0	<1.0	<5.0	<5.0
	GO	1.5	<1.0	2.7	<1.0	155	140	<0.5	1.0	<1.0	<5.0	<5.0
	HC	<1.0	<1.0	2.7	<1.0	155	140	<0.5	1.0	<1.0	5.0	<5.0

Table A-3. Spokane River Metals Data - continued

Date	STA	T-Cu	S-Cu	T=Pb	S=Pb	T-Zn	S-Zn	T-Hg	T-Cd	S-Cd	T-Ni	S-Ni
04/16/81	HA	2.0	1.0	2.4	<1.0	165	125	<0.5	1.0	<1.0	<5.0	<5.0
	HB	1.0	<1.0	1.5	<1.0	155	150		1.0	<1.0	<5.0	<5.0
	BA	<1.0	<1.0	2.7	1.0	165	125		1.0	<1.0	<5.0	<5.0
	SU	<1.0	<1.0	2.4	<1.0	155	110		1.0	<1.0	<5.0	<5.0
	EU	<1.0	<1.0	4.7	1.0	140	125		<1.0	<1.0	<5.0	<5.0
	PF	<1.0	<1.0	2.7	<1.0	140	110		1.0	<1.0	<5.0	<5.0
	UP	<1.0	<1.0	1.8	<1.0	140	125		<1.0	<1.0	<5.0	<5.0
	GR	<1.0	<1.0	<1.0	<1.0	125	120		<1.0	<1.0	<5.0	<5.0
	GO	1.0	<1.0	2.0	<1.0	140	125		1.0	<1.0	5.0	<5.0
	HC	1.0	<1.0	1.8	<1.0	155	125		1.0	<1.0	5.0	<5.0
04/30/81	HA	<1.0	<1.0	2.0	<1.0	180	110	<0.5	1.5	<1.0	<5.0	<5.0
	HB	<1.0	<1.0	2.4	<1.0	180	120	<0.5	1.0	<1.0	<5.0	<5.0
	BA	<1.0	<1.0	2.0	<1.0	180	120	<0.5	3.5	1.6	<5.0	<5.0
	SU	<1.0	<1.0	2.4	2.4	180	120	<0.5	1.6	<1.0	<5.0	<5.0
	EU	<1.0	<1.0	2.4	<1.0	190	120	<0.5	1.6	<1.0	<5.0	<5.0
	PF	<1.0	<1.0	2.0	<1.0	190	120	<0.5	1.0	<1.0	<5.0	<5.0
	UP	<1.0	<1.0	1.0	<1.0	190	120	<0.5	<1.0	<1.0	<5.0	<5.0
	GR	<1.0	<1.0	<1.0	<1.0	195	130	<0.5	<1.0	<1.0	<5.0	<5.0
