Research Technical Completion Report

PHYSICAL AND CHEMICAL WATER QUALITY OF THE SPOKANE RIVER OUTLET REACH OF LAKE COEUR D'ALENE, KOOTENAI COUNTY, IDAHO 1990 AND 1991

by

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ABSTRACT

The University of Idaho conducted a water quality study on the Spokane River outlet arm of Lake Coeur d'Alene from June, 1990 through September, 1991. The project was sponsored by the Idaho Division of Environmental Quality (Coeur d'Alene office). Objectives of the study were to: 1) Characterize baseline river water quality; 2) determine seasonal river water quality variation; 3) assess diel temperature and dissolved oxygen changes for indications of aquatic ecosystem stress; and 4) provide a cursory view of the effects of existing and proposed wastewater discharges on river water quality, to the extent that river water quality data and WWTP data will allow. The study updated earlier work by the University of Idaho and USEPA in 1980 and 1988. The study area covered the 8.1-mile reach of the Spokane River from the outlet of Lake Coeur d'Alene at River Mile 108.8 downstream to just below Post Falls Dam at River Mile 100.7. This reach is typified by swift water currents and cobble bottom channel in the upper section merging to deeper, slower lacustrine conditions in the lower section where channel cobbles yield to fine sediments in lateral embayments. Water depths ranged from 2 to 18 m through the reach.

Water flows in the 16-month study ranged from high flows of 31,750 cfs in May, 1990 to low flows of 340 cfs in September, 1990. Retention times of the study reach varied from 4.3 hours at annual high flows in 1990 and 1991, respectively, to 12.7 days at annual low flows in 1990 and 1991. Surface water temperatures peaked at 25.7 and 26.1 C in 1990 and 1991. Vertical thermal stratification was minimal, always less than 3.0 C from surface to bottom. Slight summer temperature increases were noted downstream through the reach. Sample site mean summer dissolved oxygen was always greater than 7.0 mg/l; one sample occurrence was recorded of 5.4 mg/l. Electrical conductivity generally ranged from 30 to 55 µmhos. Median pH was slightly on the acid side (5.7 to 7.8) throughout the reach.

Secchi depth ranged from 2.4 to 6.5 m with a study average of 4.0 m. High flows coincided with low secchi depths, as a result of suspended sediments and an extended spring algae pulse. Mean *year-round* chlorophyll *a* averaged 2.5 and 4.2 mg/m^3 at the upper and lower sections of this river reach for an average 73% increase over the 7.6 mile reach.

Mean *summer* chlorophyll *a* of the lower sections averaged 6.0 mg/m^3 in 1990 but only 3.3 mg/m^3 in 1991 (= 45% reduction) following 1) a very large spring algae bloom, and 2) 80% phosphorus removal from the Coeur d'Alene WWTP. The 1990 and 1991 chlorophyll *a* levels place the Spokane River in mesotrophic and meso-oligotrophic productivity ranges, re-

spectively. Mean Kjeldahl nitrogen was 0.18 mg/l and generally increased >20% below the Coeur d'Alene WWTP at low flows. There was a general trend of TKN increasing downstream through the study reach. The WWTPs contributed 25 to 50% of the TKN load to the Spokane River at low flows. Nitrate nitrogen was typically less than 0.05 mg/l through summer months with fall-winter maxima of 0.50 mg/l. At low flows, WWTPs supplied 40% of the total nitrate load to the river. Mean total ammonia in the Spokane River arm of Lake Coeur d'Alene was 0.14 mg/l. From RM 111.1 to 108.8, there typically was an average 75% increase of total ammonia in the River, but less than one third of that increase was from the Coeur d'Alene WWTP. However, 30% of the average summer ammonia load to the river was from the Coeur d'Alene WWTP (up to 60% of the total ammonia load in September, 1991 at 340 cfs river flow).

Total phosphorus ranged from 0.007 to 0.025 mg/l with a study mean of 0.014 mg/l (in the mesotrophic range). Total phosphorus increased 70% between RM 111.1 and 108.8 over the entire study. *Summer* total phosphorus increased 87% between RM 111.1 and 108.8 over the entire study, 187% in 1991, but showed a 30% decline in 1991 *after* phosphorus removal in the Coeur d'Alene WWTP. WWTPs contributed ~50% of the total phosphorus load to the reach at low flows. Upgrading the Coeur d'Alene WWTP in June, 1991 resulted in an effluent TP decline of 79%. Total N:total P ratios indicate phosphorus limitation most of the time with the exception of summer-fall 1990.

BOD_5 levels in the Spokane River were moderately high, averaging 3.4 mg/l over all sites and dates. WWTP BOD_5 levels from the Coeur d'Alene and Post Falls plants averaged 81.2 and 13.2 mg/l, respectively. Mean BOD_5 increased 14% in the lower four river sites compared to the two upstream sites. Ultimate BOD in the Spokane River averaged 10.7 mg/l. WWTP ultimate BOD levels from the Coeur d'Alene and Post Falls plants averaged 644.7 and 371 mg/l, respectively. Mean ultimate BOD increased 11% in the lowest river site compared to the uppermost site.

Median fecal coliform bacteria in the Spokane River were ~1 colony/100 ml except for immediately below the WWTPs. Median fecal coliform bacteria were 30 and 24 colonies/100 ml in the Coeur d'Alene and Post Falls WWTPs, respectively. Median fecal coliform bacteria increased ~30-fold from above to immediately below the Coeur d'Alene WWTP. River fecal coliform levels dropped to background concentrations within two river miles. Median fecal coliform bacteria increased ~2-fold from above to immediately below the Post Falls WWTP. The diel study in August, 1991 showed insignificant stratification of either temperature or oxygen and little day-to-night fluctuation of either temperature or oxygen.

INTRODUCTION

The Spokane River Project was initiated in June, 1990, under contract from the Idaho Division of Environmental Quality (IDEQ) to the University of Idaho, College of Forestry, Wildlife, and Range Sciences. Field work extended from June, 1990 through September, 1991. The study was intended to address concerns over the ability of the Spokane River arm of Lake Coeur d'Alene to continue absorbing increased amounts of point and nonpoint source pollution without violating water quality standards or creating undesirable water quality changes. Additionally, it provides an updated database for the IDEQ in Coeur d'Alene to identify problem areas and management possibilities for the Spokane River.

Specific objectives of the study were to:

1) Characterize baseline river water quality;
2) Determine seasonal river water quality variation, with an emphasis on thermally stratified conditions;
3) Assess diel temperature and dissolved oxygen changes for indications of aquatic ecosystem stress; and
4) Provide a cursory view of the effects of existing and proposed wastewater discharges on river water quality, to the extent that river water quality data and WWTP data will allow.

The Spokane River begins as the outlet to Lake Coeur d'Alene in northern Idaho. The 11-mile outlet reach (Spokane River Mile (RM) 111.1 to 102.5) from Lake Coeur d'Alene to Post Falls, Idaho, was the focus of this study (Figure 1). The Spokane River drainage area above Post Falls comprises 3,840 square miles and is drained by two major rivers flowing into Lake Coeur d'Alene, the Coeur d'Alene and St. Joe Rivers. Both drainages are principally forested, deeply dissected mountainous terrain with peaks and ridges approaching 8,000 feet msl. Population is concentrated on the valley floors, especially throughout the length of the South Fork and main Coeur d'Alene Rivers and around Coeur d'Alene on the Rathdrum Prairie at the north end of Lake Coeur d'Alene. More than a century of deep shaft mining activities for sulfide-based heavy metals has caused excessively high levels of cadmium, lead, arsenic, and zinc in the South Fork of the Coeur d'Alene River. In 1981, the USEPA designation of a portion of the South Fork as a CERCLA Superfund Site. The consequential closing of smelter plants along the river, combined with the tailings impoundments constructed in the 1960's, caused a reduction in metals content of the water in this major tributary of the Spokane River. Watershed development, principally in Coeur d'Alene and around the outlet reach of Lake Coeur d'Alene in the last decade has proceeded rapidly, raising concerns of reach water quality. Several possible point and non-point sources exist in this area.

Numerous lumber mills and associated log floating operations are along the 11-mile outlet reach. Extensive movement and storage of raw logs has resulted in accumulations of benthic bark deposits throughout the river. These deposits are potential sources of biological growth and activity. Another concern is the presence of numerous private septic systems along this developed reach. Nutrient loading from private systems from these developments on the Spokane River is an unquantified factor as is the phosphorus input from lawn fertilization along the river.

Some baseline water quality information has been collected on the upper Spokane River over the last decade. Yearsley (1980) studied water quality in the Idaho reach of the Spokane River and computed mean summer loadings of phosphorus from Lake Coeur d'Alene and from the Coeur d'Alene Waste Water Treatment Plant (WWTP). Falter and Mitchell (1982) conducted a comprehensive limnological assessment of the upper Spokane River during water year 1980. Later work by Yearsley and Duncan (1989) partitioned nutrient loading and identified areas of oxygen depletion. Oxygen depletion zones were also noted by Seitz and Jones (1981).

METHODS

Sample Dates, Sites, and Procedures

Water quality sampling on the Spokane River began on June 29, 1990, and continued every two weeks through October, 1990, for a total of 10 summer sampling periods. Throughout the winter months of low biological activity, sampling was reduced to once a month. In June, 1991, samples were again collected every two weeks until the end of WY-91 through September, 1991. This resulted in a total of 27 sampling runs on the Spokane River from June, 1990 through September, 1991.

Water samples were collected from six river locations and two wastewater treatment plant locations (Cities of Coeur d'Alene and Post Falls) (Figure 1). These stations were selected for their comparability with previous research and unique physical characteristics of each reach of the river.

Samples were distributed horizontally (with samples collected in the right, middle, and left thirds of the river for each river location) and vertically (with samples collected at mid-depth and off the bottom) within each location (Figures 2 and 3). Mid-depth water quality samples were composited horizontally to produce a single integrated sample. Deep water samples below the thermocline (collected in areas where the river was thermally stratified) were kept separate.

Samples from the municipal treatment facilities in Coeur d'Alene and Post Falls were obtained during each river sampling period from a 24-hour composite of each treatment plant effluent.

Parameter Sampling Procedures

In situ temperature, dissolved oxygen, and specific conductance profiles were taken in 1-meter increments at all ambient stations using a YSI Model 57 Oxygen Meter and a YSI Model 33 S-C-T Meter. Secchi disk transparency depth was measured at the five stations above Post Falls dam using a 20 cm standard black and white Secchi disk.

River flow records for the entire sampling period were obtained from the USGS in Sandpoint, ID, and daily flows from the municipal treatment facilities were provided by the respective plant. Cross-sectional transects of the river were measured in the spring at peak flow using a Raytheon recording fathometer.

Retention times were calculated by dividing the water volume between stations by the mean hourly outflow. The water volume between stations was determined by mechanical planimetry of morphometric data.

At each station, a cross-sectional composite water sample was collected from mid-depth when the river was thermally mixed. A separate sample was taken 1-meter off the bottom below the thermocline under stratified conditions. These water samples were collected using a 2-liter brass Kemmerer bottle and transferred to a covered, acid-washed 5-gallon plastic container. Subsamples were then taken from this large container for the following laboratory analyses:

pH and Turbidity

A subsample was obtained in a 1-liter plastic bottle, cooled to 4 C, and taken back to the University of Idaho lab for analysis of pH (Corning Model 7 pH Meter) and turbidity (Hach Model 2100A Turbidimeter).

Chlorophyll *a*

Another 1-liter subsample was collected in a dark bottle and cooled. This water was later analyzed for chlorophyll *a* according to the monochromatic spectrophotometric procedure outlined in Standard Methods (1989).

Bacteria

One sample was taken at each station in a sterile 200-ml polyethylene bottle and cooled. At the lab, 10 ml and 100 ml portions were filtered through sterile, 0.45 *u*m GN-6 Grid Metricel Membrane Filters and cultured on growth media specific for fecal coliform and fecal streptococcus bacteria. Incubation was done in accordance with Standard Methods (1989). Counting of fecal coliform and fecal streptococcus colonies was done under Wild-Leitz microscopes at 100-power magnification.

Biochemical Oxygen Demand

Five 300-ml BOD bottles from each station were filled from the composite container and cooled for transport to the lab. After warming to room temperature, a series of dilutions were made on each bottle whereby bacterial "seed" (from Moscow,ID, WWTP) and nutrients were added to the sample water in different concentrations. Dissolved oxygen was then measured using an Extech Dissolved Oxygen Meter. The bottles were then water-sealed and allowed to incubate in the dark at 20 C for 5 days. Dissolved oxygen was then measured again to determine 5-day BOD as outlined in Standard Methods (1989). Ultimate BOD was determined at stations 1 and 6. This consisted of measuring the dissolved oxygen in the bottles at 5, 10, 15, 20, 27, 35, and 45 days.

Chemical Analyses

A sub-sample was collected from the large container at each station in an acid washed 1-liter plastic bottle and immediately fixed with 2 ml concentrated H_2SO_4 for preservation. These samples were frozen at the lab and later analyzed for the following chemicals:

CHEMICAL PARAMETER	METHOD OF ANALYSIS
Total ammonia as N	Direct ammonia
Total nitrite and nitrate as N	Ultraviolet Screening
Total Kjeldahl nitrogen as N	Micro Kjeldahl
Total phosphorus as P	Persulfate digestion
Orthophosphate	Stannous chloride

All analyses were in accordance with procedures outlined in APHA Standard Methods (1989) with spectrophotometric measurements on a Beckman DU-8 Spectrophotometer.

WWTP Effluent Analyses

Turbidity, pH, all chemical analyses, 5-day BOD, ultimate BOD, and bacterial analyses of WWTP effluent were processed and analyzed in the same manner as river water samples.

Note: Ammonia oxidation was not inhibited in WWTP ultimate BOD tests. Therefore, ultimate BOD results should be viewed with caution.

Depth Transects

On August 13, 1991, we conducted a number of bottom transects on the Spokane River outlet arm to map the bottom contours and determine precise depths at each of the five established sampling stations and to verify reports of a deep hole in the vicinity of Ford Rock. Transects were recorded from a small powerboat traveling at a constant, slow speed from one side of the channel to the other at each Station. Fifteen transects were taken 20 to 50 meters apart below Station 4 at Ford Rock.

Diel Study (August 12-13, 1991)

A diel study was undertaken on August 12-13, 1991 to assess 24-hour temperature and dissolved oxygen changes in the Spokane River arm above Post Falls Dam. This diel study enabled more accurate description of diel water quality in this reach, since large fluctuations in oxygen could indicate water quality stress in the system. Pronounced afternoon thermal stratification would be conducive to algae blooms.

Temperature and dissolved oxygen profiles were taken following our standard methodology at one-meter increments, surface to bottom, in the left, middle, and right thirds of the river at Stations 4 and 5 (RM 103.5 and 102.5, respectively) and at the left third of the river off the Cedars Floating Restaurant dock near Station 1 (RM 111.1) on August 12-13, 1991. The river water quality parameters (profiles, nutrients, bacteria, and chlorophyll *a*) were sampled at Station 4 and 5 and at the Cedars dock at 6:00 p.m. on August 12 and 6:00 a.m. on August 13.

Readings were taken every three hours, beginning at 3:00 p.m. on August 12 and continuing through 3:00 p.m. August 13. Temperature and dissolved oxygen measurements were obtained at Stations 4 and 5 using a YSI Model 57 Dissolved Oxygen meter and at the Cedars dock using an Extech Dissolved Oxygen meter. Both meters were calibrated with air temperature and partial pressure and against each other for quality assurance. We determined pH in the field immediately following each run using a Nester Model 47 mini pH meter. Lab analysis of the 6:00 p.m. and 6:00 a.m. samples followed the same procedures as those used on the standard river sampling.

Quality Control / Quality Assurance

QA/QC measures were taken in all sampling procedures, as well as field and lab analyses. Sampling was conducted on Tuesdays, beginning at approximately 10:00 a.m. at Station 6 (RM 100.7) and continuing upstream to Station 1 (RM 111.1). Sampling was usually completed by 6:00 p.m. The only exceptions to this schedule were in the first four sample periods, when logistics required two days to complete sampling. Permanent shore landmarks were used at each station to ensure consistency of sampling points.

We measured pH routinely with two meters calibrated daily with pH 7.0 buffer. The low pH values measured on May 7, 1991, were confirmed for each sample with three pH meters, independently calibrated. The turbidimeter was standardized against Hach formazin turbidity standards initially and against a new set of Hach Gelex turbidity standards at every sampling after July 1, 1990. Only single samples of chlorophyll *a* were run, however. Multiple samples of chlorophyll *a* were run on July 30, 1991 samples because of low values.

Eight fecal coliform and eight fecal streptococcus bacteria samples (from the February 12, 1991 sample series) were analyzed at the Coeur d'Alene DEQ lab for comparison with our bacterial results. At least one duplicate BOD sample for 5-day BOD and ultimate BOD was analyzed at each station on every date sampled (except on April 9, 1991). Duplicates were run on at least ten percent of all chemical analyses throughout the study. Additionally, 39 samples were analyzed for TP, OP, NH_3-N, and NO_3-N by both the UI Forestry Lab and at the UI Analytical Lab for comparison. Data on the Spokane River collected by the Citizen Volunteer Monitoring Program (CVMP) and on-site effluent analyses performed by each wastewater treatment plant (WWTP) over the current study period is also presented for a check between sample groups. Detailed QA/QC data are presented in Appendix B.

RESULTS / DISCUSSION

Water Discharge

Integral to any stream water quality study is an understanding of flow conditions throughout the period in which samples are collected. We can estimate individual water quality parameters measured simultaneously, biweekly, etc. and make inferences based on these, but in order to more closely understand the entire situation in a river system, sample measurements and trends must be related to flows.

USGS stream flow reports for the Spokane River were used to compare water flows of the Spokane River over recent years. The annual hydrograph reflects the discharge character of the Spokane River watershed below the ameliorating effect of Lake Coeur d'Alene (Figure 4). Peak runoff typically occurs in May (~ 20,000 cfs), with mean monthly low flow in August-September (1,500 cfs) (Figures 5 and 6). Mean daily low flow often drops below 800 cfs in late summer. We could discern no meaningful trend in the data of minimum or maximum flow in the Spokane River since 1969 (Figure 6).

Water Year 1990 was a typical, although flashy, flow year in the Spokane River System. A mid-winter thaw caused a minor flow peak in January, 1990. Peak flow occurred in mid-April (18,000 cfs). This was approximately one month earlier than the mean historical peak runoff in the Spokane River (Figure 7). Low flows were in September, 1990 with mean daily and mean monthly low flows of 340 cfs and 1,299 cfs respectively.

Water Year 1991 was similar to WY 90, with winter flows somewhat higher than the 78-year mean for the same period. Extremely cold temperatures in late-December and early-January (-14 F on December 28) caused flows to drop during January to mean daily low flows of 4,390 cfs (Figure 4). The mean monthly flows from April through September in WY 91, were nearly identical to the 78-year mean monthly flows for the same period with peak runoff occurring in May at a mean daily peak of 31,750 cfs and a mean monthly high flow of 17,830 cfs. The WY 91 may be viewed as the more typical of the two study years for describing mean baseline water quality characteristics of the Spokane River.

Previous studies on the Spokane River by Falter and Mitchell (1982), Seitz and Jones (1981), and Yearsley and Duncan (1989) were conducted under low flow conditions, and thus might be viewed as extreme conditions when presenting an overall water quality assessment of the river (Figure 7). They are, however, valuable in describing the river during periods of drought and during summer low flows.

Wastewater Treatment Plant (WWTP) Discharge

Nutrients and suspended solids, bacterial numbers, and biochemical oxygen demand were generally much higher in treated wastewater effluent than in the Spokane River itself. As mentioned earlier, Spokane River flows fluctuate widely throughout the year, but are generally high in the winter and spring (November-June) and low in the summer and fall (July-October). In contrast, discharge from the Coeur d'Alene and Post Falls WWTPs remains relatively constant throughout the year (Figure 8). The mean yearly treated wastewater discharge into the Spokane River from Coeur d'Alene, Post Falls, and the proposed Hayden WWTPs are 4.83, 1.27, and 0.38 cfs, respectively (Figure 9). The Hayden plant would not discharge under periods of low flow (when river flow is less than 2,000 cfs during the months of June through September). WWTP discharge accounts for an insignificant portion of the total Spokane River flow during high flows (<0.03%). Dilution is very high and resulting water quality is not a problem. Discharge from the Coeur d'Alene and Post Falls WWTPs accounts for approximately 0.5% and 0.1%, respectively, of the total Spokane River flow under summer low flow conditions (Figure 10). The percentages of the Spokane River's discharge contributed by the Coeur d'Alene and Post Falls WWTPs increased to 1.4% and 0.4%, respectively, at minimum flow recorded during the study period (340 cfs on Sept 5, 1990) (Figure 11).

Mixing of wastewater effluent is a concern in the Spokane River. The Coeur d'Alene WWTP discharge pipe extends approximately 200 ft toward mid-river at RM 110.7, and effluent is discharged through ten diffusers (CDA WWTP Superintendent, personal communication, April 9, 1991). Post Falls discharges into the river at RM 101.5. The proposed Hayden Lake discharge would be through five diffusers, 150 ft into the river (Jim Kimball, Kimball Engineering, personal communication, October 25, 1991). Due to the diffuser construction of these discharge pipes, mixing of wastewater effluent is not considered a critical issue in the Spokane River.

Morphometry

On August 13, 1991, we undertook a relatively small-scale depth transect study on the Spokane River outlet arm of Lake Coeur d'Alene to map bottom contours and determine exact depths at each of the five established sampling stations of the Spokane River Water Quality Project. Earlier depth transect work by Falter and Mitchell (1982) on this portion of the Spokane River produced detailed morphometric maps of the river (Appendix C).

The Spokane River channel is shallow (1.5-3.5 m) and relatively flat from the outlet of Coeur d'Alene Lake (RM 111.2) to the upstream end of Harbor Island (RM 107.0), with mid-channel depth gradually increasing downstream (Falter and Mitchell 1982). Stations 1 (RM 111.1) and 2 (RM 108.8) have gradually sloping banks with relatively flat bottoms. Maximum depth at high water is typically 3.6 m and 5.2 m, respectively in this reach (Figure 12 and 13). Stations 3 (RM 106.2), 4 (RM 103.5), and 5 (RM 102.5), are much deeper and have steep sloping banks. Maximum depths at high water are 7.1 m, 10.8 m, and 9.8 m, respectively for the three stations (Figures 14-16). The Spokane River becomes less riverine and more lacustrine downstream as water depth at each station increases.

Seitz and Jones (1981) also carried out extensive cross sectional area mapping of the reach. Sampling efforts by the EPA after 1982 located a deep hole near Ford Rock. This deep area could be a site of stratification and oxygen depletion, thus warranting a more accurate understanding of its size and depth.

The deep hole near Ford Rock is approximately 110 m long and 94 m wide. Maximum depth is 17.7 m (Appendix C). Because of the small size and comparatively small water volume contained in this deep hole, we feel that extensive research on the characteristics of this area are unwarranted. Water exchange is probably great enough to prevent significant water quality problems in the area.

Flushing Rates and Retention Times

Flushing rate is the number of times all of the water in a section of river leaves that section in a given time. It determines how much of the nutrient load will be converted into plant biomass. When flushing rates are low, there is more time for nutrient uptake by phytoplankton, aquatic macrophytes, attached algae, etc. Conversely, high flushing rates allow less time for this uptake. The flushing rate is dependent on the volume of water within the section and the water flow through it. Large static volumes yield low flushing rates, and high water flows yield high flushing rates. In this study, in order to develop workable results, we assumed that all of the water in a section was exchanged over one flushing time.

The inverse of flushing rate is retention time. Retention time for the section between sites 1 and 3 is less than half that of the remainder of the study reach. When flows equal the 78-year mean, the retention time for the area from RM 111.1 to 106.2 is 4.9 hr compared to 11.5 hr for the area from RM 106.2 to 102.5. The downstream section of the study area is deeper which increases the volume which in turn increases the retention time.

Retention time plays a key role in the development of thermal stratification. Generally a retention time of 15 days is required for stratification to occur. The lowest mean daily flow occurring during the study was 340 cfs which resulted in a average retention time for the entire river reach of 12.7 days. The lowest flow recorded in the 78 years of record was 65 cfs (July 27, 1973) and would have resulted in a retention time of 66.4 days (Table 1).

Physical Profiles

Temperature

In 1990, water temperature in the Spokane River peaked in late July at 25.7 C and began to fall by early August. This peak is about one to two weeks earlier than we would expect in a typical slow-moving northern Idaho stream of this size (Appendix E). The earlier warming was likely a result of warm surface discharges from Lake Coeur d'Alene, combined with the lower flows for the year. Temperatures peaked on August 27, 1991, at RM 102.5 at 26.7 C (Appendix Table 1). The date of the 1991 thermal peak was more typical of this area, but the temperatures observed were relatively high. Most North Idaho streams of comparable size and flow reach a summer maximum temperature of 22-24 C. Again, these high temperatures were probably due to warm surface discharges from Lake Coeur d'Alene. Overall reach mean temperature peaked at 24.0 C on July 23, 1990, and at 25.6 C on August 27, 1991. Reach mean low temperatures of the study were recorded at 2.1 C on February 12, 1991 (Table 2).

Mean water temperatures increased slightly downstream from July through August with low discharge and increased retention times (Table 2). There was only one instance where thermal stratification (1.8 C/m) was observed. This was on July 9, 1990, at RM 102.5 when surface temperature peaked at 23.9 C. No oxygen or conductivity stratification coincided with this thermal stratification. Similarly, Falter and Mitchell (1982) found no significant vertical stratification during the 1980 study under low flow conditions. Some vertical stratification of temperature, dissolved oxygen, and pH was detected by Yearsley in a portion of the Spokane River near Ford Rock in August, 1979 (Yearsley 1980) and again in 1988 at several locations on the upper Spokane River under low flow conditions in August (Yearsley and Duncan 1989). Yearsley and Duncan (1989) conducted their study under extremely low water conditions (less than 340 cfs) which may have been the cause for the stratification during that time.

While almost no thermal stratification was noticed during the present study, some definite temperature trends were observed. Temperatures nearly always decreased gradually with depth during the summer months. This indicated some surface warming downstream through the Spokane River in summer. Also of interest was the increase in mean temperature across the channel. Mean temperatures were consistently 0.3 to 0.8 C warmer in mid-channel than along the right bank and 0.1 to 0.3 C warmer along the left bank than in mid-channel (Table 3). This slight difference was most likely due to the greater depths in mid-channel and along the right bank, and suggests that while water in the Spokane River was not thermally stratified, neither was it completely mixed.

Dissolved Oxygen

Dissolved oxygen concentrations were generally uniform throughout the water column, but decreased slightly with depth in the deeper sites of RM 103.5 and 102.5 during the warm summer months. Minor dissolved oxygen "sags" of up to 2.2 mg/l below surface concentrations were occasionally observed. Dissolved oxygen occasionally dropped below the Idaho Water Quality Standard for Cold Water Biota and Salmonid Spawning of 6.0 mg/l. This occurred during August, 1990 when mean flow in the Spokane River was lowest. Dissolved oxygen levels never dropped below 5.4 mg/l or 56% saturation. This is in contrast to the strong dissolved oxygen stratification observed by Yearsley and Duncan (1989) in 1988 when oxygen declined to near 0 mg/l in the Ford Rock area. Again, that 1988 instance is believed to be due to extremely low water conditions at the time of the 1988 data collection in a very small volume of water.

Mean dissolved oxygen levels in the Spokane River showed little variation throughout the outlet arm reach to Post Falls dam. Mean dissolved oxygen increased approximately 10% below the dam (Tables 4 & 5) probably from turbulence created as water passed over the dam.

Dissolved oxygen percent saturation varied little throughout the outlet arm reach, but increased at Station 6. Percent saturation levels were somewhat low (Table 5). Levels were well below 100% saturation during most of the year. Dissolved oxygen levels exceeded 100% during spring for a short time when flows were highest. Stations were similar in their mean dissolved oxygen concentrations (Table 3).

Electrical Conductivity

Conductivity was low, averaging 30 to 55 μmhos (Table 6). Highest conductivity occurred in July, 1990 (80 μmhos at RM 106.2). An isolated pocket of high conductivity was observed along the right bank at RM 100.7 on August 20 (120 μmhos). A general increase in conductivity with depth was seen throughout all river sections. Conductivity patterns were typical with low conductivity occurring at high flow and high conductivity at low flow. Conductivities measured in this study were comparable to values observed during WY 1977, 1980, and 1988.

Composite Measurements

pH

Median pH values among all stations of the Spokane River per sample date ranged from 5.7 to 7.8. An overall low pH of 3.3 was observed on October 1, 1990, (RM 102.5) and a high of 7.9 was measured on March 12, and April 9, 1991 (RM 103.5 to 100.7) (Table 7). The extremely low pH at RM 102.5 could have been a result of an unknown point discharge somewhere upstream, but below RM 103.5. We could not locate this discharge, but quality control assured us that this was a correct measurement and not the result of malfunctioning equipment.

River pH was quite low during the spring of 1991. Median pH values were near 6.0 during all but one sample period from May 7 to July 2, 1991 (Figure 17). This overall low pH in the river may benefit the biota, however, by reducing ammonia toxicity, which might otherwise be a problem given the high ammonia-nitrogen loading from WWTP's. No pronounced differences in pH values were observed between stations on the Spokane River during the study (Figure 18 and Table 7).

The pH values of the Post Falls and Coeur d'Alene WWTP's effluents were slightly higher than the median river water pH. Effluent pH was usually near neutral, thus causing no adverse effects on overall pH in the Spokane River (Figure 17).

Turbidity

Turbidity in the Spokane River was low with mean values ranging from 0.5 to 2.4 NTU over the sample period (Table 8). In comparison, the Post Falls and Coeur d'Alene WWTP's effluents were higher in turbidity, with overall means of 2.7 and 9.4 NTU, respectively (Figure 19).

Turbidity increased slightly downstream from the outlet of Lake Coeur d'Alene (TAble 8). This was probably due to the riverine character of the Spokane River at high flow. As flow increased in the spring, bottom sediments were stirred up and re-suspended in the water column increasing turbidity (Figures 20 and 21). Turbidity appears to be directly related to flow in the Spokane River, especially in the deeper sections of RM 106.2 to 102.5, where Falter and Mitchell (1982) reported a majority of the bottom sediments to be fines.

Secchi Disk Transparency

Numerous studies have shown that Secchi disk depth is inversely proportional to chlorophyll *a* concentrations in systems with low inorganic turbidity and can be used as an estimate of the primary productivity of a body of water. Mean Secchi disk depth between RM 106.2 and RM 102.5 in the Spokane River ranged from 2.4 to 6.5 m with an overall average of 4.0 m during the 1990-1991 study period (Figure 21 and Table 9). Wetzel (1983) gives a trophic classification system based on Secchi disk transparency, which puts the Spokane River in the mesotrophic range of two to six meters. Greatest Secchi disk depths were observed in the fall (October 15 to November 12, 1990, and September 10-24, 1991) due to low phytoplankton concentrations and low turbidity (Table 9).

Secchi disk transparency remained relatively constant between stations with only a slight decrease at River Mile 102.5. This was most likely a factor of higher turbidity at this location, rather than plankton levels.

Chlorophyll *a*

Mean chlorophyll *a* concentration in 1990 increased as the water temperature increased and flows declined into late August, peaking at downstream sites at 11.0 and 9.7 mg/m^3 chlorophyll *a* (Figure 21 and Table 10). Chlorophyll *a* concentrations in the river were very low during one summer sampling period (September 17, 1990), most likely due to a "population crash" in the phytoplankton community which was reflected in the low absorption peak ratio for the same day (Figure 22).

Chlorophyll *a* concentrations peaked much earlier in WY 91 than in 1990. Mean levels began to increase in mid-April and reached an annual maximum on May 7 (6.82 mg/m^3). Mean chlorophyll *a* concentrations then gradually decreased to a low (July 30, 1991) of 0.37 mg/m^3 (Figure 21 and Table 10). Aside from the July 30 sample, chlorophyll *a* concentrations were relatively stable throughout the summer of 1991. Values were similar to, but slightly lower than those measured in the summer of 1990. The 1991 chlorophyll *a* peak in early May coincided with high flows with declining chlorophyll *a* pacing declining flows into the summer (Figure 23). This spring plankton pulse contrasted with 1990 where chlorophyll peaked in late summer, essentially a mirror image of flow (Figure 23).

Chlorophyll *a* levels were in the mesotrophic range (2.0 to 6.0 mg/m^3). Mean summer (mid-July through September) chlorophyll *a* averaged 3.9 and 2.5 mg/m^3 in 1990 and 1991 respectively (Figures 21 and Table 10).

Mean chlorophyll *a* concentrations between stations increased from RM 111.1 to RM 103.5, and from 2.45 to 4.24 mg/m^3 over the entire study period (Figure 21 and Table 10). Downstream increases in chlorophyll *a* are a cumulative result of phosphorus and nitrogen loading from various sources along the river and the more lake-like conditions in the river as the current slows and depth increases.

It is interesting to note that Falter and Mitchell (1982) measured chlorophyll *a* values in the 0 to 5.5 mg/m^3 range with a mean of 1.9 mg/m^3 from February to mid-September in 1980. These values were determined by the Trichromatic method which does not correct for pheophytin *a* and tends to overestimate chlorophyll *a*. The actual monochromatic chlorophyll *a* level in their samples was probably somewhat lower than reported. Keeping this in mind, when comparing the current study mean of 3.39 mg/m^3 (range of 1.4 to 6.8 mg /m^3) to the 1.9

mg/m^3 mean for 1980, it appears that primary productivity in the Spokane River has increased over the last 11 years, possibly even more than these numbers indicate. A doubling of monochromatic chlorophyll *a* between 1980 and 1990-91 is probably a reasonable conclusion.

Nutrients

Primary production of any system is directly related to the concentration and availability of nutrients in the water. Those nutrients present in the lowest quantity in terms of the need of an organism control the production or growth of that organism.

Phosphorus and nitrogen are the most important nutrients since these two nutrients most often control plant growth in waters of the Columbia basin. Phosphorus, although needed in small amounts, is generally the most common phytoplankton growth-limiting nutrient because of the geochemical shortage of phosphorus in many watersheds coupled with the lack of a phosphorus equivalent to nitrogen fixation. Where phosphorus is present in relatively large quantities due to erosion or pollution, nitrogen usually becomes the nutrient limiting phytoplankton growth. Phosphorus has been shown to be the limiting nutrient most often in the Spokane River, except during August, when nitrogen has been shown to limit phytoplankton growth (Falter and Mitchell 1982).

Relatively small quantities of nitrogen exist in the combined forms of ammonia-nitrogen (NH_3), nitrate-nitrogen (NO_3), nitrite-nitrogen (NO_2), urea, and dissolved organic compounds. Nitrate is usually the most important form of nitrogen. Nitrate ions move easily through soils so the concentration and rate of supply of nitrate is intimately connected to land-use practices in the watershed. Nitrite, the partially reduced form of nitrate, is shortlived in water and usually present in insignificant quantities (Goldman and Horne 1983).

Phosphorus occurs in both organic and inorganic forms. The majority of inorganic phosphates present are in the form of orthophosphates, but there are numerous forms of phosphorus in the organic state. Phosphorus, in contrast to nitrate, is readily adsorbed to soil particles and does not move easily with groundwater. Because of this, high levels of phosphorus in water are usually associated with surface erosion in the watershed, agricultural practices, domestic wastes, and industrial wastes (Goldman and Horne 1983).

Total Kjeldahl Nitrogen (TKN)

Total Kjeldahl Nitrogen is the sum of the organic nitrogen and ammonia-nitrogen in water. Organic nitrogen includes such natural materials as proteins, peptides, nucleic acids, and urea (APHA 1989).

Mean TKN levels in the Spokane River during 1990 and 1991 remained relatively stable, ranging from 0.12 mg/l (July 16, 1991) to 0.24 mg/l (June and August, 1990). TKN concentrations fluctuated little with changes in river flow (Figure 24). Overall mean for the period was 0.18 mg/l, with slightly lower mean levels in 1991 than in 1990 (Table 11).

Mean TKN concentrations increased 21% between RM 111.1 and RM 108.8 (0.14 to 0.17 mg/l) during WY 91 (Figure 25). This increase correlated with effluent discharge from the Coeur d'Alene WWTP (91,000 kg TKN) and other undefined sources throughout the reach (116,000 kg TKN) (Figures 25 and 26). Mean TKN values gradually decreased from RM 108.8 to RM 103.5, but then increased by about 25% between RM 103.5 and RM 102.5 (from 0.16 mg/l to 0.20 mg/l). The source of this increased TKN loading in the lower reaches is unclear, but private drainfields along this heavily developed stretch of shoreline may be partially responsible. A similar increase in TKN in this reach was noted during August 1980 by Falter and Mitchell (1982). Mean TKN values decreased below RM 102.5. There was no significant TKN increase below the Post Falls WWTP (Figure 25).

WWTPs accounted for a study-wide average of 9.3% of TKN load to the river (Figure 27). With lower flows in the Spokane River, the percentage of the TKN load contributed from the Coeur d'Alene WWTP increased (Figure 28). In 1991, during mean summer low flows, (August to mid-October = 1,300 cfs), the Coeur d'Alene WWTP contributed over 25% of the TKN, while at the lowest flow during the study (340 cfs on Sept 5, 1990) Coeur d'Alene WWTP contributed over 50% of the TKN load in the Spokane River. These results are comparable to those determined by Yearsley (1980) under low flow conditions. A general increase in TKN between RM 111.1 and RM 102.5 was observed in all three studies (Figure 29).

Nitrate-Nitrogen (NO_3)

Nitrate-nitrogen concentrations in the Spokane River were consistently low throughout the summers of 1990 and 1991 (<.05 mg/l) (Table 12). A mid-December maximum (0.49 mg/l), was observed when flows in the Spokane River increased indirectly as a result of abnormally high air temperatures (46 F on December 8, 1990). Similar but smaller peaks were observed throughout the spring of 1991 as melting snow and rains brought nitrate-rich runoff from the watershed into the Spokane River. This pattern of high nitrate concentrations at high flow and low concentrations at low flow is typical of most North Idaho streams.

Concentrations of nitrate-nitrogen between sampling stations showed a general increase downstream, from RM 111.1 to RM 100.7 (Figure 30). Mean nitrate-nitrogen concentrations increased over 100% from RM 108.8 to RM 106.2 and over 75% from RM 102.5 to RM 100.7. The high levels at RM 106.2 are a result of undefined loading between RM 108.8 and RM 106.2 (Figure 30). This increase may be from conversion of ammonia-nitrogen to nitrate-nitrogen within the reach, but this is purely speculative. The Coeur d'Alene WWTP contributes very little nitrate-nitrogen to the Spokane River (13,400 kg NO_3 during the entire study) (Figure 31). The high levels of nitrate-nitrogen at RM 100.7 are partially due to the Post Falls WWTP, but most loading between RM 102.5 and RM 100.7 is undefined. Even though Post Falls effluent is high in nitrate (Figure 30), the small volume of Post Falls effluent discharged to the Spokane River makes it an insignificant source of NO_3 compared to the total nitrate load (21,800 kg during the entire study).

Nitrate-nitrogen loading from wastewater treatment plants, as a percentage of the total load in the river, increased as Spokane River flows decreased (Figure 32). The contribution from WWTPs made up over 40% of the total nitrate load, nearly 25% of which came from Post Falls during summer low flows.

Ammonia-Nitrogen (NH_3)

Note: The Direct Ammonia procedure used to analyze ammonia samples is no longer approved by the EPA because of the possibility of background interference, however it is still an approved APHA method (APHA 1989). The extremely low turbidity of the Spokane River, and consequential improbability of background interference, convinced us of the validity of these ammonia-nitrogen measurements with no distillation. Values determined for the WWTPs however, should be received with caution due to the possibility of background interference in those samples of high organic content.

Ammonia-nitrogen concentrations in the Spokane River were similar to, although slightly lower than, TKN concentrations throughout the study period (Figure 33 and Table 13). Ammonia-nitrogen levels ranged from a low mean of 0.08 mg/l on September 24, 1991, to a maximum mean over the entire river of 0.20 mg/l on August 20, 1990, and July 30, 1991 (Table 13). Mean ammonia-nitrogen concentration of the Spokane River over the entire period was 0.14 mg/l. Comparing this to a mean TKN concentration over the period of 0.18 mg/l shows that nearly 80% of the TKN in the Spokane River is in the form of ammonia-nitrogen. This is a very high percentage, and is potentially significant from both a toxicity and eutrophication concern. The high summer temperatures in the Spokane River make ammonia toxicity a potential problem. Observed low pH values, however, may counter the high temperatures and cause ammonia toxicity to be of little concern.

The high ammonia concentrations are of concern in another way during the short periods in which the Spokane River is nitrogen-limited. Ammonia is the form of nitrogen most readily available for plant uptake, so a high ammonia concentration could at times support phytoplankton blooms in the river.

Mean concentrations of ammonia-nitrogen at the different sampling stations followed the same general pattern as mean TKN values, increasing to RM 108.8, decreasing to RM

103.5, and increasing to RM 102.5 (Figure 33). The 42% increase in Water Year 1991 and 58% increase over the study period in ammonia-nitrogen concentrations between RM 111.1 and RM 108.8 is of particular concern. Coeur d'Alene WWTP effluent contributed slightly over 10% (113,200 kg) of the total ammonia-nitrogen load to the Spokane River during the study period (Figure 34). While this was a substantial amount, it did not account for the entire increase in ammonia-nitrogen between RM 111.1 and RM 108.8. There was a substantial ammonia-nitrogen load coming into the Spokane River (over 300,000 kg in WY 91) between RM 111.1 and RM 108.8 aside from that entering from the Coeur d'Alene WWTP. We were unable to determine the source of outside ammonia-nitrogen loading within the scope of this study.

It appears that much of this ammonia-nitrogen is being converted to nitrate-nitrogen between RM 108.8 and RM 103.5. Thus, the high ammonia-nitrogen loading in the upper reaches may be an indirect source of nitrate-nitrogen loading in the lower reaches.

Ammonia-nitrogen loading from the Coeur d'Alene WWTP accounted for nearly 30% of the total ammonia-nitrogen load during the summer of 1991 and over 60% of the total ammonia-nitrogen load at low flow (340 cfs) on September 5, 1991 (Figures 34 and 36). Low flow discharge by the Coeur d'Alene WWTP accounted for a significant portion of the overall summer load. Post Falls WWTP did not appreciably increase the ammonia-nitrogen load to the Spokane River.

Total Phosphorus (TP)

Total phosphorus is the sum of all of the orthophosphates, condensed phosphates, and organically bound phosphates in water (APHA 1989). It is a very common measurement used in assessing the productivity of a body of water and can be used to determine N:P ratios.

Mean total phosphorus levels in the Spokane River during the June 29, 1990 to September 24, 1991, sample period varied considerably, ranging from 0.007 mg/l (September 10, 1991) to 0.025 mg/l (September 3, 1990) (Table 14). Mean TP concentration throughout the entire study area over the period was .014 mg/l. These phosphorus values are in the mesotrophic range described by Wetzel (1983), and compare well with chlorophyll *a* and Secchi disk transparency values which also put the Spokane River in the mesotrophic range. Lower TP levels were observed in 1991 compared to 1990. This was probably due to greater flushing by the high flows during the spring of 1991 (Figure 37) and also a result of phosphorus removal by the CDA WWTP in 1991.

A general increase in total phosphorus, between RM 111.1 and RM 102.5, similar to that in TKN, was observed in Water Year 1991 (Figure 29). Total phosphorus more than doubled between WY 1980 and 1988, but dropped significantly in WY 1991 to levels only slightly higher than WY 1980. This increase was significant because it showed an overall deterioration in water quality of the Spokane River from 1980 to 1988, but major improvement in TP in WY 1991.

Within WY 91, mean concentrations of total phosphorus between stations increased 45% between RM 111.1 and RM 108.8, decreased slightly downstream to RM 102.5, and increased 12% between RM 102.5 and RM 100.7 (Figure 38). Concentrations between RM 108.8 and RM 102.5 decreased gradually as reactive phosphorus was taken up by phytoplankton and converted into plant biomass. The Coeur d'Alene and Post Falls WWTPs contributed most of the phosphorus loading (within this reach) of the Spokane River. The river itself acted as a phosphorus sink (Figure 26). Coeur d'Alene WWTP contributed over 3 times as much total phosphorus to the Spokane River as Post Falls WWTP (18,000 kg TP vs. 5,900 kg TP, respectively) during the study period (Figures 26 and 39). The two plants combined accounted for almost 25% of the total phosphorus load entering the Spokane River over the period. Coeur d'Alene WWTP was responsible for 18% of the total load. This is substantially less than the 66.7% calculated by Yearsley (1980).

Total phosphorus entering the Spokane River through both WWTP effluents nearly always accounted for a substantial amount of the total phosphorus load in the river (Figure 40). The load from the Coeur d'Alene and Post Falls WWTPs made up over 50% of the total phosphorus load in the river during mean summer low flows.

Since June, 1991, when the Coeur d'Alene WWTP initiated phosphorus removal of treated effluent, mean phosphorus levels in effluent from the Coeur d'Alene WWTP decreased 80%, from 4.24 mg/l to 0.87 mg/l (Table 14). This substantially lowered the amount of total phosphorus in the Spokane River throughout the the summer when WWTP TP loading is such a significant part of the TP load. Summer TP concentrations in 1991 were approximately half of summer 1990 values (Figure 37).

Orthophosphorus (OP)

Orthophosphorus, or soluble-reactive phosphorus, is the form of phosphorus that is readily available for plant growth (APHA 1989). Mean orthophosphorus concentrations in the Spokane River were nearly always below the detection limit of 0.006 mg/l, except from July 23, 1990 to September 17, 1990, when values ranged from 0.006 mg/l to 0.019 mg/l (Table 15). Orthophosphorus concentrations mimicked total phosphorus concentrations when O-P was detectable. Orthophosphorus levels increased during low flows in the summer of 1990 (Figure 43).

Mean concentrations of orthophosphorus at different sample stations were consistently below detection limits, except at RM 108.8 during Water Year 1991. Mean concentrations increased 46% between RM 111.1 and RM 108.8 during Water Year 1991. This increase occurred below the Coeur d'Alene WWTP and other sources below RM 111.1 (Figure 41).

Both Coeur d'Alene and Post Falls WWTPs contributed a substantial portion of the total orthophosphorus load to the Spokane River (16,500 Kg OP and 5,800 Kg O-P, respectively) (Figure 42). This load becomes important in the summer, when much of this available orthophosphorus is converted into phytoplankton biomass. The Coeur d'Alene WWTP contributed nearly 25% of the total orthophosphorus load to the Spokane River even under moderately high flow conditions, while the Post Falls WWTP contributed approximately half this amount. The combined orthophosphorus load from both WWTP's was nearly 10% of the total during mean summer low flows. The concentration of orthophosphorus in the Spokane River is deceptively low, because unlike total phosphorus, most of the available orthophosphorus is converted rapidly into phytoplankton biomass.

The implementation of phosphorus removal by the Coeur d'Alene WWTP has greatly reduced the amount of orthophosphorus in its effluent. Loading levels have decreased approximately 80% since June, 1991, from an effluent mean of 3.9 mg/l to a mean of 0.78 mg/l (Table 15).

N:P Ratio

Falter and Mitchell (1982) determined that productivity in the Spokane River was phosphorus-limited through most of the year except in August when nitrogen was the limiting nutrient. Chlorophyll *a* levels correlate very well with TP concentrations, but appear to be independent of TKN concentrations (Figure 44).

Total N:Total P ratios determined during the study ranged from 10.9:1 to 75.9:1 with a mean ratio of 19.8:1, indicating phosphorus limitation most of the time. The mean N:P ratio decreased to 17.6:1 when the high value of 75.9:1 (December 18, 1990) was deleted from the data. This was still above the 14-16:1 ratio range considered to be the minimum N:P ratio range indicating phosphorus limitation. Figure 45 illustrates the trend in mean N:P ratios determined during the study (all sites averaged). The only period of apparent extended nitrogen limitation, when the N:P ratio dropped below 16:1, occurred from August 8 to October 1, 1990. Nitrogen levels in the river at this time did not decrease, but instead phosphorus levels increased causing the N:P ratio to drop to 12-14 making it appear that nitrogen limitation occurred (Figure 44). Total nitrogen levels remained above 0.2 mg/l during the time in question. Sporadic nitrogen limitation occurred in Spring and Summer, 1991.

Site-specific N:P ratios present a different picture as shown in the following data:

	Station 1	Station 2	Station 3
1990 Summer Mean N:P Ratio (pre TP removal)	21:1	11:1	12:1
1991 Summer Mean N:P Ratio (post TP removal)	17:1	28:1	21:1
Winter 1990-1991 Mean N:P Ratio	24:1	17:1	22:1

The lake station showed phosphorus limitation all year. Prior to TP removal, stations below the Coeur d'Alene WWTP showed nitrogen limitation; after TP removal, these sites showed phosphorus limitation on average. Winter conditions prior to TP removal also showed phosphorus limitation.

Current data and that collected over the past ten years on chlorophyll *a* and nutrients indicate nitrogen-limitation has limited productivity in the Spokane River at times, particularly late in the growing season. This also is the time when the lowest flows occur. The data collected in the current project shows that phosphorus-limitation is the major factor affecting productivity with respect to nutrients.

Zinc

One factor not addressed in the current study, but of potential importance in determining phytoplankton levels in the Spokane River, is the amount of zinc in the river. Zinc is a trace element required by plants in very minute quantities. If the concentration of dissolved zinc is high growth inhibition and direct toxicity will result in many phytoplankton species (Goldman and Horne 1983) and has been documented in the Spokane River (Falter and Mitchell 1982). Zinc concentrations in the Spokane River during 1980 ranged from 85 to 160 mg/l. These are high levels and probably were a significant factor in controlling phytoplankton biomass at that time (chlorophyll *a* values were at 0 to 5.5 mg/m^3). Since shut-down of the smelter in the Silver Valley area in 1980, zinc concentrations in the Spokane River have dropped significantly. Yearsley and Duncan (1989) found zinc concentrations during August 1988, to range from >5 to 75 µg/l. Water Year 1990 total zinc averaged 82 µg/l (USGS 1991). These lower levels may not be inhibiting phytoplankton growth to the extent that they were 10 years ago. This may be another factor which contributes to the increased phytoplankton biomass.

Biochemical Oxygen Demand (BOD)

5-day BOD

Biochemical oxygen demand is a measure of the oxygen required for the biochemical degradation of organic material and the oxygen used to oxidize inorganic material such as sulfides and ferrous iron (APHA 1989). BOD is not a pollutant itself, it is simply a gauge by which we can make inferences about oxygen demand in a water body.

BOD samples analyzed and presented in the Spokane River Interim Data Summary (Falter & Riggers 1990 and 1991) were incorrect. Calculations were based on a 300-ml sample, and not adjusted up to 1-liter. Therefore, those earlier values were in mg/300ml, and were approximately 70% below the true BOD value for the sample. This error has been corrected, and the correct values are presented in Table 16.

Mean 5-day BOD in the Spokane River was moderately high, ranging from 0.3 mg/l to 7.5 mg/l over the sample period (Table 16). Overall mean for the river during the study was 3.4 mg/l. These values are approximately three times greater than March, 1980, through January, 1981, mean 5-day BOD values reported by Seitz and Jones (1981). Again, this suggests a general, overall deterioration of water quality in the Spokane River over the last decade. Highest 5-day BOD values during the current study were observed in the spring of 1991 (Figure 46). This was most likely a result of high phytoplankton standing crop during this period, reflected in the corresponding high chlorophyll *a* values at the same time (Figure 44) as well as organics and detritus in the high flow runoff.

Mean 5-day BOD of the wastewater treatment plants throughout the study was extremely variable and consistently higher than that of the Spokane River (Figure 47 and Table 16). In Water Year 1991, Post Falls WWTP effluent 5-day BOD averaged nearly 4 times that of the Spokane River. Coeur d'Alene WWTP effluent 5-day BOD over the same period averaged nearly 25 times that in the river (**Note:**We point out that our measured values were considerably higher than those of the Coeur d'Alene WWTP. We have checked our data and can find no reason for the discrepancy).

Mean 5-day BOD levels increased nearly 11% between RM 111.1 and RM 108.8 and nearly 25% between RM 111.1 and 106.2 over the study period (Figure 47). Yearsley and Duncan (1988) reported a similar significant contribution of 5-day BOD from the Coeur d'Alene WWTP. A portion of this downstream increase in BOD is secondary 5-day BOD from phytoplankton production in the lower reaches, but a significant portion is undoubtedly directly attributable to Coeur d'Alene WWTP discharges. Five-day BOD gradually decreased in the Spokane River between RM 106.2 and RM 102.5, and then increased again between RM 102.5 and RM 100.7. The Post Falls WWTP effluent was probably partially responsible for this slight increase below Post Falls Dam; the flushing of deep water below RM 102.5 through the dam and through RM 100.7 was also a factor.

Ultimate BOD

Note: Ammonia oxidation was not inhibited in ultimate BOD test. The results should be used for guidance only.

Ultimate biochemical oxygen demand (BOD analyses carried out over time to the point where increased incubation time does not give a higher BOD value) determines the total biochemical oxygen demand in a sample of water. It also gives an estimate of the relative life span of the organic material in different water samples.

Ultimate BOD in the Spokane River ranged from 5.7 mg/l to 29.3 mg/l with a mean of 9.4 mg/l at RM 111.1. Values were similar at RM 100.7 with a range of 5.7 mg/l to 31.3 mg/l and a mean of 9.4 mg/l (Table 17). Although mean ultimate BOD was identical between RM 111.1 and RM 100.7, the number of days required to reach this level was different (Figure 48). Ultimate BOD was reached after 27 days at RM 100.7 compared to 35 days for water samples from RM 111.1.

Ultimate BOD in Post Falls WWTP effluent ranged from 28.0 mg/l to 44.0 mg/l, with a mean of 35.9 mg/l. Ultimate BOD was much higher in Coeur d'Alene WWTP effluent ranging from 283.3 mg/l to 1,000 mg/l, with a mean of 626.6 mg/l (Table 17). These high levels of ultimate BOD could create a substantial oxygen demand in the Spokane River, especially during summer low flow conditions. Ultimate BOD was reached at 35 days and 27 days in the Post Falls and Coeur d'Alene WWTP effluents, respectively (Figure 48).

Since retention times n the Spokane River are generally much less than the time required for incubating samples to realize ultimate BOD values, we submit that ultimate BOD is not a major cause for concern in the Spokane River outlet arm.

Fecal Coliform Bacteria

Samples analyzed for fecal coliform and fecal streptococcus bacteria showed extremely variable counts throughout the 1990 sample period (Tables 18 and 19). Fecal coliform counts were highest on July 23, 1990, (220 colonies/100 ml at RM 111.1) and on August 20, 1990 (180 colonies/100 ml at RM 106.2). Fecal streptococci counts were also extremely high on these same dates (>1,000 colonies/100 ml at RM 111.1 and 2,000 colonies/100 ml at RM 100.7 on each date, respectively). Plate counts of both bacteria were much lower and less variable in the Spokane River during 1991.

Plate counts of fecal coliform and fecal streptococci were consistently higher in WWTP effluent than in Spokane River water (Figure 49 and Table 18-19). Fecal coliform levels ranged from <1 to 1,620 colonies/100 ml (April 9, 1991) with a median of 35 colonies/100 ml in Coeur d'Alene WWTP effluent and <1 to >600 colonies/100 ml (March 12, 1991) with a median of 40 colonies/100 ml in Post Falls WWTP effluent during Water Year 1991. As a result, fecal coliform bacteria showed increases below the Coeur d'Alene and Post Falls plants (Figure 49). Fecal streptococci counts ranged from <1 to 570 colonies/100 ml (April 9, 1991) with a median of 20 colonies/100 ml in Coeur d'Alene WWTP effluent and <1 to 203 colonies/100 ml (April 9, 1991) with a median of 15 colonies/100 ml in Post Falls WWTP effluent during Water Year 1991. Fecal streptococci levels show an increase at RM 108.8 and RM 100.7. The higher levels of fecal streptococci below WWTP discharges are, to some extent, a result of the WWTP effluent discharges into the river. It is worth noting that Falter and Mitchell (1982) found lower concentrations of fecal coliform in the river during their sampling in 1980.

Diel Study

Mean temperature in the Spokane River varied only slightly over the August 24 hour diel, never declining more than 1 degree C from mid-afternoon peaks to early morning lows at a sample station (Figure 50). Diel temperature profiles at each station showed little variation with depth, except for the early morning bottom reading at RM 111.1, which was approximately 1^{o} C lower than surface, 1 m depth, and 2 m depth readings (Figures 50, 52, 53, and 54).

Mean dissolved oxygen patterns followed the same general trend of mid-afternoon highs over 90% saturation with early morning lows of approximately 80 to 85% saturation (Figure 51). Diel oxygen profiles showed little variation with depth (Figure 55 and 57). A minor dissolved oxygen sag near the bottom was measured at RM 111.1 during the mid-afternoon sample.

These diel patterns are quite typical for mesotrophic waters during the summer months, and show no indication of ecosystem stress. Similar diel temperature and dissolved oxygen patterns in the Spokane River were observed by Falter and Mitchell (1982) and Seitz and Jones (1981).

Idaho Water Quality Standards

The Spokane River outlet arm of Lake Coeur d'Alene designated uses include domestic and agricultural water supply, cold water biota, salmonid spawning, and primary and secondary contact recreation. General minimum water quality standards for each of these designated uses are provided in Appendix D.

The data indicate (not definitively because of the lack of closely spaced sampling series within a specified time period) that this reach of the Spokane River violated at lest three of the guidlelines for cold water biota and salmonid spawning during the study period.

Dissolved oxygen occasionally dropped below the 6.0 mg/l guildeline, especially during August of 1990 and 1991 (Table A-2). pH values were commonly below 6.5, and dropped to a median (over the entire reach) of 5.7 in early May, 1991 (Table 7). Water temperatures wee consistently greater than 22°C (the standard for cold water biota) during August of both study years. Additionally, water temperatures were higher than the 13°C standard for salmonid spawning during some of the cutthroat trout spawing and incubation period in the Spring (Table A-1).

Subjective Observations on Conditions in the River

Two additional observations on general biotic conditions in this reach were made, but not quantified during this study.

1) Attached algae growths in the river were very heavy through the summer months and continuing through the winter if substrates remained fully submerged. Conversations with many property owners assured us that this was a recurring problem which has visibly worsened through the 1980's.

2) Aquatic macrophyte beds were quite heavy in 1990-91 in the summer in shallower embayments and even on the open river channel. *Elodea nuttalli* is the dominant species. Again, numerous property owners told us that the abudnace of these macrophytes has increased dramatically over recent years.

CONCLUSIONS

1. • The Spokane River arm of Coeur d'Alene Lake is shallow near the lake outlet (2 m maximum depth) with gradually increasing depth towards Post Falls (17.7 m maximum depth).

2. • *Mean daily* Retention Times in the study ranged from 4.3 hr to 12.7 days. Over the 12-year period 1980-1991, *mean monthly* retention times ranged from 4.3 hr to 8.6 days.

3. • Surface water temperatures peaked at 25.7 and 26.1 C in 1990 and 1991, respectively.
   • Vertical thermal stratification was only observed once, at RM 102.5 but surface to bottom temperature differences were still <3 C.
   • Water temperatures increased slightly downstream in summer months.

4. • Dissolved oxygen levels were generally less than 100% saturation throughout the year, and showed up to 2.0 mg.l depletion with depth.
   • Minimum dissolved oxygen observed was 5.4 mg/l or 55% saturation.
   • River mean oxygen levels at each each sample time were always >7.0 mg/l in summer months
   • Oxygen levels were similar between stations; downstream oxygen sags were not seen..

5. • Electrical conductivity generally was 30 to 55 µmhos with a study high of 120 µmhos.

6. • Median pH was 5.7 - 7.8 with highs and lows of 7.9 and 3.3, respectively.
   • WWTP effluent pH was typically near neutral.

7. • River turbidity averaged 0.5 to 2.4 NTU and increased slightly downstream.
   • Effluent turbidity from the Coeur d'Alene and Post Falls WWTPs averaged 9.4 and 2.7 NTUs, respectively.

Conclusions (cont.)

8. • Secchi depth ranged from 2.4 to 6.5 meters with a study average of 4.0 meters.

• High flows stirred up bottom sediments through the reach and combined with a spring algae pulse to reduce secchi depth to 2.2 m at those times.

9. • Mean *year-round* chlorophyll *a* averaged 2.5 and 4.2 mg/m^3 at the upper and lower sections of this river reach for an average 73% increase over the 7.6 mile reach.

• Mean *summer* chlorophyll *a* of the lower sections averaged 6.0 mg/m^3 in 1990 but only 3.3 mg/m^3 in 1991 (= 45% reduction) following: 1) a very large spring algae bloom; and 2) 80% phosphorus removal from the Coeur d'Alene WWTP.

• The 1990 and 1991 chlorophyll *a* levels place the Spokane River in mesotrophic and meso-oligotrophic productivity ranges, respectively.

• 1990-91 mean chlorophyll *a* levels were approximately double 1980 levels but summer chlorophyll *a* dropped to near 1980 levels following phosphorus removal from Coeur d'Alene WWTP effluent.

10. • Mean Kjeldahl nitrogen was 0.18 mg/l and generally increased >20% below the Coeur d'Alene WWTP at low flows.

• There was a general trend of TKN increasing downstream through the study reach.

• TKN varied little with time of year or with water flows.

• The WWTPs contributed 25 to 50% of the TKN load to the Spokane River at low flows.

11. • Nitrate-nitrogen was typically less than 0.05 mg/l through summer months with fall-winter maxima of 0.50 mg/l.

12. • Mean total ammonia-nitrogen in the Spokane River arm of Lake Coeur d'Alene was 0.14 mg/l.

• Mean *summer* total ammonia-nitrogen in the Spokane River arm of Lake Coeur d'Alene was 0.16 mg/l.

• From RM 111.1 to 108.8, there typically was an average 75% increase of total ammonia-nitrogen in the River, but less than one third of that increase was from the Coeur d'Alene WWTP. However, 30% of the average summer ammonia-nitrogen load to the river was from the Coeur d'Alene WWTP (up to 60% of the total ammonia-nitrogen load in September, 1991 at 340 cfs river flow).

Conclusions (cont.)

13. • Total phosphorus ranged from 0.007 to 0.025 mg/l with a study mean of 0.014 mg/l (in the mesotrophic range).

• Total phosphorus increased 70% between RM 111.1 and 108.8 over the entire study.

• Total Phosphorus increase between RM 111.1 and RM 100.7 averaged only 40%, so the reach was most likely a net phosphorus sink during this study.

• *Summer* total phosphorus increased 87% between RM 111.1 and 108.8 over the entire study, 187% in 1991, but showed a 30% decline in 1991 after phosphorus removal in the Coeur d'Alene WWTP.

• WWTPs contributed ~50% of the total phosphorus load to the reach at low flows.

• Upgrading the Coeur d'Alene WWTP in June, 1991 resulted in an effluent TP decline of 79%.

14. • Orthophosphorus averaged <0.006 mg/l in the river during this study.

• Very rapid uptake and transformation of O-P kept river concentrations low.

• Upgrading the Coeur d'Alene WWTP in June, 1991 resulted in an effluent O-P decline of 80%.

15. • Total N:total P ratios exceeded 16:1 throughout most of the study, suggesting phosphorus-limitation. Some nitrogen limitation was apparent in summer-fall 1990.

16. • Five-day BOD levels in the Spokane River were moderately high averaging 3.4 mg/l over all sites and dates.

• WWTP five-day BOD levels from the Coeur d'Alene and Post Falls plants averaged 81.2 and 13.2 mg/l, respectively.

• Mean five-day BOD increased 14% in the lower four river sites compared to the two upstream sites.

17. • Ultimate BOD in the Spokane River averaged 10.7 mg/l.

• WWTP ultimate BOD levels from the Coeur d'Alene and Post Falls plants averaged 644.7 and 371 mg/l, respectively.

• Mean ultimate BOD increased 11% in the lowest river site compared to the uppermost site.

Conclusions (cont.)

18. • Median fecal coliform bacteria in the Spokane River were ~1 colony/100 ml except for immediately below the WWTPs.

• Median fecal coliform bacteria were 30 and 24 colonies/100 ml in the Coeur d'Alene and Post Falls WWTPs, respectively.

• Median fecal coliform bacteria increased ~30-fold from above to immediately below the Coeur d'Alene WWTP. River fecal coliform levels dropped to background concentrations within two river miles.

• Median fecal coliform bacteria increased ~2-fold from above to immediately below the Post Falls WWTP.

19. • The diel study in August, 1991 showed insignificant stratification of either temperature or oxygen and little day-to-night fluctuation of either temperature or oxygen.

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GLOSSARY OF LIMNOLOGICAL TERMS RELEVANT TO THE SPOKANE RIVER STUDY

acre-foot • The quantity of water needed to cover one acre to a depth of one foot. Equals 43,560 cubic feet = l,233.4 cubic meters = 325,851 gallons = 1,233,480 liters.

adsorption • The adhesion of one substance to the surface of another; clays, for example, can adsorb phosphorus and organic molecules to the surface of the clay particle.

aerobic • Characterizing organisms able to live only in the presence of air or free oxygen, and conditions that exist only in the presence of air or free oxygen.

algae • Small aquatic plants which occur as single cells, colonies, or filaments.

algal bloom • Rapid, even explosive growth of algae on the surface of lakes, streams, or ponds; stimulated by nutrient enrichment.

alkaline • The presence of alkalies (hydroxides, bicarbonates, or carbonates) in water or soil in amounts sufficient to raise the pH value above 7.0.

allochthonous • Energy and nurtients which enter a stream *via* the watershed. Terrestrial leaves, grasses, and other debris contribute large amounts of allochthonous material to small streams. Contrast with **autocthonous**.

anaerobic • Characterizing organisms able to live and grow only where there is no air or free oxygen (O_2), and conditions that exist only in the absence of air or free oxygen.

annual flood • The highest peak discharge of a stream in a water year.

aquatic macrophyte • The larger, non-microscopic aquatic plants found in shallow areas of lakes and streams. Some common examples are cattails, milfoil, rushes, duckweed, watercress, etc.

attached benthic algae (periphyton) • The community of algae (but which, in practice, also includes bacteria, protozoans, and rotifers) living on submerged surfaces.

autochthonous - Energy and nutrients which originate within the stream itself. Attached algae, macrophytes, and mosses, contribute to the autochthonous input of streams. Contrast with **allocthonous**.

average flow • The average of annual water volume carried by a channel converted to an average yearly rate of flow; measured in cubic feet per second (cfs) or cubic meters per second (cms).

bedload • The larger or heavier particles of the stream load moved along the bottom of a stream by the moving water and not continuously in suspension or solution.

benthic region • The bottom or substrate of a body of water, supporting the benthos.

benthos • All the plant and animals living on or closely associated with the bottom or substrate of a body of water.

best management practices (BMP's) • Accepted methods for controlling nonpoint source pollution; may include one or more conservation practices.

biochemical oxygen demand (BOD) • A measure of the amount of oxygen removed from aquatic environments by aerobic microorganisms for their metabolic requirements. Measurement of BOD is used to determine the level of organic pollution of a stream or lake.

biological community • All of the living things in a given environment.

biomass • The weight of biological matter. Standing crop is the amount of biomass (*eg.*, fish) in a body of water at a given time or algae on a submerged surface at a point in time.

biota • The plant and animal life in a region or ecosystem.

chemical oxygen demand (COD) • A measure of the amount of oxygen needed to oxidize all organic and inorganic material present in water or sediment; a measure of the organic and inorganic pollutant level of sewage and industrial waste water; COD includes BOD of a water sample.

chlorophyll a • The dominant green, photosynthetic pigment in plants; a measure of aquatic plant production.

coliform bacteria • A group of bacteria found in the colons of animals and humans but also in natural soil and water where organic content is high. The presence of coliform bacteria in water is an indicator of possible pollution by fecal material.

cubic feet per second (cfs) • A unit expressing rate of discharge, typically used in measuring streamflow. One cubic foot per second is equal to the discharge in a stream of a cross section one foot wide and one foot deep, flowing with an average velocity of one foot per second; = 448.8 gallons per minute.

decomposition • The transformation of organic molecules (*eg.*, sugar) to inorganic molecules (*eg.*, carbon dixide and water) through biological and non-biological processes.

discharge • In the simplest form, discharge means outflow of water. The use of this term is not restricted as to course or location and it can be used to describe the flow of water from a pipe or from a drainage basin. Other words related to discharge are **runoff, streamflow**, and **yield**.

dissolved oxygen (DO) • Molecular oxygen freely available in water and necessary for the respiration of aquatic life and the oxidation of organic materials.

drainage area • The land area contributing runoff to a stream or other body of water, and generally defined in terms of acres, square miles, or square kilometers.

effluent • The sewage or industrial liquid waste which is released into natural waters by sewage treatment plants, industry, or septic tanks.

epilimnion • The near surface, uppermost, warmer layer of water in a lake or pond which lies above the horizontal zone of maximum temperature and density gradient.

eutrophication • The natural process by which lakes and ponds become enriched with dissolved nutrients, resulting in increased growth of algae and other microscopic plants.

export coefficient •The amount of a substance (usually nutrients such as nitrogen or phosphorus) which leaves a watershed *via* surface runoff per unit area of watershed per unit time, *eg*. kg P/sq. mile/year.

fauna • The entire animal population of a specific region and/or time.

fecal streptococci • Enteric (in the gut), chain-forming bacteria found in the intestines of warm-blooded animals, including humans. Occurrence in fresh water is indicative of fecal contamination by either humans or animals.

flora • The entire plant population of a specified region and/or time.

flow • The rate of water discharged past a point; expressed in water volume per unit time

flushing rate • The rate at which water exits a lake through outflows; (= Rho) and measured as number of flushings per year.

flushing time • The amount of time it takes for all of a lake's water to exit through the outflow.

free-flowing • Without artificial restrictions (dams) to water movement down-channel.

hydraulic residence time • The amount of time it would take to completely fill a lake if it were empty; = lake volume/water inflow.

hypolimnion • The lowermost, non-circulating layer of cold water in a thermally stratified lake; usually deficient in oxygen.

internal loading • The release of lake sediment-bound nutrients into the water column. This process most commonly occurs when phosphorus is released from the sediments when low dissolved oxygen occurs at the sediment-water interface.

lentic • Characterizing aquatic communities found in standing water (=lacustrine).

limnology • The branch of science pertaining to the study of the physical, chemical, biological, and ecological aspects of fresh water; the structure and dynamics of ponds, lakes, streams, and wetlands.

liter • The basic unit of measurement for volume in the metric system; equal to 61.025 cubic inches or 1.057 liquid quarts.

littoral • The region along the lakeshore.

lotic environment • Characterizing aquatic communities found in running water.

mean depth • A lake's volume divided by its surface area.

mesotrophic • Literally, "moderate nutrients". Generally refers to a moderately fertile body of water.

metalimnion • The zone of a lake over which temperature drops relatively rapidly with depth.

milligram (mg) • One-thousandth of a gram.

model • A simulation, by descriptive, statistical, or other means, of a process otherwise difficult or impossible to observe directly.

morphometry • The shape or form of a lake basin or stream channel.

nonpoint source pollution • Pollution discharged over a wide land area, not from one specific location.

nutrient loading • The addition of nutrients, usually nitrogen or phosphorus, to a water body (often expressed as g/m^2 of lake surface area per year). The majority of nutrient loading in a lake usually comes from its tributaries.

nutrients • Elements or compounds essential to life, including but not limited to oxygen, carbon, nitrogen, phosphorus.

oligotrophic • Literally, "nutrient poor". Generally refers to an infertile, unproductive body of water. Contrast with **eutrophication**.

organic matter • Plant and animal residues; substances made by living organisms.

overturn • The complete circulation or mixing of upper and lower layers of water when temperatures, and therefore densities, are similar. Overturn usually occurs in the spring and fall.

parts per million (PPM) • The number of "parts" by weight of a substance per million parts of water. This unit is commonly used to represent pollutant concentrations. Large concentrations are expressed in percentages...equivalent to mg/l.

pH • An expression of both acidity and alkalinity on a scale of 0-14, with 7 representing neutrality; numbers less than 7 indicate increasing acidity, and numbers greater than 7 indicate increasing alkalinity.

pheophytin • A degredation product of chlorophyll. The relative amount of pheophtyin can be used to determine the "health" of the phytoplankton community.

photic zone • The zone in a lake through which light penetrates and plant growth occurs.

phytoplankton • Usually microscopic aquatic plants (sometimes consisting of only a cell).

point source pollution • Pollutants discharged from any identifiable point, including pipes, ditches, channels, sewers, tunnels, and containers of various types.

pollution • Any alteration in the character or quality of the environment which renders it unfit or less suited for certain uses. See **water contamination** and **water pollution.**

profundal • The deeper portion of a body of water below the area of plant growth.

reach • Any arbitrarily defined length of a stream.

reservoir • A pond, lake, or basin (natural or artificial) that stores, regulates, or controls water flow downstream.

riparian area • Land areas directly influenced by a body of water. Usually have visible vegetation or physical characteristics showing this water influence. Stream sides, lake borders, and marshes are typical riparian areas.

secchi depth • The mean depth at which a black and white disk 20-cm in diameter is no longer visible from the water surface; a measure of water transparency.

sediment • Fragmented organic or inorganic material derived from the weathering of soil, alluvial, and rock materials; removed by erosion and transported by water, wind, ice, and gravity.

senescent • Aging, growing old; with a lake, senescent = **eutrophic.**

stratification • The forming or arrangement of layers. This is usually caused by differences in temperature and density between layers.

substrate • The permenant bottom material of a lake or stream which forms the lake basin or stream bed.

terrestrial • Living or growing in a land-based ecosystem rather than in water or air.

topographic maps • Maps with lines showing equal elevation or a region's relief; also showing natural surface features, including hills, valleys, rivers, and lakes; as well as man-made surface features such as canals, bridges, roads, cities, etc.

total dissolved solids (TDS) • The quantity of dissolved materials in the water.

total suspended solids • Solids, found in waste water or in a stream, which can be removed by filtration. The origin of suspended matter may be man-made wastes or natural sources such as silt.

toxin • Any of a variety of unstable, poisonous compounds produced by organisms; may be capable of causing certain diseases.

trophic • Refering to the nourishment status of a lake. **Oligotrophic** = poorly nourished; **Eutrophic** = well-nourished.

turbidity • Cloudiness caused by the presence of suspended solids in water; an indicator of water quality.

ultimate BOD • The biochemical oxygen demand exerted in an oxygen consumption test run long enough so that no further oxygen reduction occurs.

water quality standard • Legally mandated and enforceable maximum contaminant levels of chemical parameters (*e.g.*, BOD, TDS, iron, arsenic, and others) of water. These parameters are established for water used by municipalities, industries, agriculture, and recreation.

water quality • A term used to describe the chemical, physical, and biological characteristics of water with respect to its suitability for a particular use.

water year • The 12-month period October 1 through September 30, and designated by the calendar year in which the water year ends.

watershed • Area of land that contributes surface runoff to a given point in a drainage system.

wetlands • Lands where water saturation of the soil for at least part of the year is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the surrounding environment. Other common names for wetlands are sloughs, ponds, swamps, marshes, and riparian zones

FIGURES

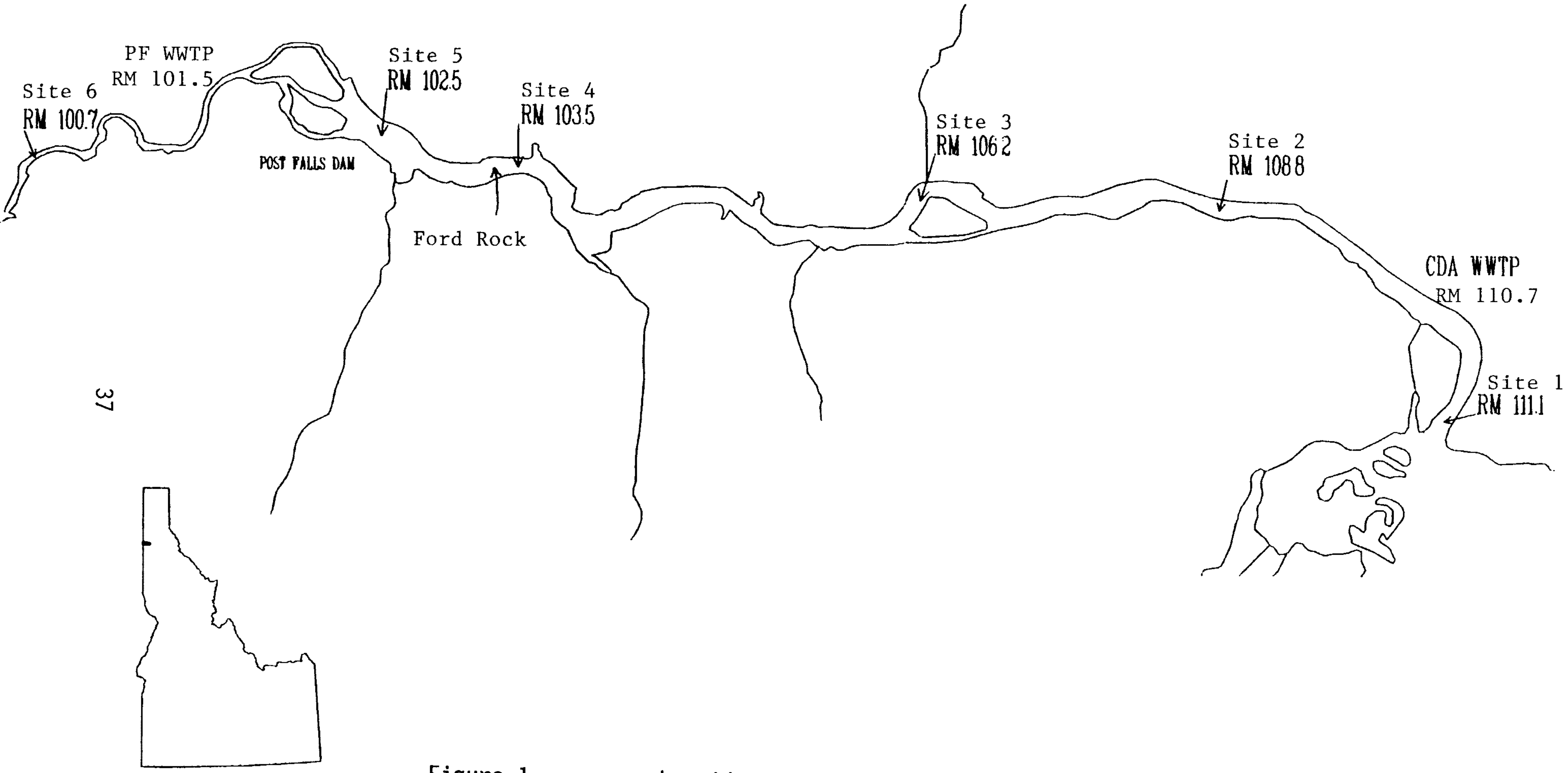


Figure 1. Location map and sampling sites for the Spokane River outlet arm of Lake Coeur d'Alene water quality survey, June 29, 1990 to September 24, 1991.

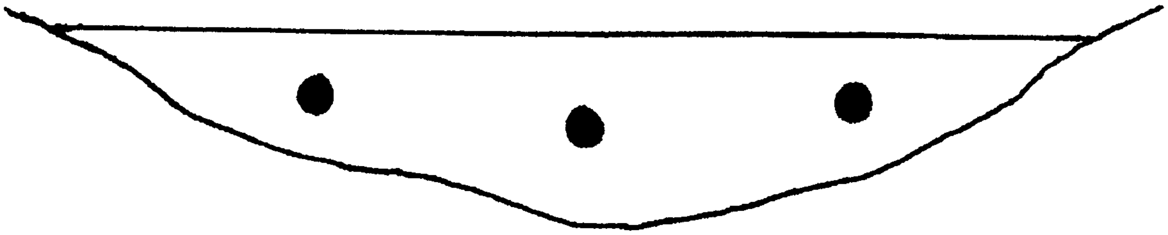


Figure 2. Water quality grab sampling locations at mid-depth for Spokane River stations exhibiting *mixed* conditions.

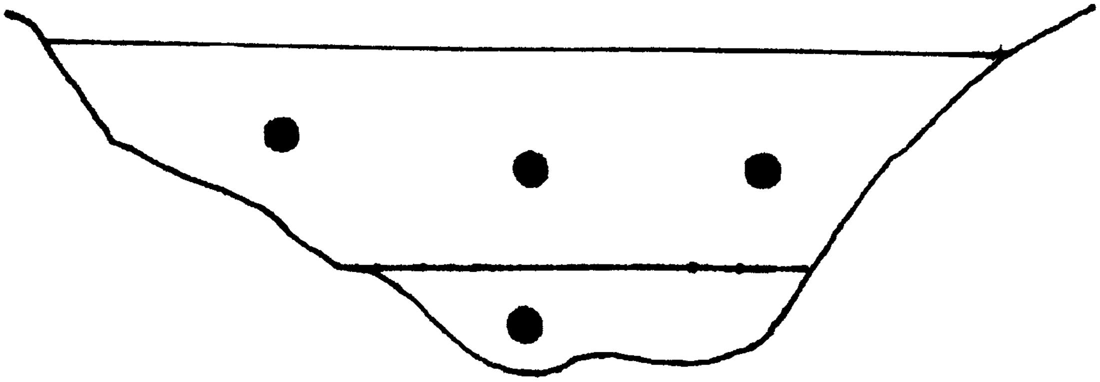


Figure 3. The spatial distribution of water quality grab samples for Spokane River sampling stations exhibiting stratified conditions.

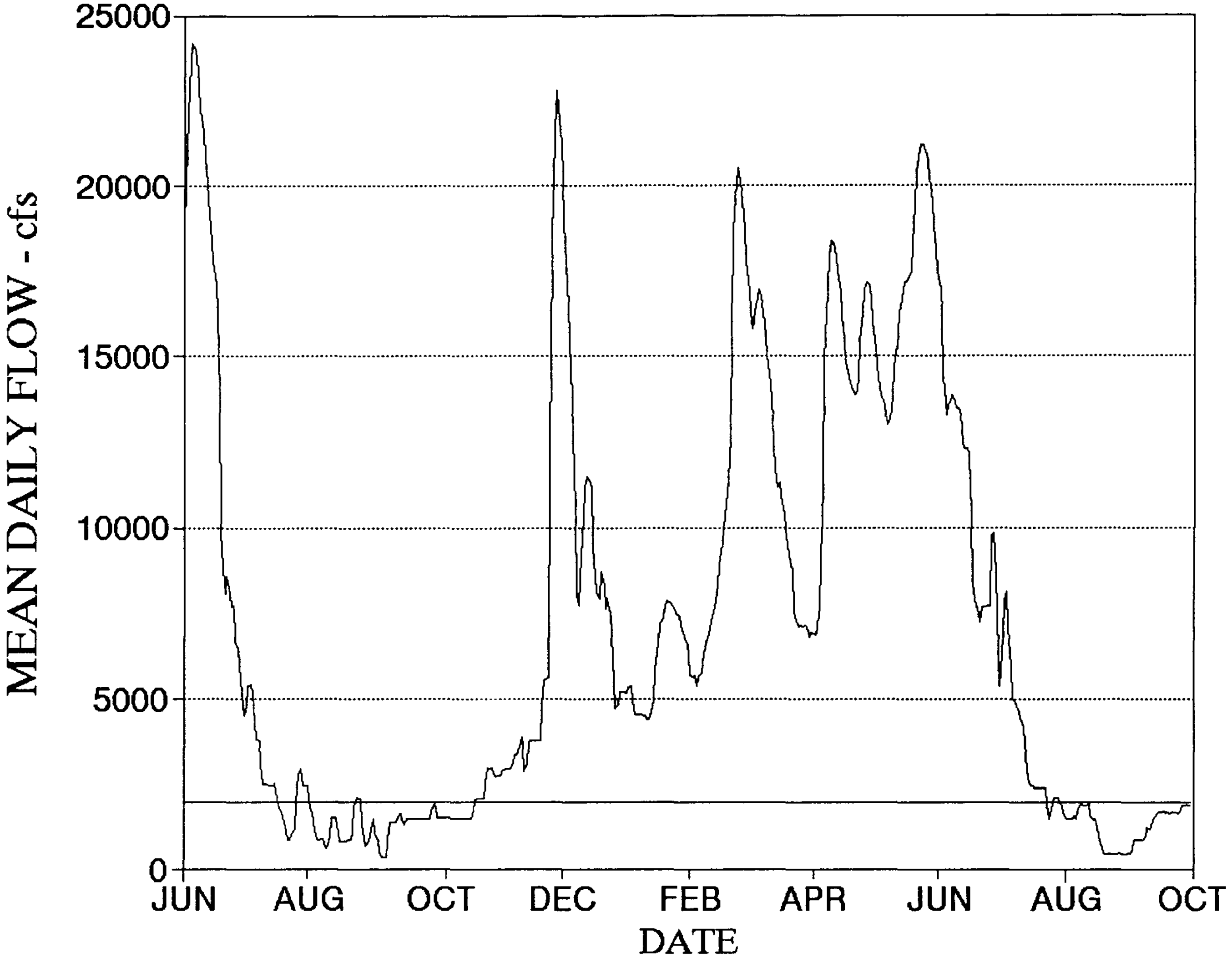


Figure 4. Mean daily flow of the Spokane River near Post Falls (station number 12419000) for June 29, 1990 to September 24, 1991, (USGS 1990 and USGS 1991).

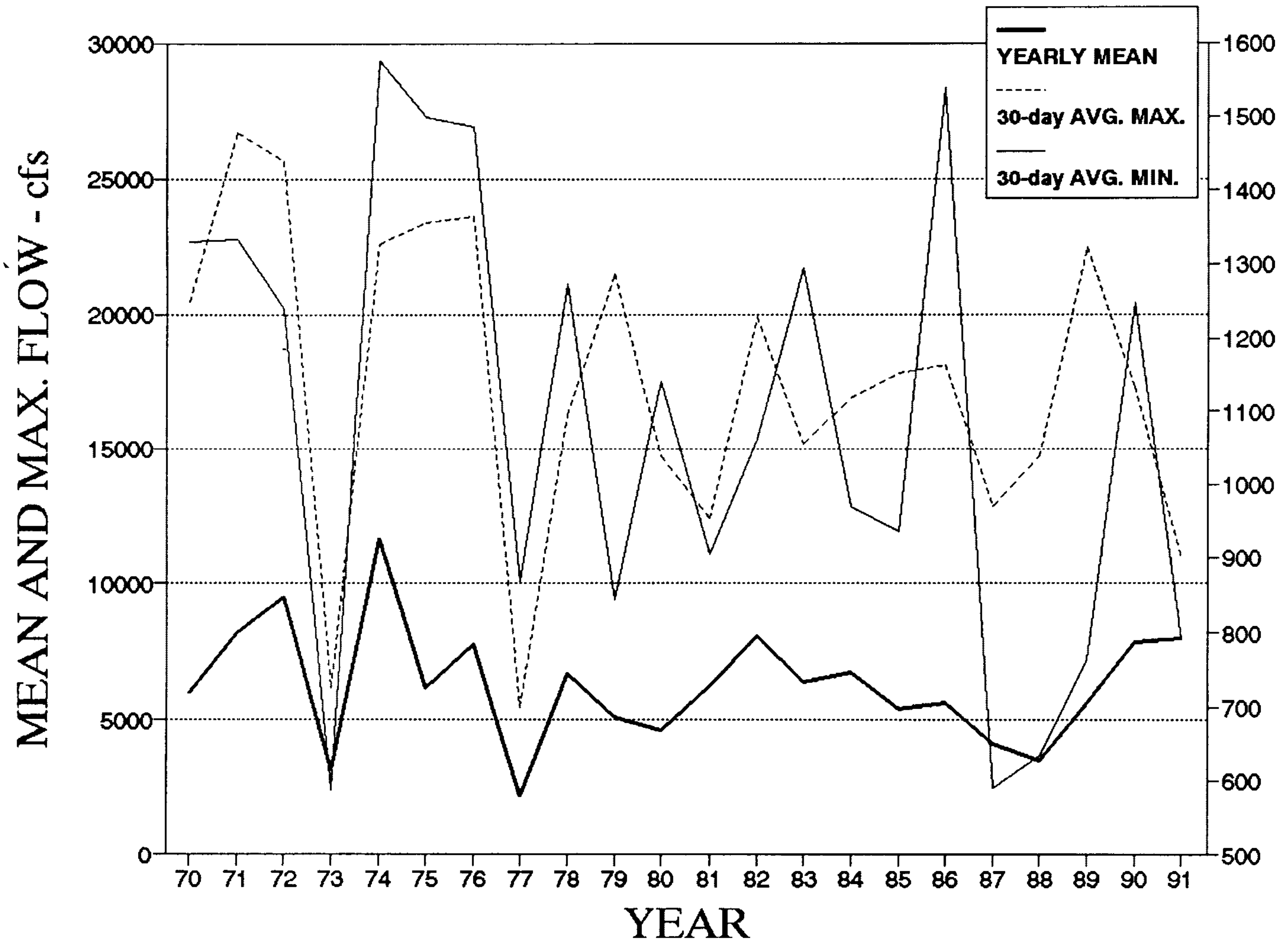


Figure 5. Flow characteristics of the Spokane River near Post Falls over the past 22 water years (USGS 1970-1991).

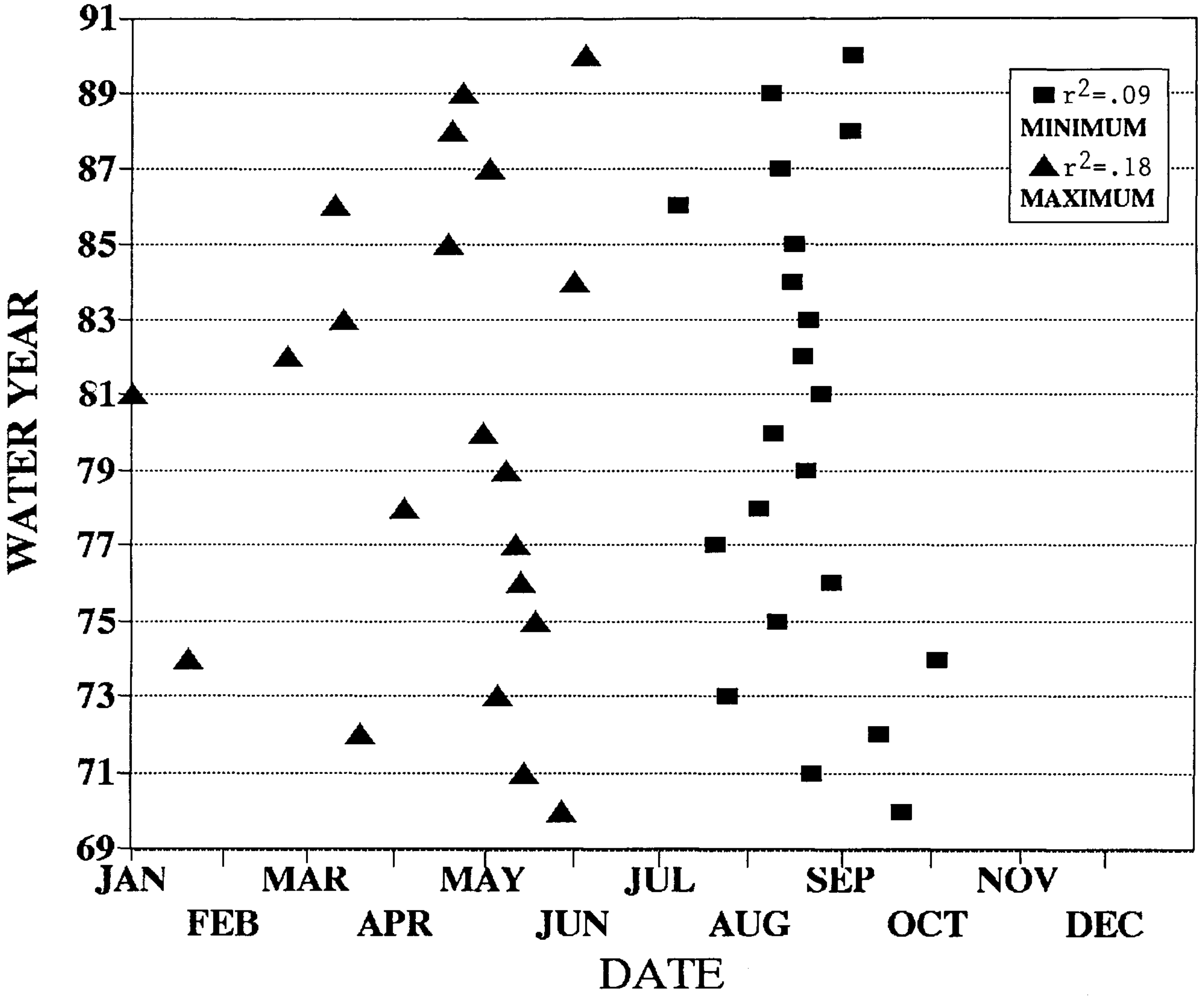


Figure 6. Date of minimum and maximum flow on the Spokane River near Post Falls over the past 22 water years (USGS 1970-1991).