	GO	<1.0	<1.0	<1.0	<1.0	195	130	<0.5	4.0	<1.0	<5.0	<5.0
	HC	<1.0	<1.0	<1.0	<1.0	195	150	<0.5	3.0	<1.0	<5.0	<5.0
05/19/81	HA	<1.0	<1.0	<1.0	<1.0	130	95	<0.5	1.0	<1.0	<5.0	<5.0
	HB	<1.0	<1.0	<1.0	<1.0	130	80	<0.5	1.0	<1.0	<5.0	<5.0
	BA	<1.0	<1.0	<1.0	<1.0	130	95	<0.5	<1.0	<1.0	<5.0	<5.0
	SU	<1.0	<1.0	<1.0	<1.0	95	95	<0.5	<1.0	<1.0	<5.0	<5.0
	EU	<1.0	<1.0	1.0	<1.0	130	95	<0.5	<1.0	<1.0	<5.0	<5.0
	PF	<1.0	<1.0	1.0	<1.0	130	80	0.8	1.0	<1.0	<5.0	<5.0
	UP	<1.0	<1.0	<1.0	<1.0	130	50	0.8	<1.0	<1.0	<5.0	<5.0
	GR	<1.0	<1.0	<1.0	<1.0	120	95	<0.5	<1.0	<1.0	<5.0	<5.0
	GO	<1.0	<1.0	<1.0	<1.0	130	95	<0.5	<1.0	<1.0	<5.0	<5.0
	HC	<1.0	<1.0	1.0	<1.0	130	130	<0.5	<1.0	<1.0	<5.0	<5.0
06/05/81	HA	<1.0	<1.0	<1.0	<1.0	130	50	0.5	<1.0	<1.0	<5.0	<5.0
	HB	<1.0	<1.0	1.0	<1.0	120	95	1.8	<1.0	<1.0	<5.0	<5.0
	BA	<1.0	<1.0	<1.0	<1.0	120	95	<0.5	<1.0	<1.0	<5.0	<5.0
	SU	<1.0	<1.0	<1.0	<1.0	120	120	<0.5	<1.0	<1.0	<5.0	<5.0
	EU	<1.0	<1.0	<1.0	<1.0	130	95	<0.5	<1.0	<1.0	<5.0	<5.0
	PF	<1.0	<1.0	<1.0	<1.0	120	120	<0.5	<1.0	<1.0	<5.0	<5.0
	UP	<1.0	<1.0	<1.0	<1.0	120	95	0.5	<1.0	<1.0	<5.0	<5.0
	GR	<1.0	<1.0	<1.0	<1.0	95	95	0.5	<1.0	<1.0	<5.0	<5.0
	GO	<1.0	<1.0	<1.0	<1.0	95	80	<0.5	2.0	<1.0	<5.0	<5.0
	HC	<1.0	<1.0	<1.0	<1.0	95	95	0.7	<1.0	<1.0	<5.0	<5.0