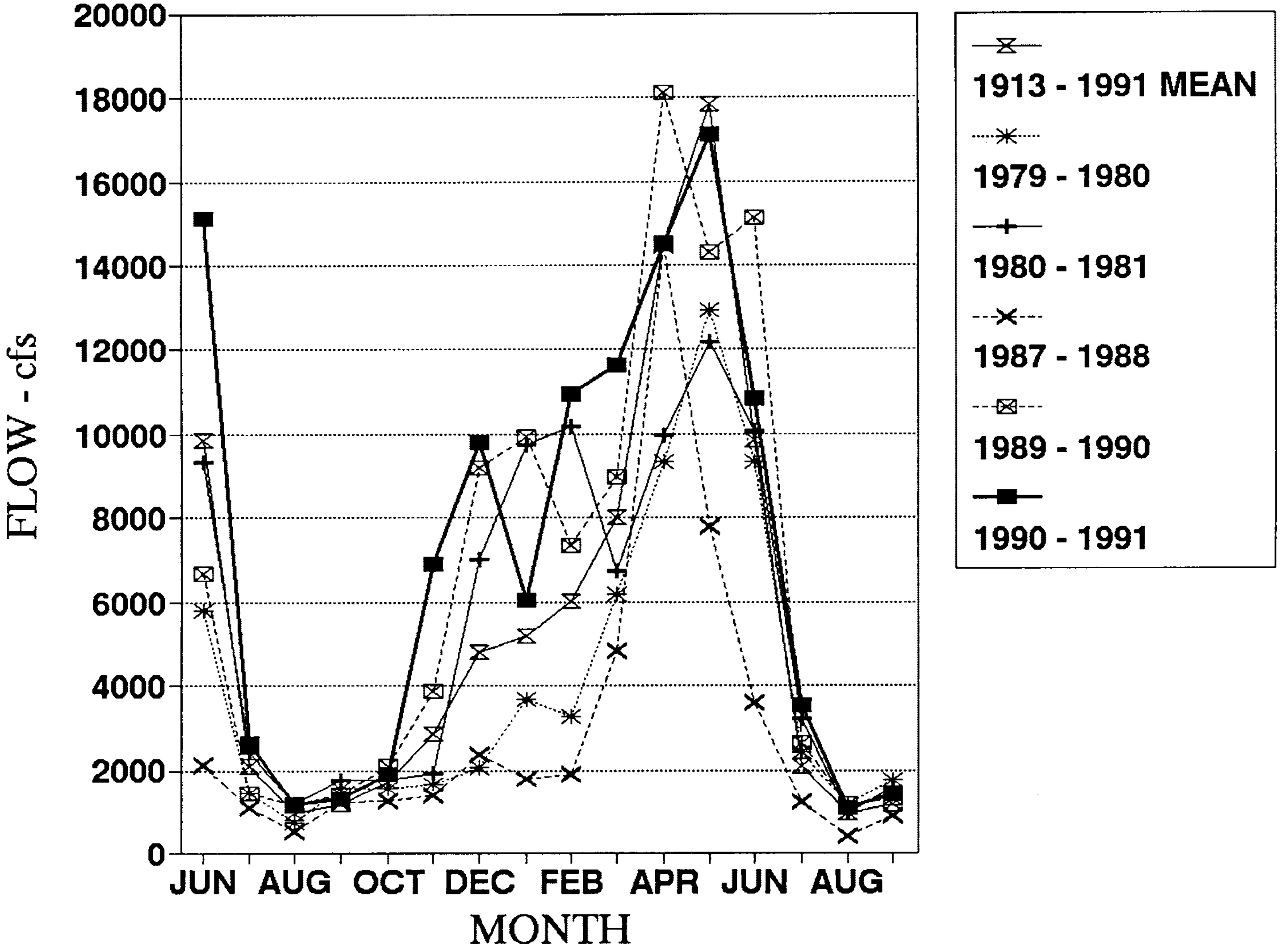


Figure 7. Mean monthly flow (cfs) of the Spokane River near Post Falls during water quality study periods--(Falter and Mitchell 11/79-10/80), (Seitz and Jones 3/80-1/81), (Yearsley and Duncan 8/15-18/88), (Falter and Riggers 6/90-9/91), and over the seventy-eight year period of record (1913-1991) (USGS 1979, 1980, 1987-1991).

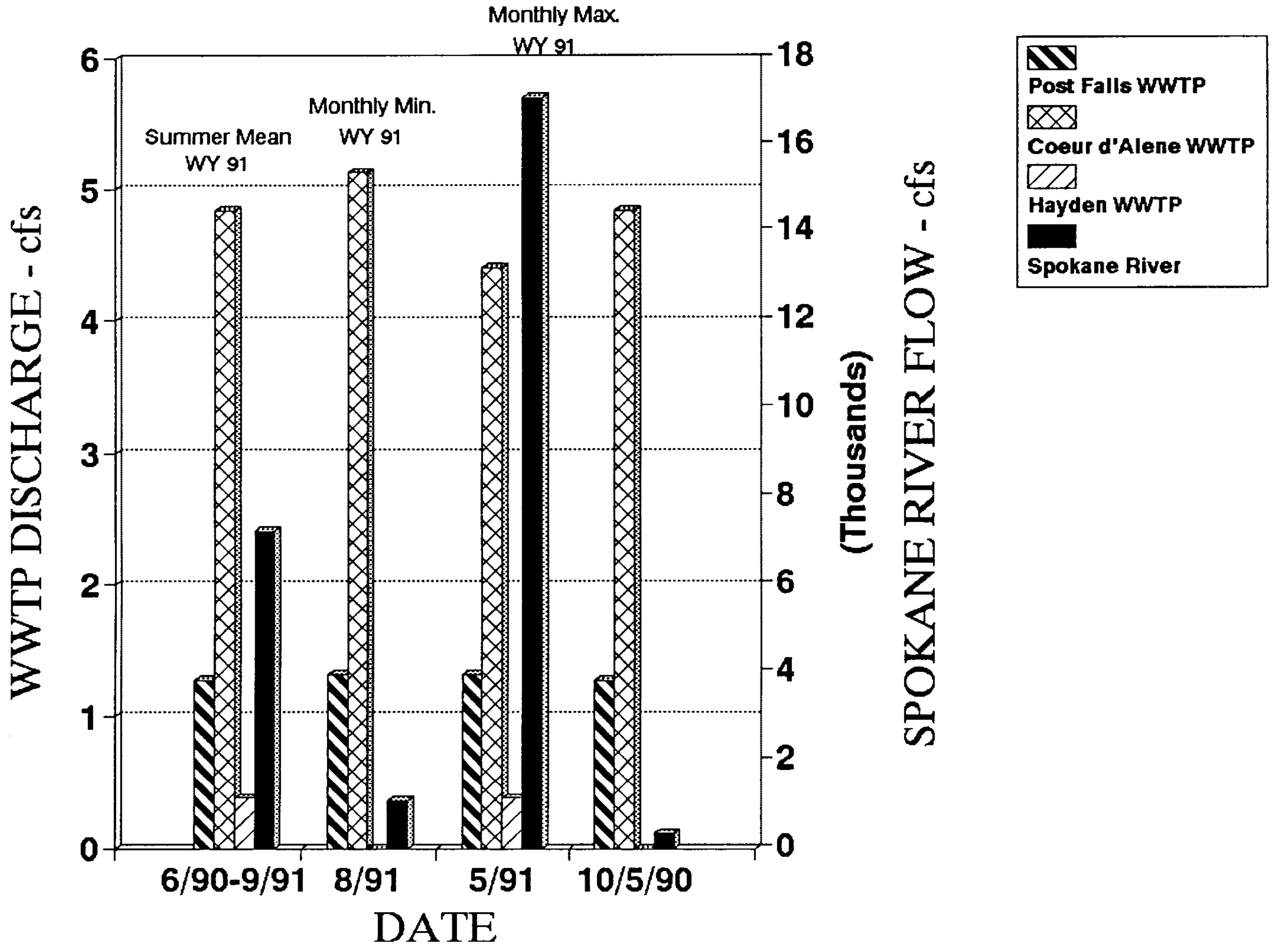


Figure 8. Mean flow (cfs) of the Spokane River and discharge (cfs) to the river from Coeur d'Alene, Post Falls, and Hayden (proposed) wastewater treatment plants under various flow conditions for June 29, 1990 to September 24, 1991.

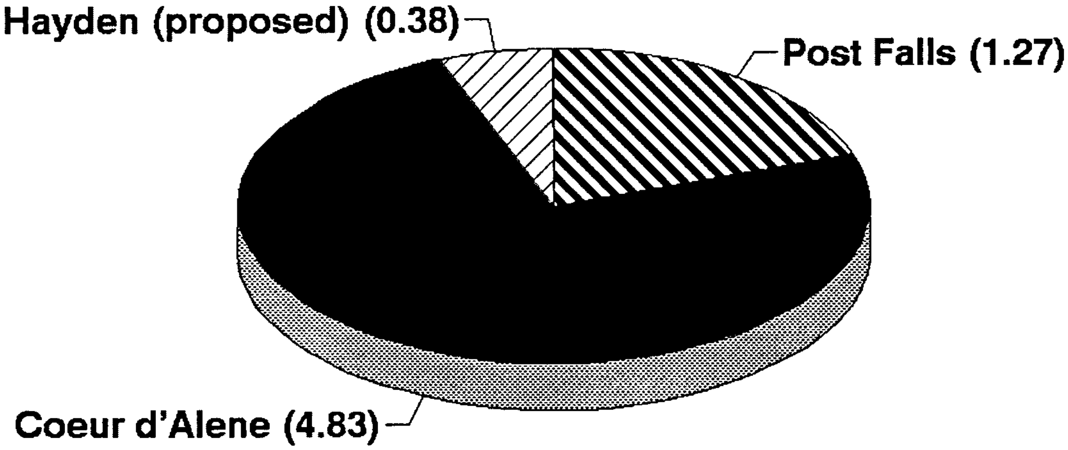


Figure 9. Mean yearly discharge (cfs) to the Spokane River from Coeur d'Alene and Post Falls wastewater treatment plant and from the proposed City of Hayden Outfall.

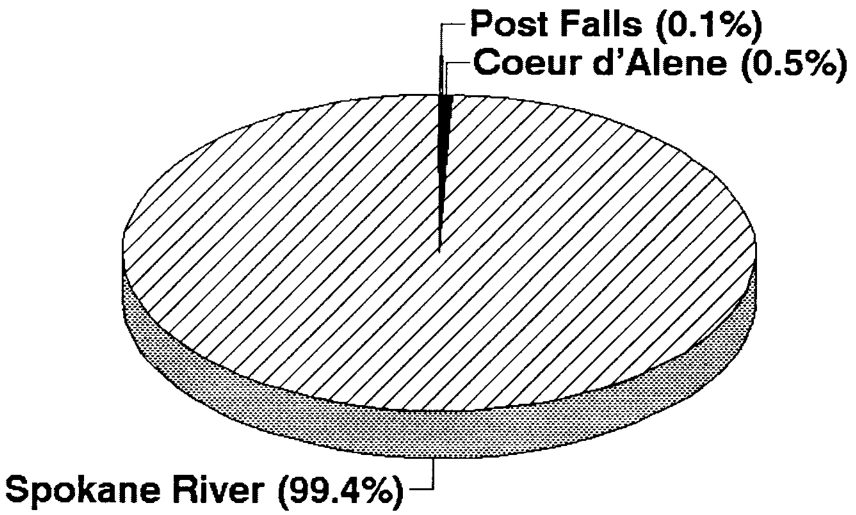


Figure 10. Wastewater treatment plant discharge to the Spokane River as a percentage of river flow under the lowest mean monthly flow conditions (1,075 cfs) during the June 29, 1990 to September 24, 1991 study period.

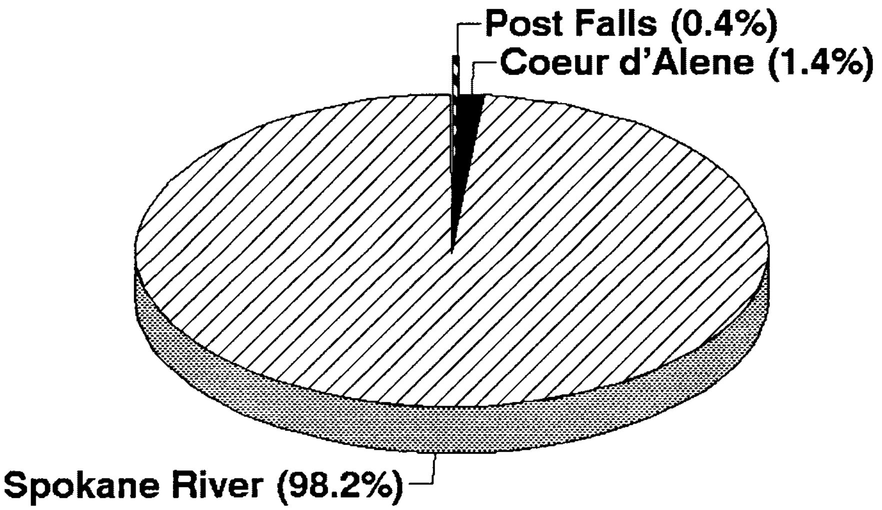


Figure 11. Wastewater treatment plant discharge to the Spokane River as a percentage of river flow under the lowest flow conditions (340 cfs) during the June 29, 1990 to September 24, 1991 study period.

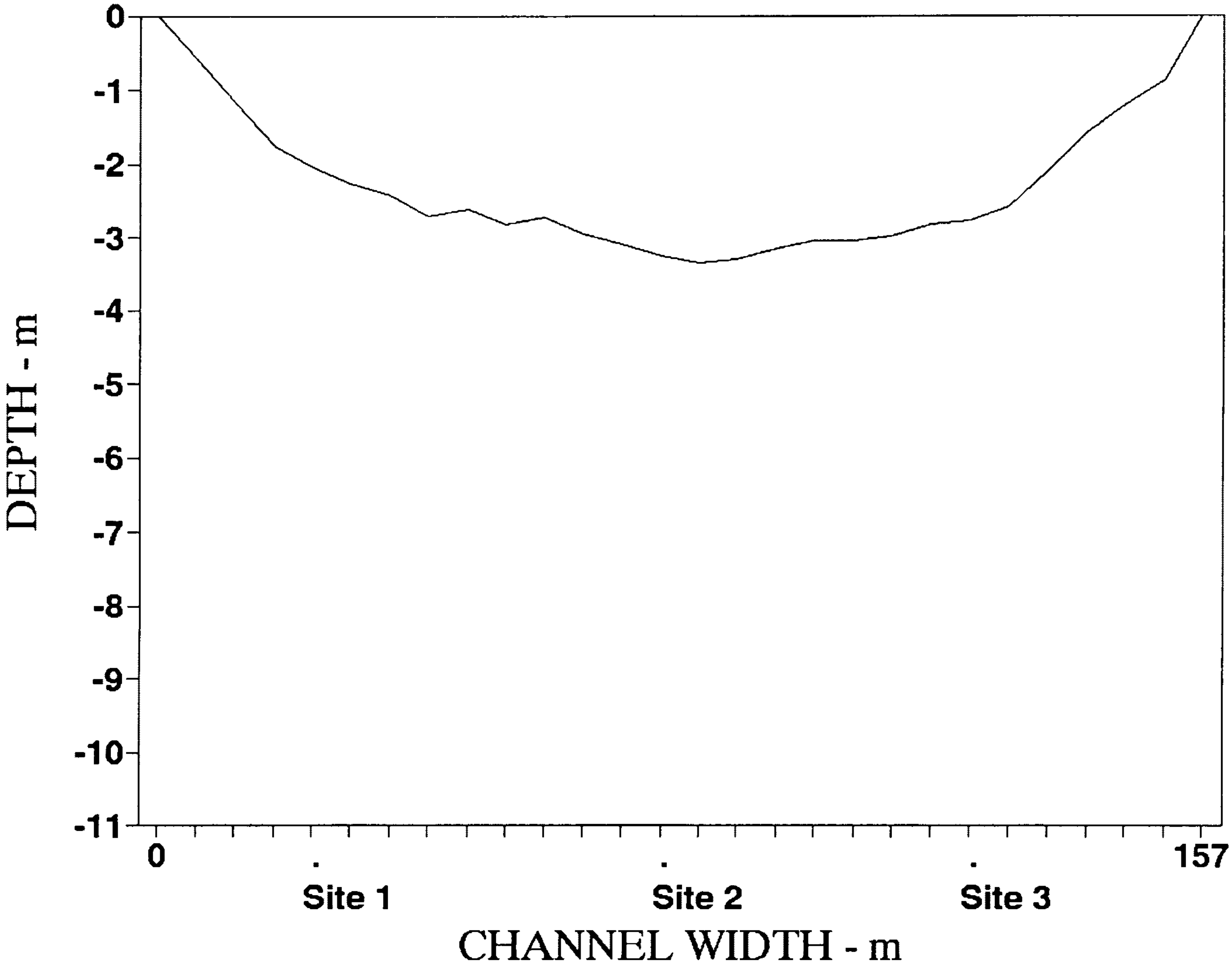


Figure 12. Bottom profile and sample site location for Station 1 (RM 111.1), Spokane River, 1991.

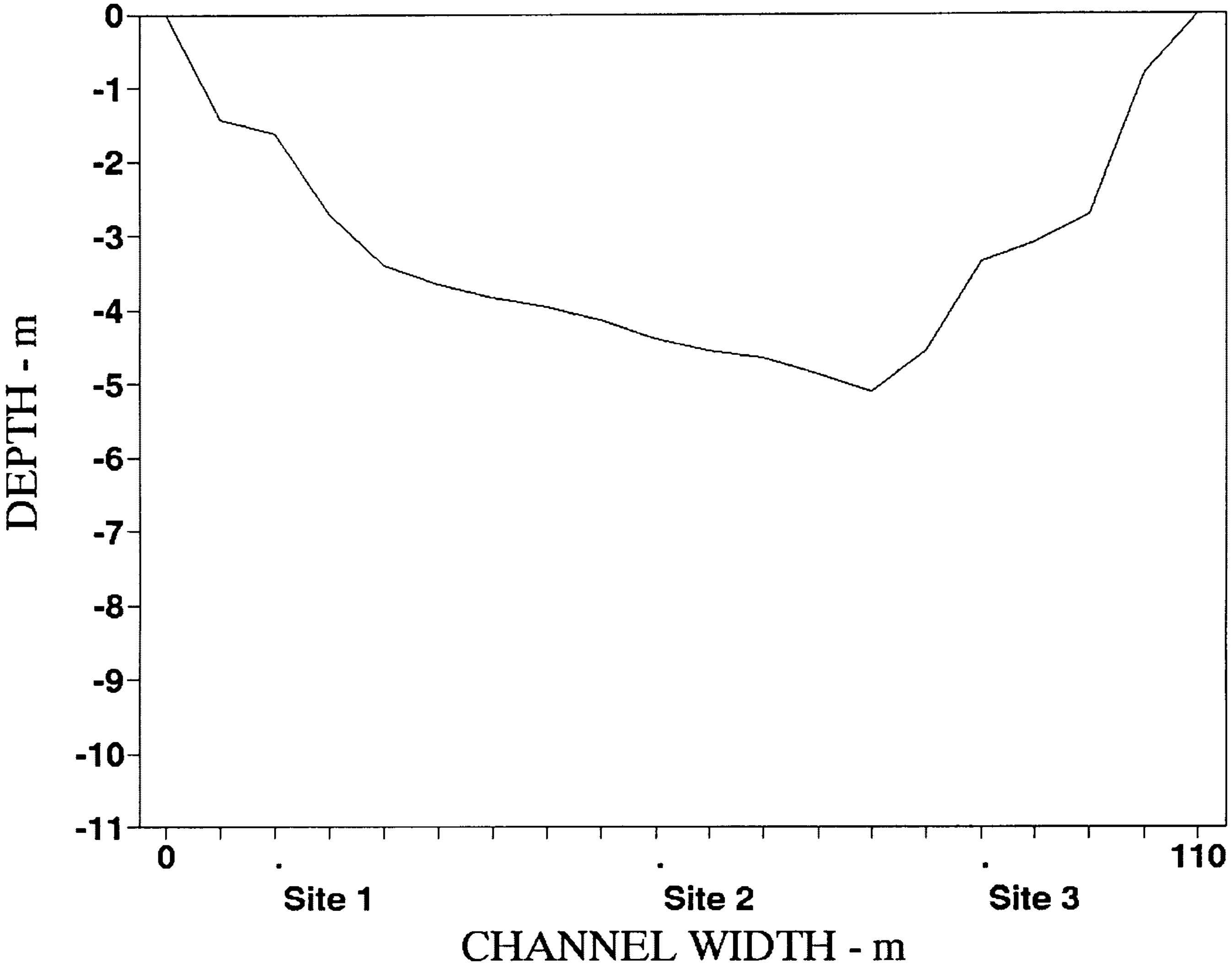


Figure 13. Bottom profile and sample site location for Station 2 (RM 108.8), Spokane River, 1991.

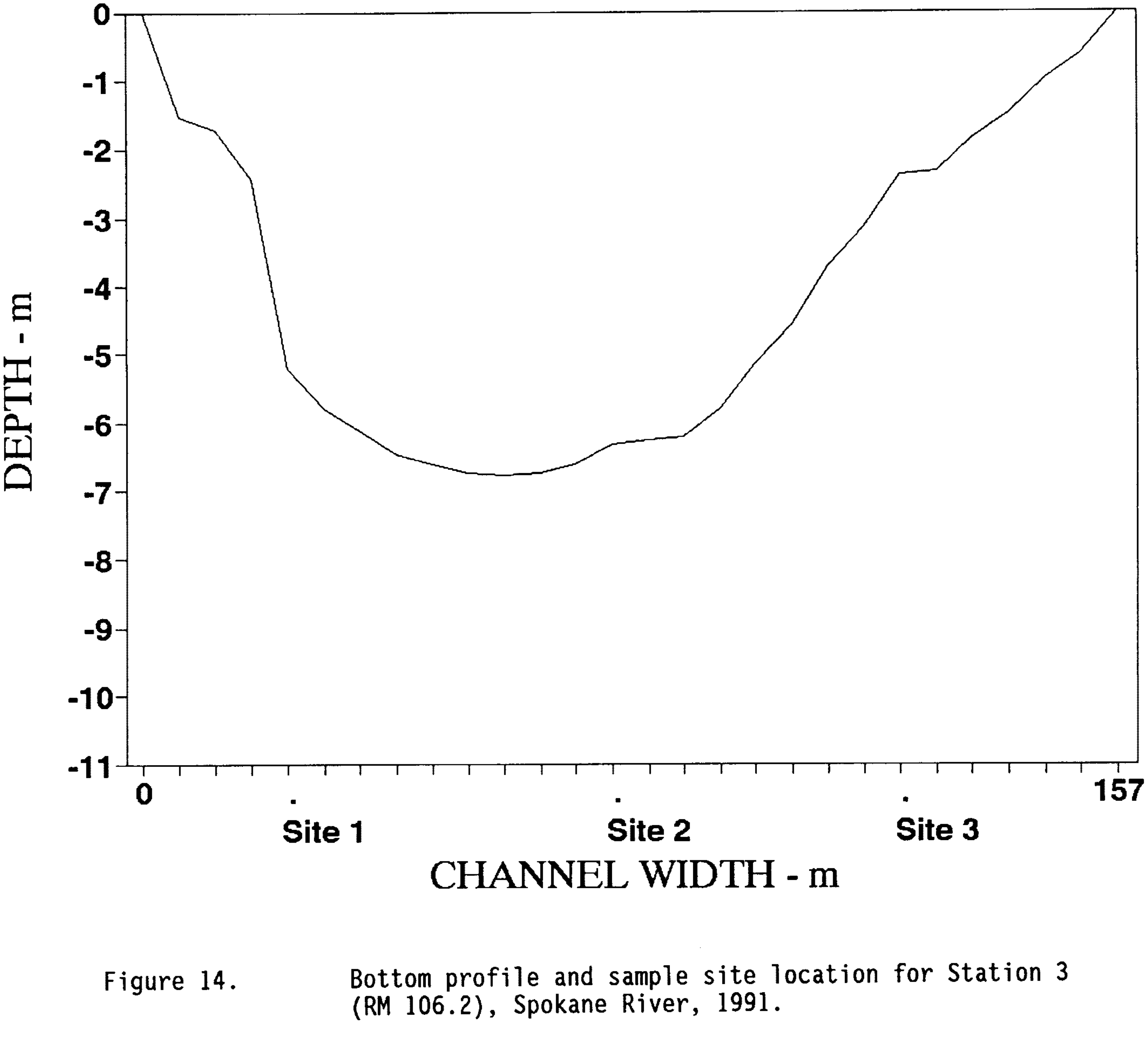


Figure 14. Bottom profile and sample site location for Station 3 (RM 106.2), Spokane River, 1991.

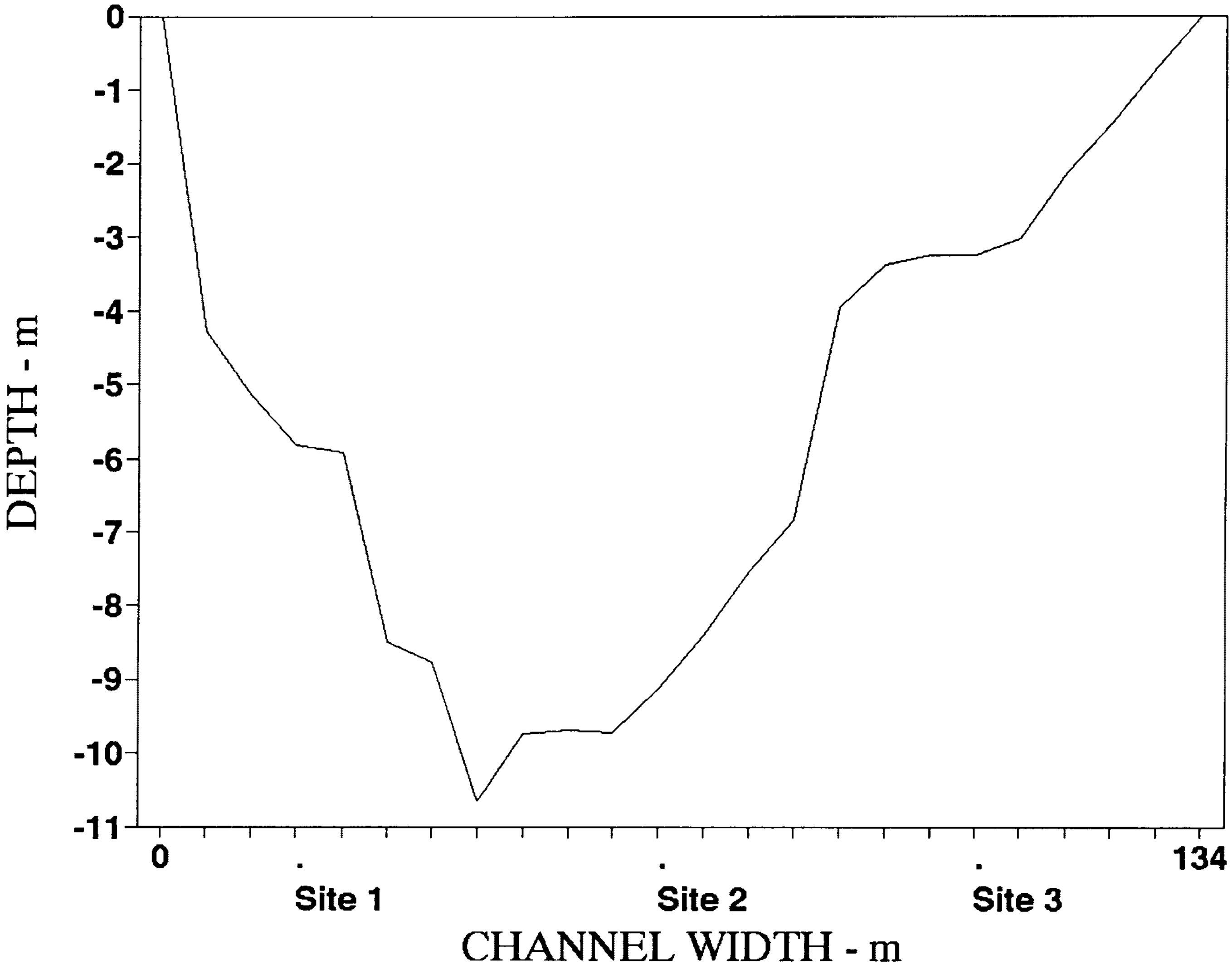


Figure 15. Bottom profile and sample site location for Station 4 (RM 103.5), Spokane River, 1991.

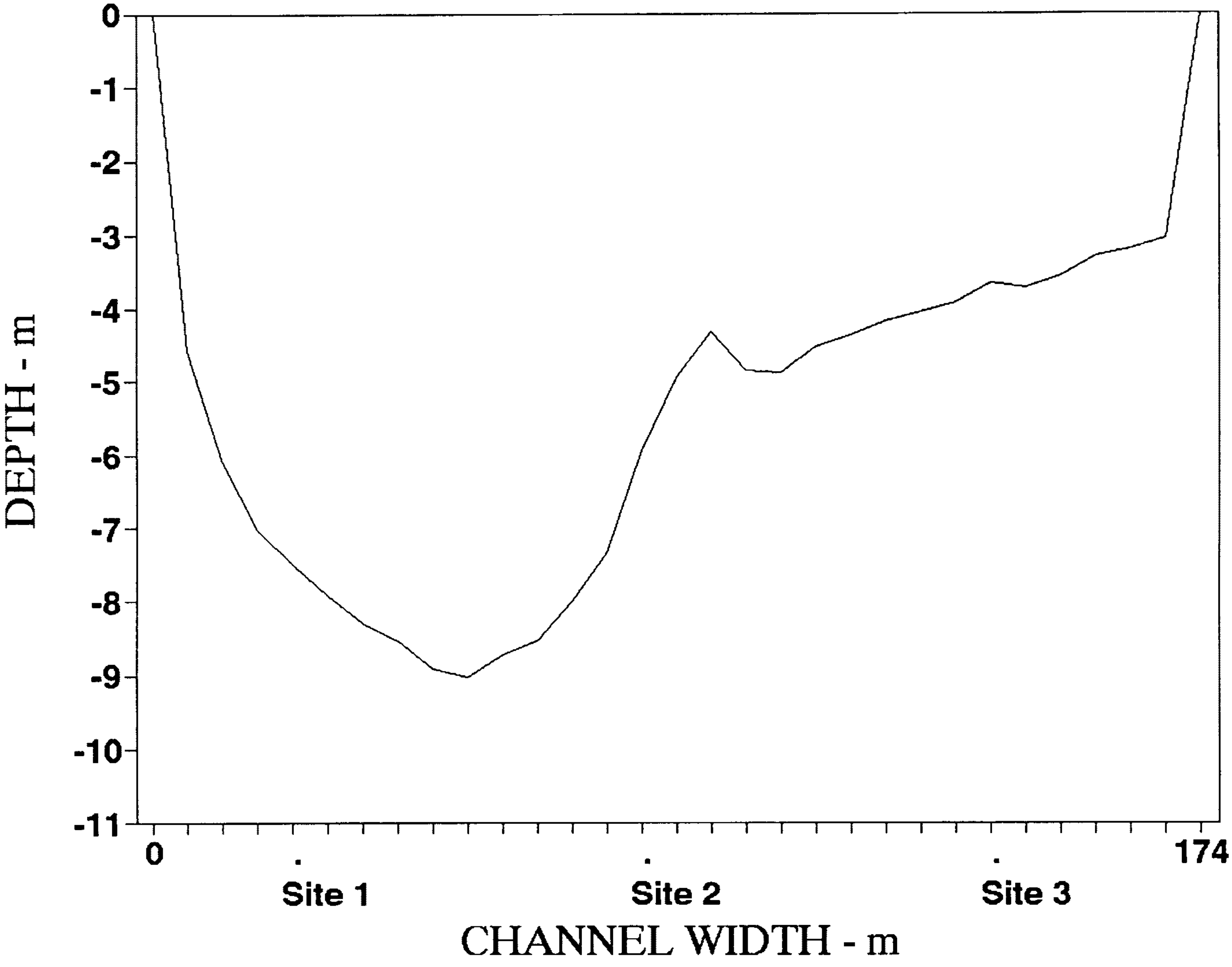


Figure 16. Bottom profile and sample site location for Station 5 (RM 102.5), Spokane River, 1991.

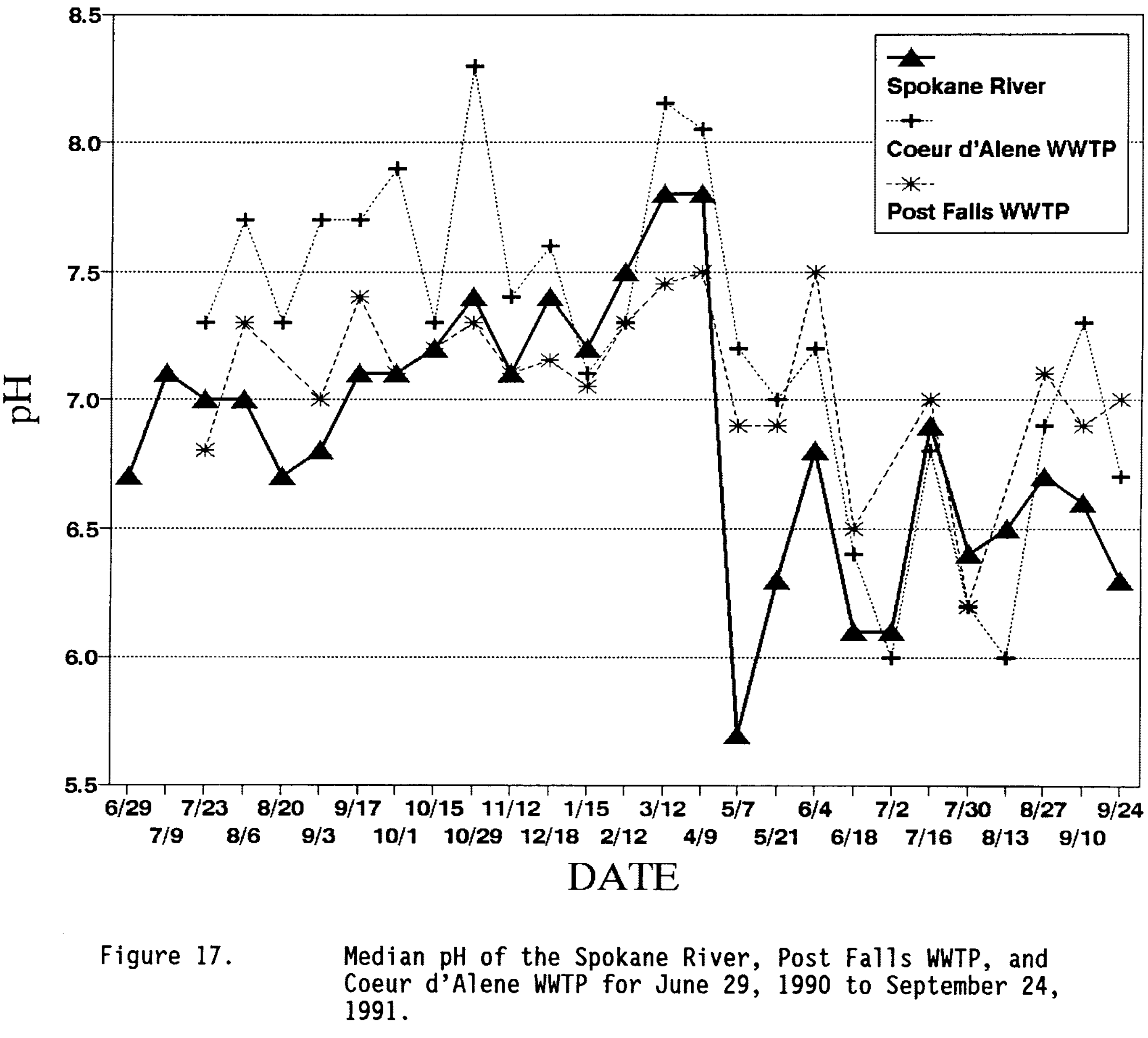


Figure 17. Median pH of the Spokane River, Post Falls WWTP, and Coeur d'Alene WWTP for June 29, 1990 to September 24, 1991.

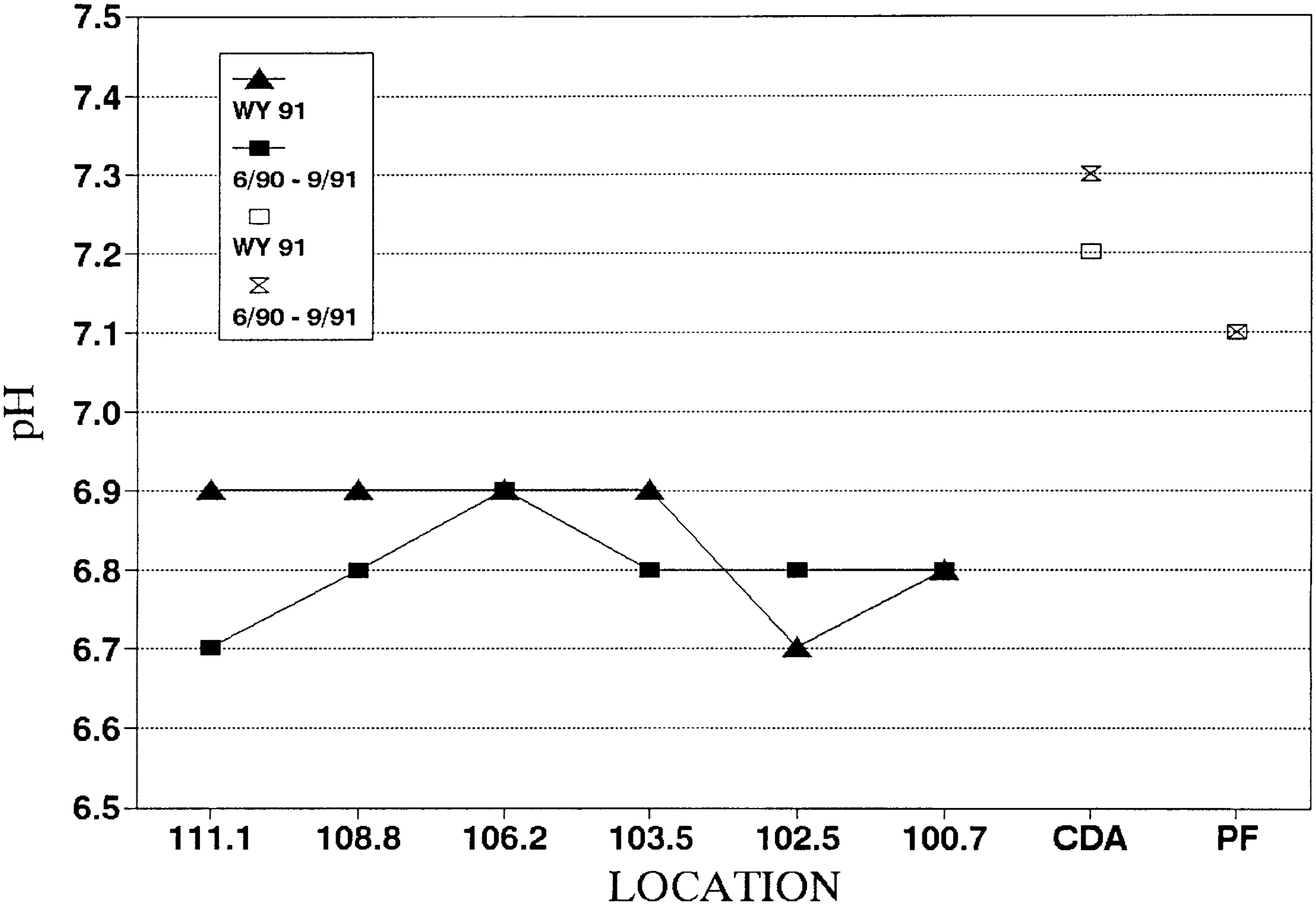


Figure 18. Median pH between stations; Spokane River RM 111.1 to RM 100.7, Post Falls WWTP, and Coeur d'Alene WWTP during Water Year 1991 and June 29, 1990 to September 24, 1991.

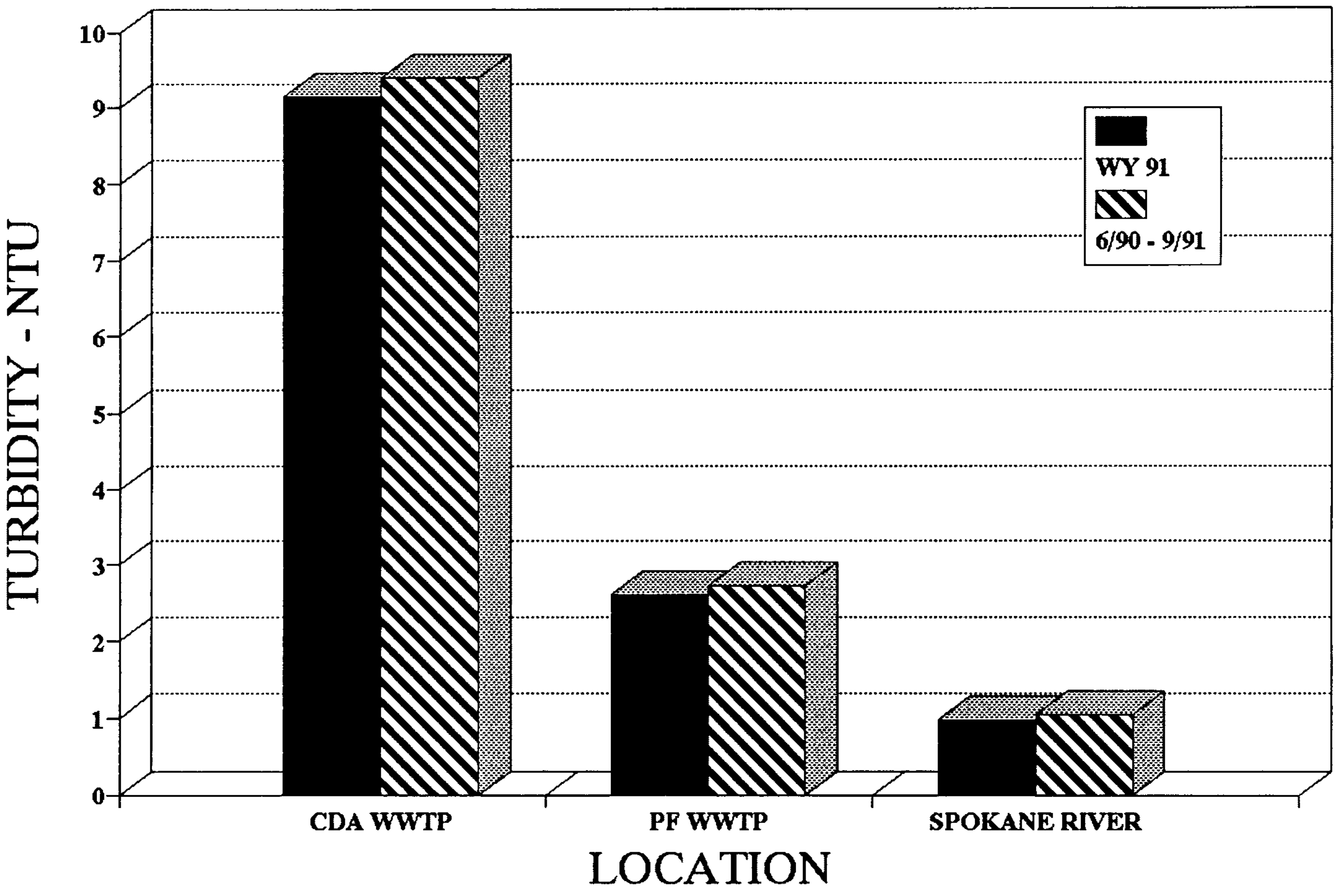


Figure 19. Mean turbidity of the Spokane River and Post Falls and Coeur d'Alene Wastewater Treatment Plants during Water Year 1991 and June 29, 1990 to September 24, 1991.

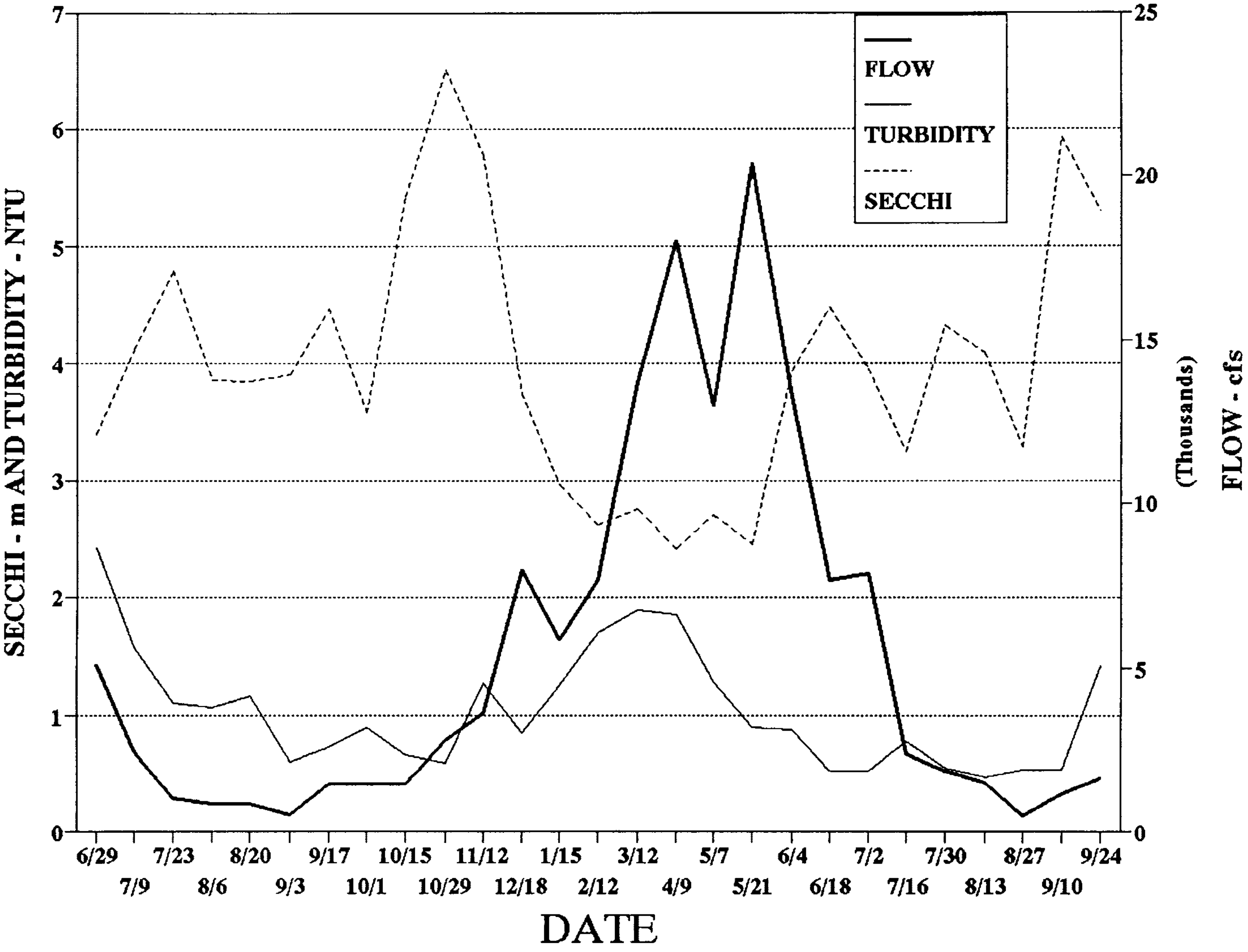


Figure 20. Mean Secchi depth and turbidity versus flow in the Spokane River on each sample date for June 29, 1990 to September 24, 1991.

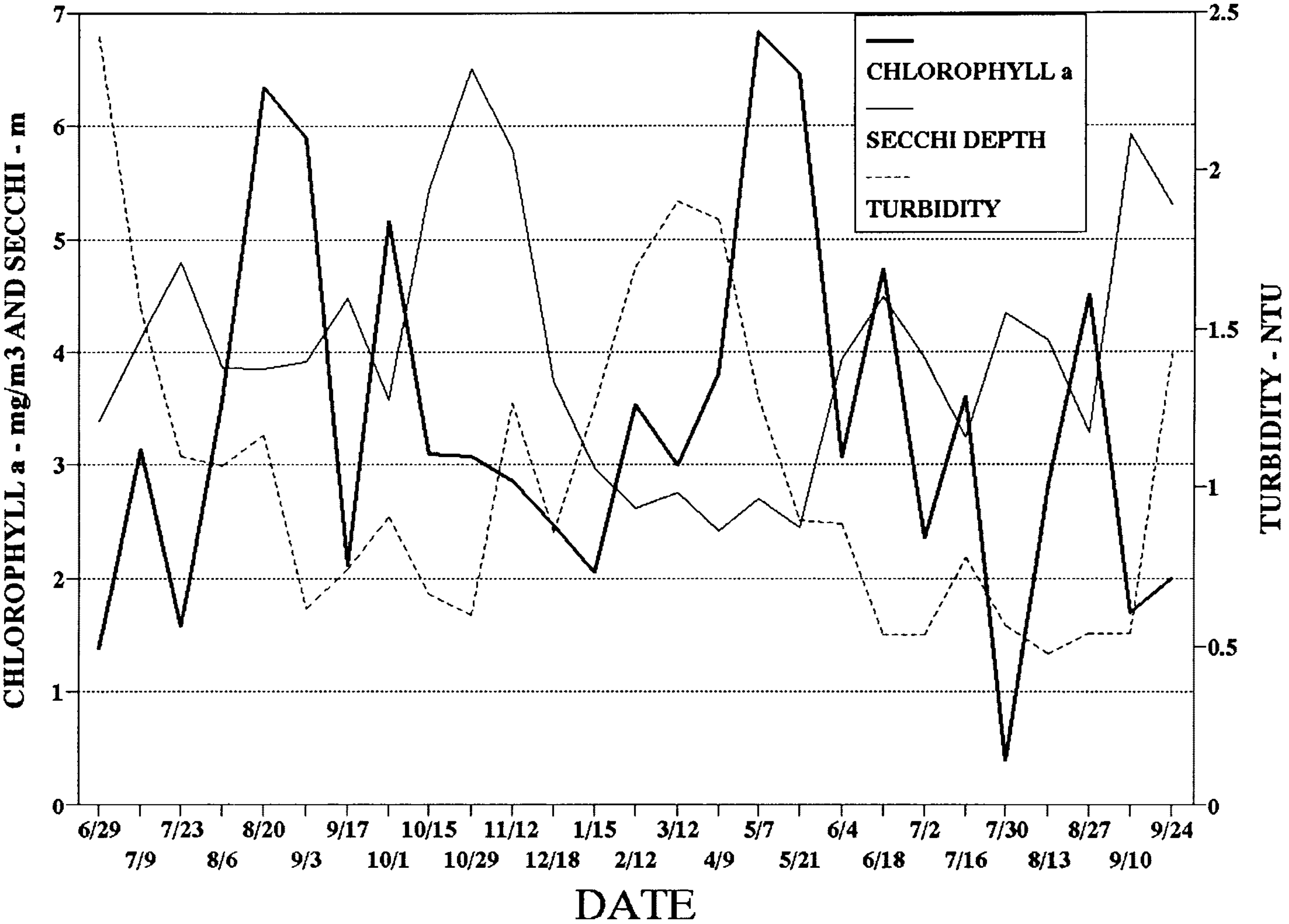


Figure 21. Mean chlorophyll *a*, secchi depth, and turbidity in the Spokane River on each sample date for June 29, 1990 to September 24, 1991.

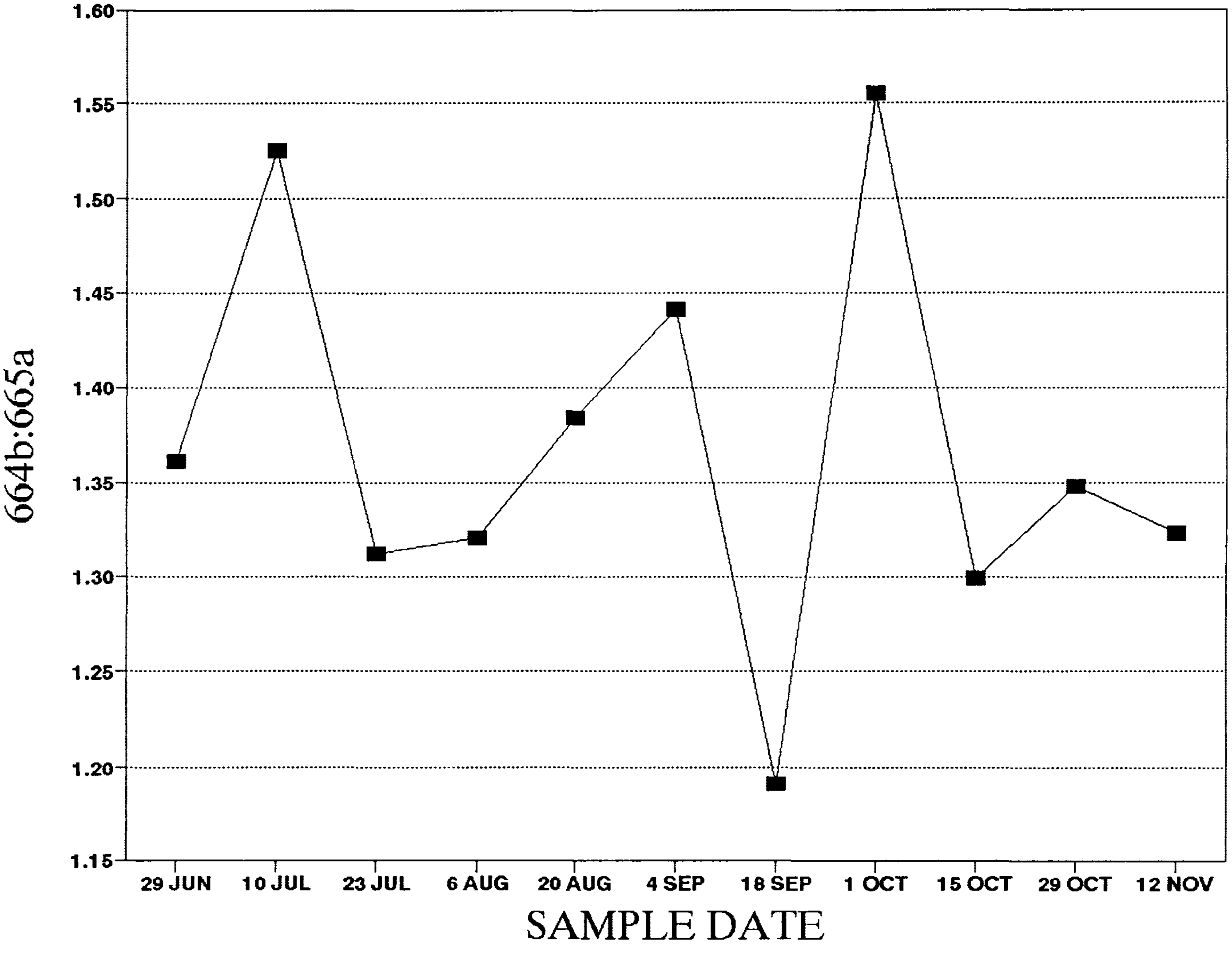


Figure 22. Absorption peak ratios for chlorophyll *a* samples collected June 29, to November 17, 1990. Ratio values near 1.70 indicate healthy chlorophyll a. Values near 1.00 indicate high pheophytin content.

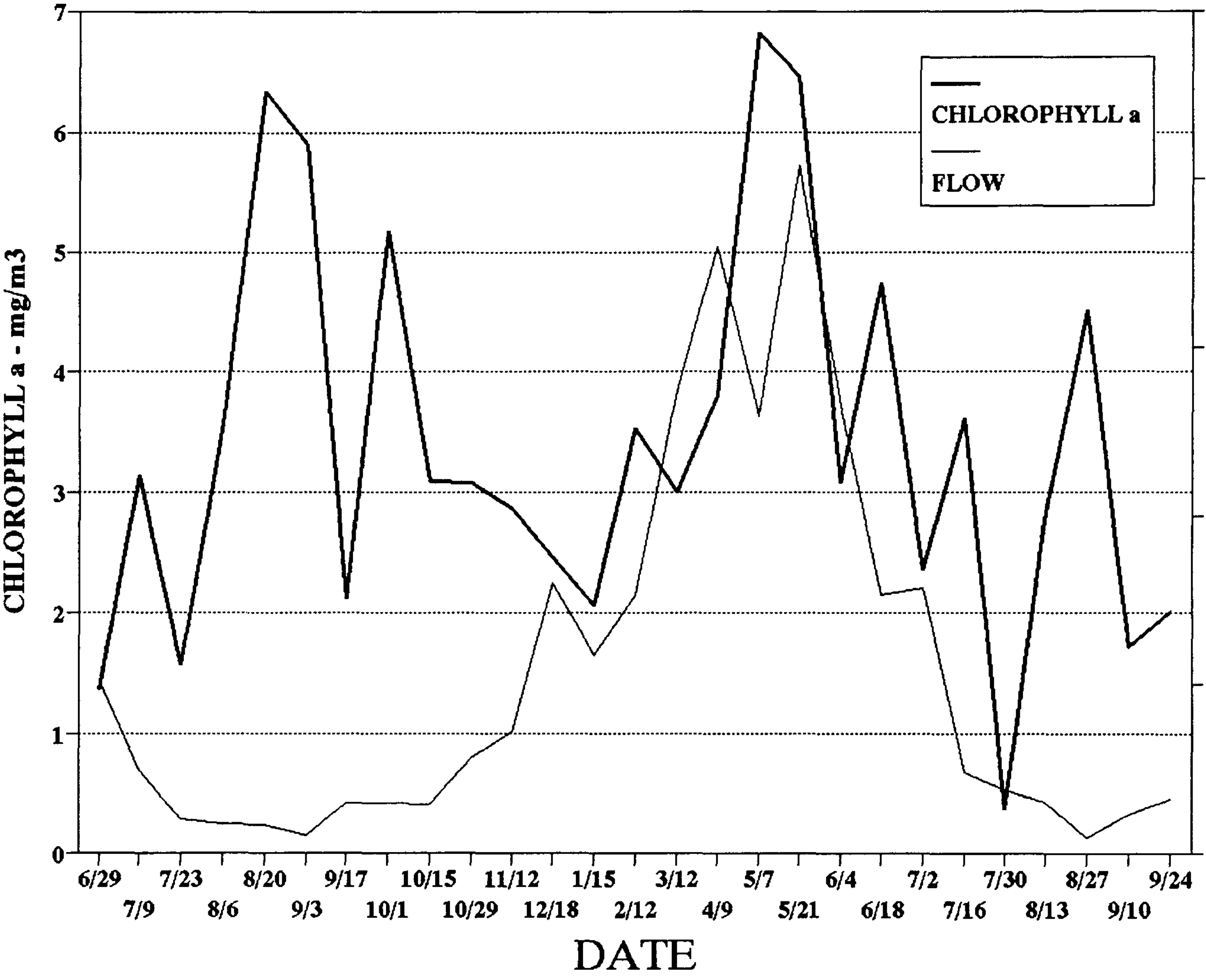


Figure 23. Mean chlorophyll *a* versus flow in the Spokane River on each sample date for June 29, 1990 to September 24, 1991.

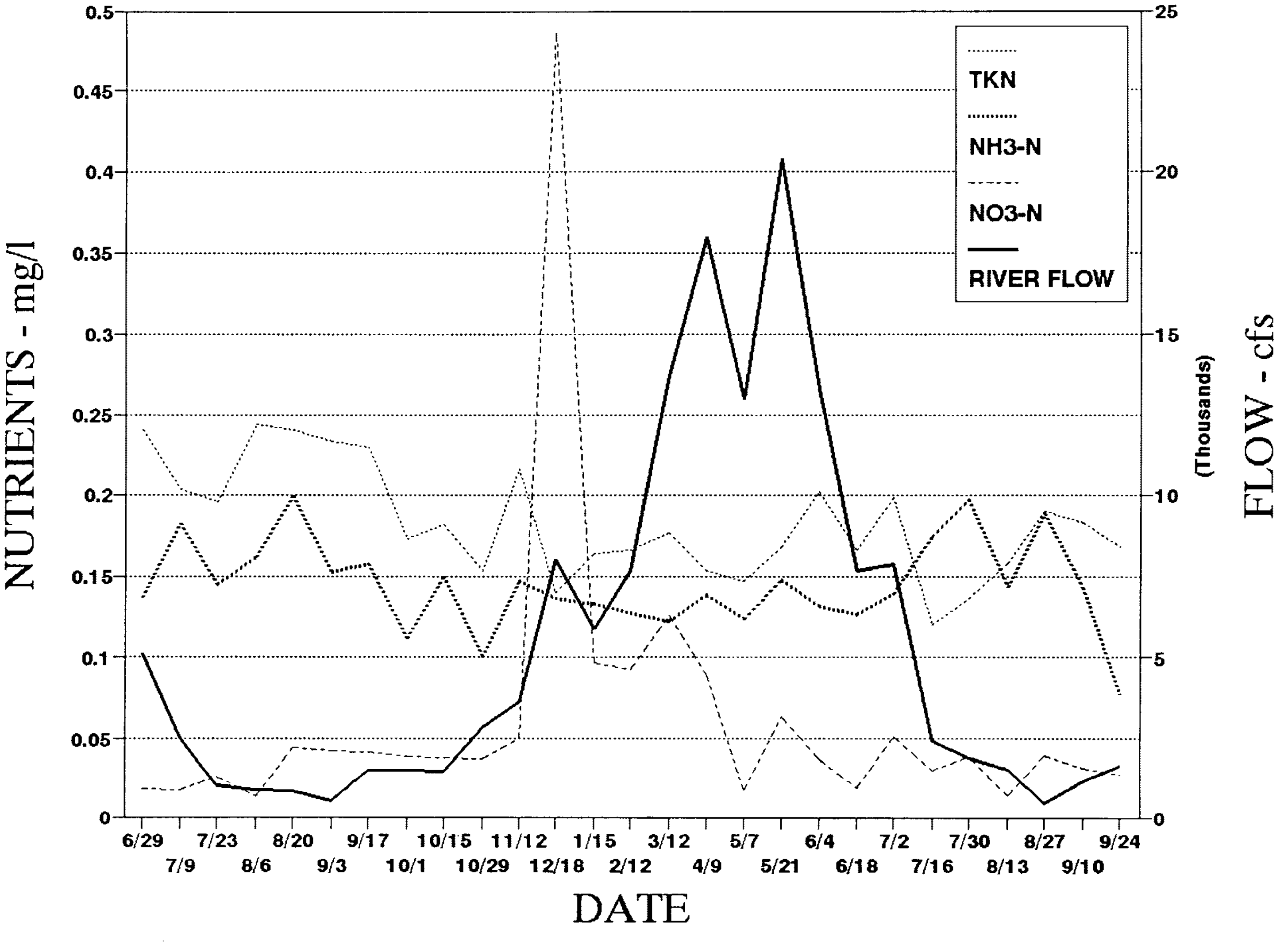


Figure 24. Total Kjeldahl nitrogen, ammonia-nitrogen, and nitrate-nitrogen concentrations versus flow in the Spokane River on each sample date for June 29, 1990 to September 24, 1991.

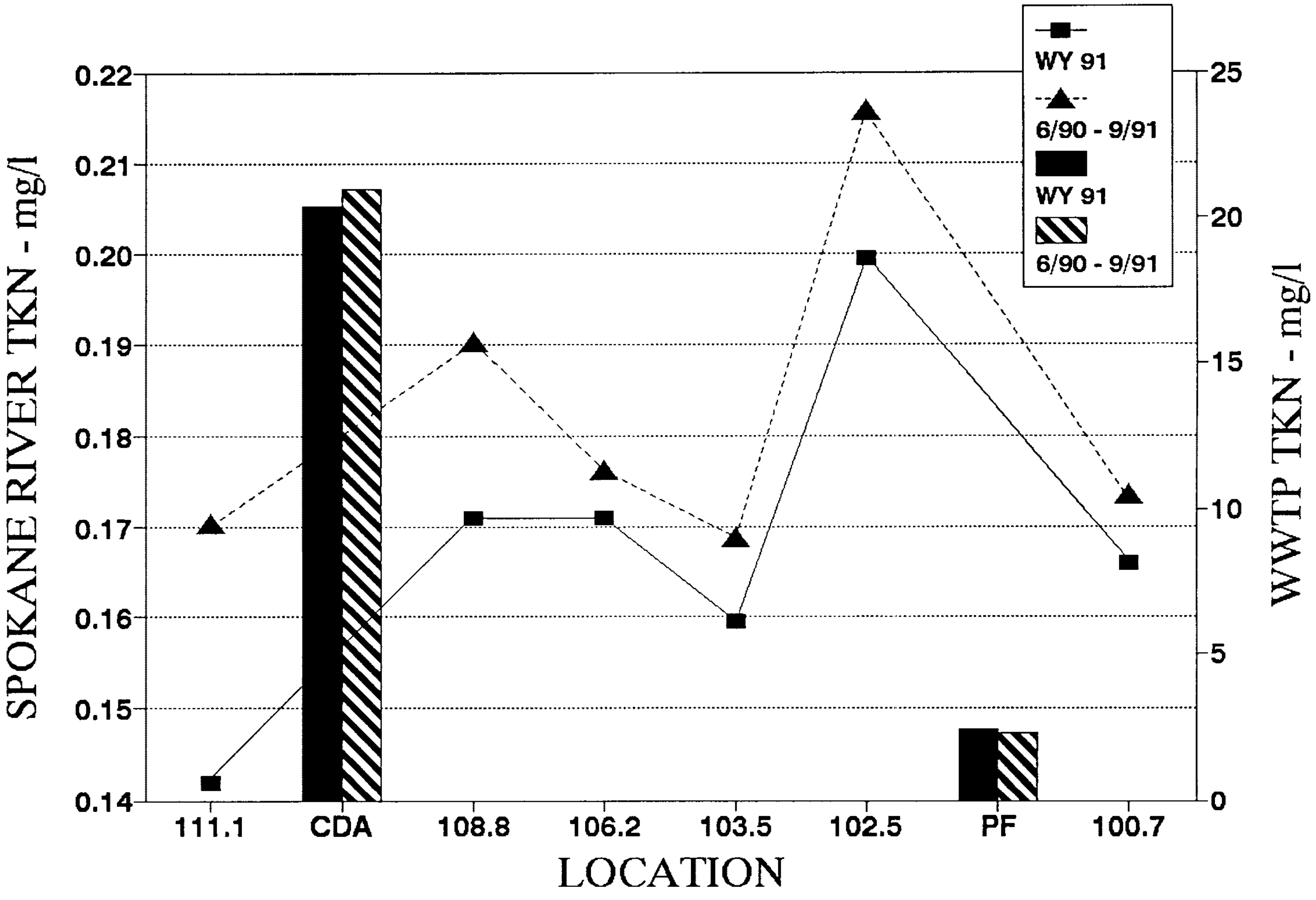


Figure 25. Mean total Kjeldahl nitrogen concentrations in the Spokane River and Coeur d'Alene and Post Falls wastewater treatment plants during Water Year 1991 and June 29, 1990 to September 24, 1991.

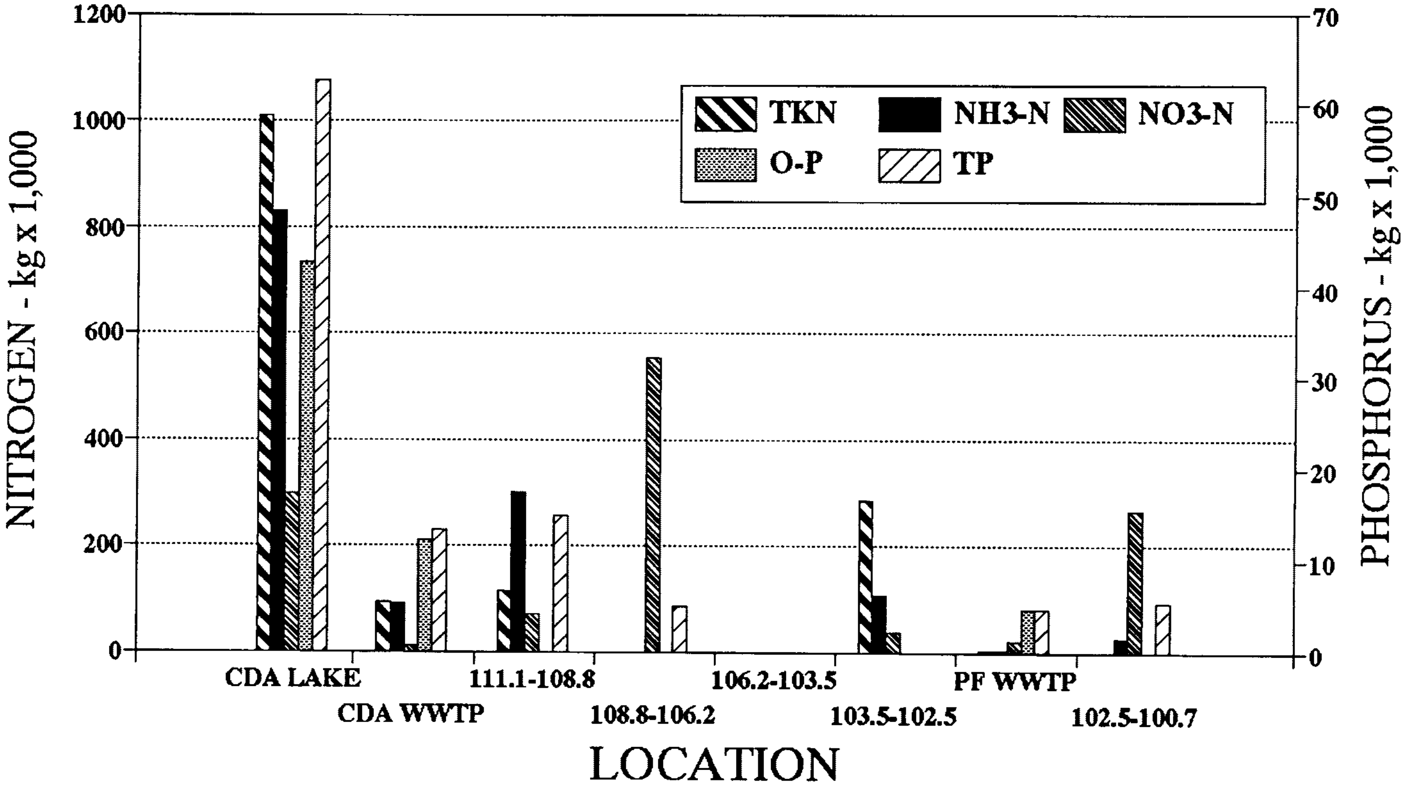


Figure 26. Sources and amounts of nutrient loading to the Spokane River during Water Year 1991.

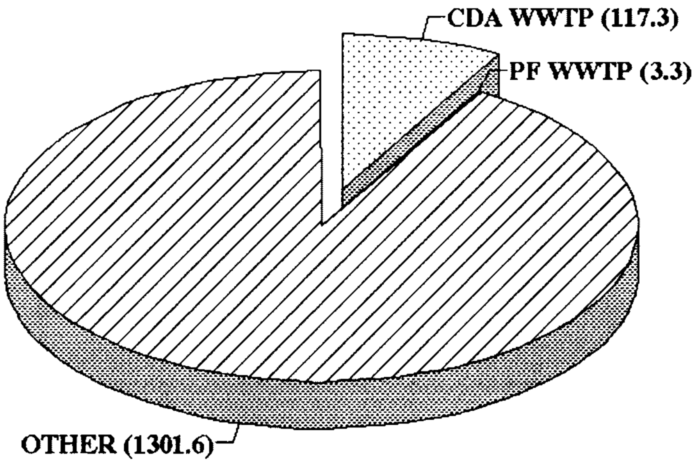


Figure 27. Total Kjeldahl nitrogen loading from Coeur d'Alene and Post Falls wastewater treatment plants for June 29, 1990 to September 24, 1991 (kg X 10^3/study period).

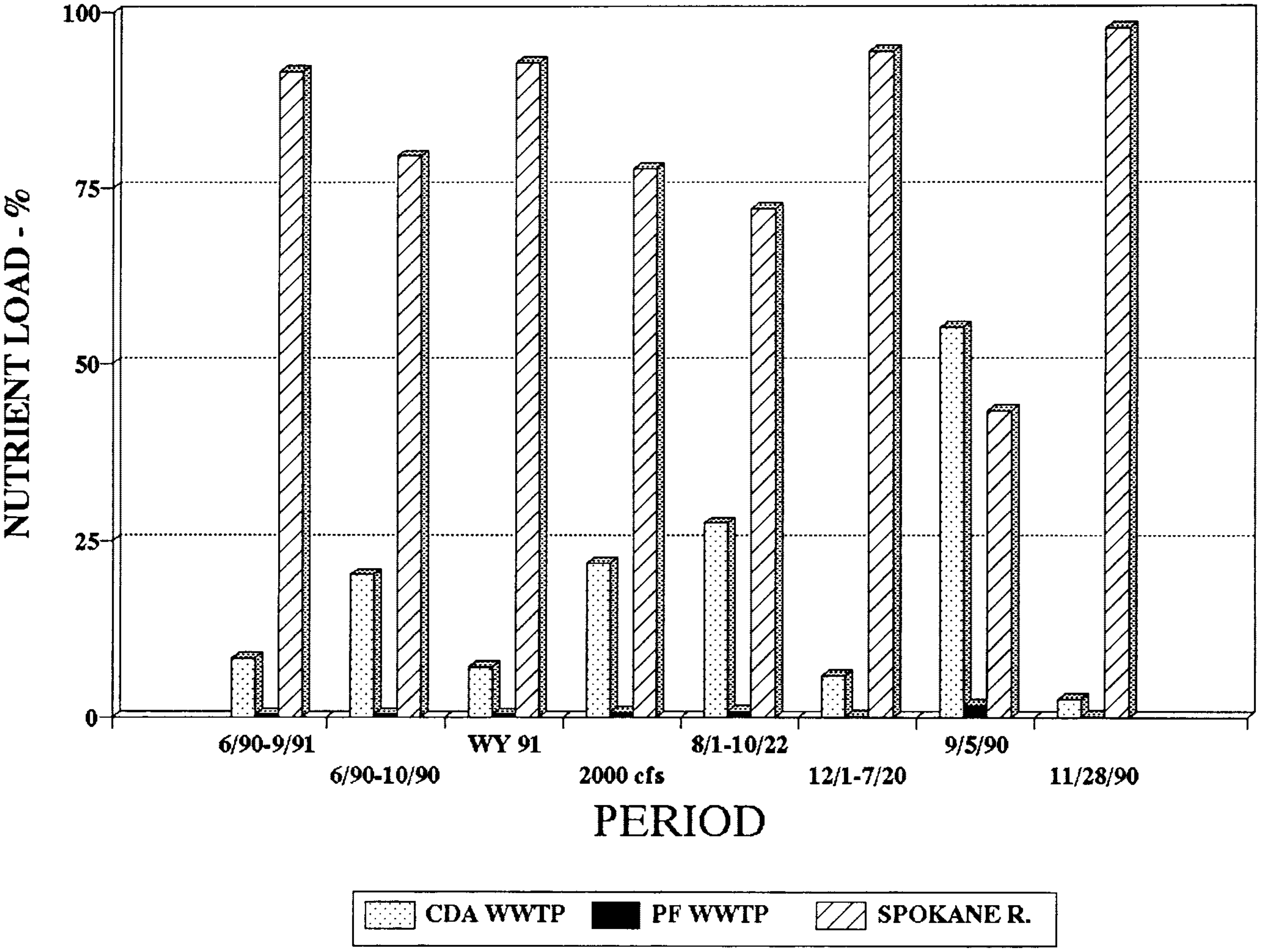


Figure 28. Percentage of total Kjeldahl nitrogen load from Coeur d'Alene and Post Falls wastewater treatment plants and the Spokane River at various time periods from June 29, 1990 to September 24, 1991.

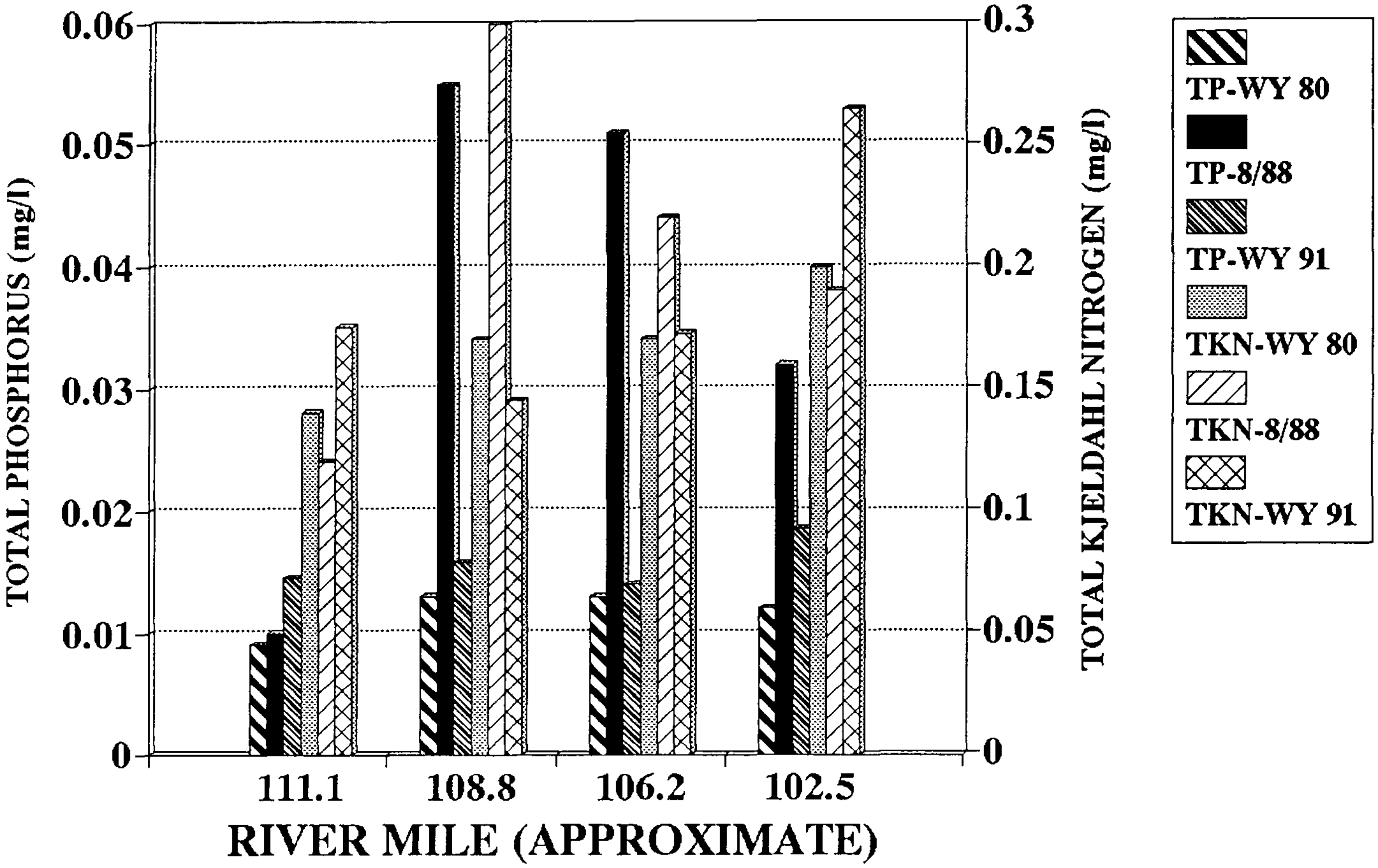


Figure 29. Total phosphorus and total Kjeldahl nitrogen throughout the Spokane River during Water Year 1991 (current study), August, 1988 (Yearsley and Duncan), and Water Year 1980 (Falter and Mitchell).

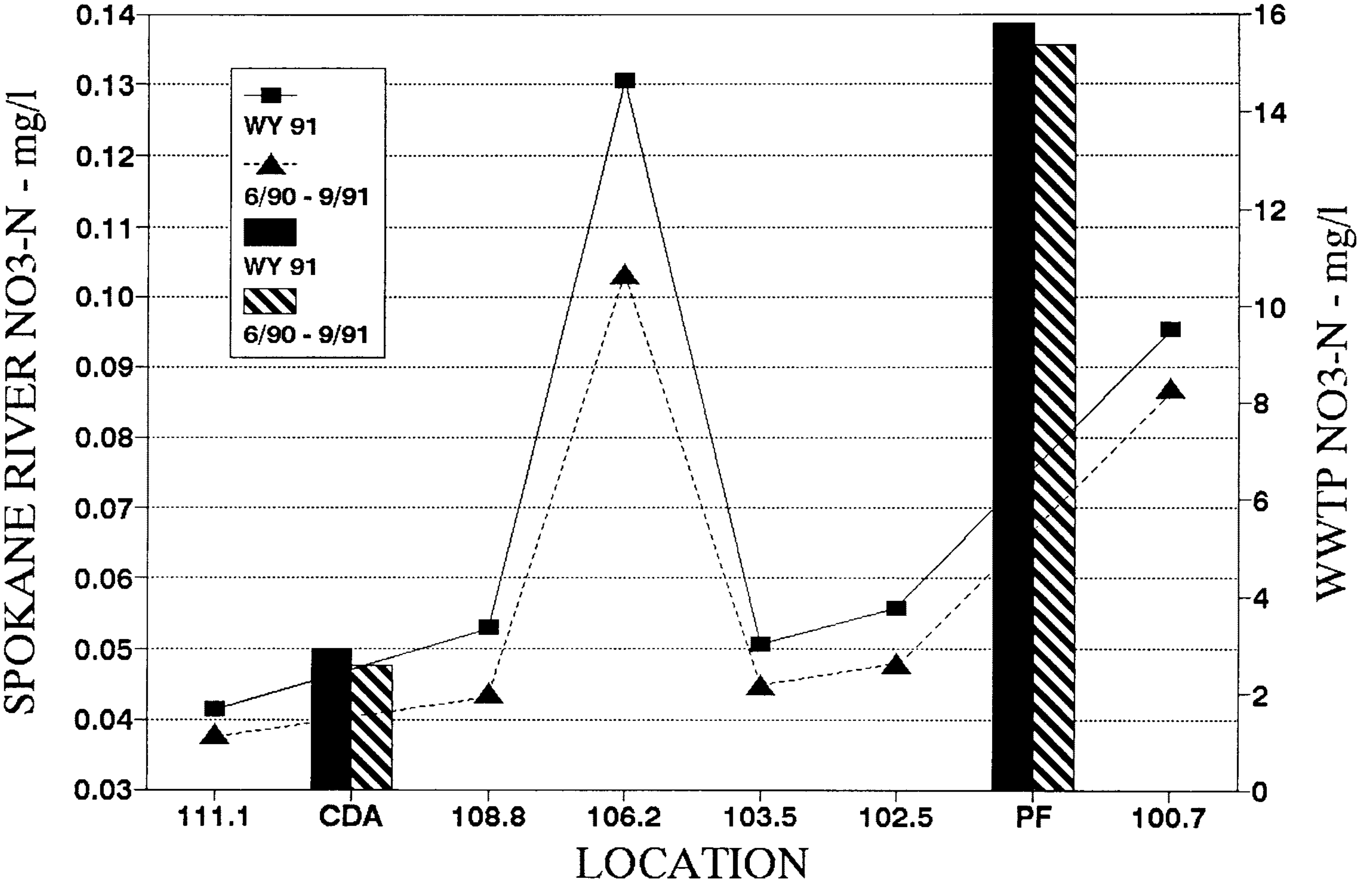


Figure 30. Mean nitrate-nitrogen concentrations in the Spokane River and Coeur d'Alene and Post Falls wastewater treatment plants during Water Year 1991 and for the period June 29, 1990 to September 24, 1991.

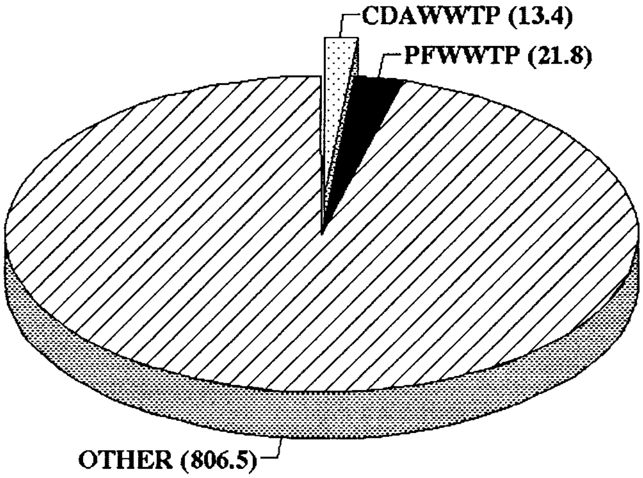


Figure 31. Total nitrate-nitrogen loading from Coeur d'Alene and Post Falls wastewater treatment plants for June 29, 1990 to September 24, 1991 (kg X 10^3/study period).

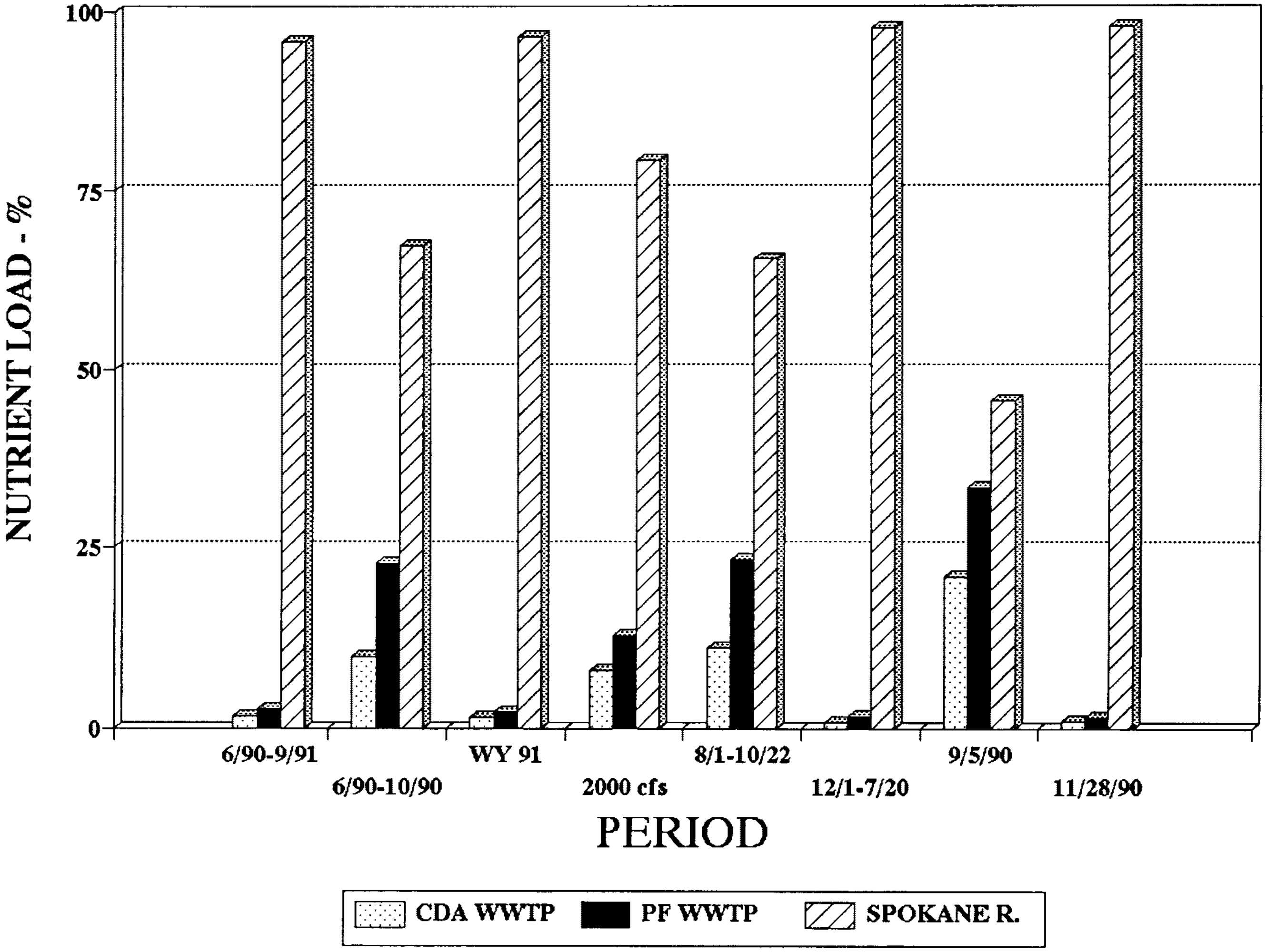


Figure 32. Percentage of total nitrate-nitrogen load from Coeur d'Alene and Post Falls wastewater treatment plants and the Spokane River at various time periods from June 29, 1990 to September 24, 1991.

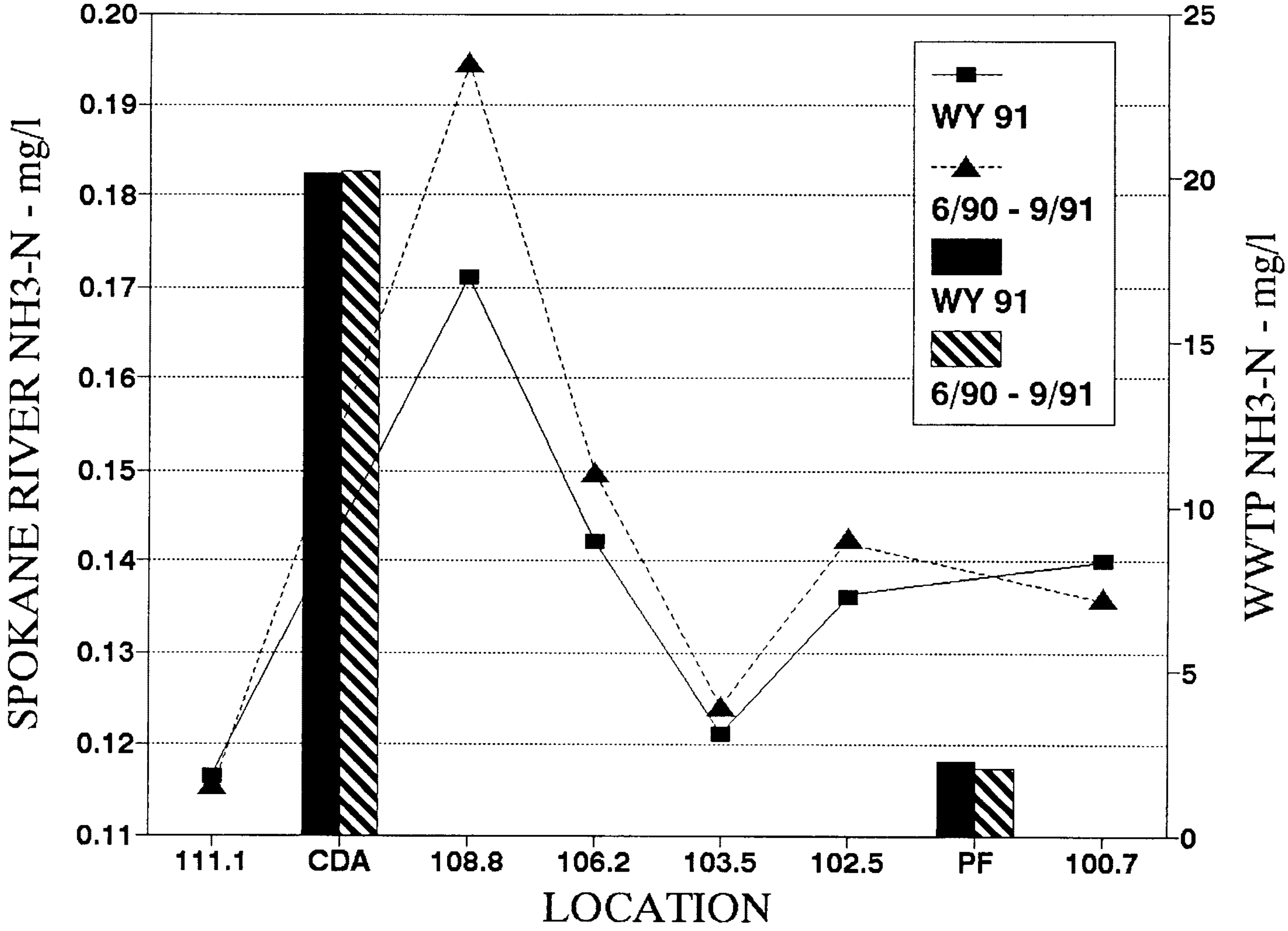


Figure 33. Mean total ammonia-nitrogen concentrations in the Spokane River and Coeur d'Alene and Post Falls wastewater treatment plants during Water Year 1991 and from the period June 29, 1990 to September 24, 1991.