Table A-3. Spokane River Metals Data - continued

Date	STA	T-Cu	S-Cu	T=Pb	S=Pb	T-Zn	S-Zn	T-Hg	T-Cd	S-Cd	T-Ni	S-Ni
06/11/81	HA	<1.0	<1.0	1.0	<1.0	130	120	<0.5	<1.0	<1.0	<5.0	<5.0
	HB	<1.0	<1.0	<1.0	<1.0	130	95	<0.5	<1.0	<1.0	<5.0	<5.0
	BA	<1.0	<1.0	<1.0	<1.0	130	95	0.5	<1.0	<1.0	<5.0	<5.0
	SU	<1.0	<1.0	<1.0	<1.0	130	130	<0.5	<1.0	<1.0	<5.0	<5.0
	EU	<1.0	<1.0	<1.0	<1.0	130	95	<0.5	<1.0	<1.0	<5.0	<5.0
	PF	<1.0	<1.0	<1.0	<1.0	130	130	1.4	<1.0	<1.0	<5.0	<5.0
	UP	<1.0	<1.0	<1.0	<1.0	95	95	<0.5	<1.0	<1.0	<5.0	<5.0
	GR	3.5	<1.0	<1.0	<1.0	130	95	<0.5	1.0	<1.0	<5.0	<5.0
	GO	<1.0	<1.0	1.0	<1.0	95	95	<0.5	<1.0	<1.0	<5.0	<5.0
	HC	<1.0	<1.0	1.0	<1.0	95	95	<0.5	<1.0	<1.0	<5.0	<5.0
06/25/81	HA	80.0	5.7	<1.0	<1.0	120	95	<0.5	<1.0	<1.0	<5.0	<5.0
	HB	2.6	<1.0	<1.0	<1.0	120	120	0.5	<1.0	<1.0	<5.0	<5.0
	BA	<1.0	<1.0	<1.0	<1.0	95	95	<0.5	<1.0	<1.0	<5.0	<5.0
	SU	<1.0	<1.0	<1.0	<1.0	120	120	<0.5	1.0	<1.0	<5.0	<5.0
	EU	3.5	<1.0	<1.0	<1.0	120	95	2.4	<1.0	<1.0	<5.0	<5.0
	PF	<1.0	<1.0	<1.0	<1.0	130	95	<0.5	<1.0	<1.0	<5.0	<5.0
	UP	<1.0	<1.0	<1.0	<1.0	120	95	<0.5	<1.0	<1.0	<5.0	<5.0
	GR	<1.0	<1.0	<1.0	<1.0	120	95	<0.5	<1.0	<1.0	<5.0	<5.0
	GO	<1.0	<1.0	<1.0	<1.0	120	95	<0.5	<1.0	<1.0	<5.0	<5.0
	HC	<1.0	<1.0	<1.0	<1.0	120	95	<0.5	<1.0	<1.0	<5.0	<5.0
07/09/81	HA	<1.0	<1.0	<1.0	<1.0	110	80	<0.5	<1.0	<1.0	<5.0	<5.0
	HB	<1.0	<1.0	<1.0	<1.0	110	70	<0.5	<1.0	<1.0	<5.0	<5.0
	BA	<1.0	<1.0	<1.0	<1.0	120	95	<0.5	<1.0	<1.0	<5.0	<5.0
	SU	<1.0	<1.0	<1.0	<1.0	100	80	<0.5	<1.0	<1.0	<5.0	<5.0
	EU	<1.0	<1.0	<1.0	<1.0	82	60	5.2	<1.0	<1.0	<5.0	<5.0
	PF	<1.0	<1.0	<1.0	<1.0	95	60	0.5	<1.0	<1.0	<5.0	<5.0
	UP	<1.0	<1.0	<1.0	<1.0	110	60	<0.5	<1.0	<1.0	<5.0	<5.0
	GR	<1.0	<1.0	<1.0	<1.0	100	60	1.3	<1.0	<1.0	<5.0	<5.0
	GO	<1.0	<1.0	<1.0	<1.0	100	60	2.3	1.0	<1.0	<5.0	<5.0
	HC	<1.0	<1.0	<1.0	<1.0	110	60	<0.5	<1.0	<1.0	<5.0	<5.0
07/24/81	HA	<1.0	<1.0	<1.0	<1.0	110	25	4.8	<1.0	<1.0	<5.0	<5.0
	HB	<1.0	<1.0	<1.0	<1.0	95	25	2.6	<1.0	<1.0	8.0	<5.0
	BA	<1.0	<1.0	<1.0	<1.0	85	25	<0.5	<1.0	<1.0	<5.0	<5.0
	SU	2.0	<1.0	<1.0	<1.0	95	50	<0.5	<1.0	<1.0	5.0	<5.0
	EU	1.0	<1.0	<1.0	<1.0	120	40	0.5	<1.0	<1.0	<5.0	<5.0
	PF	15.0	<1.0	<1.0	<1.0	95	40	0.8	<1.0	<1.0	19.0	<5.0
	UP	<1.0	<1.0	<1.0	<1.0	90	50	<0.5	6.8	<1.0	9.0	<5.0
	GR	<1.0	<1.0	<1.0	<1.0	70	40	<0.5	<1.0	<1.0	<5.0	<5.0
	GO	<1.0	<1.0	<1.0	<1.0	80	40	<0.5	<1.0	<1.0	<5.0	<5.0
	HC	<1.0	<1.0	<1.0	<1.0	80	40	<0.5	3.8	<1.0	<5.0	<5.0