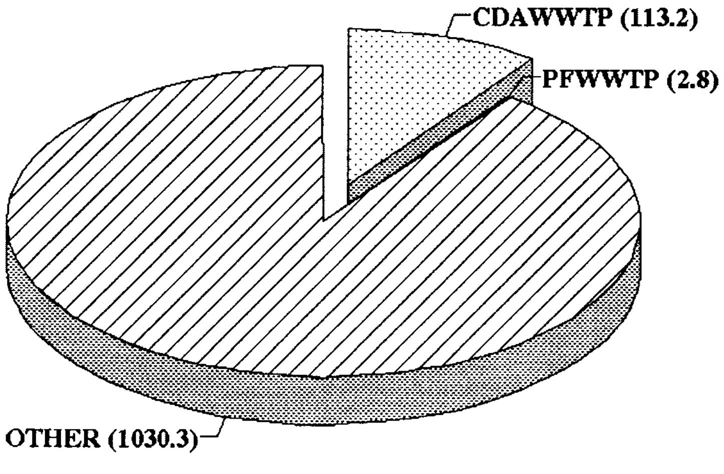


Figure 34. Total ammonia-nitrogen loading from Coeur d'Alene and Post Falls wastewater treatment plants for June 29, 1990 to September 24, 1991 (kg x 10^3/study period).

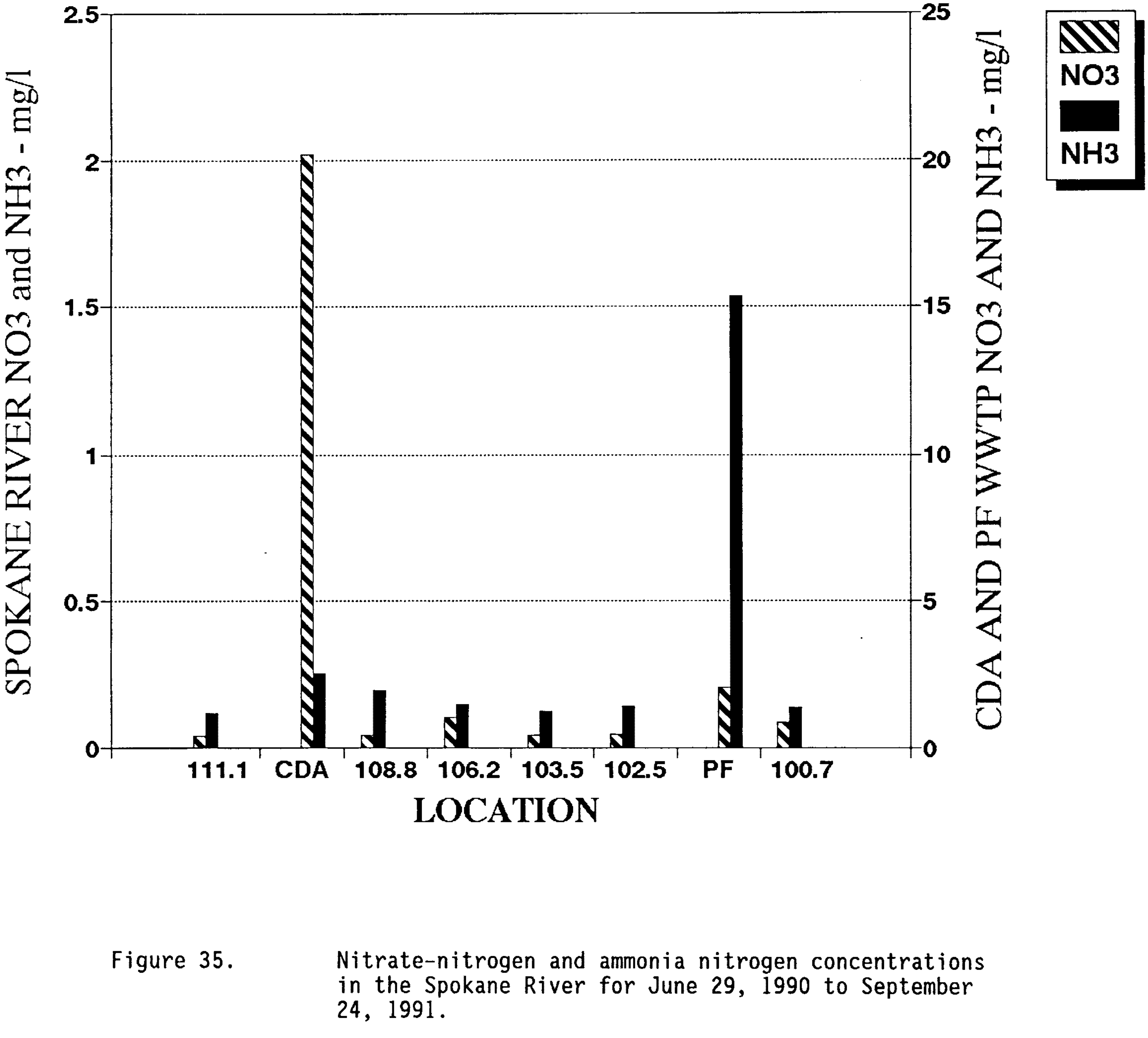


Figure 35. Nitrate-nitrogen and ammonia nitrogen concentrations in the Spokane River for June 29, 1990 to September 24, 1991.

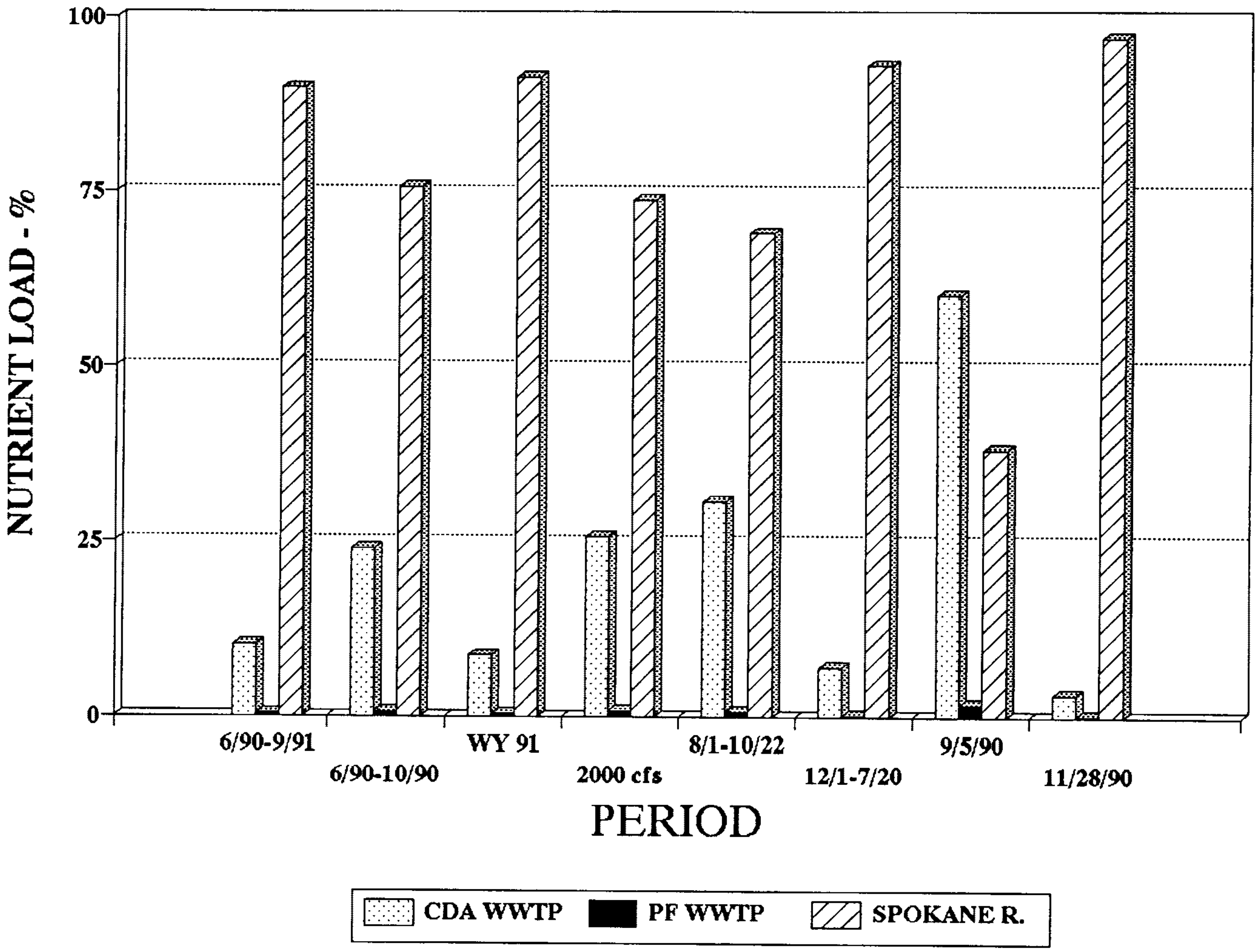


Figure 36. Percentage of total ammonia-nitrogen load from Coeur d'Alene and Post Falls wastewater treatment plants and the Spokane River at various time periods from June 29, 1990 to September 24, 1991.

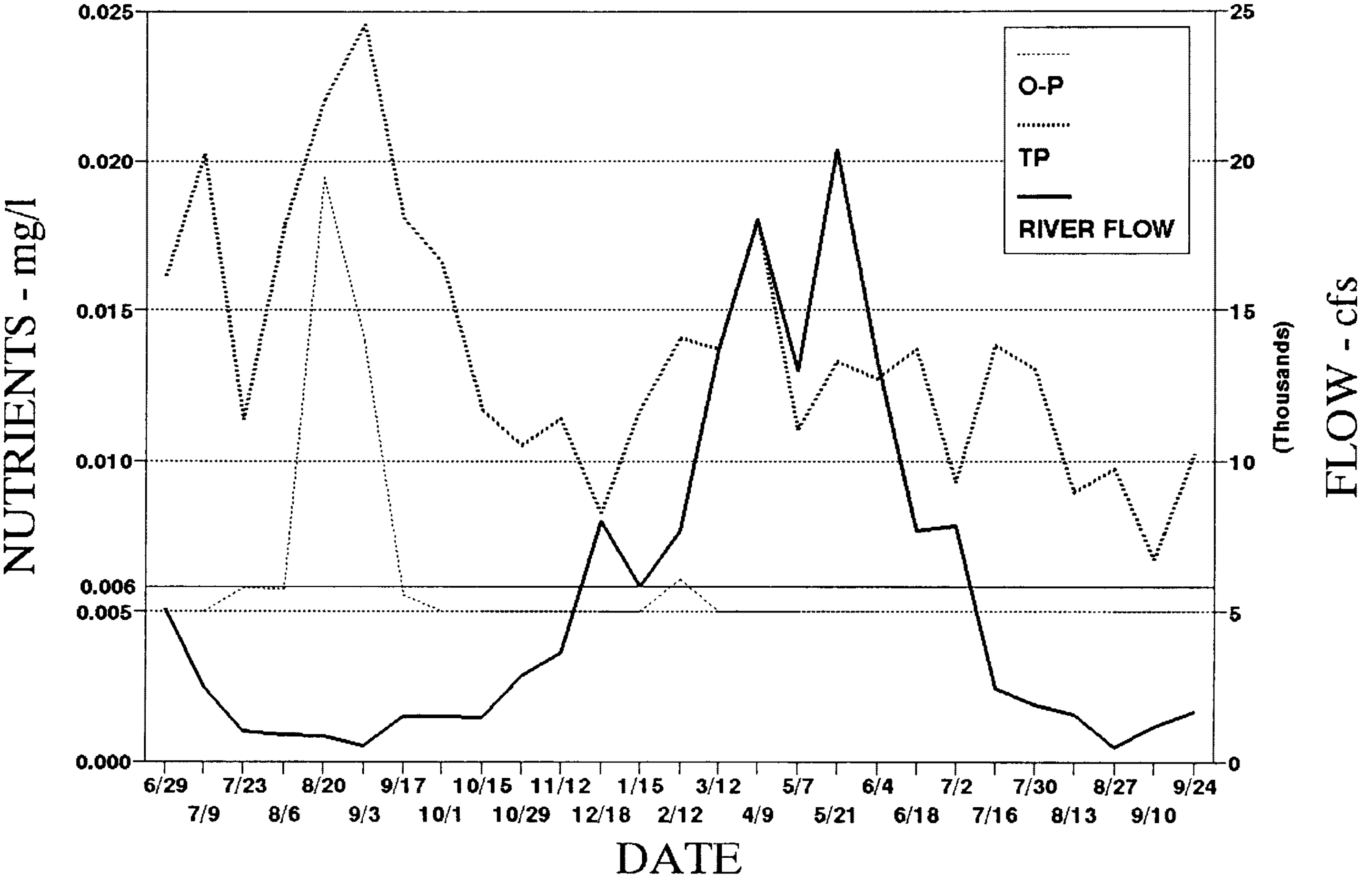


Figure 37. Total orthophosphorus and total phosphorus concentrations versus flow in the Spokane River on each sample date for June 29, 1990 to September 24, 1991.

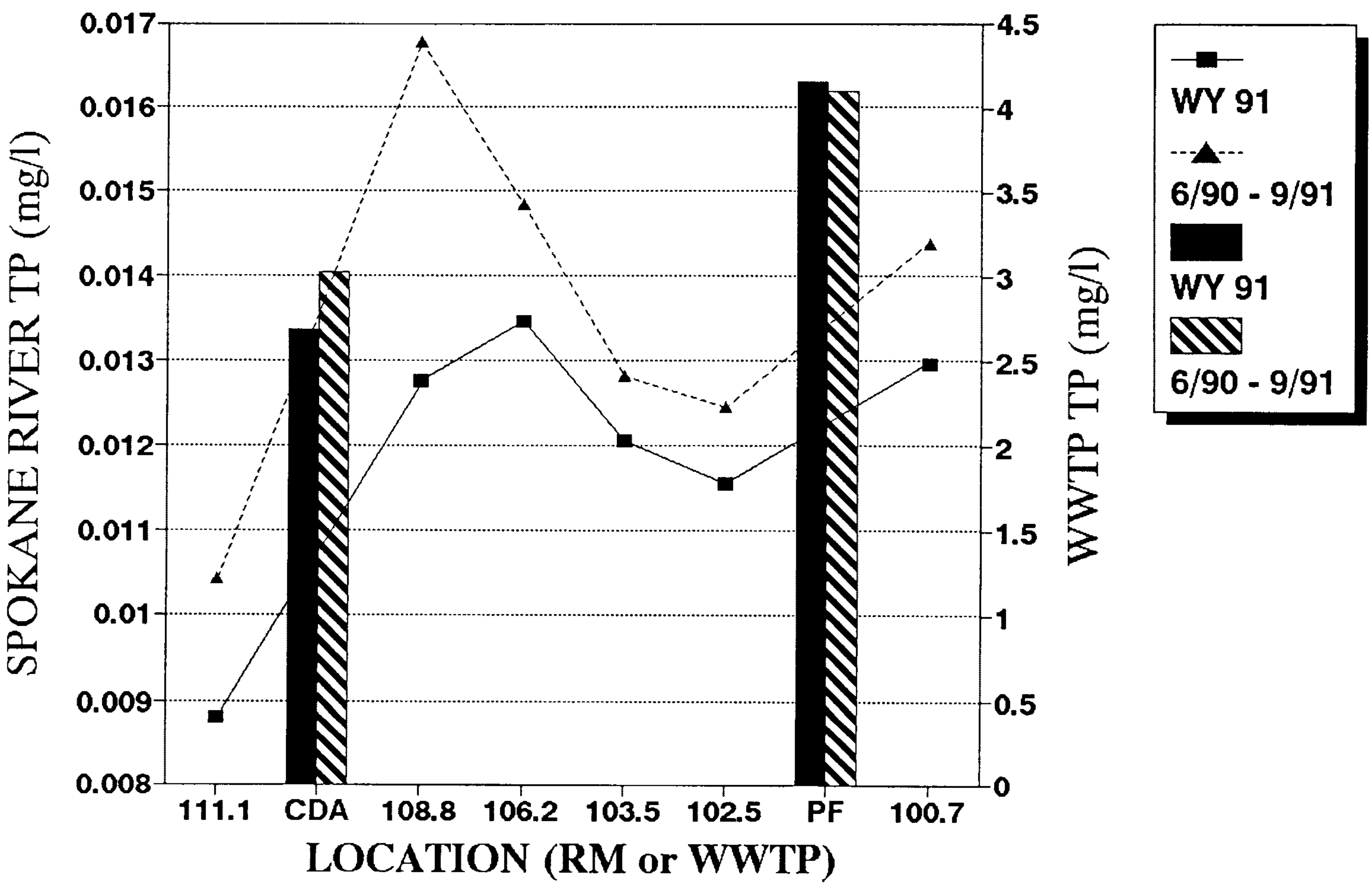


Figure 38. Mean total phosphorus concentrations in the Spokane River and Coeur d'Alene and Post Falls wastewater treatment plants during Water Year 1991 and over the period June 29, 1990 to September 24, 1991.

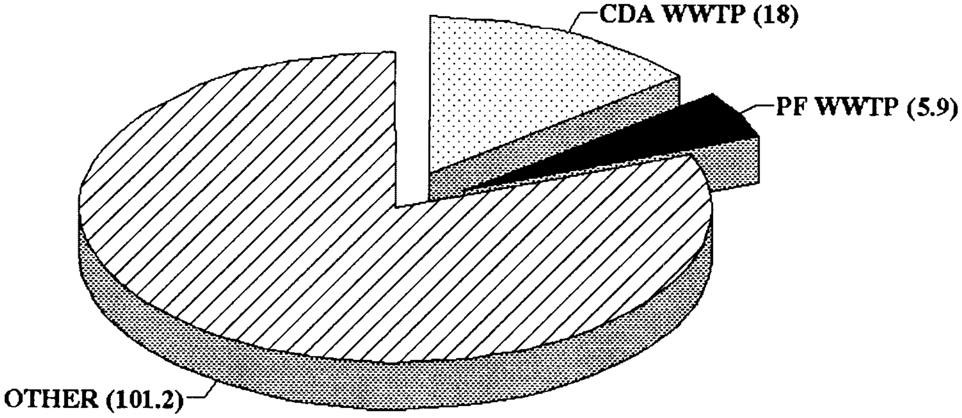


Figure 39. Total phosphorus loading from Coeur d'Alene and Post Falls wastewater treatment plants for June 29, 1990 to September 24, 1991 (kg X 10^3/study period).

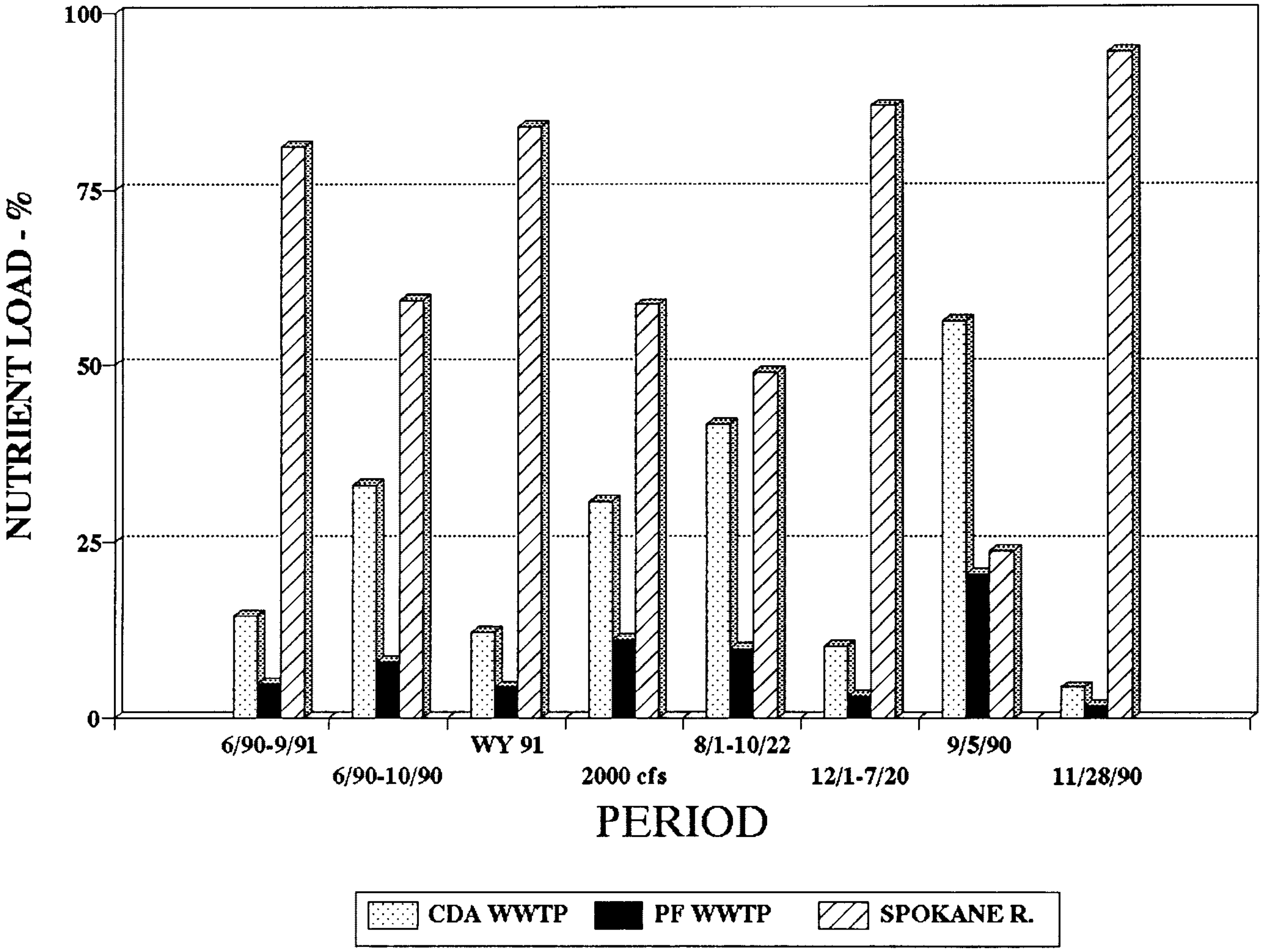


Figure 40. Percentage of total phosphorus load from Coeur d'Alene and Post Falls wastewater treatment plants and the Spokane River at various time periods during June 29, 1990 to September 24, 1991.

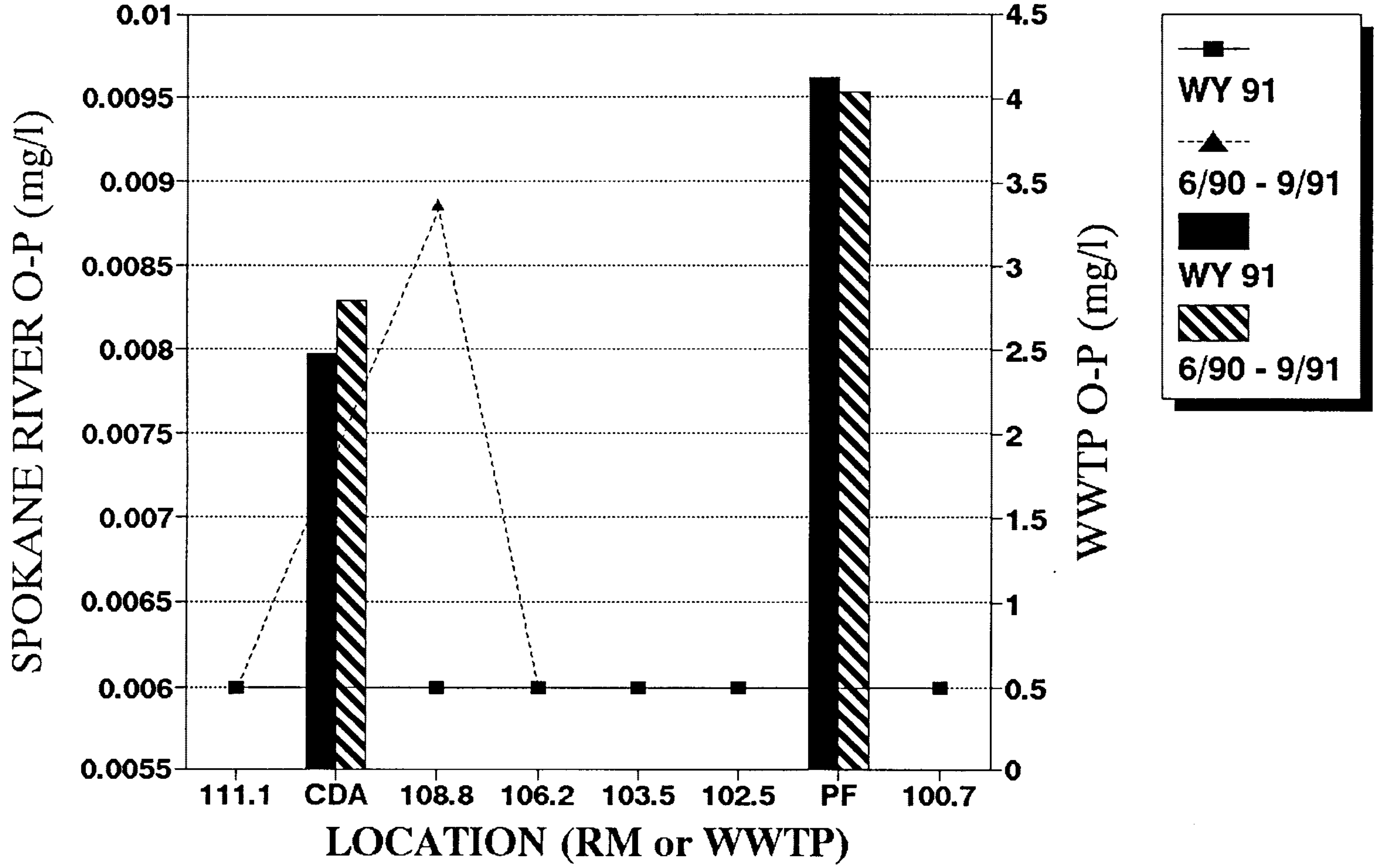


Figure 41. Mean total orthophosphorus concentrations in the Spokane River and Coeur d' Alene and Post Falls wastewater treatment plants during Water Year 1991 and the period June 29, 1990 to September 24, 1991.

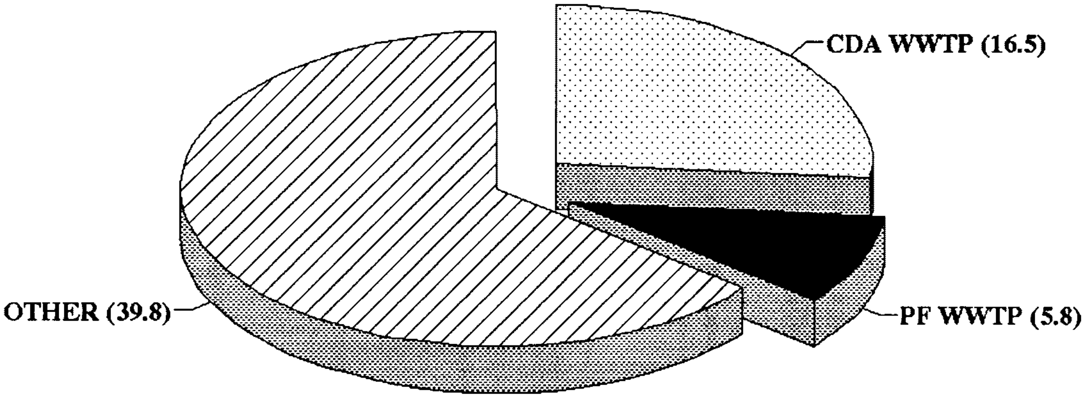


Figure 42. Total orthophosphorus loading from Coeur d'Alene and Post Falls wastewater treatment plants for June 29, 1990 to September 24, 1991 (kg X 10^3/study period).

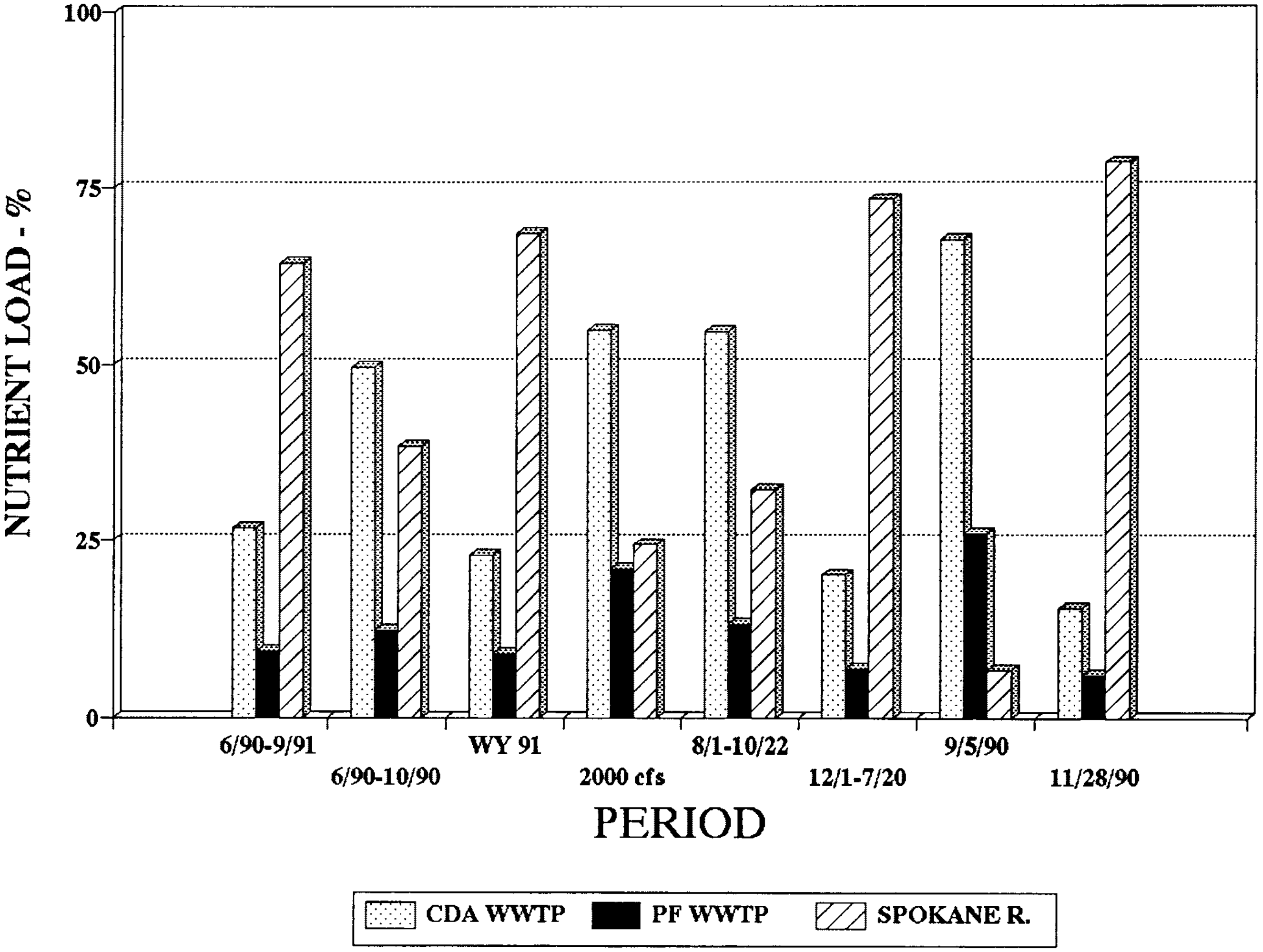


Figure 43. Percentage of total orthophosphorus load from Coeur d'Alene and Post Falls wastewater treatment plants and the Spokane River at various time periods from June 29, 1990 to September 24, 1991.

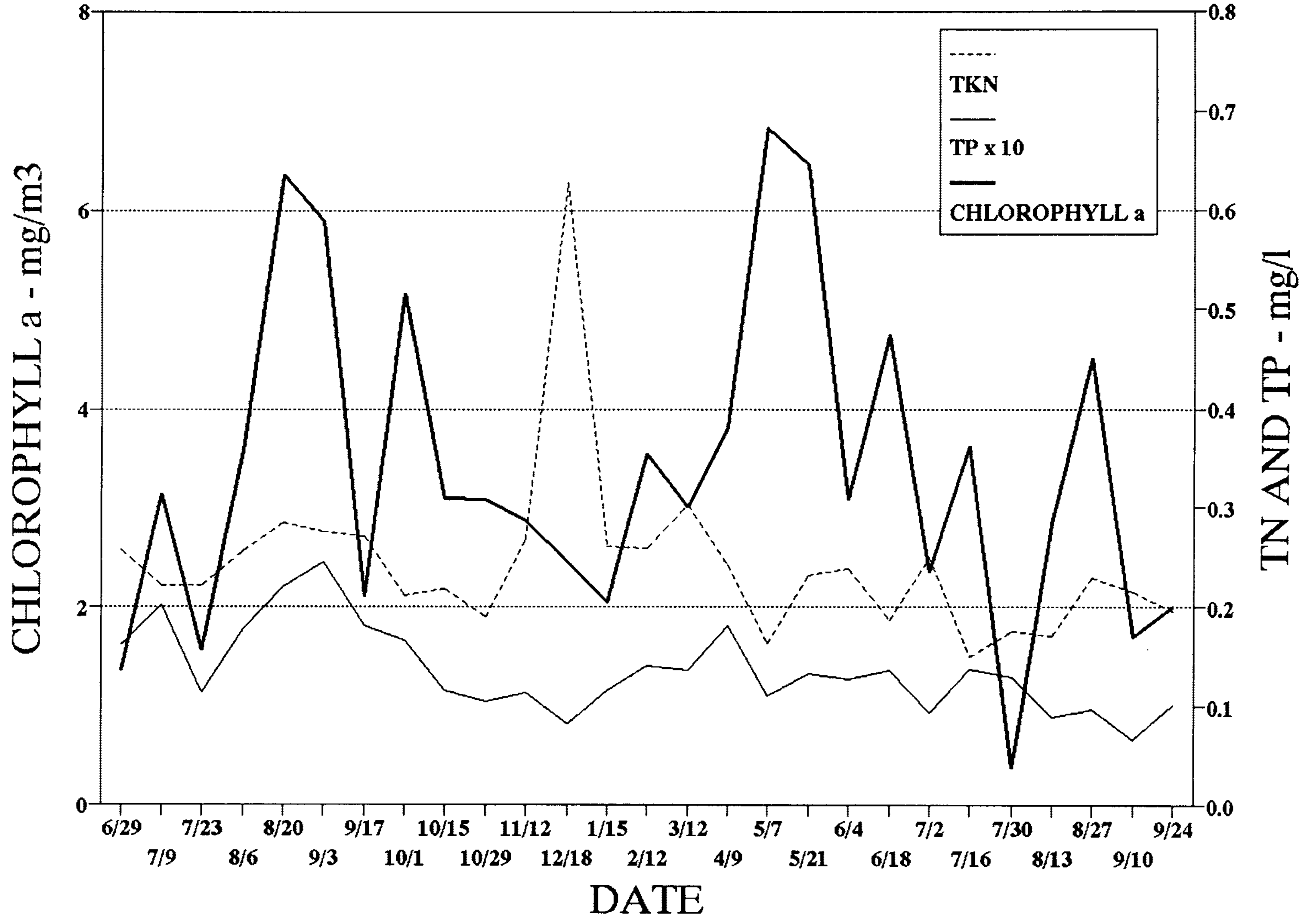


Figure 44. Mean chlorophyll a, total Kjeldahl nitrogen, and total phosphorus in the Spokane River on each sample date during June 29, 1990 to September 24, 1991.

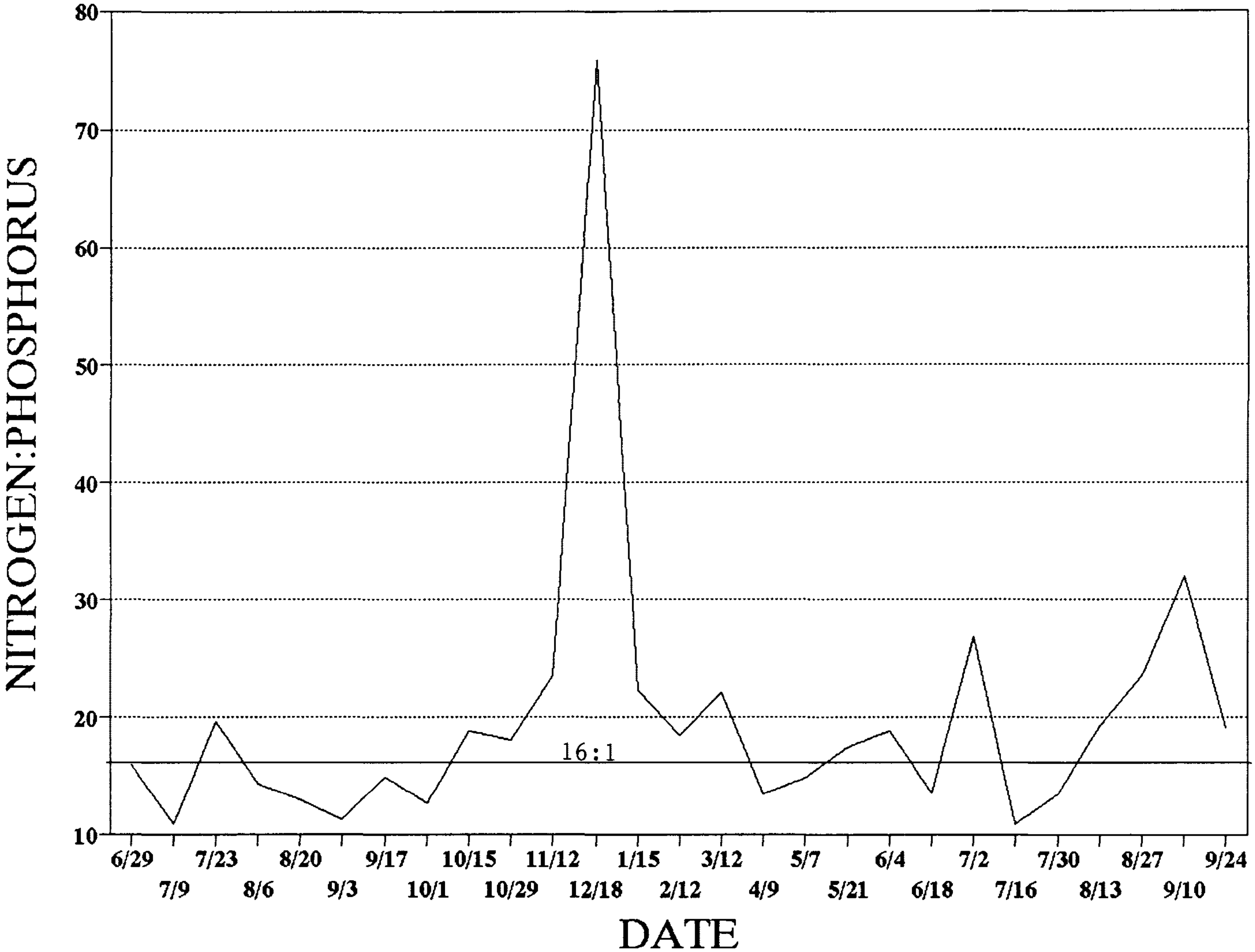


Figure 45. TN:TP ratios in the Spokane River for each sample date during June 29, 1990 to September 24, 1991.

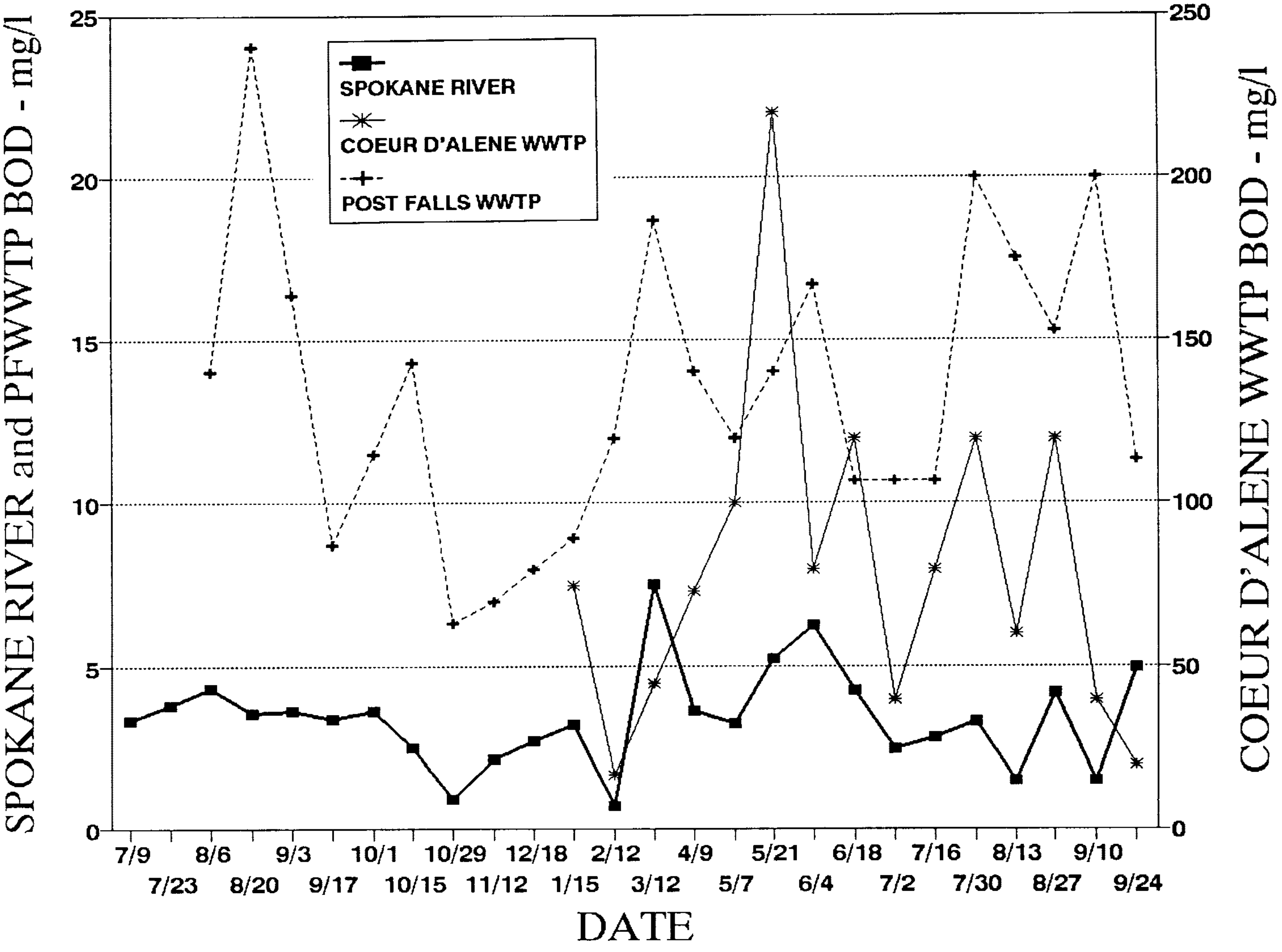


Figure 46. Mean 5-day Biochemical Oxygen Demand in the Spokane River, Coeur d'Alene WWTP, and Post Falls WWTP on each sample date during June 29, 1990 to September 24, 1991. Note: Problems with dilutions of WWTP effluent resulted in no BOD data in the early WWTP tests.

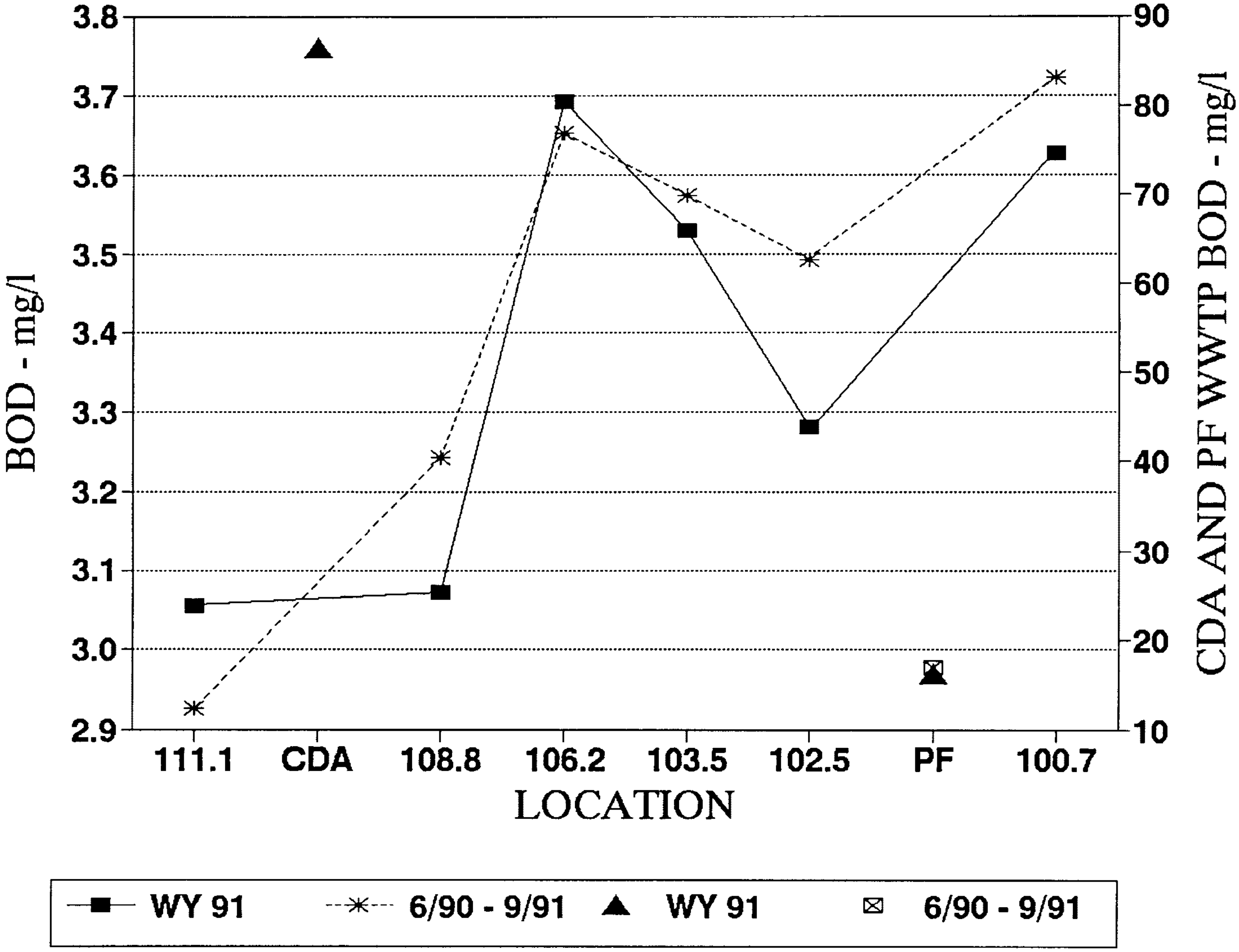


Figure 47. Mean 5-day Biochemical Oxygen Demand in the Spokane River and Coeur d'Alene and Post Falls wastewater treatment plants during Water Year 1991 and the period June 29, 1990 to September 24, 1991.

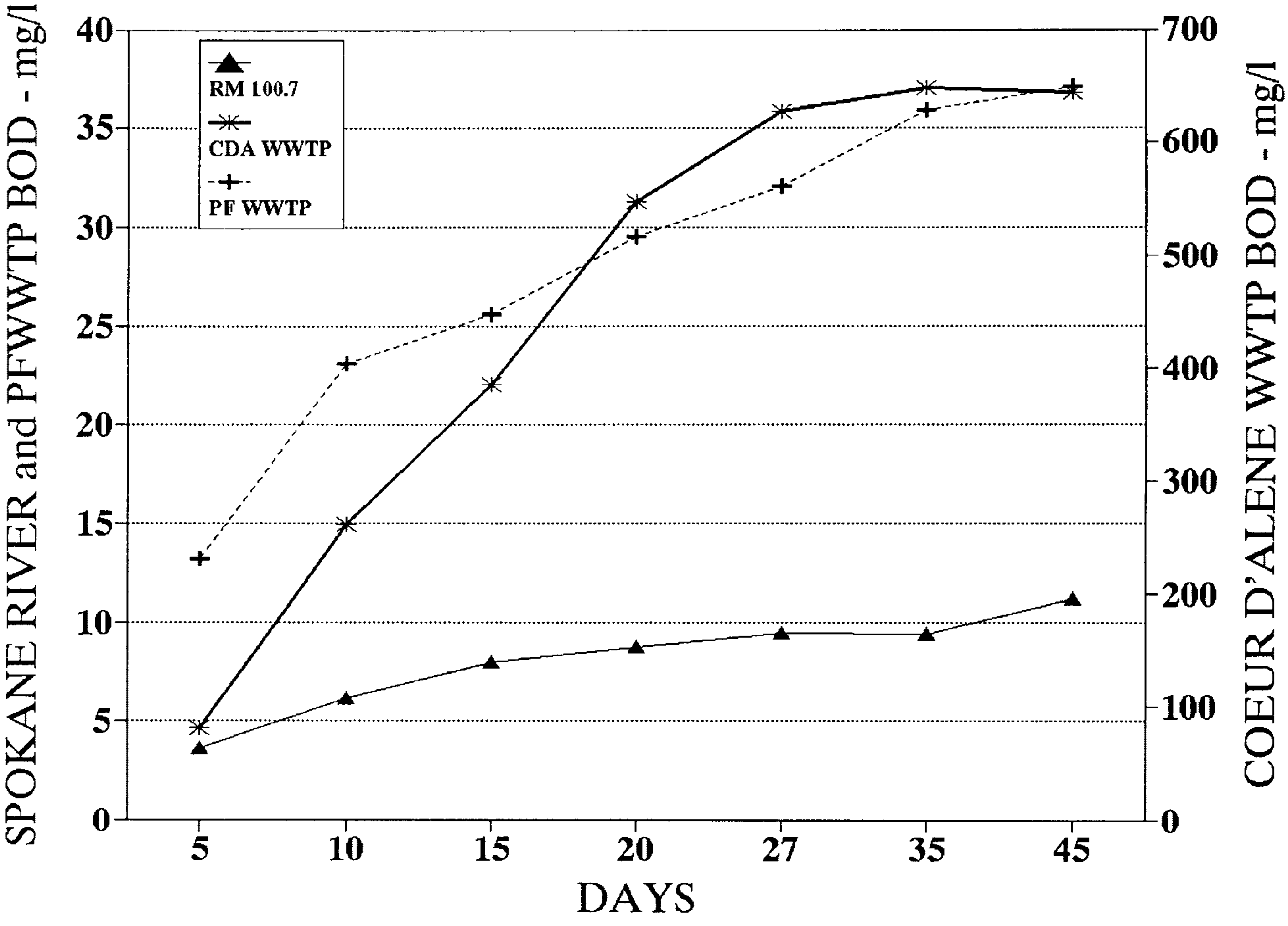


Figure 48. Mean ultimate Biochemical Oxygen Demand at RM 111.1 and RM 100.7, and in Coeur d'Alene and Post Falls WWTP effluents during Water Year 1991.

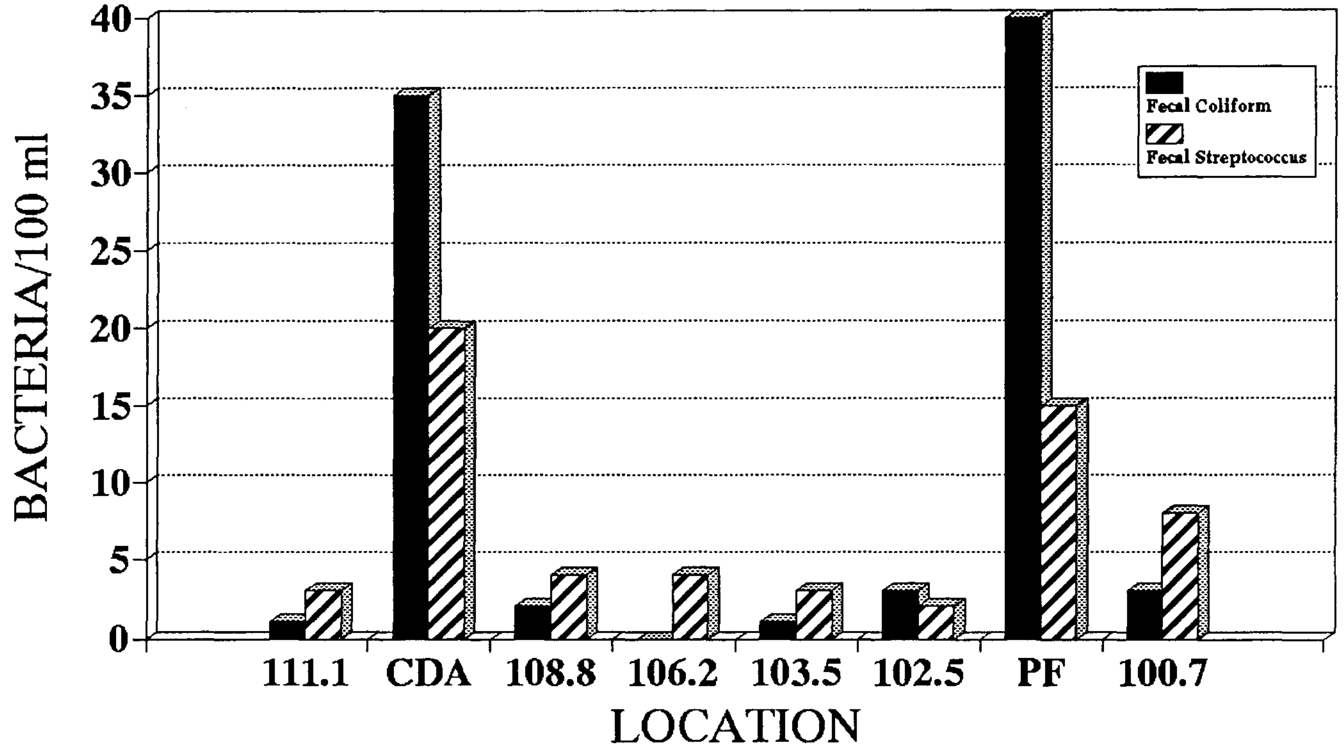


Figure 49. Median fecal coliform and fecal streptococcus bacteria counts in the Spokane River during Water Year 1991.

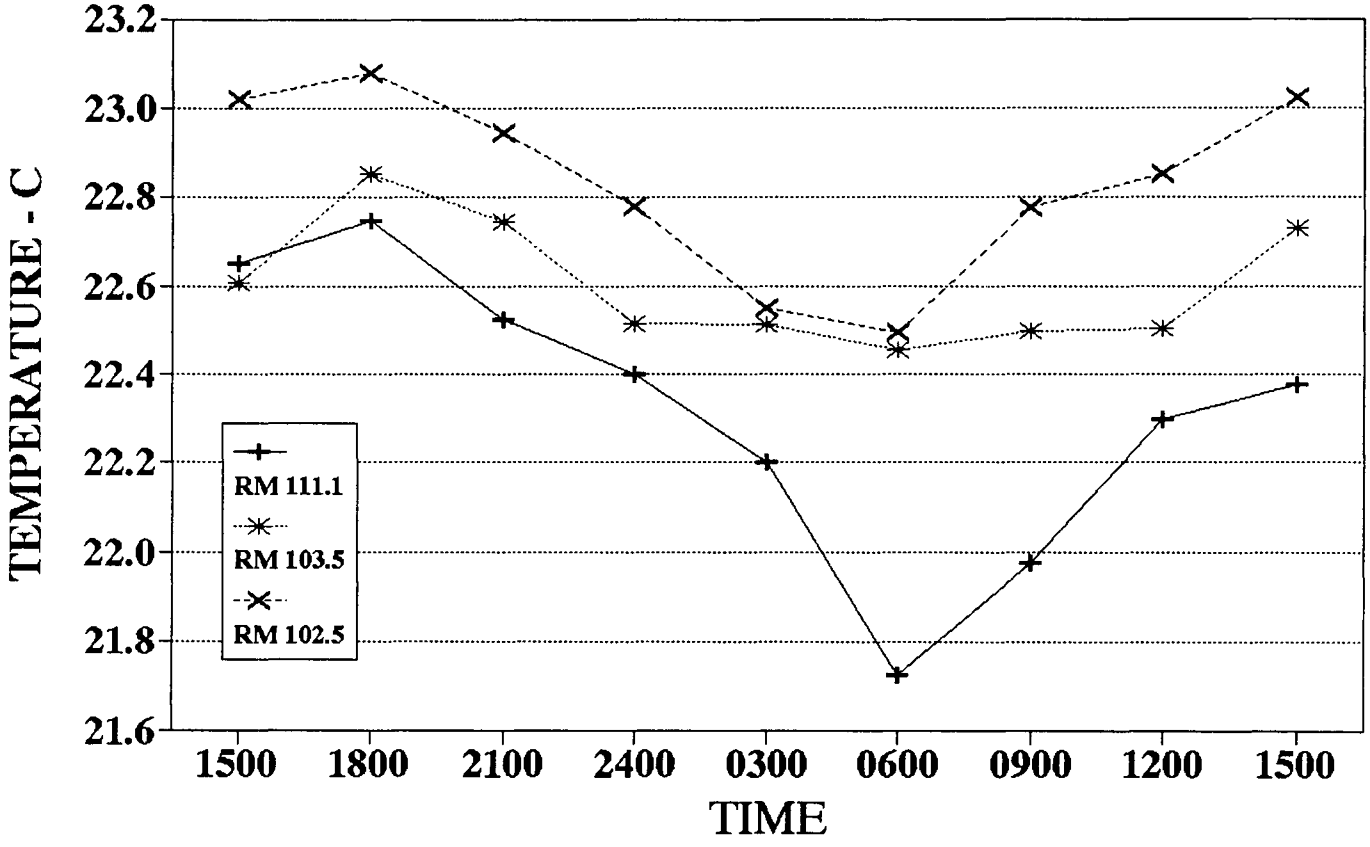


Figure 50. Mean temperature at RM 111.1, RM 103.5, and RM 102.5 in the Spokane River during the diel study of August 12-13, 1991.

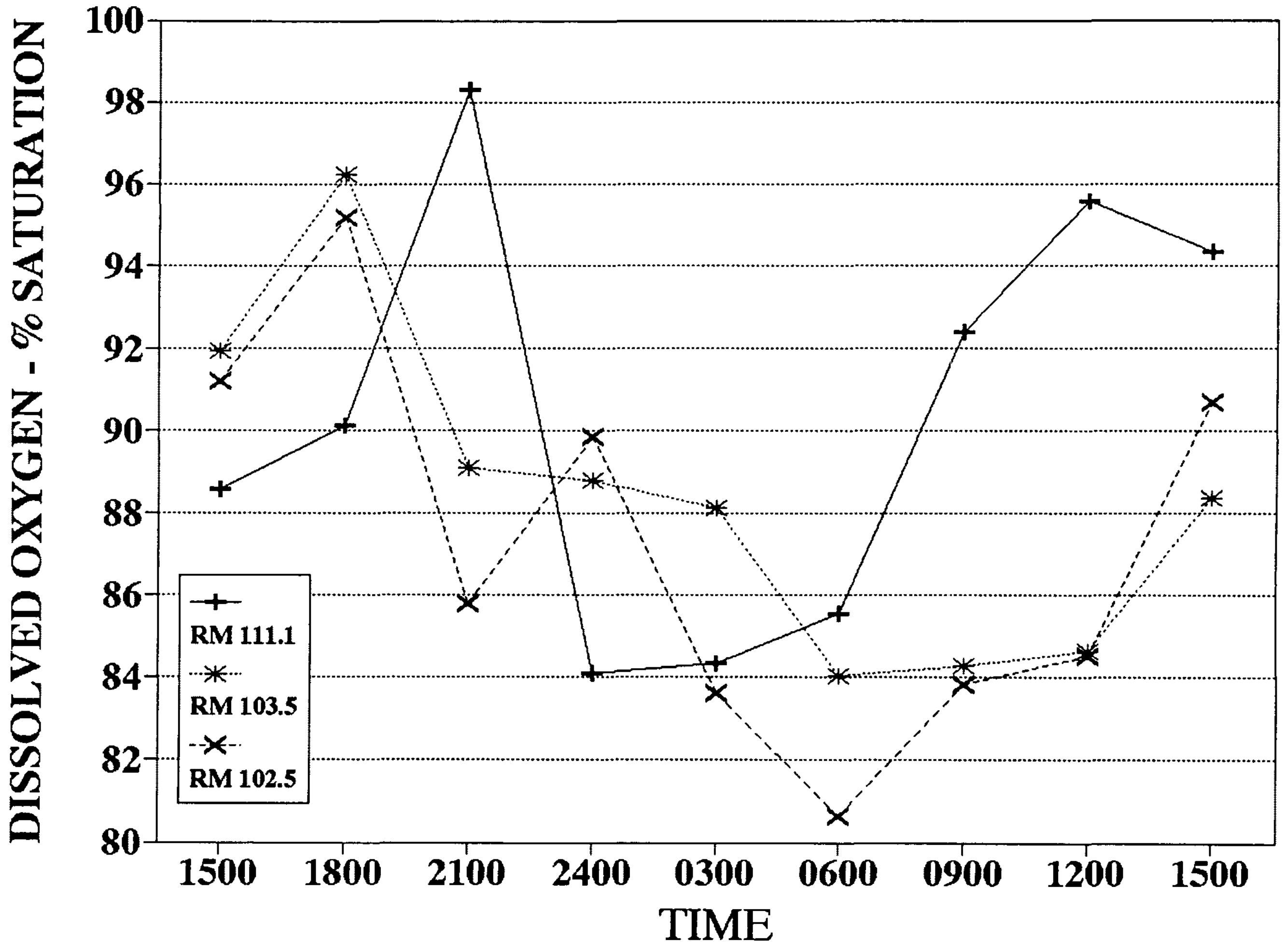


Figure 51. Mean dissolved oxygen percent saturation at RM 111.1, RM 103.5, and RM 102.5 in the Spokane River during the diel study of August 12-13, 1991.

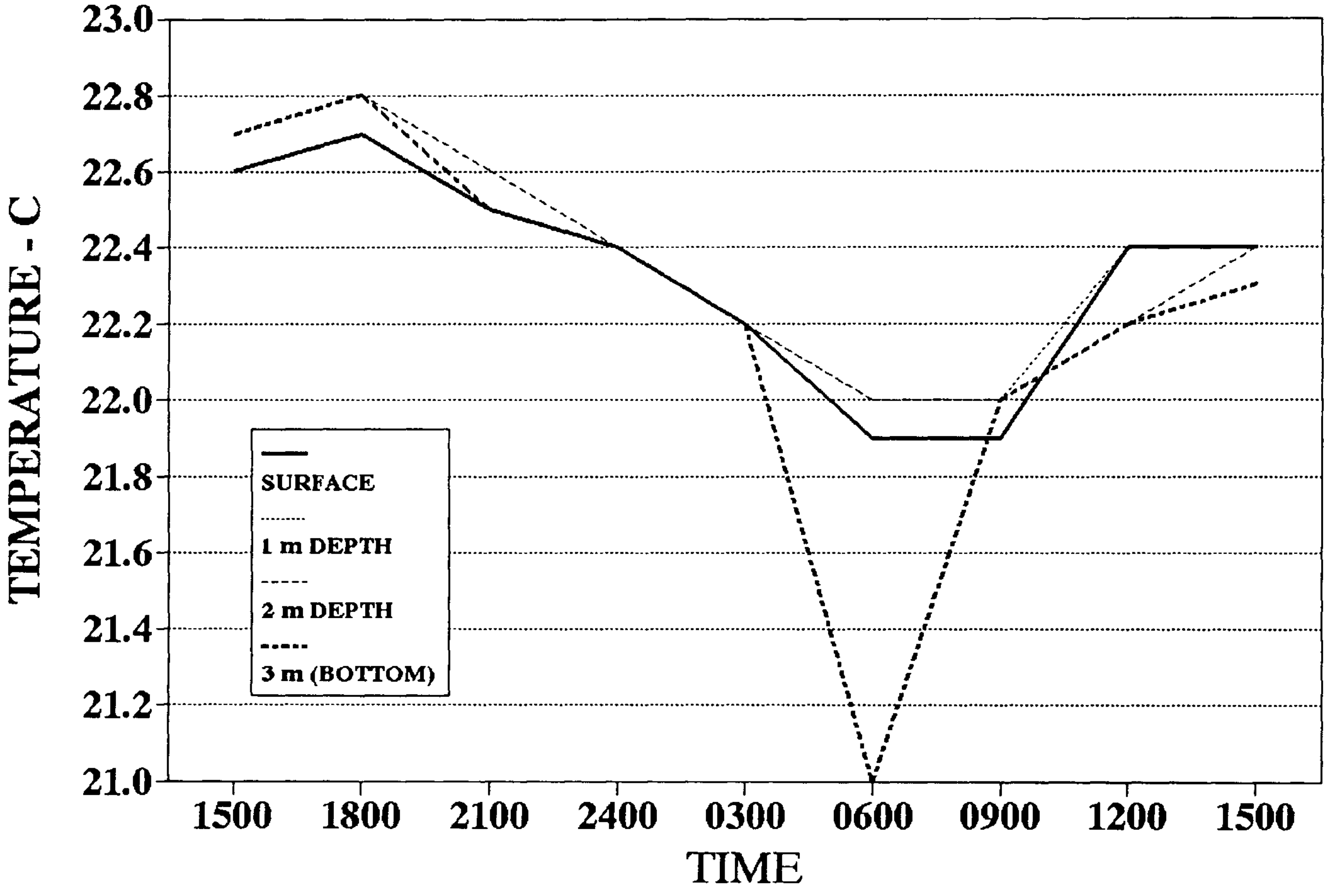


Figure 52. Temperature profiles at RM 111.1 in the Spokane River during the diel study of August 12-13, 1991.

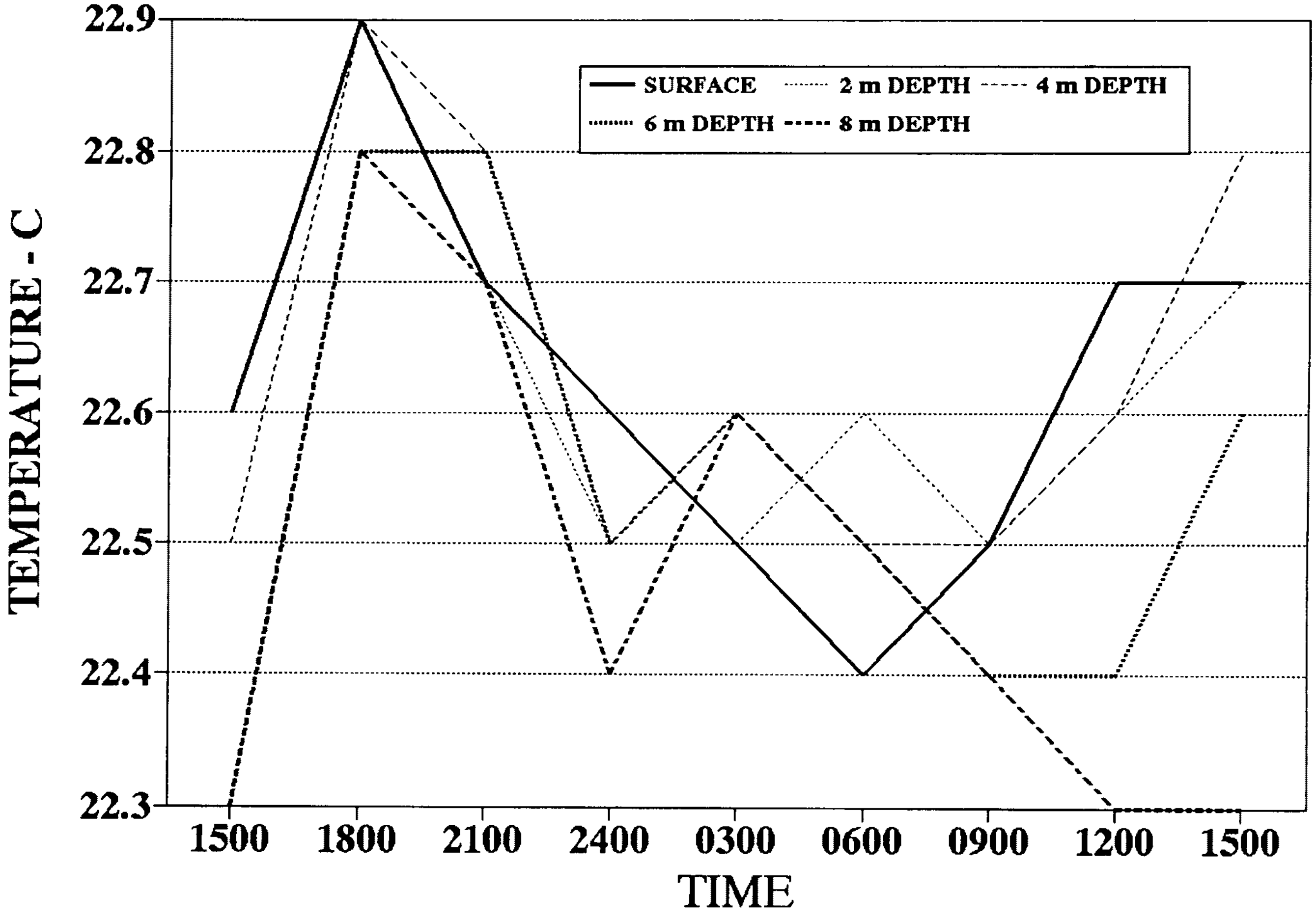


Figure 53. Temperature profiles at RM 103.5 in the Spokane River during the diel study of August 12-13, 1991.

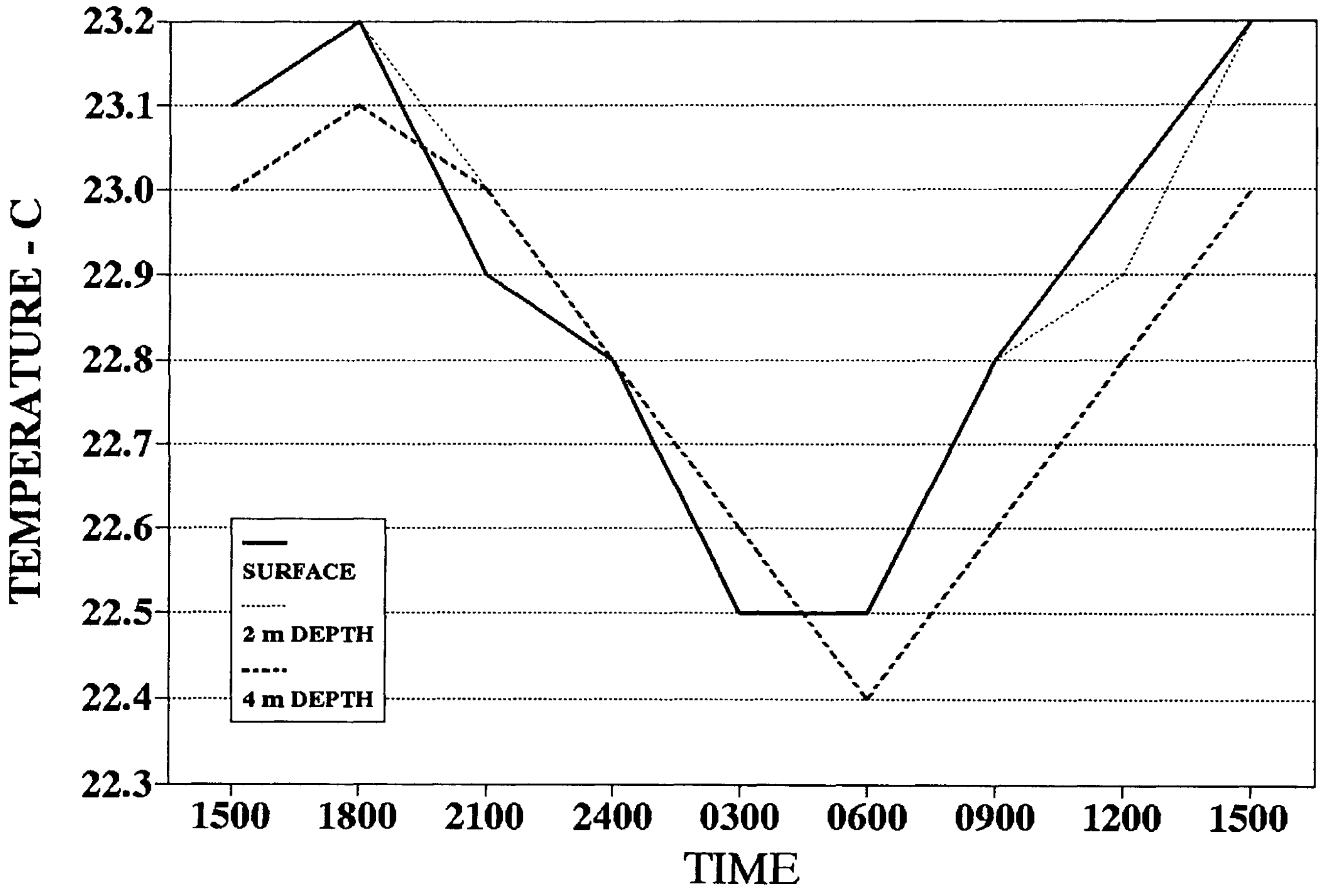


Figure 54. Temperature profiles at RM 102.5 in the Spokane River during the diel study of August 12-13, 1991.

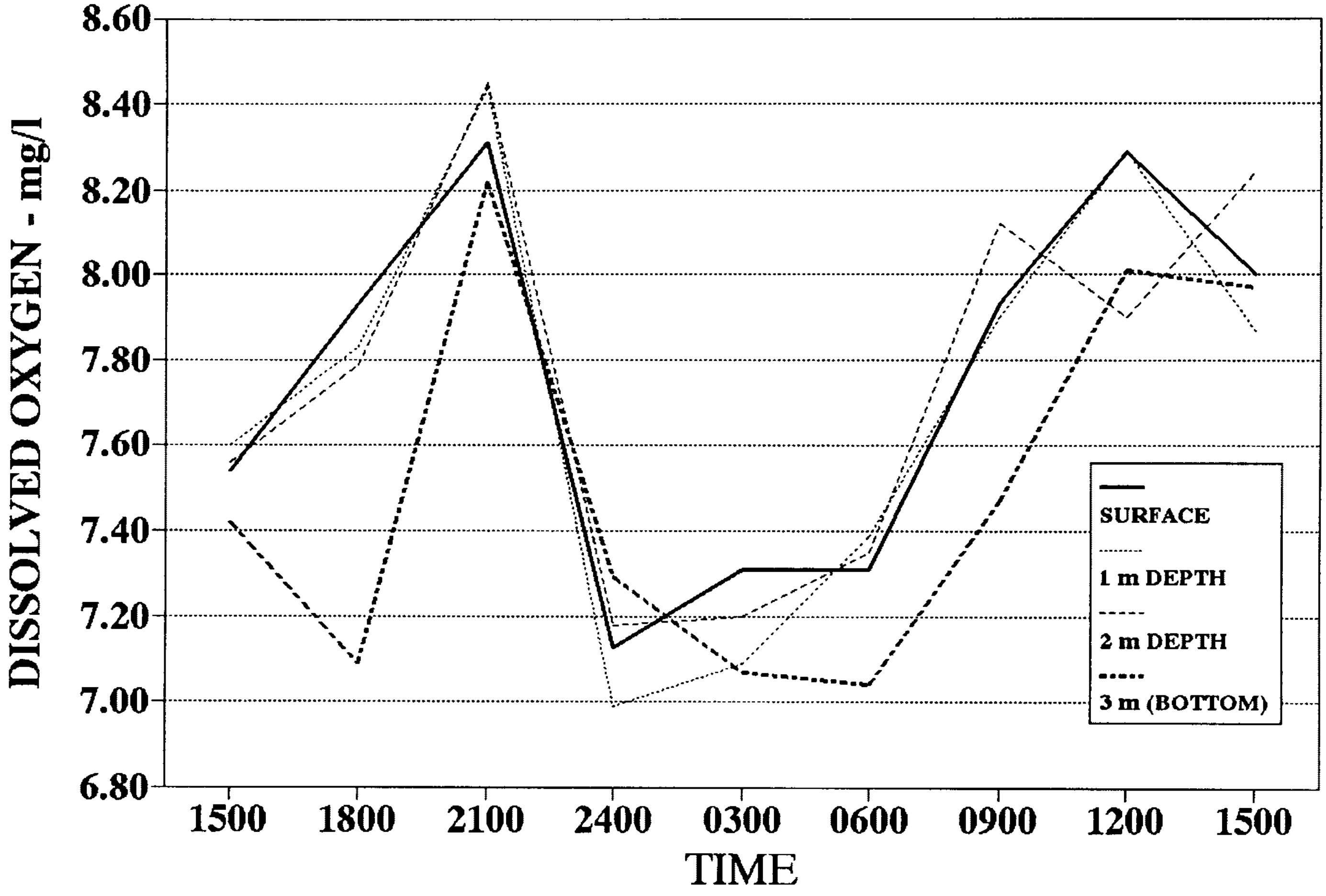


Figure 55. Diel oxygen profiles at RM 111.1 in the Spokane River during the diel study of August 12-13, 1991.

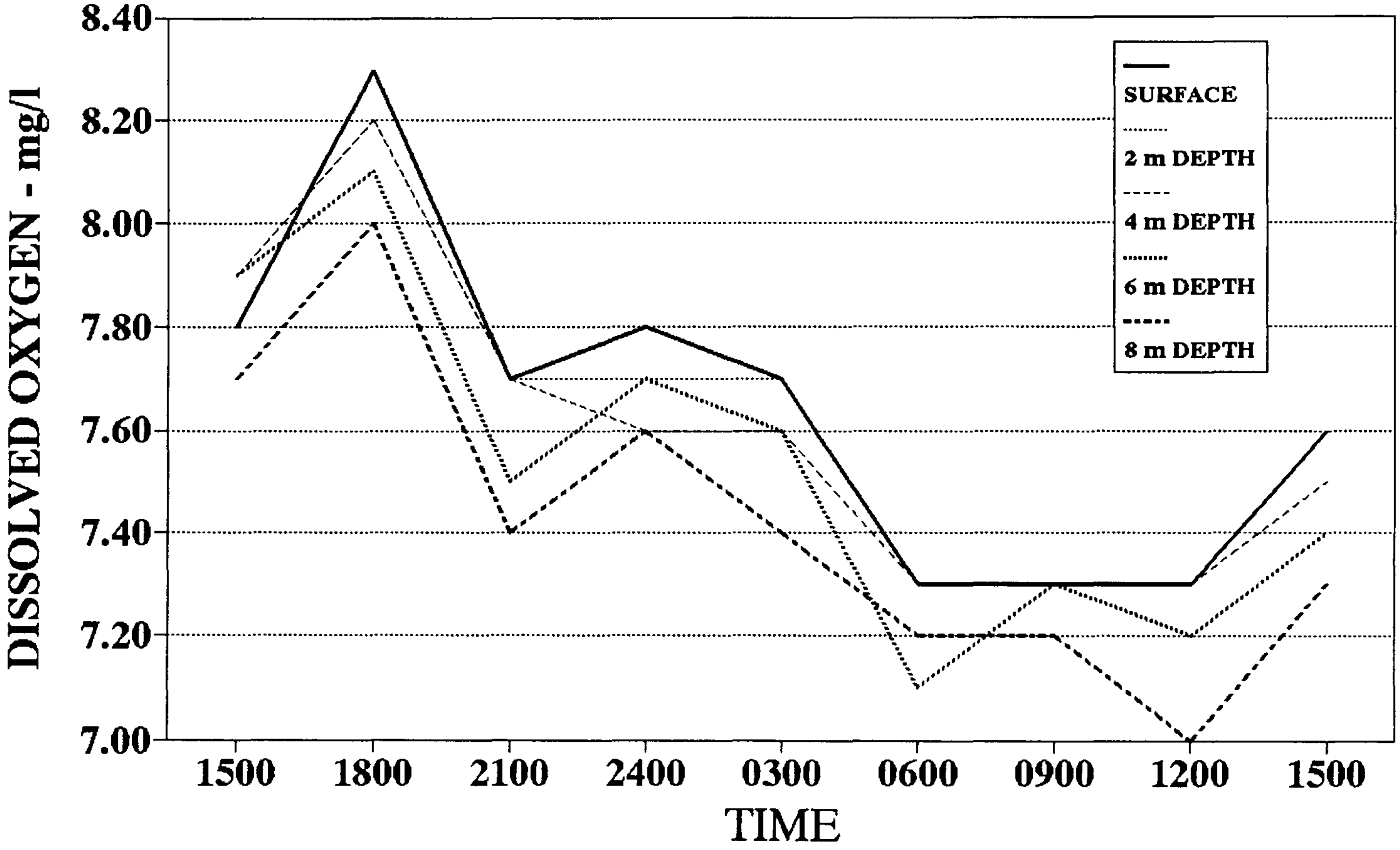


Figure 56. Mean dissolved oxygen percent saturation at RM 103.5 in the Spokane River during the diel study of August 12-13, 1991.

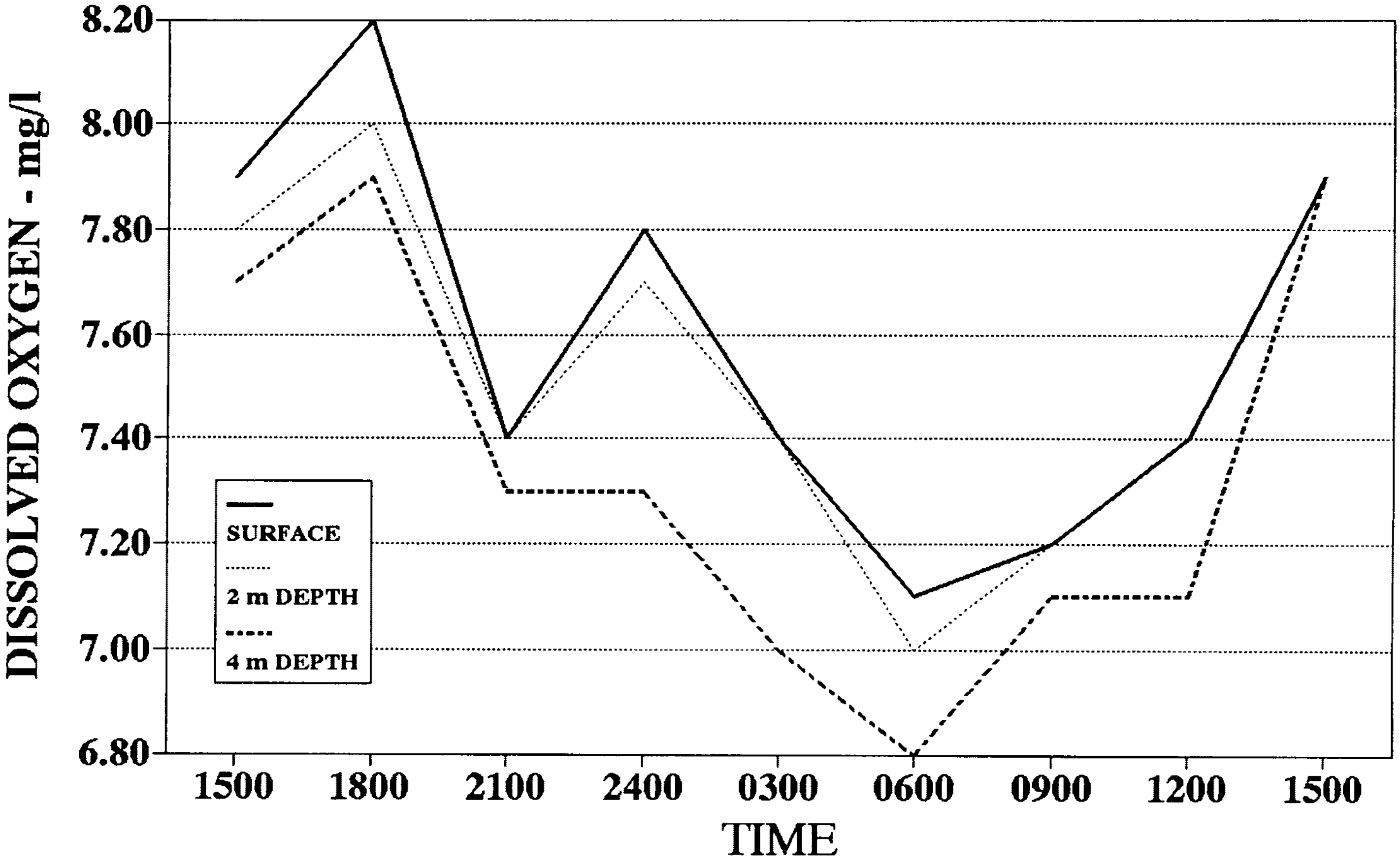


Figure 57. Mean dissolved oxygen percent saturation at RM 102.5 in the Spokane River during the diel study of August 12-13, 1991.

TABLES

Table 1. Retention times of sections on the Spokane River, RM 111.1 to Post Falls Dam, June 24, 1990 to September 29, 1991.