Table A-3. Spokane River Metals Data - continued

Date	STA	T-Cu	S-Cu	T=Pb	S=Pb	T-Zn	S-Zn	T-Hg	T-Cd	S-Cd	T-Ni	S-Ni
08/06/81	HA	<1.0	<1.0	<1.0	<1.0	100	65	0.6	<1.0	<1.0	<5.0	<5.0
	HB	<1.0	<1.0	<1.0	<1.0	90	80	<0.5	<1.0	<1.0	<5.0	<5.0
	BA	<1.0	<1.0	<1.0	<1.0	100	70	<0.5	<1.0	<1.0	<5.0	<5.0
	SU	<1.0	<1.0	<1.0	<1.0				<1.0	<1.0	5.0	<5.0
	EU	3.0	<1.0	<1.0	<1.0	90	50	6.7	<1.0	<1.0	<5.0	<5.0
	PF	5.0	<1.0	<1.0	<1.0	90	40	3.2	<1.0	<1.0	<5.0	<5.0
	UP	1.0	<1.0	<1.0	<1.0	80	30	0.6	<1.0	<1.0	<5.0	<5.0
	GR	<1.0	<1.0	<1.0	<1.0	30	10	4.1	<1.0	<1.0	<5.0	<5.0
	GO	11.0	<1.0	<1.0	<1.0				<1.0	<1.0	<5.0	<5.0
	HC	1.0	<1.0	<1.0	<1.0	50	30	<0.5	<1.0	<1.0	<5.0	<5.0
08/25/81	HA	<1.0	<1.0	<1.0	<1.0	40	10	0.8	<1.0	<1.0	<5.0	<5.0
	HB	<1.0	<1.0	<1.0	<1.0	40	10	<0.5	<1.0	<1.0	<5.0	<5.0
	BA	<1.0	<1.0	<1.0	<1.0	15	15	2.5	<1.0	<1.0	<5.0	<5.0
	SU	<1.0	<1.0	<1.0	<1.0	20	5	<0.5	<1.0	<1.0	<5.0	<5.0
	EU	2.0	<1.0	<1.0	<1.0	15	15	<0.5	<1.0	<1.0	<5.0	<5.0
	PF	1.5	<1.0	<1.0	<1.0	10	10	<0.5	<1.0	<1.0	<5.0	<5.0
	UP	1.0	<1.0	<1.0	<1.0	10	<5.0	<0.5	<1.0	<1.0	<5.0	<5.0
	GR	<1.0	<1.0	<1.0	<1.0	15	<5.0	<0.5	<1.0	<1.0	<5.0	<5.0
	GO	2.0	<1.0	<1.0	<1.0	5	<5.0	<0.5	<1.0	<1.0	13.0	<5.0
	HC	5.0	<1.0	<1.0	<1.0	15	<5.0	<0.5	<1.0	<1.0	<5.0	<5.0
09/03/81	HA	<1.0	<1.0	<1.0	<1.0	65	65	<0.5	<1.0	<1.0	<5.0	<5.0
	HB	<1.0	<1.0	<1.0	<1.0	60	40	2.9	<1.0	<1.0	<5.0	<5.0
	BA	<1.0	<1.0	<1.0	<1.0	80	70	<0.5	<1.0	<1.0	<5.0	<5.0
	SU	3.0	<1.0	<1.0	<1.0	90	40	<0.5	<1.0	<1.0	<5.0	<5.0
	EU	5.0	<1.0	<1.0	<1.0	70	60	<0.5	<1.0	<1.0	<5.0	<5.0
	PF	2.0	<1.0	<1.0	<1.0	30	10	<0.5	<1.0	<1.0	<5.0	<5.0
	UP			<1.0	<1.0				<1.0	<1.0	5.0	<5.0
	GR	<1.0	<1.0	<1.0	<1.0	25	<5.0	0.5	<1.0	<1.0	5.0	<5.0
	GO	<1.0	<1.0	<1.0	<1.0	30	20	<0.5	<1.0	<1.0	5.0	<5.0
	HC	1.0	<1.0	<1.0	<1.0	30	20	1.0	<1.0	<1.0	5.0	<5.0
09/24/81	HA	<1.0	<1.0	<1.0	<1.0	60	50	<0.5	<1.0	<1.0	<5.0	<5.0
	HB	<1.0	<1.0	<1.0	<1.0	30	30	<0.5	<1.0	<1.0	<5.0	<5.0
	BA	<1.0	<1.0	<1.0	<1.0	65	30	<0.5	<1.0	<1.0	<5.0	<5.0
	SU	<1.0	<1.0	<1.0	<1.0			<0.5	<1.0	<1.0	<5.0	<5.0
	EU	1.5	<1.0	<1.0	<1.0	50	50	<0.5	<1.0	<1.0	<5.0	<5.0
	PF	1.0	<1.0	<1.0	<1.0	50	25	<0.5	<1.0	<1.0	<5.0	<5.0
	UP	1.0	<1.0	<1.0	<1.0	30	30	<0.5	<1.0	<1.0	<5.0	<5.0
	GR	1.0	<1.0	<1.0	<1.0	50	25	<0.5	<1.0	<1.0	<5.0	<5.0
	GO	2.0	<1.0	<1.0	<1.0	60	60	<0.5	<1.0	<1.0	<5.0	<5.0
	HC	1.5	<1.0	<1.0	<1.0	30	20	<0.5	<1.0	<1.0	<5.0	<5.0