RIVER MILE	CONTOUR DEPTH (ft)	CONTOUR DEPTH (m)	CONTOUR AREA (m2)	CONTOUR VOLUME (m3)	TOTAL SECTION VOLUME (m3)
111.1-108.8	0	0	6.44E+05	7.38E+05	1,190,000
	4	1.2	5.68E+05	2.97E+05	
	6	1.8	4.11E+05	1.42E+05	
	8	2.4	9.32E+04	1.61E+04	
	9	2.7	2.12E+04		
108.8-106.2	0	0	8.39E+05	1.48E+06	1,920,000
	6	1.8	7.80E+05	3.76E+05	
	8	2.4	4.66E+05	6.71E+04	
	9	2.7	4.66E+04		
106.2-103.5	0	0	1.12E+06	2.52E+06	4,900,000
	8	2.4	9.45E+05	1.58E+06	
	14	4.3	7.84E+05	7.65E+05	
	20	6.1	1.40E+05	4.18E+04	
	22	6.7	1.69E+04		
103.5-102.5	0	0	4.66E+05	1.07E+06	2,520,000
	8	2.4	4.11E+05	1.21E+06	
	20	6.1	2.58E+05	2.41E+05	
	26	7.9	3.81E+04		

TOTAL RIVER SECTION VOLUME (RM 111.1-102.5) = 10,500,000 m3

SPOKANE RIVER TOTAL DISCHARGE FOR WATER-YEAR 1990 = 7,010,000,000 m3

RETENTION TIMES FOR SPECIFIC SECTIONS AND THE RIVER

FLOW	DATE	111.1-108.8	108.8-106.2	106.2-103.5	103.5-102.5	RIVER
50,100 cfs	78 YR. MAX (DEC 25, 1933)	0.2 hr	0.4 hr	1.0 hr	0.5 hr	2.1 hr
24,200 cfs	DAILY HIGH (jUNE 5,1990)	0.5 hr	0.8 hr	2.0 hr	1.0 hr	4.3 hr
23,891 cfs	80-91 MEAN MAX MONTHLY	0.5 hr	0.8 hr	2.0 hr	1.0 hr	4.3 hr
6,300 cfs	78 YR MEAN	1.9 hr	3.0 hr	7.6 hr	3.9 hr	16.4 hr
65 cfs	78 YR MIN (JULY 25, 1973)	7.5 day	12.1 day	30.9 day	15.9 day	66.4 day
340 cfs	DAILY LOW (SEPT 5, 1990)	1.4 day	2.3 day	5.9 day	3.0 day	12.7 day
500 cfs	80-91 MEAN MIN MONTHLY	1.0 day	1.6 day	4.0 day	2.1 day	8.6 day

Table 2. Mean temperature (C) among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	Sta. 6 (RM 100.7)	RIVER MEAN
29 JUN 90	18.2	19.6	20.0	19.4	19.2	N/A	19.3
09 JUL 90	22.1	21.8	21.7	N/A	22.0	22.0	18.3
23 JUL 90	23.7	23.4	24.0	24.4	24.7	24.0	24.0
06 AUG 90	24.1	23.6	23.7	23.7	23.8	23.6	23.8
20 AUG 90	21.7	21.7	22.7	23.1	23.1	22.2	22.4
03 SEP 90	20.1	20.5	20.6	20.6	20.7	20.9	20.6
17 SEP 90	19.8	19.6	19.3	19.3	19.7	19.0	19.5
01 OCT 90	18.4	18.2	17.9	18.2	18.2	16.9	18.0
15 OCT 90	12.7	12.4	12.2	12.1	12.0	11.2	12.1
29 OCT 90	11.1	11.0	10.9	10.7	10.1	10.3	10.7
12 NOV 90	10.3	10.2	10.0	9.8	9.7	8.5	9.8
18 DEC 90	6.1	6.1	6.0	5.7	5.7	5.3	5.8
15 JAN 91	3.4	3.4	3.0	2.9	2.8	2.0	2.9
12 FEB 91	2.1	2.3	2.1	2.1	2.0	1.9	2.1
12 MAR 91	2.2	2.2	2.2	2.2	2.2	2.1	2.2
09 APR 91	3.8	3.9	4.0	3.9	3.8	N/A	3.9
07 MAY 91	8.3	8.3	8.7	9.0	8.8	N/A	8.6
21 MAY 91	10.2	10.6	10.5	10.5	10.4	9.3	10.3
04 JUN 91	12.2	12.6	12.8	13.3	12.4	12.2	12.6
18 JUN 91	13.2	13.4	13.9	13.8	13.5	15.2	13.8
02 JUL 91	17.7	17.5	17.2	17.0	17.3	16.8	17.3
16 JUL 91	20.7	20.6	20.3	20.4	20.7	N/A	20.5
30 JUL 91	22.0	21.8	21.7	22.0	22.5	22.5	22.1
13 AUG 91	22.5	22.2	22.6	22.5	22.9	23.1	22.6
27 AUG 91	25.2	25.1	25.1	26.0	26.1	26.3	25.6
10 SEP 91	19.8	19.7	19.9	20.2	20.5	20.6	20.1
24 SEP 91	18.0	17.4	17.1	16.9	16.8	17.9	17.4
WY 91 MEAN	13.0	12.9	12.9	13.0	12.9	13.1	13.0
STUDY MEAN	15.2	15.2	15.2	14.4	15.2	15.4	15.1

Table 3. Mean temperature, dissolved oxygen, and electrical conductivity in the right (R), middle (M), and left (L) thirds of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

TEMPERATURE (C)						
RIVER	WY 91			90-91		
MILE	R	M	L	R	M	L
111.1	13.2	13.5	13.6	15.4	15.8	15.6
108.8	13.4	13.7	13.8	15.5	15.8	16.0
106.2	13.0	13.8	14.1	15.5	16.1	16.4
103.5	13.2	13.9	14.2	15.2	15.9	16.2
102.5	13.3	13.9	14.2	15.5	16.3	16.5
100.7	12.6	13.2	13.1	14.9	14.3	14.5
OXYGEN (mg/l)						
RIVER	WY 91			90-91		
MILE	R	M	L	R	M	L
111.1	9.8	9.7	9.8	9.2	9.2	9.2
108.8	9.6	9.6	9.6	9.1	9.1	9.1
106.2	9.6	9.5	9.6	9.1	9.0	9.1
103.5	9.6	9.5	9.4	9.3	9.1	9.1
102.5	9.5	9.4	9.4	9.1	9.0	9.0
100.7	10.3	10.3	10.2	9.7	10.0	9.8
ELECTRICAL CONDUCTIVITY (umhos)						
RIVER	WY 91			90-91		
MILE	R	M	L	R	M	L
111.1	39.0	39.3	39.3	39.9	40.7	40.6
108.8	41.1	40.6	40.4	42.4	42.1	42.2
106.2	40.6	41.2	40.5	42.7	43.2	42.2
103.5	41.0	41.3	41.0	42.8	43.2	42.4
102.5	40.7	40.7	41.0	42.1	42.2	42.2
100.7	38.5	39.1	39.6	43.6	41.6	42.1

Table 4. Mean dissolved oxygen (mg/l) among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	Sta. 6 (RM 100.7)	RIVER MEAN
29 JUN 90	10.2	10.2	10.3	9.3	8.4	N/A	9.7
09 JUL 90	8.5	8.6	8.3	N/A	8.7	8.8	8.6
23 JUL 90	7.3	7.3	6.9	7.9	8.1	7.5	7.5
06 AUG 90	8.0	7.8	8.1	8.4	8.2	8.0	8.1
20 AUG 90	5.9	5.8	6.5	6.8	6.6	6.8	6.4
03 SEP 90	6.5	6.9	8.1	8.4	8.3	8.0	7.7
17 SEP 90	8.0	7.7	7.5	7.6	7.7	7.9	7.7
01 OCT 90	8.4	8.3	8.2	8.3	8.0	8.1	8.2
15 OCT 90	8.6	8.5	8.5	8.7	8.7	9.3	8.7
29 OCT 90	8.7	9.0	8.9	8.8	8.5	9.3	8.9
12 NOV 90	10.2	9.2	9.1	9.1	9.1	9.9	9.4
18 DEC 90	10.6	10.6	10.6	10.5	10.4	12.4	10.9
15 JAN 91	12.0	11.8	11.7	11.5	11.5	12.7	11.9
12 FEB 91	12.6	12.0	12.8	12.7	12.4	12.9	12.6
12 MAR 91	12.8	12.8	12.8	12.7	12.7	13.1	12.8
09 APR 91	12.5	12.4	12.4	12.5	12.6	N/A	12.5
07 MAY 91	11.2	11.2	11.3	11.3	11.1	N/A	11.2
21 MAY 91	11.6	11.7	11.7	11.7	11.7	11.7	11.7
04 JUN 91	10.7	10.8	10.8	11.0	10.6	11.5	10.9
18 JUN 91	10.5	10.5	10.4	10.5	10.4	10.5	10.5
02 JUL 91	9.7	9.7	9.8	9.8	9.8	9.5	9.7
16 JUL 91	7.9	7.9	7.6	7.8	7.8	N/A	7.8
30 JUL 91	7.5	7.5	7.2	7.4	7.2	8.0	7.5
13 AUG 91	7.5	7.0	6.8	7.2	7.2	8.5	7.4
27 AUG 91	7.7	7.6	7.4	7.1	7.0	7.9	7.5
10 SEP 91	8.0	8.0	7.8	7.9	7.8	8.1	7.9
24 SEP 91	8.1	8.4	8.2	7.9	8.1	8.7	8.2
WY 91 MEAN	9.8	9.7	9.7	9.7	9.6	10.2	9.8
STUDY MEAN	9.3	9.2	9.2	9.3	9.2	9.7	9.3

Table 5. Mean dissolved oxygen (percent saturation) among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	Sta. 6 (RM 100.7)	RIVER MEAN
29 JUN 90	108.2	111.0	113.3	101.3	90.8	N/A	104.9
09 JUL 90	97.0	97.7	94.4	N/A	99.4	100.6	97.8
23 JUL 90	86.7	85.3	82.0	94.6	97.3	88.9	89.1
06 AUG 90	95.5	92.4	95.3	99.7	97.2	94.8	95.8
20 AUG 90	66.8	66.4	75.2	79.5	77.6	78.2	74.0
03 SEP 90	71.6	76.3	90.3	93.5	92.2	89.1	85.5
17 SEP 90	87.8	83.5	81.3	82.8	83.8	85.2	84.1
01 OCT 90	89.9	88.1	86.0	88.2	85.1	83.9	86.9
15 OCT 90	81.3	79.7	79.2	81.2	80.5	84.9	81.1
29 OCT 90	79.4	81.5	80.8	79.4	75.8	83.0	80.0
12 NOV 90	90.9	82.2	80.4	80.0	80.2	84.7	83.1
18 DEC 90	85.2	85.3	84.8	84.0	83.0	97.8	86.7
15 JAN 91	90.2	88.8	86.8	85.1	84.9	92.2	88.0
12 FEB 91	91.4	87.7	92.8	92.4	90.0	92.7	91.2
12 MAR 91	93.0	93.0	92.8	92.5	92.6	95.0	93.2
09 APR 91	94.4	94.5	94.4	94.8	95.3	N/A	94.7
07 MAY 91	94.9	95.7	97.0	98.0	96.0	N/A	96.3
21 MAY 91	103.0	104.9	104.7	105.2	105.1	101.9	104.1
04 JUN 91	100.2	101.3	101.9	104.8	94.0	107.5	101.6
18 JUN 91	99.6	100.8	100.9	101.1	99.7	104.8	101.2
02 JUL 91	102.0	101.5	101.5	100.9	102.4	98.2	101.1
16 JUL 91	88.0	87.4	84.5	86.6	86.9	N/A	86.7
30 JUL 91	85.4	85.7	81.6	84.5	83.2	92.2	85.4
13 AUG 91	86.3	80.2	78.9	83.1	83.5	99.2	85.2
27 AUG 91	93.8	91.8	90.2	87.0	86.3	97.6	91.1
10 SEP 91	87.1	87.4	85.9	87.3	86.8	90.4	87.5
24 SEP 91	85.6	87.4	85.1	81.8	83.4	91.9	85.9
WY 91 MEAN	91.1	90.2	89.5	89.9	88.7	94.0	90.6
STUDY MEAN	90.2	89.5	89.7	90.4	89.4	92.8	90.3

Table 6. Mean electrical conductivity (umhos) among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	Sta. 6 (RM 100.7)	RIVER MEAN
29 JUN 90	39.4	39.9	40.2	40.4	40.3	N/A	40.0
09 JUL 90	41.1	44.8	46.3	N/A	45.2	39.0	43.3
23 JUL 90	62.7	65.8	69.4	69.1	58.5	61.6	64.5
06 AUG 90	48.1	48.4	49.7	49.2	47.7	41.9	47.5
20 AUG 90	33.5	34.3	39.6	41.4	41.5	103.6	49.0
03 SEP 90	39.0	45.0	44.4	43.8	42.6	40.5	42.6
17 SEP 90	39.7	41.6	41.1	42.8	42.3	42.9	41.7
01 OCT 90	37.5	39.7	40.1	40.7	40.4	34.3	38.8
15 OCT 90	33.4	36.2	35.4	36.4	36.1	42.5	36.7
29 OCT 90	40.4	41.6	41.2	41.7	40.3	36.6	40.3
12 NOV 90	39.7	40.7	40.5	40.7	40.1	35.5	39.5
18 DEC 90	32.5	33.6	33.7	34.0	33.8	33.2	33.5
15 JAN 91	30.4	30.9	31.1	29.9	31.5	28.6	30.4
12 FEB 91	30.3	30.6	30.5	30.6	30.4	27.8	30.0
12 MAR 91	30.0	29.5	32.0	29.9	29.6	32.7	30.6
09 APR 91	29.9	30.2	30.2	28.9	29.5	N/A	29.7
07 MAY 91	N/A	N/A	N/A	N/A	N/A	N/A	N/A
21 MAY 91	32.7	32.9	33.1	32.8	32.5	29.3	32.2
04 JUN 91	35.0	36.5	36.6	37.4	37.7	29.7	35.5
18 JUN 91	37.8	38.6	38.9	40.0	39.5	38.4	38.9
02 JUL 91	41.4	41.9	42.0	42.7	41.9	40.4	41.7
16 JUL 91	44.5	46.9	46.7	47.5	47.1	N/A	46.5
30 JUL 91	48.9	49.9	50.1	50.3	50.2	49.0	49.7
13 AUG 91	49.3	49.9	50.6	51.0	50.6	49.7	50.2
27 AUG 91	48.6	53.8	52.8	53.4	53.0	57.6	53.2
10 SEP 91	47.8	49.4	49.6	51.1	50.6	51.6	50.0
24 SEP 91	47.3	48.2	48.1	48.6	47.6	48.5	48.1
WY 91 MEAN	38.8	40.1	40.2	40.4	40.1	39.1	39.8
STUDY MEAN	40.0	41.6	42.1	42.2	41.6	43.3	41.8

Table 7. pH among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	Sta. 6 (RM 100.7)	CDAWWTP (RM 110.7)	PFWWTP (RM 101.5)	RIVER MEDIAN
29 JUN 90	6.7	6.8	6.7	6.7	6.6	N/A	N/A	N/A	6.7
09 JUL 90	7.1	7.1	7.1	N/A	6.8	6.6	N/A	N/A	7.1
23 JUL 90	6.7	6.9	6.9	7.0	7.0	7.0	7.3	6.8	7.0
06 AUG 90	6.7	6.8	6.9	7.0	7.0	7.0	7.7	7.3	7.0
20 AUG 90	6.5	6.6	6.7	6.7	6.8	6.8	7.3	N/A	6.7
03 SEP 90	6.5	6.6	6.7	6.7	6.8	6.8	7.7	7.0	6.8
17 SEP 90	6.9	7.0	7.0	7.1	7.1	7.1	7.7	7.4	7.1
01 OCT 90	7.0	7.1	7.1	7.1	3.3	6.3	7.9	7.1	7.1
15 OCT 90	7.1	7.1	7.2	7.2	7.2	7.3	7.3	7.2	7.2
29 OCT 90	7.4	7.3	7.3	7.4	7.3	7.5	8.3	7.3	7.4
12 NOV 90	7.1	7.1	7.1	7.2	6.7	7.1	7.4	7.1	7.1
18 DEC 90	7.3	7.3	7.4	7.4	7.4	7.4	7.6	7.2	7.4
15 JAN 91	7.1	7.2	7.2	7.2	7.2	7.2	7.1	7.1	7.2
12 FEB 91	7.5	7.5	7.5	7.6	7.6	7.6	7.3	7.3	7.5
12 MAR 91	7.7	7.7	7.7	7.9	7.9	7.9	8.2	7.5	7.8
09 APR 91	7.6	7.7	7.8	7.8	7.8	7.9	8.1	7.5	7.8
07 MAY 91	5.1	5.2	5.4	5.5	5.7	5.8	7.2	6.9	5.7
21 MAY 91	5.7	5.9	6.1	6.3	6.2	6.3	7.0	6.9	6.3
04 JUN 91	6.8	6.8	6.8	6.8	6.9	6.8	7.2	7.5	6.8
18 JUN 91	6.3	5.7	5.5	6.1	6.1	5.7	6.4	6.5	6.1
02 JUL 91	5.7	6.0	6.1	6.2	6.3	6.3	6.0	N/A	6.1
16 JUL 91	6.9	6.9	6.9	6.9	6.9	6.9	6.8	7.0	6.9
30 JUL 91	6.5	6.5	6.5	6.4	6.4	6.0	6.2	6.2	6.4
13 AUG 91	6.5	6.8	6.9	6.7	6.4	6.5	6.0	N/A	6.5
27 AUG 91	6.7	6.6	6.7	6.6	6.6	6.7	6.9	7.1	6.7
10 SEP 91	6.4	6.4	6.3	6.7	6.6	6.5	7.3	6.9	6.6
24 SEP 91	6.3	6.3	6.4	6.3	6.3	6.2	6.7	7.0	6.3
WY 91 MEDIAN	6.9	6.9	6.9	6.9	6.7	6.8	7.2	7.1	6.9
STUDY MEDIAN	6.7	6.8	6.9	6.8	6.8	6.8	7.3	7.1	6.8

Table 8. Turbidity (NTU) among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	Sta. 6 (RM 100.7)	CDAWWT (RM 110.7)	PFWWTP (RM 101.5)	RIVER MEAN
29 JUN 90	2.9	2.7	1.9	1.6	3.0	N/A	N/A	N/A	2.4
09 JUL 90	2.0	1.9	1.5	1.6	1.4	1.0	N/A	N/A	1.6
23 JUL 90	0.7	0.7	1.1	1.4	1.5	1.2	9.1	1.2	1.1
06 AUG 90	0.8	1.1	1.1	1.0	1.6	0.8	11.2	2.5	1.1
20 AUG 90	0.9	2.2	0.6	0.8	1.2	1.3	15.0	N/A	1.2
03 SEP 90	0.5	0.6	0.6	0.6	0.7	0.7	7.2	7.7	0.6
17 SEP 90	0.6	0.6	0.6	0.7	0.6	1.3	9.6	1.9	0.7
01 OCT 90	0.5	0.7	1.0	0.9	0.8	1.6	6.6	1.4	0.9
15 OCT 90	0.5	0.8	0.6	0.7	0.9	0.7	13.0	3.7	0.7
29 OCT 90	0.3	0.5	0.5	1.0	1.0	0.5	9.2	1.4	0.6
12 NOV 90	0.4	0.4	0.5	0.4	5.4	0.6	9.4	2.4	1.3
18 DEC 90	0.8	0.8	0.8	0.8	0.9	1.1	14.1	2.4	0.9
15 JAN 91	1.1	1.1	1.3	1.3	1.3	1.5	10.5	2.8	1.3
12 FEB 91	1.6	1.7	1.7	1.7	1.7	1.8	13.5	2.3	1.7
12 MAR 91	1.7	2.3	1.9	2.0	1.7	2.0	10.5	2.2	1.9
09 APR 91	1.8	1.7	1.9	1.9	1.8	2.0	11.0	3.7	1.9
07 MAY 91	1.5	1.5	1.4	1.2	1.1	1.1	12.0	2.0	1.3
21 MAY 91	0.8	0.8	1.0	0.8	1.1	0.9	9.4	1.3	0.9
04 JUN 91	0.9	0.9	0.8	1.0	1.1	0.6	5.1	2.3	0.9
18 JUN 91	0.5	0.5	0.6	0.5	0.6	0.5	8.1	2.2	0.5
02 JUL 91	0.5	0.6	0.5	0.6	0.5	0.5	9.6	N/A	0.5
16 JUL 91	0.7	0.8	0.8	0.8	0.8	0.9	9.8	3.6	0.8
30 JUL 91	0.4	0.5	0.6	0.6	0.7	0.6	9.0	4.8	0.6
13 AUG 91	0.4	0.5	0.5	0.5	0.5	0.5	8.7	N/A	0.5
27 AUG 91	0.4	0.5	0.6	0.8	0.6	0.6	4.7	1.9	0.5
10 SEP 91	0.4	0.5	0.5	0.6	0.6	0.7	2.4	3.4	0.5
24 SEP 91	1.3	1.5	1.4	1.3	1.6	1.4	6.2	3.2	1.4
WY 91 MEAN	0.8	0.9	0.9	1.0	1.2	1.0	9.1	2.6	1.0
STUDY MEAN	0.9	1.0	1.0	1.0	1.3	1.0	9.4	2.7	1.0

Table 9. Mean secchi disk depths (m) among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	RM 106.2 - RM 102.5 MEAN
29 JUN 90	>3.3	3.6	3.8	3.3	3.1	3.4
09 JUL 90	>3.2	3.7	4.7	N/A	3.6	4.1
23 JUL 90	>3.4	>4.5	5.0	4.4	5.1	4.8
06 AUG 90	>3.2	>4.7	4.0	4.0	3.6	3.9
20 AUG 90	>3.2	2.0	3.6	3.9	4.1	3.9
03 SEP 90	>3.1	>4.5	4.0	3.6	4.2	3.9
17 SEP 90	>3.2	>4.3	4.8	4.5	4.2	4.5
01 OCT 90	>2.8	3.8	3.6	3.5	3.7	3.6
15 OCT 90	>2.7	>4.0	5.8	5.5	5.0	5.4
29 OCT 90	>2.7	>3.8	>6.1	6.2	7.2	6.5
12 NOV 90	>2.8	>4.0	5.4	5.9	6.1	5.8
18 DEC 90	>2.8	>3.8	3.9	4.0	3.4	3.8
15 JAN 91	>1.9	>2.8	3.1	3.1	2.7	3.0
12 FEB 91	>2.0	1.8	2.6	2.5	2.9	2.6
12 MAR 91	>2.2	>2.8	2.7	2.8	2.8	2.8
09 APR 91	>2.1	2.8	2.3	2.9	2.2	2.4
07 MAY 91	2.8	2.7	2.8	2.7	2.6	2.7
21 MAY 91	2.9	2.8	2.7	2.4	2.3	2.5
04 JUN 91	>3.0	>3.8	3.4	4.2	4.2	3.9
18 JUN 91	>3.1	4.3	4.2	5.0	4.3	4.5
02 JUL 91	>3.1	3.5	4.2	3.8	3.9	4.0
16 JUL 91	>3.0	3.3	3.8	2.9	3.1	3.2
30 JUL 91	>3.2	>4.6	4.4	4.9	3.8	4.3
13 AUG 91	>3.0	>4.2	4.2	4.1	4.1	4.1
27 AUG 91	>3.0	4.1	3.8	3.1	2.9	3.3
10 SEP 91	>3.2	>4.4	6.2	5.8	5.8	5.9
24 SEP 91	>2.9	4.1	5.5	5.2	5.2	5.3
WY 91 MEAN	N/A	N/A	4.0	4.0	3.9	4.0
STUDY MEAN	N/A	N/A	4.1	4.0	3.9	4.0

Table 10. Chlorophyll *a* concentrations (mg/m3) among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	Sta. 6 (RM 100.7)	RIVER MEAN
29 JUN 90	1.93	1.06	1.62	0.93	1.30	N/A	1.37
09 JUL 90	1.77	2.40	2.82	N/A	3.80	4.90	3.14
23 JUL 90	0.00	0.04	2.17	5.32	1.49	0.40	1.57
06 AUG 90	1.79	2.08	5.19	7.37	5.06	0.00	3.58
20 AUG 90	2.55	3.18	3.92	10.96	9.66	7.80	6.35
03 SEP 90	2.19	3.38	6.73	8.58	7.37	7.07	5.89
17 SEP 90	1.50	1.71	1.59	2.23	2.42	3.20	2.11
01 OCT 90	2.82	4.35	4.43	6.58	5.85	6.98	5.17
15 OCT 90	2.72	3.81	2.66	2.91	3.32	3.11	3.09
29 OCT 90	1.90	4.61	3.31	2.97	2.69	3.01	3.08
12 NOV 90	2.46	2.72	3.02	2.64	2.66	3.65	2.86
18 DEC 90	4.41	3.10	2.77	3.52	0.94	0.00	2.46
15 JAN 91	1.83	1.83	1.37	2.76	2.17	2.38	2.06
12 FEB 91	3.34	3.53	3.82	3.53	3.72	3.25	3.53
12 MAR 91	3.02	3.00	2.91	3.06	2.83	3.12	2.99
09 APR 91	3.52	3.87	1.16	4.66	4.31	5.30	3.80
08 MAY 91	7.38	6.95	6.66	7.00	6.36	6.54	6.82
21 MAY 91	6.19	6.19	6.70	6.15	7.00	6.52	6.46
04 JUN 91	3.10	3.31	2.97	2.94	2.65	3.46	3.07
18 JUN 91	3.25	12.14	3.69	3.71	2.90	2.72	4.74
02 JUL 91	2.18	1.43	2.55	2.52	3.10	2.35	2.36
16 JUL 91	1.16	1.63	1.93	2.83	3.57	10.55	3.61
30 JUL 91	0.12	0.00	0.00	2.12	0.00	0.00	0.37
13 AUG 91	1.27	3.03	2.18	3.49	3.80	3.21	2.83
27 AUG 91	1.51	2.09	4.11	6.55	5.91	6.87	4.51
10 SEP 91	0.90	1.08	1.40	2.70	4.14	0.00	1.70
24 SEP 91	1.24	1.90	1.76	2.18	2.55	2.39	2.00
WY 91 MEAN	2.72	3.53	2.97	3.75	3.52	3.77	3.38
STUDY MEAN	2.45	3.13	3.09	4.24	3.76	3.80	3.39

32) Page 23, Conclusions.

The conclusions section reads in many ways like a results section. If statements are made about increases between stations, they should be backed up statistically. Conclusions should relate back to study objectives.

If early in the sampling, or even before initiation of sampling, it was known that there would be significant increases in concentrations between stations 111.1 and 108.8, it would have been insightful to include a block sampling design in the study. Same day site replications at the station grids could have led to standard ANOVA testing which would have more appropriately addressed objective 4.

The study objectives, although concise in appearance and number, are quite detailed and require a lengthy conclusion section in order to address them adequately. For instance, we cannot "characterize baseline river water quality" into one statement by saying it is "good" or "bad".

Table 11. Total Kjeldahl nitrogen concentrations among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	Sta. 6 (RM 100.7)	CDAWWTP	PFWWTP	RIVER MEAN
29 JUN 90	0.46	0.20	0.18	0.20	0.16	N/A	N/A	N/A	0.24
09 JUL 90	0.24	0.20	0.18	N/A	0.26	0.14	N/A	N/A	0.20
23 JUL 90	0.18	0.16	0.20	0.20	0.24	N/A	25.32	1.74	0.20
06 AUG 90	0.24	0.20	0.20	0.24	0.36	0.22	23.96	1.37	0.24
20 AUG 90	0.20	0.40	0.20	0.22	0.22	0.20	22.60	N/A	0.24
03 SEP 90	0.22	0.36	0.20	0.14	0.26	0.22	20.69	2.31	0.23
17 SEP 90	0.22	0.20	0.18	0.20	0.34	0.24	24.78	1.40	0.23
01 OCT 90	0.12	0.18	0.16	0.16	0.20	0.22	20.69	<.04	0.17
15 OCT 90	0.20	0.20	0.16	0.14	0.26	0.13	19.45	2.40	0.18
29 OCT 90	0.10	0.16	0.16	0.14	0.22	0.14	22.06	0.15	0.15
12 NOV 90	0.22	0.16	0.24	0.20	0.30	0.18	20.51	1.60	0.22
18 DEC 90	0.14	0.14	0.18	0.12	0.14	0.12	22.60	1.36	0.14
15 JAN 91	0.12	0.16	0.16	0.16	0.16	0.22	20.69	2.18	0.16
12 FEB 91	0.14	0.18	0.16	0.14	0.18	0.20	23.15	1.47	0.17
12 MAR 91	0.16	0.22	0.16	0.22	0.16	0.14	21.51	1.36	0.18
09 APR 91	0.16	0.16	0.18	0.12	0.16	0.14	24.10	1.58	0.15
07 MAY 91	0.14	0.14	0.14	0.12	0.20	0.14	26.14	1.14	0.15
21 MAY 91	0.14	0.14	0.22	0.10	0.22	0.19	26.41	0.06	0.17
04 JUN 91	0.16	0.12	0.22	0.23	0.34	0.14	22.60	0.06	0.20
18 JUN 91	0.10	0.20	0.16	0.18	0.20	0.16	18.79	0.44	0.17
02 JUL 91	0.22	0.30	0.20	0.14	0.15	0.18	19.33	N/A	0.20
16 JUL 91	0.14	0.12	0.12	0.10	0.12	0.12	17.15	1.20	0.12
30 JUL 91	0.12	0.12	0.12	0.12	0.16	0.18	20.42	9.42	0.14
13 AUG 91	0.10	0.18	0.17	0.16	0.18	0.16	20.42	N/A	0.16
27 AUG 91	0.14	0.22	0.20	0.18	0.22	0.18	15.79	1.25	0.19
10 SEP 91	0.10	0.14	0.16	0.24	0.24	0.22	11.44	17.05	0.18
24 SEP 91	0.12	0.18	0.15	0.22	0.18	0.16	14.16	0.68	0.17
WY 91 MEAN	0.14	0.17	0.17	0.16	0.20	0.17	20.37	2.41	0.17
STUDY MEAN	0.17	0.19	0.18	0.17	0.22	0.17	20.99	2.28	0.18

Table 12. Nitrate-nitrogen concentrations among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	Sta. 6 (RM 100.7)	CDAWWTP (RM 110.7)	PFWWTP (RM 101.5)	RIVER MEAN
29 JUN 90	0.079	<.006	<.006	<.006	<.006	N/A	N/A	N/A	0.018
09 JUL 90	0.022	0.029	0.028	N/A	<.006	<.006	N/A	N/A	0.017
23 JUL 90	0.024	0.035	0.028	<.006	0.022	0.045	0.896	11.34	0.026
06 AUG 90	0.015	<.006	<.006	0.007	<.006	0.046	0.609	13.70	0.013
20 AUG 90	0.012	0.014	0.031	0.042	0.074	0.093	0.560	N/A	0.044
03 SEP 90	0.012	0.032	0.045	0.044	0.036	0.085	2.064	13.69	0.042
17 SEP 90	0.031	<.006	0.040	0.054	0.040	0.081	1.596	14.51	0.041
01 OCT 90	0.017	0.061	<.006	0.053	0.040	0.058	2.853	13.07	0.039
15 OCT 90	0.055	0.052	0.014	<.006	0.088	0.014	2.480	12.99	0.038
29 OCT 90	0.036	<.006	0.037	0.058	0.040	0.048	2.845	17.50	0.037
12 NOV 90	<.006	0.077	0.075	0.038	0.030	0.077	2.359	15.85	0.050
18 DEC 90	0.227	0.183	1.596	0.267	0.238	0.407	3.835	13.40	0.486
15 JAN 91	0.036	0.056	0.215	0.040	0.077	0.156	1.164	9.47	0.097
12 FEB 91	0.071	0.089	0.106	0.094	0.087	0.107	1.457	19.12	0.092
12 MAR 91	0.114	0.113	0.107	0.116	0.155	0.150	2.041	15.81	0.126
09 APR 91	0.070	0.097	0.072	0.069	0.090	0.136	1.899	11.90	0.089
07 MAY 91	0.013	<.006	0.020	0.033	<.006	0.031	1.808	23.34	0.017
21 MAY 91	0.017	<.006	<.006	<.006	0.050	0.306	1.646	23.14	0.064
04 JUN 91	<.006	0.020	0.044	0.047	<.006	0.107	1.450	20.79	0.037
18 JUN 91	0.011	0.020	0.023	0.021	0.022	0.018	3.550	19.75	0.019
02 JUL 91	0.058	0.064	0.107	0.029	<.006	0.050	1.428	N/A	0.052
16 JUL 91	0.036	0.008	0.014	0.046	0.031	0.046	3.421	29.31	0.030
30 JUL 91	0.027	0.034	0.039	0.011	0.044	0.076	4.006	9.55	0.039
13 AUG 91	0.007	0.036	0.031	<.006	<.006	<.006	3.769	N/A	0.014
27 AUG 91	0.008	0.080	0.044	0.019	0.038	0.049	5.132	8.04	0.040
10 SEP 91	0.008	0.040	0.040	0.026	0.049	0.027	6.081	2.07	0.032
24 SEP 91	0.014	0.022	0.024	0.038	0.021	0.044	5.022	19.25	0.027
WY 91 MEAN	0.041	0.053	0.131	0.051	0.056	0.095	2.912	15.80	0.071
STUDY MEAN	0.038	0.044	0.103	0.045	0.048	0.087	2.559	15.35	0.061

Table 13. Ammonia concentration (mg/l) among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	Sta. 6 (RM 100.7)	CDAWWTP (RM110.7)	PFWWTP (RM 101.5)	RIVER MEAN
29 JUN 90	0.20	0.15	0.11	0.10	0.12	N/A	N/A	N/A	0.14
09 JUL 90	0.05	0.28	0.20	N/A	0.25	0.14	N/A	N/A	0.18
23 JUL 90	0.12	0.24	0.20	0.13	0.10	0.07	24.7	1.79	0.15
06 AUG 90	0.09	0.17	0.17	0.18	0.23	0.13	21.1	0.91	0.16
20 AUG 90	0.11	0.43	0.23	0.14	0.14	0.16	18.3	N/A	0.20
03 SEP 90	0.16	0.34	0.15	0.09	0.10	0.07	17.4	1.32	0.15
17 SEP 90	0.07	0.22	0.14	0.16	0.18	0.17	21.5	0.74	0.16
01 OCT 90	0.09	0.18	0.10	0.10	0.11	0.08	17.9	1.49	0.11
15 OCT 90	0.15	0.20	0.11	0.16	0.16	0.13	14.9	0.65	0.15
29 OCT 90	0.08	0.13	0.10	0.08	0.13	0.09	19.2	1.28	0.10
12 NOV 90	0.15	0.13	0.22	0.07	0.20	0.11	18.2	0.90	0.15
18 DEC 90	0.12	0.18	0.16	0.12	0.11	0.13	21.6	1.39	0.14
15 JAN 91	0.10	0.14	0.14	0.13	0.14	0.16	20.5	1.03	0.13
12 FEB 91	0.09	0.12	0.16	0.12	0.17	0.10	22.2	0.93	0.13
12 MAR 91	0.11	0.16	0.11	0.13	0.12	0.11	20.5	0.81	0.12
09 APR 91	0.13	0.15	0.16	0.13	0.14	0.12	26.0	0.38	0.14
07 MAY 91	0.13	0.14	0.13	0.11	0.13	0.11	25.2	0.29	0.12
21 MAY 91	0.14	0.17	0.14	0.14	0.14	0.16	24.6	0.68	0.15
04 JUN 91	0.14	0.14	0.12	0.11	0.13	0.15	24.5	0.69	0.13
18 JUN 91	0.13	0.11	0.14	0.13	0.11	0.14	20.1	0.67	0.13
02 JUL 91	0.13	0.14	0.14	0.14	0.13	0.15	18.5	N/A	0.14
16 JUL 91	0.14	0.24	0.17	0.15	0.16	0.18	18.4	0.99	0.17
30 JUL 91	0.16	0.24	0.19	0.14	0.24	0.21	21.0	9.02	0.20
13 AUG 91	0.10	0.20	0.17	0.14	0.11	0.14	22.2	N/A	0.14
27 AUG 91	0.12	0.41	0.19	0.15	0.10	0.15	17.8	0.89	0.19
10 SEP 91	0.07	0.12	0.10	0.11	0.12	0.33	13.0	17.92	0.14
24 SEP 91	0.05	0.13	0.08	0.07	0.08	0.06	16.2	0.65	0.08
WY 91 MEAN	0.12	0.17	0.14	0.12	0.14	0.14	20.1	2.26	0.14
STUDY MEAN	0.12	0.19	0.15	0.12	0.14	0.14	20.2	2.06	0.14

Table 14. Total phosphorus concentrations among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	Sta. 6 (RM 100.7)	CDAWWTP (RM 110.7)	PFWWTP (RM 101.5)	RIVER MEAN
29 JUN 90	0.019	0.019	0.016	0.011	0.016	N/A	N/A	N/A	0.016
09 JUL 90	0.031	0.020	0.017	N/A	0.022	0.011	N/A	N/A	0.020
23 JUL 90	<.006	0.015	0.022	0.017	<.006	0.009	4.62	3.44	0.011
06 AUG 90	0.007	0.016	0.014	0.023	0.022	0.025	4.77	4.01	0.018
20 AUG 90	0.016	0.055	0.021	0.015	0.007	0.019	3.75	N/A	0.022
03 SEP 90	0.020	0.055	0.023	0.012	0.006	0.032	4.29	3.96	0.025
17 SEP 90	0.011	0.017	0.019	0.015	0.029	0.019	4.51	3.99	0.018
01 OCT 90	0.010	0.021	0.018	0.017	0.012	0.021	3.97	3.96	0.017
15 OCT 90	<.006	0.017	0.011	0.013	0.016	0.011	3.41	2.74	0.012
29 OCT 90	<.006	0.014	0.012	0.011	0.009	0.014	3.63	3.23	0.011
12 NOV 90	0.015	0.015	0.011	0.013	<.006	0.011	4.50	4.52	0.011
18 DEC 90	<.006	<.006	0.027	<.006	0.006	0.008	4.09	3.90	0.008
15 JAN 91	0.007	0.011	0.011	0.008	0.017	0.016	4.01	3.50	0.012
12 FEB 91	0.012	0.014	0.015	0.017	0.018	0.010	3.74	4.02	0.014
12 MAR 91	<.006	0.020	0.021	0.015	0.013	0.011	4.13	3.95	0.014
09 APR 91	0.016	0.026	0.018	0.015	0.014	0.019	4.68	3.53	0.018
07 MAY 91	0.010	0.013	0.011	0.012	0.010	0.012	5.01	5.08	0.011
21 MAY 91	0.011	0.017	0.011	0.014	0.014	0.013	4.72	4.36	0.013
04 JUN 91	0.012	0.011	0.013	0.013	0.017	0.011	1.30	4.40	0.013
18 JUN 91	0.012	0.017	0.011	0.015	0.012	0.015	0.95	4.44	0.014
02 JUL 91	0.007	0.009	0.013	0.009	0.009	0.009	1.01	N/A	0.009
16 JUL 91	0.015	0.017	0.014	0.013	0.013	0.011	1.11	5.28	0.014
30 JUL 91	0.010	0.008	0.013	0.016	0.017	0.015	1.04	5.54	0.013
13 AUG 91	<.006	<.006	0.018	0.012	<.006	0.015	0.91	N/A	0.009
27 AUG 91	0.013	<.006	0.006	0.009	0.011	0.018	0.08	4.24	0.010
10 SEP 91	<.006	0.007	0.006	0.007	0.008	0.009	0.59	4.19	0.007
24 SEP 91	0.009	0.010	0.011	0.011	0.010	0.011	0.88	3.96	0.010
WY 91 MEAN	0.009	0.013	0.013	0.012	0.012	0.013	2.69	4.16	0.012
STUDY MEAN	0.010	0.017	0.015	0.013	0.012	0.014	3.03	4.10	0.014

Table 15. Orthophosphorus concentrations among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	Sta. 6 (RM 100.7)	CDAWWTP (RM 110.7)	PFWWTP (RM 101.5)	RIVER MEAN
29 JUN 90	<.006	<.006	<.006	<.006	0.006	N/A	N/A	N/A	<.006
09 JUL 90	<.006	0.008	0.006	N/A	<.006	<.006	N/A	N/A	<.006
23 JUL 90	<.006	0.010	0.009	0.007	<.006	<.006	4.38	3.32	0.006
06 AUG 90	<.006	<.006	<.006	0.008	0.009	0.008	4.07	3.92	0.006
20 AUG 90	<.006	0.087	0.008	0.006	<.006	0.011	3.39	N/A	0.019
03 SEP 90	0.009	0.038	0.009	<.006	<.006	0.022	4.00	3.66	0.014
17 SEP 90	<.006	0.009	0.006	<.006	0.006	0.007	4.44	3.75	0.006
01 OCT 90	<.006	0.007	<.006	<.006	<.006	<.006	3.91	4.04	<.006
15 OCT 90	<.006	0.010	<.006	<.006	0.006	<.006	3.56	2.73	<.006
29 OCT 90	<.006	<.006	<.006	<.006	<.006	<.006	3.38	3.46	<.006
12 NOV 90	<.006	<.006	<.006	<.006	<.006	0.006	4.28	4.48	<.006
18 DEC 90	<.006	<.006	<.006	<.006	<.006	0.006	3.63	3.88	<.006
15 JAN 91	<.006	<.006	<.006	<.006	<.006	<.006	3.36	3.31	<.006
12 FEB 91	<.006	0.006	0.009	<.006	0.007	0.008	3.38	3.77	0.006
12 MAR 91	<.006	0.007	<.006	<.006	<.006	<.006	3.68	4.18	<.006
09 APR 91	<.006	<.006	<.006	<.006	<.006	<.006	4.38	3.51	<.006
07 MAY 91	<.006	<.006	<.006	<.006	<.006	0.007	4.59	5.10	<.006
21 MAY 91	<.006	<.006	<.006	<.006	<.006	<.006	4.41	4.33	<.006
04 JUN 91	<.006	<.006	<.006	<.006	<.006	<.006	1.09	4.33	<.006
18 JUN 91	<.006	<.006	<.006	<.006	<.006	<.006	0.94	4.30	<.006
02 JUL 91	<.006	<.006	<.006	<.006	<.006	<.006	0.90	N/A	<.006
16 JUL 91	<.006	<.006	<.006	<.006	<.006	<.006	0.90	5.33	<.006
30 JUL 91	<.006	<.006	<.006	<.006	<.006	<.006	0.79	5.29	<.006
13 AUG 91	<.006	0.006	<.006	<.006	<.006	<.006	0.65	N/A	<.006
27 AUG 91	<.006	<.006	<.006	<.006	<.006	<.006	<.06	4.27	<.006
10 SEP 91	<.006	<.006	<.006	<.006	<.006	<.006	1.02	4.07	<.006
24 SEP 91	<.006	<.006	<.006	<.006	<.006	<.006	0.72	3.86	<.006
WY 91 MEAN	<.006	<.006	<.006	<.006	<.006	<.006	2.48	4.12	<.006
STUDY MEAN	<.006	0.009	<.006	<.006	<.006	<.006	2.80	4.04	<.006

Table 16. Five Day Biochemical Oxygen Demand (BOD_5) (mg/l) among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	Sta. 6 (RM 100.7)	CDAWWT	PFWWTP	RIVER MEAN
29 JUN 90	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
09 JUL 90	1.7	4.0	3.7	N/A	3.7	3.7	N/A	N/A	3.3
23 JUL 90	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
06 AUG 90	2.3	4.3	4.3	5.7	5.0	4.3	>50.0	14.0	4.3
20 AUG 90	3.3	5.3	2.3	2.7	3.7	4.0	>51.3	24.0	3.6
03 SEP 90	1.8	2.8	4.2	4.8	4.2	4.2	N/A	N/A	3.7
17 SEP 90	3.0	3.0	3.0	2.0	5.0	4.3	>28.8	8.7	3.4
01 OCT 90	3.7	4.7	3.7	4.7	0.8	4.3	N/A	N/A	3.6
15 OCT 90	1.5	2.5	3.2	2.2	2.8	2.8	>28.3	14.3	2.5
29 OCT 90	0.5	1.5	0.5	0.5	1.2	1.2	N/A	6.3	0.9
12 NOV 90	2.0	2.0	2.3	2.0	2.0	2.7	>46.7	7.0	2.2
18 DEC 90	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15 JAN 91	3.8	3.0	3.4	3.0	2.7	3.5	74.7	8.9	3.2
12 FEB 91	1.7	<.3	<.3	<.3	<.3	2.6	16.7	12.0	0.7
12 MAR 91	6.7	8.7	6.7	8.0	6.7	8.4	45.0	18.7	7.5
09 APR 91	3.3	3.3	4.7	3.3	3.3	4.0	N/A	14.0	3.7
08 MAY 91	3.0	3.3	5.7	2.7	2.0	3.0	100.0	12.0	3.3
21 MAY 91	4.7	5.0	5.3	4.7	5.7	6.0	220.0	14.0	5.2
04 JUN 91	3.7	4.7	8.7	7.3	8.7	4.4	80.0	16.7	6.3
18 JUN 91	2.3	2.7	6.0	5.3	6.0	3.3	120.0	10.7	4.3
02 JUL 91	2.7	0.7	2.7	2.7	2.7	3.3	40.0	N/A	2.5
16 JUL 91	2.7	0.7	2.0	6.7	2.0	3.0	80.0	10.7	2.9
30 JUL 91	3.3	2.0	4.0	3.3	4.0	3.3	120.0	20.0	3.3
13 AUG 91	1.3	2.3	1.3	0.7	1.7	1.7	60.0	N/A	1.5
27 AUG 91	3.2	4.0	3.3	4.7	6.0	4.0	120.0	15.3	4.2
10 SEP 91	3.0	1.3	2.0	1.3	<.3	1.4	40.0	20.0	1.5
24 SEP 91	5.0	6.0	4.7	4.0	4.0	6.0	20.0	11.3	5.0
WY 91 MEAN	3.1	3.1	3.7	3.5	3.3	3.6	81.2	13.2	3.4
STUDY MEAN	2.9	3.2	3.7	3.6	3.5	3.7	N/A	13.6	3.4

Table 17. Ultimate Biochemical Oxygen Demand (mg/l) among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

Sample Date	STATION	5 Day	10 Day	15 Day	20 Day	27 Day	35 Day	45 Day
20 AUG 90	1	3.3	N/A	N/A	7.2	N/A	N/A	12.0
20 AUG 90	6	4.0	N/A	N/A	9.2	N/A	N/A	11.7
03 SEP 90	1	1.8	N/A	N/A	4.8	N/A	N/A	24.0
03 SEP 90	6	4.2	N/A	N/A	9.5	N/A	N/A	27.3
17 SEP 90	1	3.0	N/A	N/A	5.7	7.7	9.3	N/A
17 SEP 90	6	4.3	N/A	N/A	9.2	10.0	11.5	N/A
01 OCT 90	1	3.7	4.0	N/A	N/A	N/A	7.8	8.3
01 OCT 90	6	4.3	5.0	N/A	N/A	N/A	9.8	10.8
15 OCT 90	1	1.5	N/A	3.0	3.2	3.8	N/A	N/A
15 OCT 90	6	2.8	N/A	5.3	5.2	7.2	N/A	N/A
29 0CT 90	1	0.5	0.0	0.3	0.0	2.0	N/A	N/A
29 0CT 90	2	1.5	2.0	3.0	2.7	4.0	N/A	N/A
29 0CT 90	3	0.5	2.0	1.7	2.7	4.0	N/A	N/A
29 0CT 90	4	0.5	2.0	2.3	2.7	4.0	N/A	N/A
29 0CT 90	5	1.2	2.0	2.3	4.0	5.3	N/A	N/A
29 0CT 90	6	1.2	2.7	3.7	4.0	4.7	N/A	N/A
29 0CT 90	PFWWTP	6.3	9.7	11.0	14.3	16.3	N/A	N/A
12 NOV 90		N/A	N/A	N/A	N/A	N/A	N/A	N/A
18 DEC 90	1	N/A	N/A	N/A	N/A	8.4	8.0	8.6
18 DEC 90	2	N/A	N/A	N/A	N/A	7.7	8.0	8.0
18 DEC 90	3	N/A	N/A	N/A	N/A	8.7	8.7	9.0
18 DEC 90	4	N/A	N/A	N/A	N/A	2.7	4.0	4.0
18 DEC 90	5	N/A	N/A	N/A	N/A	9.3	9.3	9.7
18 DEC 90	6	N/A	N/A	N/A	N/A	9.7	10.2	10.4
18 DEC 90	CDAWWTP	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18 DEC 90	PFWWTP	N/A	N/A	N/A	N/A	28.4	30.7	30.4
15 JAN 91		N/A	N/A	N/A	N/A	N/A	N/A	N/A
12 FEB 91	1	1.7	2.7	5.0	6.3	6.3	6.3	6.7
12 FEB 91	6	3.0	5.3	6.3	7.0	7.0	7.0	7.0
12 FEB 91	CDAWWTP	16.7	46.7	70.0	110.0	283.3	286.7	286.7
12 FEB 91	PFWWTP	12.0	22.0	26.7	30.0	32.7	36.7	37.3
12 MAR 91	1	6.7	14.4	15.3	12.4	12.4	12.0	13.0
12 MAR 91	6	8.4	15.0	18.0	16.3	16.7	15.7	15.7
12 MAR 91	CDAWWTP	45.0	>270	N/A	N/A	N/A	N/A	N/A
12 MAR 91	PFWWTP	18.7	24.7	28.0	35.3	39.3	41.3	42.7
09 APR 91	1	3.3	14.0	25.3	26.7	28.7	28.7	29.3
09 APR 91	2	3.3	14.0	26.0	26.7	29.3	30.0	30.7
09 APR 91	3	4.7	14.0	26.0	27.3	30.0	30.0	30.7
09 APR 91	4	3.3	13.3	26.0	27.3	25.3	24.7	25.3

Table 17. (cont.)