Table A-3. Spokane River Metals Data - continued

Date	STA	T-Cu	S-Cu	T=Pb	S=Pb	T-Zn	S-Zn	T-Hg	T-Cd	S-Cd	T-Ni	S-Ni
11/03/81	HA	20.0	13.0	<1.0	<1.0	70	55	<0.5	<1.0	<1.0	<5.0	<5.0
	HB	<1.0	<1.0	<1.0	<1.0	90	75	<0.5	<1.0	<1.0	<5.0	<5.0
	BA	<1.0	<1.0	<1.0	<1.0	40	25	<0.5	<1.0	<1.0	<5.0	<5.0
	SU	<1.0	<1.0	.0	<1.0	65	40	<0.5	<1.0	<1.0	<5.0	<5.0
	EU	<1.0	<1	<1.0	<1.0	70	40	<0.5	<1.0	<1.0	<5.0	<5.0
	PF	[illegible]	<1.0	<1.0	<1.0	65	50	<0.5	<1.0	<1.0	<5.0	<5.0
	UI	<1.0	<1.0	<1.0	<1.0	65	50	<0.5	<1.0	<1.0	<5.0	<5.0
	GR	<1.0	[illegible]	[illegible]	[illegible]	[illegible]	30	<0.5	<1.0	<1.0	<5.0	<5.0
	GO	1.0	<1.0	<1.0	<1.0			<0.5	<1.0	<1.0	<5.0	<5.0
	HC	<1.0	<1.0	<1.0	<1.0	30	30	<0.5	<1.0	<1.0	<5.0	<5.0

APPENDIX B

Table B-1. Spokane River Fecal Coliform Data. Expressed in Organisms/100ml. MF=Millipore Filter, MPN=Most Probable Number

STATIONS: ST=Stateline, HA=Harvard Above, HB=Harvard Below, BA=Barker, SU=Sullivan, EU=Euclid, PF=Plantes Ferry, UP=Upriver Drive, GR=Greene Street, GO=Gonzaga, HC=Hangman Creek.

DATE	ST	HA	BA	SU	EU	PF	UP	GR	GO	HC	
12/04/80	<1	<1	*2	<1	*2	<1	<1	*1	*2	*280	
12/16/80	*5	*1	*2	<1	*1	*1	<1	*26	*3	*5	
01/04/80	<1	<1	*1	<1	*2	<1	<1	*23	*2	*4	
02/18/80	<1	<1	<1	<1	<1	*1	*12	23	*18	49	
03/05/80	<1	<1	<1	<1	<1	<1	<1	30	*4	24	
	HA	HB	BA	SU	EU	PF	UP	GR	GO	HC	
03/22/80	*1	<1	<1	<1		<1	*3	*7	*17	*6	
04/04/80	<1	<1	<1	<1	<1	*1	50	*840	*300	*8	
04/21/80	*2	<1	*1	<1	<1	*3	*6	*16	*8	*2	
05/14/80	*3	60	<1	<1	*3	*4	*8	28	20	*12	
06/03/80	<1	*2	<1	*1	*1	<1	<1	142	*8	*1	
06/17/80	*1	*4	*1	<1	<1	*4	*2	<1	*10	*14	
07/02/80	*4	<1	*2	*1	*2	<1	*4	*14	*16	21	
07/17/80	*3	<1	*4	*2	*2		*3	*7	*6	*13	MF ↑
07/29/80	*3	*3	*3	*3	4	*3	4	43	15	7	MPN ↓
08/12/80	<3	<3	<3	<3	*9	43	<3	*9	*15	150	
08/26/80	*4	*4	20	*4	*6	*10	*6	104	*14	114	
09/09/80	<3	43	*7	23	*9	23	43	43	93	460	
09/24/80	9	9	9	4	9	9	23	75	460	460	
10/10/80	23	23	4	15	15	7	43	15	43	23	
11/14/80	23	23	9	23	23	43	43	93	150	460	
12/17/80	15	<3	4	7	4	7	<3	4	43	39	
01/20/81	4	4	<3	<3	4	9	21	240	20	150	
02/26/81	<3	<3	4	<3	<3	<3	4	<3	4	<3	
03/27/81	<3	<3	4	<3	<3	<3	<3	4	<3	7	
04/16/81	4	<3	4	<3	<3	<3	4	<3	7	9	
04/30/81	7	9	9	<3	4	<3	<3	4	9	11	
05/19/81	11	43	39	43	150	75	15	93	93	460	
06/05/81	4	23	4	9	7	23	9	93	7	23	
06/11/81	15	9	15	93	21	9	28	43	28	150	
06/25/81	<3	<3	<3	<3	9	4	4	93	64	150	
07/09/81	9	<3	<3	4	7	3	7	7	4	75	

Table B-1. Spokane River Fecal Coliform Data - continued

DATE	ST	HA	BA	SU	EU	PF	UP	GR	GO	HC
07/24/81	4	<3	43	43	240	4	4	20	15	23
08/06/81	20	11	11	43	460	75	21	75	21	150
08/25/81	7	*	*	93	15	43	9	7	43	43
09/03/81	21	15	43	43	<3	<3	<3	9	9	93
09/24/81	<3	<3	4	<3	<3	23	4	4	150	43
11/03/81	9	<3	3	4	3	4	<3	<3	21	150

APPENDIX C

Table C-1. Spokane River Periphyton Ash-free Dry Weight Data (g/m^2).

Colonization Period	Location 1		Location 2	
	Natural Substrate	Artificial Substrate	Natural Substrate	Artificial Substrate
Colonization Period 1 7/16-8/13/80	8.9	3.8	7.7	4.6
	10.9	3.4	6.6	4.0
	9.1	3.6	7.3	4.1
Colonization Period 2 8/13-9/8/80	3.4	1.4	4.5	2.1
	5.8	2.0	6.8	2.9
	4.3	2.9	3.5	2.5
Colonization Period 3 9/8-10/5/80	18.1	8.5	8.8	9.8
	18.1	12.9	12.4	6.9
	16.5	3.9	9.4	6.9
Colonization Period 4 10/5-11/2/80	16.6	6.7	15.5	5.6
	5.6	5.8	23.5	6.6
	6.0	1.7	20.2	11.8

Table C-2. Spokane River Periphyton Chlorophyll a Data (mg/m^2).

Colonization Period	Location 1		Location 2	
	Natural Substrate	Artificial Substrate	Natural Substrate	Artificial Substrate
Colonization Period 1 7/16-8/13/80	19.9 12.8 7.6	5.9 9.2 12.2	20.7 11.0 15.3	4.9 9.5 8.9
Colonization Period 2 8/13-9/8/80	1.8 8.3 3.9	7.0 5.6 4.1	4.6 10.0 6.3	7.7 12.4 9.2
Colonization Period 3 9/8-10/5/80	58.2 46.2 108.5	39.5 27.7 49.2	28.8 44.8 43.7	37.1 42.7 24.6
Colonization Period 4 10/5-11/2/80	48.1 50.4 32.0	45.8 35.6 23.6	69.4 62.5 78.0	38.6 50.8 119.6

Table C-3. Spokane River Periphyton Total Cell Numbers Data ($X10^6/m^2$).

Colonization Period	Location 1		Location 2	
	Natural Substrate	Artificial Substrate	Natural Substrate	Artificial Substrate
Colonization Period 1 7/16-8/13/80	3,161 6,683 3,059	5,576 7,390 4,937	4,320 5,201 6,665	5,577 3,322 4,752
Colonization Period 2 8/13-9/8/80	2,662 2,082 2,036	5,220 2,612 4,497	1,769 1,350 1,440	8,274 3,052 4,155
Colonization Period 3 9/8-10/5/80	5,258 7,397 11,000	8,673 13,220 11,570	8,569 3,688 9,401	4,882 4,127 8,042
Colonization Period 4 10/5-11/2/80	4,306 6,040 3,901	2,621 3,424 3,347	9,806 6,224 5,201	12,970 13,043 11,716

Table C-4. Spokane River Periphyton Percent Organic Content Data (%)

Colonization Period	Location 1		Location 2	
	Natural Substrate	Artificial Substrate	Natural Substrate	Artificial Substrate
Colonization Period 1 7/16-8/13/80	36.76	45.26	36.40	61.19
	37.76	55.59	36.88	58.14
	32.75	54.92	39.34	58.36
Colonization Period 2 8/13-9/8/80	26.44	53.54	20.77	63.70
	64.00	50.20	26.81	58.01
	77.22	57.17	36.31	58.95
Colonization Period 3 9/8-10/5/80	28.43	29.70	23.98	27.71
	30.03	29.60	27.05	27.69
	30.12	28.99	30.53	26.69
Colonization Period 4 10/5-11/2/80	23.10	29.07	20.82	24.83
	29.08	28.88	21.75	27.74
	26.52	31.43	21.06	31.58

Table C-5. Spokane River Periphyton Community Structure Ratio Data (Nondiatom/Diatom).

Colonization Period	Location 1		Location 2	
	Natural Substrate	Artificial Substrate	Natural Substrate	Artificial Substrate
Colonization Period 1 7/16-8/13/80	0.23	1.47	0.92	0.73
	0.55	1.82	1.32	0.44
	0.27	1.77	1.68	0.88
Colonization Period 2 8/13-9/8/80	0.82	1.74	0.44	9.31
	2.63	1.32	0.90	4.80
	1.45	0.70	0.56	13.73
Colonization Period 3 9/8-10/5/80	0.64	1.01	2.17	0.74
	1.39	1.19	1.06	0.58
	0.38	0.80	2.02	0.83
Colonization Period 4 10/5-11/2/80	0.85	0.67	0.67	1.16
	0.22	0.33	0.20	0.90
	0.48	0.33	0.07	0.95

Table C-6. Analysis of Variance of Ash-free Dry Weights of Spokane River Periphyton (transformed by lnx).

Source of variation	df	SS	MS	F
Location, L	1	0.24	0.24	0.42
Period, P	3	9.29	3.10	5.44*
Error (a), LP	3	1.71	0.57	
Substrate, S	1	6.10	6.10	87.98**
Location x substrate, LS	1	0.16	0.16	
Error (b), PS + PLS	6	0.42	0.07	
Error (c), within among triplicates	32	3.90	0.12	
Total	47	21.82		

* Significant at P $\leq$0.10.
**Significant at P $\leq$0.05.

Table C-7. Analysis of Variance of Chlorophyll a Values for Spokane River Periphyton (transformed by lnx).

Source of variation	df	SS	MS	F
Location, L	1	0.47	0.47	0.84
Period, P	3	38.86	12.95	23.38*
Error (a), LP	3	1.66	0.55	
Substrate, S	1	0.37	0.37	0.28
Location x substrate, LS	1	0.01	0.01	
Error (b), PS + PLS	6	1.55	0.26	
Error (c), within among triplicates	32	4.85	0.15	
Total	47	47.76		

* Significant at $P \leq 0.05$.

Table C-8. Analysis of Variance of Total Cell Numbers of Spokane River Periphyton (transformed by lnx).

Source of variation	df	SS	MS	F
Location, L	1	0.10	0.10	0.11
Period, P	3	6.16	2.05	2.20
Error (a), LP	3	2.81	0.94	
Substrate, S	1	0.98	0.98	2.14
Location x substrate, LS	1	0.04	0.04	
Error (b), PS + PLS	6	2.75	0.46	
Error (c), within among triplicates	32	3.10	0.10	
Total	47	15.94		

Table C-9. Analysis of Variance of Percent Organic Content Values for Spokane River Periphyton (transformed lnx).

Source of variation	df	SS	MS	F
Location, L	1	0.11	0.11	1.71
Period, P	3	3.23	1.08	17.33*
Error (a), LP	3	0.19	0.06	
Substrate, S	1	0.82	0.82	8.09*
Location x substrate, LS	1	0.18	0.18	
Error (b), PS + PLS	6	0.61	0.10	
Error (c), within among triplicates	32	0.96	0.03	
Total	47	6.09		

*Significant at $P \leq 0.05$.

Table C-10. Analysis of Variance of Community Structure Ratios of Spokane River Periphyton (transformed by lnx).

Source of variation	df	SS	MS	F
Location, L	1	0.89	0.89	7.07*
Period, P	3	11.11	3.71	29.32*
Error (a), LP	3	0.38	0.13	
Substrate, S	1	3.60	3.60	1.32
Location x substrate, LS	1	0.18	0.18	
Error (b), PS + PLS	6	16.38	2.73	
Error (c), within among triplicates	32	8.00	0.25	
Total	47	40.54		

*Significant at P <0.10.