Sample Date	STATION	5 Day	10 Day	15 Day	20 Day	27 Day	35 Day	45 Day
09 APR 91	5	3.3	12.0	22.7	27.3	26.0	26.0	26.0
09 APR 91	6	4.0	17.3	25.3	30.7	30.0	31.3	31.3
09 APR 91	CDAWWTP	N/A	380.0	520.0	520.0	500.0	490.0	500.0
09 APR 91	PFWWTP	14.0	19.3	22.0	24.0	28.7	28.0	30.0
07 MAY 91	1	3.0	4.3	6.3	8.3	10.0	11.0	11.7
07 MAY 91	2	3.3	4.7	8.7	10.3	12.0	12.7	13.0
07 MAY 91	3	5.7	6.3	7.0	9.7	11.0	12.3	13.0
07 MAY 91	4	2.7	3.3	7.0	8.7	10.3	11.0	11.7
07 MAY 91	5	2.0	3.3	7.3	8.0	10.7	11.3	12.7
07 MAY 91	6	3.0	6.0	7.7	9.0	10.7	12.0	13.0
07 MAY 91	CDAWWTP	100.0	120.0	200.0	420.0	660.0	740.0	740.0
07 MAY 91	PFWWTP	12.0	16.0	18.7	22.7	26.7	28.0	30.0
21 MAY 91	1	4.7	6.0	8.3	10.0	10.7	11.0	11.7
21 MAY 91	6	6.0	6.7	8.3	10.0	11.0	12.3	12.3
21 MAY 91	CDAWWTP	220.0	600.0	900.0	960.0	1000.0	1020.0	1020.0
21 MAY 91	PFWWTP	14.0	26.0	30.7	33.3	34.7	36.7	38.0
04 JUN 91	1	3.7	5.3	6.0	6.7	8.0	9.0	9.0
04 JUN 91	6	4.4	6.0	7.7	7.7	8.2	8.3	8.3
04 JUN 91	CDAWWTP	80.0	160.0	200.0	560.0	660.0	780.0	800.0
04 JUN 91	PFWWTP	16.7	28.0	34.0	36.7	38.7	42.0	42.7
18 JUN 91	1	2.3	3.7	4.7	5.0	6.3	6.7	7.3
18 JUN 91	6	3.3	4.0	5.3	6.7	6.7	8.3	8.7
18 JUN 91	CDAWWTP	120.0	340.0	430.0	440.0	450.0	430.0	380.0
18 JUN 91	PFWWTP	10.7	27.3	33.3	38.7	41.3	44.0	45.3
02 JUL 91	1	2.7	2.7	3.0	4.7	5.3	5.7	5.7
02 JUL 91	6	3.3	3.7	4.0	5.3	7.0	7.0	7.3
02 JUL 91	CDAWWTP	40.0	60.0	160.0	540.0	680.0	700.0	700.0
02 JUL 91	PFWWTP	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16 JUL 91	1	2.7	3.0	3.3	4.3	4.7	5.7	5.7
16 JUL 91	6	3.0	5.0	6.0	7.0	7.7	8.3	8.3
16 JUL 91	CDAWWTP	80.0	280.0	380.0	540.0	660.0	660.0	660.0
16 JUL 91	PFWWTP	10.7	17.3	23.3	28.7	32.7	36.0	37.3
30 JUL 91	1	3.3	3.0	5.7	6.0	4.0	5.7	6.0
30 JUL 91	6	3.3	5.7	5.7	6.3	6.7	7.0	7.0
30 JUL 91	CDAWWTP	120.0	300.0	360.0	660.0	660.0	660.0	660.0
30 JUL 91	PFWWTP	20.0	39.3	>41.3	N/A	N/A	N/A	N/A
13 AUG 91	1	1.3	2.0	2.7	3.7	5.0	5.7	6.0
13 AUG 91	6	1.7	2.7	3.3	3.7	4.7	5.0	5.7
13 AUG 91	CDAWWTP	60.0	140.0	360.0	560.0	660.0	660.0	700.0

Table 17. (cont.)

Sample Date	STATION	5 Day	10 Day	15 Day	20 Day	27 Day	35 Day	45 Day
13 AUG 91	PFWWTP	N/A	N/A	N/A	N/A	N/A	N/A	N/A
27 AUG 91	1	3.2	2.7	3.3	3.7	5.7	7.3	N/A
27 AUG 91	6	4.0	3.3	4.7	6.0	6.7	8.3	N/A
27 AUG 91	CDAWWTP	120.0	300.0	560.0	620.0	680.0	700.0	N/A
27 AUG 91	PFWWTP	15.3	24.0	28.7	31.3	33.3	35.3	N/A
10 SEP 91	1	3.0	2.8	3.3	4.3	N/A	N/A	N/A
10 SEP 91	6	1.4	4.3	6.0	7.7	N/A	N/A	N/A
10 SEP 91	CDAWWTP	40.0	400.0	480.0	640.0	N/A	N/A	N/A
10 SEP 91	PFWWTP	20.0	N/A	N/A	N/A	N/A	N/A	N/A
24 SEP 91	1	5.0	N/A	N/A	N/A	N/A	N/A	N/A
24 SEP 91	6	6.0	N/A	N/A	N/A	N/A	N/A	N/A
24 SEP 91	CDAWWTP	20.0	N/A	N/A	N/A	N/A	N/A	N/A
24 SEP 91	PFWWTP	11.3	N/A	N/A	N/A	N/A	N/A	N/A
WY 91 MEAN	1	3.1	4.7	6.4	7.0	8.1	9.4	10.1
	6	3.6	6.1	8.0	8.8	9.5	9.4	11.2
	CDAWWTP	81.2	260.6	385.0	547.5	626.6	647.9	644.7
	PFWWTP	13.2	23.1	25.6	29.5	32.1	35.9	37.1

Table 18. Fecal coliform bacterial counts (#/100ml) among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	Sta. 6 (RM 100.7)	CDAWWTP	PFWWTP	RIVER MEDIAN
29 JUN 90	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
09 JUL 90	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23 JUL 90	220	>60	>60	23	>60	200	N/A	N/A	200
06 AUG 90	1	<1	<1	1	<1	30	>600	CG	1
20 AUG 90	80	>60	180	36	49	160	N/A	N/A	80
03 SEP 90	3	3	10	2	2	<10	730	<1	3
17 SEP 90	1	11	7	10	12	32	42	54	11
01 OCT 90	<1	5	<1	5	3	1	<1	40	3
15 OCT 90	4	11	3	5	10	6	>600	21	6
29 OCT 90	<1	<1	<1	<1	<1	<1	240	1	<1
12 NOV 90	<1	<1	<1	<1	9	<1	<1	75	<1
18 DEC 90	<1	<1	2	<1	20	<1	>600	21	<1
15 JAN 91	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12 FEB 91	1	7	3	2	5	1	10	340	3
12 MAR 91	20	>60	N/A	11	8	2	>600	>600	11
09 APR 91	4	6	2	7	8	17	1620	253	7
07 MAY 91	<1	<1	<1	<1	<1	1	N/A	<1	<1
21 MAY 91	<1	<1	<1	1	<1	<1	<1	10	<1
04 JUN 91	2	3	<1	<1	2	4	320	140	2
18 JUN 91	<1	<1	<1	1	<1	2	30	12	<1
02 JUL 91	<1	1	<1	<1	1	<1	30	N/A	<1
16 JUL 91	1	10	18	<1	4	3	35	180	4
30 JUL 91	1	<1	<1	<1	<1	<1	5	175	<1
13 AUG 91	<1	2	<1	<1	<1	3	227	N/A	<1
27 AUG 91	<1	2	6	<1	4	5	<1	24	4
10 SEP 91	<1	<1	<1	<1	<1	4	16	<1	<1
24 SEP 91	<1	1	<1	<1	3	5	8	4	1
WY 91 MEDIAN	1	35	2	<1	1	3	35	40	2
STUDY MEDIAN	<1	30	1	<1	<1	3	30	24	1

Table 19. Fecal streptococcus bacterial counts (#/100ml) among sampled stations of the Spokane River during the June 29, 1990 to September 24, 1991 sample period.

Sample Date	Sta. 1 (RM 111.1)	Sta. 2 (RM 108.8)	Sta. 3 (RM 106.2)	Sta. 4 (RM 103.5)	Sta. 5 (RM 102.5)	Sta. 6 (RM 100.7)	CDAWWTP	PFWWTP	RIVER MEDIAN
29 JUN 90	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
09 JUL 90	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23 JUL 90	>1000	>100	>100	>100	>100	180	N/A	N/A	>100
06 AUG 90	3	<1	<1	<10	<1	1000	700	26	3
20 AUG 90	71	56	29	28	3	2000	N/A	N/A	56
03 SEP 90	<1	<1	<1	<1	<1	<1	110	<1	<1
17 SEP 90	14	13	11	1	6	11	2	20	11
01 OCT 90	72	31	42	16	<1	8	7	15	31
15 OCT 90	8	81	19	10	10	2	33	3	10
29 OCT 90	N/A	129	6	71	3	238	50	3	71
12 NOV 90	13	26	16	20	<1	8	40	21	16
18 DEC 90	5	3	6	7	6	2	190	13	6
15 JAN 91	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12 FEB 91	1	7	3	4	2	2	20	20	3
12 MAR 91	3	70	N/A	1	1	<1	240	130	1
09 APR 91	6	3	6	6	10	28	570	203	6
07 MAY 91	<1	<1	4	5	2	3	N/A	1	3
21 MAY 91	<1	1	<1	1	2	2	70	<1	1
04 JUN 91	1	1	<1	2	2	4	<1	110	2
18 JUN 91	<1	1	4	1	1	1	20	110	1
02 JUL 91	3	1	2	1	2	5	10	N/A	2
16 JUL 91	7	15	2	3	9	10	50	165	9
30 JUL 91	3	4	<1	<1	<1	8	<1	<1	3
13 AUG 91	3	6	5	1	<1	12	3	N/A	5
27 AUG 91	<1	<1	3	<1	<1	3	<1	4	<1
10 SEP 91	5	3	2	1	<1	9	4	4	3
24 SEP 91	2	<1	<1	1	<1	3	4	4	1
WY 91 MEDIAN	3	4	4	3	2	8	20	15	4
STUDY MEDIAN	3	3	4	2	2	4	20	13	3

Table 20. Post Falls and Coeur D'Alene Wastewater Treatment Plant monthly mean values for selected parameters of treated effluent during the June 29, 1990 to September 24, 1991 Spokane River study period. (Data submitted by the respective WWTP.)

POST FALLS WWTP

DATE	FLOW (MGD)	TEMP (C)	pH	TURB. (NTU)	D.O. (mg/l)	5d BOD (mg/l)	F.C. (#/100ml)	T.P. (mg/l)	NH3-N (mg/l)	RES. CHLOR. (mg/l)
6/90	0.76	20.0	6.8	N/A	6.3	2.7	1.0	5.8	0.98	0.33
7/90	0.78	23.0	6.8	N/A	6.4	1.5	1.0	4.6	0.28	0.34
8/90	0.82	24.0	6.8	N/A	6.4	1.4	1.0	5.1	<0.05	0.26
9/90	0.83	23.0	6.8	N/A	6.6	1.6	2.0	4.4	0.56	0.26
10/90	0.80	18.0	6.8	N/A	6.8	2.0	21.0	4.5	0.56	0.33
11/90	0.78	15.0	6.7	N/A	7.7	3.7	98.0	4.7	0.53	0.28
12/90	0.78	12.0	6.6	N/A	8.3	4.2	1.0	4.6	0.15	0.32
1/91	0.80	12.0	6.5	N/A	8.1	5.0	54.0	4.5	0.08	0.30
2/91	0.79	13.0	6.9	N/A	8.0	5.0	33.0	4.7	0.08	0.29
3/91	0.78	13.0	6.9	N/A	8.4	5.6	85.0	4.7	0.15	0.24
4/91	0.83	15.0	7.1	N/A	7.6	4.1	9.0	4.4	0.25	0.22
5/91	0.86	17.0	7.1	N/A	7.5	3.6	36.0	3.5	N/A	0.23
6/91	0.86	19.0	7.1	N/A	7.4	4.3	116.0	4.8	0.30	0.23
7/91	0.86	22.0	6.9	N/A	6.4	6.5	>16.5	3.9	0.10	0.19
8/91	0.86	23.0	7.2	N/A	6.8	3.9	11.0	4.4	0.60	0.22
9/91	1.00	21.0	7.1	N/A	6.4	5.5	21.0	4.4	14.50	0.38

COEUR D'ALENE WWTP

DATE	FLOW (MGD)	TEMP. (C)	pH	TURB. (NTU)	D.O. (mg/l)	5d BOD (mg/l)	F.C. (#/100ml)	T.P. (mg/l)	NH3-N (mg/l)	RES. CHLOR. (mg/l)
6/90	3.13	N/A	6.9	6.9	4.4	9.0	1.7	5.8	20.44	0.44
7/90	3.49	N/A	7.0	7.9	2.6	18.0	7.5	5.0	21.50	0.17
8/90	3.35	N/A	6.9	7.8	2.1	23.0	32.0	4.8	23.05	0.22
9/90	3.15	N/A	6.9	6.5	3.2	15.0	1.8	5.1	21.53	0.20
10/90	3.12	N/A	7.0	12.2	4.8	13.0	<1	4.7	18.57	0.23
11/90	3.04	N/A	6.9	14.0	3.5	14.0	2.6	4.6	19.64	0.04
12/90	3.16	N/A	7.0	14.7	4.3	16.0	3.9	4.9	23.00	0.25
1/91	3.53	N/A	6.9	14.0	3.2	19.0	1.0	4.7	20.58	0.10
2/91	3.64	N/A	6.8	15.2	2.6	14.0	1.1	5.1	21.87	0.06
3/91	2.88	N/A	N/A	N/A	N/A	15.8	N/A	5.1	21.45	0.03
4/91	2.88	N/A	6.7	19.6	2.9	19.7	4072.0	4.9	24.55	0.09
5/91	2.87	N/A	6.7	16.4	2.6	15.8	1.9	4.3	22.27	0.05
6/91	2.98	N/A	6.6	N/A	4.9	15.7	1.1	1.2	21.39	0.03
7/91	3.21	N/A	6.4	N/A	4.9	6.1	1.3	1.0	19.71	0.07
8/91	3.34	N/A	6.3	N/A	4.4	7.0	7.8	0.8	19.34	0.07
9/91	2.60	N/A	6.4	N/A	4.3	8.2	2.1	0.9	14.21	0.05

Table 21. Spokane River Citizen Volunteer Monitoring Program (CVMP) water quality data, at Cedars, Harbor Island, and Post Falls Bridge, May 1988 to August, 1991.

CEDARS

DATE	SECCHI (m)	MEAN TEMP. (C)	MEAN D.O. (mg/l)	NH3-N (mg/l)	NO2 + NO3 (mg/l)	TKN (mg/l)	TP (mg/l)	OP (mg/l)	EC (umhos)	CHLOR. a (ug/l)	N:P
25 MAY 88	2.8	12.8	12.0	0.013	0.014	0.11	0.011	N/A	52	N/A	11.3:1
27 JUN 88	2.8	20.5	4.0	0.014	0.008	0.13	0.009	0.001	45	1.1	15.3:1
19 JUL 88	2.8	20.5	8.0	0.050	0.018	0.05	0.008	0.001	48	1.1	8.5:1
23 AUG 88	2.6	20.0	7.5	0.007	0.020	0.09	0.009	0.002	51	1.7	12.2:1
27 SEP 88	2.5	16.0	8.0	0.018	0.020	0.12	0.007	0.002	51	1.0	20.0:1
18 OCT 88	N/A	N/A	N/A	0.007	0.012	0.13	0.008	0.001	54	0.7	17.8:1
02 MAY 89	2.0	8.0	8.0	0.020	0.005	0.18	0.013	0.001	N/A	4.4	14.2:1
13 JUN 89	2.8	19.0	9.0	0.071	0.022	0.03	0.013	0.003	N/A	1.3	3.6:1
18 JUL 89	2.8	20.0	8.0	0.020	0.002	0.14	0.008	0.002	N/A	0.6	17.8:1
28 AUG 89	2.6	19.0	9.0	0.018	0.001	0.12	0.007	0.001	N/A	2.0	17.3:1
11 SEP 89	2.6	15.0	9.0	0.042	0.001	0.11	0.008	0.003	N/A	2.0	13.9:1
10 OCT 89	2.2	15.0	10.0	0.093	0.042	0.18	0.008	0.003	N/A	1.8	27.8:1
12 JUN 90	2.5	11.0	8.0	0.003	0.003	0.08	0.009	0.001	N/A	3.5	9.2:1
24 JUL 90	2.8	21.0	9.0	0.005	0.003	0.12	0.010	0.001	N/A	1.1	12.3:1
28 AUG 90	2.8	19.0	8.0	0.114	0.003	0.07	0.007	0.001	N/A	1.3	10.4:1
16 OCT 90	2.3	11.5	8.5	0.094	0.007	0.25	0.014	0.001	N/A	2.1	18.3:1
02 JUL 91	N/A	N/A	N/A	0.033	0.005	0.37	0.006	0.002	N/A	0.8	N/A
13 AUG 91	N/A	N/A	N/A	0.027	0.005	0.13	0.006	0.002	N/A	0.5	N/A

HARBOR ISLAND

DATE	SECCHI (m)	MEAN TEMP. (C)	MEAN D.O. (mg/l)	NH3-N (mg/l)	NO2 + NO3 (mg/l)	TKN (mg/l)	TP (mg/l)	OP (mg/l)	EC (umhos)	CHLOR. a (ug/l)	N:P
25 MAY 88	3.3	13.3	12.0	0.011	0.019	0.14	0.014	0.001	50	N/A	11.3:1
27 JUN 88	3.8	20.5	9.0	0.027	0.017	0.13	0.017	0.007	46	1.6	8.6:1
19 JUL 88	3.3	21.0	7.5	0.045	0.009	0.12	0.018	0.003	50	1.7	7.2:1
23 AUG 88	2.8	21.0	6.0	0.026	0.027	0.19	0.037	0.022	55	6.5	5.9:1
27 SEP 88	4.5	15.0	8.5	0.053	0.036	0.17	0.029	0.017	53	0.8	7.1:1
18 OCT 88	N/A	N/A	N/A	0.024	0.025	0.13	0.020	0.013	56	0.6	7.8:1
13 JUN 89	4.5	19.0	9.0	0.035	0.011	0.03	0.016	0.002	N/A	1.2	2.3:1
18 JUL 89	3.3	21.0	7.3	0.043	0.004	0.15	0.019	0.011	N/A	1.2	8.1:1
28 AUG 89	5.8	19.0	8.0	0.054	0.050	0.22	0.030	0.006	N/A	3.0	9.0:1
11 SEP 89	4.0	16.0	9.0	0.070	0.007	0.09	0.021	0.007	N/A	3.0	4.6:1
10 OCT 89	4.5	15.0	8.5	0.187	0.033	0.13	0.020	0.010	N/A	1.8	8.2:1
24 JUL 90	6.3	23.5	6.5	0.040	0.003	0.24	0.019	0.008	N/A	1.4	12.7:1
28 AUG 90	5.3	19.9	7.5	0.107	0.003	0.07	0.025	0.006	N/A	3.9	2.9:1
16 OCT 90	5.3	11.5	7.8	0.129	0.013	0.21	0.028	0.009	N/A	1.2	8.0:1
02 JUL 91	N/A	N/A	N/A	0.029	0.029	0.19	0.002	0.002	N/A	1.0	N/A
13 AUG 91	N/A	N/A	N/A	0.045	0.010	0.30	0.006	0.003	N/A	1.0	N/A

POST FALLS BRIDGE

DATE	SECCHI (m)	MEAN TEMP. (C)	MEAN D.O. (mg/l)	NH3-N (mg/l)	NO2 + NO3 (mg/l)	TKN (mg/l)	TP (mg/l)	OP (mg/l)	EC (umhos)	CHLOR. a (ug/l)	N:P
25 MAY 88	3.3	13.7	13.0	0.013	0.017	0.14	0.014	N/A	N/A	N/A	11.2:1
27 JUN 88	3.5	20.4	5.0	0.019	0.021	0.12	0.016	0.005	48	2.6	8.8:1
19 JUL 88	2.8	21.8	9.0	0.028	0.003	0.13	0.017	0.002	50	3.4	7.8:1
23 AUG 88	4.8	22.0	9.0	0.010	0.016	0.12	0.028	0.010	55	3.1	4.9:1
27 SEP 88	4.8	15.0	8.0	0.035	0.033	0.16	0.027	0.017	54	2.4	7.1:1
18 OCT 88	N/A	N/A	N/A	0.024	0.018	0.16	0.023	0.014	56	0.9	7.7:1
13 JUN 89	3.3	19.0	7.0	0.037	0.004	0.03	0.015	0.003	N/A	2.4	1.9:1
18 JUL 89	3.5	21.0	6.5	0.021	0.005	0.15	0.018	0.009	N/A	1.7	8.6:1
28 AUG 89	5.8	19.0	8.0	0.020	0.011	0.18	0.015	0.001	N/A	4.0	12.7:1
11 SEP 89	3.3	17.0	9.0	0.034	0.001	0.09	0.024	0.007	N/A	6.0	3.8:1
10 OCT 89	4.5	15.0	8.0	0.021	0.005	0.12	0.014	0.007	N/A	2.6	8.9:1
24 JUL 90	5.5	23.5	6.0	0.007	0.003	0.30	0.016	0.003	N/A		20.6:1
28 AUG 90	5.5	20.0	8.0	0.038	0.003	0.07	0.017	0.003	N/A	4.8	4.3:1
16 OCT 90	5.3	11.1	7.8	0.098	0.013	0.25	0.019	0.007	N/A	2.1	13.8:1
02 JUL 91	N/A	N/A	N/A	0.050	0.008	0.55	0.007	0.002	N/A	1.0	N/A
13 AUG 91	N/A	N/A	N/A	0.033	0.011	0.23	0.008	0.002	N/A	2.1	N/A

Table 22. August 13, 1991, water quality profiles at Cedars, Harbor Island, and Post Falls Bridge, collected by the Spokane River CVMP.

STATION	DEPTH (m)	D.O. (mg/l)	TEMP. (C)	EC (umhos)	pH
CEDARS	0	7.3	23.3	44	6.3
CEDARS	1	7.2	22.2	44	6.3
CEDARS	2	7.3	22.2	44	6.4
CEDARS	2.75	7.3	22.2	44	6.4
HARBOR IS.	0	7.4	22.7	46	6.1
HARBOR IS.	1	7.3	22.6	46	6.3
HARBOR IS.	2	7.3	22.5	46	6.3
HARBOR IS.	3	7.0	22.5	46	6.3
HARBOR IS.	4	6.9	22.5	46	6.3
HARBOR IS.	5	6.9	22.5	46	6.3
P.F. BRIDGE	0	7.2	22.9	46	6.2
P.F. BRIDGE	1	7.9	22.9	46	6.4
P.F. BRIDGE	2	7.8	22.9	46	6.4
P.F. BRIDGE	3	7.6	22.9	46	6.4
P.F. BRIDGE	4	7.5	22.8	46	6.3
P.F. BRIDGE	5	7.3	22.8	45	6.4
P.F. BRIDGE	6	7.3	22.8	45	6.4
P.F. BRIDGE	7	7.3	22.8	45	6.4
P.F. BRIDGE	8	7.3	22.7	45	6.4
P.F. BRIDGE	8.75	7.3	22.7	45	6.4

APPENDIX A

APPENDIX TABLES A-1...4

Tables of Physical /Chemical Profiles and Diel Study

Table A-1 Temperature (C) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 100.7 to 111.1, 1991.

	DEPTH	RM 111.1			RM 108.8			RM 106.2			RM 103.5			RM 102.5			RM 100.7		
DATE	(m)	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L
18DEC90	0	6.2	6.0	5.8	6.1	6.1	6.0	6.0	6.0	5.6	5.8	5.8	5.7	5.6	5.7	5.6	5.4	5.4	5.3
	1	6.2	6.0	6.1	6.2	6.2	6.0	6.1	6.0	5.6	5.8	5.8	5.7	5.7	5.7	5.8	5.4	5.3	5.3
	2	6.2	6.0	(1.2)6.1	6.3	6.2	6.0	6.1	6.1	(1.6)5.7	3.8	5.8	5.7	5.7	5.7	5.8	(1.3)5.3	(1.6)5.3	(1.1)5.3
	3	(2.4)6.2	(2.8)6		6.2	6.2	(2.3)6	6.1	6.1		5.9	5.8	(2.2)5.7	5.7	5.7	5.8			
	4					(3.8)6.2		6.1	6.1		5.9	5.8		5.7	5.7				
	5							6.1	6.1		5.8	5.9		5.7					
	6							(5.3)6.1	(5.5)6.1		5.8	5.9		5.8					
	7										5.9	5.9		5.7					
	8										5.9	(7.7)5.9		5.8					
	9										5.9			(8.5)5.7					
											(9.7)5.9								
15JAN91	0	3.3	3.3	3.5	3.1	3.4	3.4	3.0	3.1	3.1	3.0	3.0	3.1	2.8	3.0	2.9	2.1	2.0	2.0
	1	3.3	3.3	(0.9)3.4	3.4	3.3	3.4	3.0	3.1	3.0	2.9	3.0	3.0	2.7	2.9	2.9	2.1	2.0	1.9
	2	(1.8)3.4	(1.9)3.3		3.3	3.4	3.4	3.0	3.0	(1.7)3.1	2.9	3.0	(1.6)3	2.7	2.9	(1.8)2.9	(1.9)2.1	2.0	(1.3)1.9
	3				(2.4)3.3	3.4	(2.6)3.4	3.0	3.0		2.9	3.0		2.7	(2.4)2.9			(2.3)2.1	
	4							3.0	3.1		2.9	3.0		2.7					
	5							(4.7)3	(4.1)3.1		2.8	(4.2)3		2.7					
	6										2.9			2.7					
	7										2.8			2.7					
	8										2.9			(7.2)2.7					
											(8.8)2.9								
12FEB91	0	2.1	2.1	2.2	2.2	2.2	2.4	2.2	2.1	2.1	2.0	2.2	2.2	2.1	2.1	2.2	1.9	1.9	1.9
	1	2.1	2.1	2.2	2.2	2.1	2.5	2.1	2.2	2.1	2.0	2.1	2.2	2.0	2.1	2.2	1.9	1.9	1.8
	2	2.1	2.1	(1.2)2.2	2.2	2.2	2.4	2.1	2.2	(1.2)2.1	2.0	2.1	(1.5)2.2	2.0	2.1	2.2	(1.1)1.9	1.9	(1.5)1.9
	3				(2.9)2.2	(2.8)2.2	(2.9)2.5	2.1	2.1		2.1	2.1		2.0	2.1			(2.1)1.9	
	4							2.1	2.1		2.0	2.1		2.0	2.1				
	5							(4.8)2.1	(4.2)2.1		2.0	2.1		1.9					
	6										2.0	2.1		1.9					
	7										2.0	2.2		1.9					
	8										2.0	(7.1)2.2		(7.3)1.9					
12MAR91	0	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.1	2.2	2.1	2.2	2.2	2.2	2.2	2.1	2.2	2.2
	1	2.2	2.2	2.2	2.2	2.2	2.2	2.1	2.2	2.2	2.2	2.1	2.2	2.2	2.2	2.2	2.1	2.1	2.1
	2	2.3	2.2	(1.2)2.2	2.2	2.2	(1.5)2.2	2.1	2.1	(1.4)2.2	2.2	2.2	(1.2)2.2	2.2	2.2	(1.7)2.2	2.1	2.2	(1.9)2.2
	3	(2.1)2.3	(2.2)2.2		(2.2)2.2	(2.8)2.2		2.2	(3.1)2.1		2.2	2.2		2.2	(2.9)2.2		(2.1)2.1	(2.6)2.2	
	4							2.2			2.2	(4.2)2.2		2.2					
	5							(4.2)2.2			2.2			2.2					
	6										2.2			2.2					
	7										2.2			2.2					
	8										2.2			2.2					
											(8.1)2.2								
9APR91	0	3.8	3.7	3.8	3.9	3.8	3.9	4.0	4.0	4.0	4.0	3.9	3.9	3.8	3.8	3.8	3.9	3.9	3.8
	1	3.8	3.7	3.8	3.9	3.9	3.9	4.0	4.0	4.0	4.0	3.9	3.9	3.8	3.8	3.9	3.9	3.9	3.8
	2	3.7	3.7	(1.7)3.8	3.9	3.9	(1.4)3.9	4.0	4.0	(1.5)4	3.9	3.9	(1.8)3.9	3.8	3.8	(1.6)3.8	3.9	3.9	(1.9)3.8
	3	(2.1)3.7			3.9	3.9		4.0	4.0		3.9	3.9		3.8	(2.2)3.8		(2.1)3.9	(2.5)3.9	
	4				(3.2)3.8	(3.4)3.8		3.9	4.0		3.9	3.9		3.8					
	5							3.9			3.9	3.9		3.8					
	6							(5.4)3.9			3.9	3.9		3.8					
	7										3.9	(6.7)3.9		3.8					
	8										3.9								
											(8.6)3.9								

Table A-1 (continued) Temperature (C) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 100.7 to 111.1, 1991.

	DEPTH	RM 111.1			RM 108.8			RM 106.2			RM 103.5			RM 102.5			RM 100.7		
DATE	(m)	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L
8MAY91	0	8.2	8.2	8.3	8.3	8.3	8.3	8.8	8.8	8.6	9.0	8.9	8.9	8.8	8.8	8.8	9.0	8.9	8.8
	1	8.2	8.2	8.3	8.4	8.3	8.4	8.8	8.7	8.6	9.0	9.0	9.0	8.8	8.8	8.8	8.9	8.9	8.8
	2	8.2	8.3	(1.2)8.3	8.4	8.3	8.4	8.9	8.7	(1.8)8.6	9.0	9.0	(1.2)9	8.9	8.8	(1.4)8.9	8.9	8.9	(1.9)8.9
	3	(2.8)8.2	8.3		(2.4)8.4	8.3	(2.9)8.4	8.9	8.6		9.0	9.0		8.9	(2.6)8.8		(2.1)8.9	(2.8)8.9	
	4		(3.2)8.3			8.3		(3.6)8.9	8.7		9.0	(3.9)9		8.8					
	5					8.3			8.7		9.0			8.9					
	6								(5.1)8.7		9.0			(5.1)8.9					
	7										9.0								
	8										9.0								
	9										9.0								
	10										9.0								
21MAY91	0	10.3	10.3	10.1	10.7	10.5	10.6	10.5	10.5	10.4	10.5	10.5	10.3	10.6	10.5	9.8	9.3	9.3	9.3
	1	10.3	10.3	10.1	10.7	10.5	10.6	10.5	10.5	10.4	10.5	10.5	10.3	10.6	10.5	9.9	9.3	9.3	9.4
	2	10.3	10.3	10.2	10.6	10.5	10.6	10.4	10.5	10.4	10.5	10.4	10.3	10.6	10.5	10.0	9.3	9.3	9.4
	3	10.2	10.3	10.2	10.6	10.5	(2.9)10.6	10.4	10.5	10.4	10.5	10.4	(2.8)10.3	10.6	10.4	(2.3)10	(2.9)9.3	9.3	(2.2)9.3
	4	(3.8)10.2	10.2	(3.4)10.1	10.6	10.5		10.5	10.5	(3.6)10.4	10.5	10.4		10.6	(3.2)10.4			(3.1)9.3	
	5				(4.2)10.6	(4.6)10.5		10.5	(4.8)10.4		10.5	10.4		10.6					
	6							10.5			10.5	10.4		10.6					
	7										10.6	(6.4)10.3		10.6					
	8										10.5			10.6					
	9										10.6			10.6					
	10										10.6			(9.1)10.6					
											(10.6)10.7								
4JUN91	0	12.3	12.3	12.5	12.8	12.4	12.5	12.8	12.7	13.1	12.8	14.4	12.7	12.2	12.7	12.6	12.3	12.2	12.1
	1	12.3	11.9	12.5	12.8	12.5	12.3	12.7	12.8	13.0	12.8	14.3	12.8	12.2	12.6	12.6	12.3	12.2	12.1
	2	12.3	11.9	(1.6)12.5	12.8	12.5	12.6	12.8	12.7	13.0	12.8	14.3	12.8	12.2	12.6	12.6	(1.5)12.3	12.3	(1.7)12.1
	3	12.3	11.9		12.7	12.5	12.6	12.8	12.7	13.1	12.7	14.3	(2.3)12.8	12.2	12.6	(2.9)12.6		(2.2)12.2	
	4				(3.2)12.7	(3.8)12.5		12.8	12.8	(3.8)13	12.7	14.3		12.2	12.6				
	5							12.8	12.8		12.8	14.3		12.2					
	6							(5.5)12.8	(5.5)12.7		12.8	14.3		12.2					
	7										12.8	14.4		12.2					
	8										12.8	14.4		12.2					
	9										12.8			12.2					
	10										12.8								
											(10.6)12.8								
18JUN91	0	13.3	13.2	13.2	13.6	13.3	13.7	13.9	13.9	14.1	13.7	13.9	13.8	13.7	13.8	13.9	15.0	15.1	15.4
	1	13.2	13.2	13.2	13.5	13.2	13.6	13.9	13.8	14.0	13.7	13.9	13.8	13.4	13.6	13.9	(0.9)15	15.1	15.4
	2	13.2	13.1	13.2	13.5	13.2	13.4	13.9	13.8	14.0	13.6	13.8	13.8	13.3	13.5	13.7		15.1	(1.2)15.4,
	3	(2.8)13.1	13.1	(2.8)13.1	13.5	13.2	13.3	13.9	13.7	14.1	13.6	13.8	13.8	13.3	13.5	13.5		(2.1)15.1	
	4		(3.1)13.1		(3.2)13.5	13.1	(3.2)13.3	13.8	13.7	(3.1)14.1	13.5	13.8	(3.1)13.9	13.3	13.5	(3.5)13.5			
	5					(4.5)13.1		13.8	13.7		13.5	13.9		13.3	(4.1)13.5				
	6							13.8	13.7		13.5	15.8		13.3					
	7								(6.2)13.7		13.4	13.8		13.3					
	8										13.5	13.8		13.3					
	9										13.4	13.8		13.3					
											(9.3)13.4	(9.2)13.8							

Table A-1 (continued) Temperature (C) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 100.7 to 111.1, 1991.

	DEPTH	RM 111.1			RM 108.8			RM 106.2			RM 103.5			RM 102.5			RM 100.7		
DATE	(m)	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L
2JUL91	0	18.0	17.8	17.6	17.8	17.4	17.7	17.3	17.1	17.3	17.3	17.0	16.9	17.6	17.6	17.6	16.8	16.8	16.7
	1	18.0	17.7	17.5	17.8	17.3	17.7	17.2	17.1	17.3	17.2	17.0	16.9	17.5	17.5	17.4	16.8	16.8	16.7
	2	18.0	17.5	17.5	17.8	17.3	17.6	17.2	17.2	17.3	17.2	16.9	16.9	17.5	17.3	17.2	16.8	(1.4)16.8	(1.1)16.7
	3	17.9	17.3	(1.9)17.5	17.7	17.2	17.6	17.2	17.2	17.4	17.1	16.9	16.8	17.4	17.3	17.2			
	4		(3.1)17.3		(3.5)17.7	17.2	17.5	17.2	17.2	(3.1)17.4	17.1	16.9		17.3	17.3	(3.5)17			
	5					(4.2)17.2		17.2	17.2		17.0	16.9		17.3	(4.2)17.3				
	6							17.3	17.2		17.0	16.9		17.3					
	7							(6.1)17.3	(6.2)17.2		17.0	16.9		17.2					
	8										16.9	16.9		17.2					
	9										16.8	(8.4)16.9		17.2					
											(9.4)16.8								
16JUL91	0	20.6	20.8	20.6	20.3	20.5	20.9	20.4	20.3	20.4	20.2	20.6	20.7	20.7	20.8	20.7	21.1	21.0	20.9
	1	20.7	20.7	20.6	20.3	20.5	20.9	20.3	20.3	20.4	20.2	20.6	20.8	20.7	20.8	20.7	21.1	21.0	20.9
	2	20.6	20.7	20.6	20.3	20.6	20.9	20.3	20.3	20.4	20.1	20.5	20.8	20.7	20.7	20.7	(1.9)21.1	(1.4)21	(1.1)20.9
	3	20.7	20.7		20.3	20.6	20.8	20.3	20.3	(2.6)20.4	20.1	20.5	20.8	20.6	20.7	20.6			
	4				(3.5)20.3	20.6	(3.6)20.9	20.3	20.3		20.1	20.5	(3.2)20.8	20.7	20.6	(3.8)20.5			
	5					(4.3)20.6		20.3	20.3		20.1	20.5		20.6	(4.3)20.6				
	6								20.3		20.1	20.5		20.6					
	7								(6.2)20.3		20.1	20.5		20.6					
	8										20.1	20.5		20.6					
	9										(8.7)20.1	(8.7)20.5		20.5					
30JUL91	0	22.1	22.3	22.1	21.7	21.8	22.1	22.3	21.6	22.7	22.4	22.6	22.4	22.9	22.9	23.3	22.7	22.4	22.2
	1	22.0	22.1	22.0	21.5	21.8	22.0	22.1	21.5	22.3	22.3	22.5	22.3	22.7	22.9	23.1	22.7	22.3	(0.5)22.2
	2	21.9	22.0	(1.9)21.9	21.5	21.8	22.0	22.0	21.4	21.9	22.3	22.4	22.2	22.5	22.7	22.7	(1.3)22.8	(1.1)22.4	
	3	21.8	21.9		21.5	21.7	22.0	21.8	21.3	21.8	22.1	22.3	22.1	22.3	22.3	22.4			
	4		(3.2)21.9		(3.4)21.4	21.7	(3.3)21.9	21.7	21.3	(3.6)21.7	21.9	22.0	(3.4)21.9	22.3	22.2	(3.8)22.3			
	5					(4.6)21.7		21.7	21.3		21.7	21.9		22.2	(4.5)22.2				
	6							(5.9)21.6	21.2		21.7	21.9		22.2					
	7								(6.6)21.2		21.6	21.8		22.1					
	8										21.6	21.8		22.1					
	9										21.5	(8.2)21.8		22.0					
	10										21.4								
											(10.5)21.4								
13AUG91	0	22.5	22.5	22.6	22.3	22.3	22.2	22.6	22.8	22.7	22.7	22.7	22.6	23.0	23.0	23.1	23.0	23.1	23.1
	1	22.6	22.4	22.7	22.2	22.2	22.2	22.7	22.8	22.6	22.6	22.6	22.6	23.0	23.0	23.0	23.0	23.1	23.1
	2	22.4	22.4	22.5	22.2	22.2	22.1	22.7	22.7	22.6	22.5	22.6	22.6	23.0	22.9	22.9	(1.9)23	23.1	(1.4)23.1
	3	(2.8)22.5	22.4	(2.1)22.5	22.2	22.2	22.1	22.6	22.6	(2.2)22.6	22.5	22.6	22.6	22.9	22.8	22.8		(2.1)23.1	
	4				(3.2)22.2	22.2		22.6	22.6		22.5	22.6	(3.3)22.5	22.8	22.8	(3.2)22.8			
	5					(4.2)22.2		22.6	22.7		22.5	22.5		22.8	(4.1)22.8				
	6							(5.3)22.6	22.6		22.5	22.4		22.8					
	7								(6.4)22.6		22.5	22.3		22.7					
	8										22.4	22.3		22.7					
	9										22.4	22.3		22.6					
	10										22.4	(9.5)22.3		(9.3)22.6					

Table A-1 (continued) Temperature (C) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 100.7 to 111.1, 1991.

	DEPTH	RM 111.1			RM 108.8			RM 106.2			RM 103.5			RM 102.5			RM 100.7		
DATE	(m)	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L
27AUG91	0	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.2	25.5	26.3	26.3	26.2	26.2	26.4	26.7	26.2	26.3	26.3
	1	25.2	25.2	25.2	25.2	25.2	25.1	25.1	25.2	25.6	26.2	26.3	26.3	26.2	26.3	26.7	26.3	26.3	26.4
	2	25.2	25.2	25.2	25.2	25.2	25.1	25.1	25.2	25.5	26.2	26.3	26.3	26.2	26.3	26.4	(1.8)26.3	26.2	(1.6)26.4
	3	(2.9)25.3	25.3	(2.7)25.2	25.1	25.1	25.1	25.0	25.1	25.4	26.0	26.2	26.3	26.0	26.2	26.3		(2.1)26.2	
	4				(3.6)25.1	25.1	(3.2)25.1	24.9	25.1	25.2	25.9	26.2	(3.5)26.3	25.9	26.1	(3.4)26.2			
	5					(4.3)25.1		24.8	25.0		25.9	26.1		25.9	(4.1)26.1				
	6							24.8	24.9		25.8	26.0		25.7					
	7								(6.3)24.9		25.8	25.9		25.7					
	8										25.8	(7.3)25.9		25.6					
	9										25.8			25.6					
	10										25.3								
											(10.8)24.8								
10SEP91	0	19.6	20.0	20.1	20.4	20.5	19.3	20.5	20.2	20.4	21.0	20.8	21.0	21.4	21.0	21.6	20.6	20.7	20.6
	1	19.5	20.0	20.0	20.1	20.3	18.7	20.3	20.0	20.2	21.0	20.7	20.8	21.0	20.7	21.0	20.6	20.6	20.6
	2	19.4	19.8	19.9	19.8	20.1	18.9	20.0	19.9	19.8	20.5	20.4	20.3	20.6	20.6	20.4	(1.4)20.6	20.6	(1.3)20.7
	3	(2.9)19.4	19.7		19.7	20.0	18.9	19.8	19.7	19.8	20.2	20.2	20.2	20.4	20.4	20.4		(2.1)20.5	
	4		(3.2)19.7		(3.5)19.2	20.0	(3.7)18.9	19.7	19.6	(3.2)19.8	20.1	20.0	(3.2)20.2	20.4	20.4	(3.6)20.4			
	5					(4.4)20		19.6	19.6		20.0	19.9		20.3	(4.9)20.4				
	6							19.5	19.6		20.0	19.8		20.3					
	7							19.5	(6.7)19.6		19.9	19.8		20.2					
	8										19.9	19.8		20.1					
	9										19.8	(8.8)19.7		20.0					
	10										19.9			(9.3)20					
											(10.5)19.9								
24SEP91	0	18.2	18.0	18.0	17.5	17.3	17.8	17.3	17.3	17.1	17.2	17.7	17.6	17.2	17.2	17.8	17.9	17.9	17.8
	1	18.2	17.9	18.0	17.4	17.3	17.6	17.3	17.3	17.0	16.9	17.5	17.4	16.9	17.0	17.7	17.9	17.9	17.8
	2	18.1	17.8	17.9	17.4	17.2	17.5	17.2	17.3	17.0	16.8	17.3	17.2	16.7	16.8	16.8		(1.8)17.9	(1.9)17.8
	3	(2.3)18	(2.9)17.7	(2.2)17.9	17.4	17.1	17.4	17.2	17.2	17.0	16.8	17.1	17.0	16.6	16.7	16.7			
	4				(3.3)17.4	17.1	(3.1)17.4	17.1	17.1	(3.1)17	16.8	16.9	(3.2)16.8	16.4	16.6	(3.2)16.7			
	5					(4.1)17.1		17.1	17.1		16.8	16.8		16.4	(4.1)16.5				
	6							(5.8)17	17.0		16.7	16.8		16.3					
	7										16.6	16.7		16.3					
	8										16.4	16.6		16.3					
	9										16.3	(8.1)16.6		(8.9)16.3					
	10										16.3								
											(10.1)16.3								

Table A-2 Dissolved oxygen (ppm) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 100.7 to 111.1, 1991.

	DEPTH	RM 111.1			RM 108.8			RM 106.2			RM 103.5			RM 102.5			RM 100.7		
DATE	(m	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L
18DEC90	0	10.5	10.6	10.5	10.6	10.5	10.8	10.4	10.6	10.7	10.6	10.7	10.4	10.5	10.5	10.5	12.4	12.4	12.4
	1	10.5	10.6	10.5	10.5	10.5	10.7	10.4	10.7	10.7	10.6	10.6	10.3	10.5	10.5	10.5	12.4	12.4	12.4
	2	10.6	10.6	(1.2)10.7	10.5	10.5	10.6	10.4	10.7	(1.6)10.8	10.6	10.6	10.4	10.5	10.3	10.5	(1.1)12.4	(1.1)12.3	(1.6)12.4
	3	(2.4)10.6	(2.8)10.7		10.6	10.5	(2.3)10.7	10.3	10.6		10.6	10.6	(2.2)10.5	10.5	10.0	10.8			
	4					(3.8)10.6		10.3	10.6		10.6	10.6		10.4	10.1				
	5							10.3	10.6		10.5	10.5		10.4					
	6							(5.3)10.4	(5.5)10.7		10.5	10.5		10.3					
	7										10.5	10.5		10.3					
	8										10.4	(7.7)10.5		10.3					
	9										10.4			(8.5)10.4					
											(9.7)10.5								
15JAN91	0	12.1	12.0	11.8	11.9	11.9	11.7	11.6	11.8	11.8	11.5	11.4	11.6	11.4	11.6	11.4	12.7	12.8	12.7
	1	12.1	12.0	(.9)11.9	11.9	11.9	11.6	11.6	11.8	11.8	11.5	11.4	11.7	11.4	11.7	11.4	12.7	12.8	12.7
	2	(1.8)12.2	(1.9)12.1		11.9	11.9	11.6	11.5	11.7	(1.7)11.9	11.5	11.4	(1.6)11.8	11.4	12.3	(1.8)11.6	(1.9)12.8	12.8	(1.3)12.6
	3				(2.4)12	12.1	(2.8)11.7	11.4	11.7		11.5	11.3		11.4	(2.4)12.3			(2.3)12.8	
	4							11.4	11.7		11.5	11.3		11.3					
	5							(4.7)11.6	(4.1)11.8		11.5	(4.2)11.5		11.3					
	6										11.4			11.3					
	7										11.4			11.0					
	8										11.3			(7.2)11					
											(8.8)11.4								
12FEB91	0	12.6	12.5	12.6	13.0	12.6	13.0	12.8	13.0	12.9	12.8	12.8	12.9	12.5	12.5	12.6	12.9	12.9	12.8
	1	12.6	12.5	12.6	13.0	12.6	12.9	12.7	12.9	12.9	12.7	12.8	13.0	12.4	12.4	12.6	12.8	12.9	12.8
	2	12.7	12.5	(1.2)12.7	3.0	12.6	12.9	12.7	12.8	(1.2)12.9	12.7	12.8	(1.5)12.9	12.4	12.3	12.7	(1.1)12.9	12.9	(1.5)12.8
	3				(2.9)13	(2.8)12.7	(2.9)13.1	12.6	12.8		12.7	12.7		12.4	12.3			(2.1)12.9	
	4							12.6	12.7		12.7	12.7		12.4	12.3				
	5							(4.8)12.7	(4.2)12.8		12.7	12.7		12.4					
	6										12.6	12.7		12.4					
	7										12.7	12.7		12.4					
	8										12.7	(7.1)12.7		(7.3)12.4					
12MAR91	0	12.7	12.8	12.8	12.9	12.8	12.8	12.8	12.8	12.8	12.7	12.7	12.8	12.7	12.8	12.7	13.1	13.0	13.2
	1	12.7	12.8	12.8	12.8	12.7	12.8	12.8	12.8	12.7	12.7	12.8	12.8	12.7	12.8	12.8	13.1	13.0	13.2
	2	12.8	12.8	(1.2)12.8	12.8	12.8	(1.5)12.8	12.8	12.8	(1.4)12.8	12.7	12.8	(1.2)12.8	12.7	12.8	(1.7)12.7	13.0	13.0	(1.9)13.1
	3	(2.1)12.7	(2.2)12.9		(2.2)12.8	(2.8)12.7		12.8	(3.1)12.8		12.7	12.7		12.7	(2.9)12.8		(2.1)13.1	(2.6)13.1	
	4							12.8			12.7	(4.2)12.7		12.7					
	5							(4.2)12.7			12.7			12.7					
	6										12.7			12.7					
	7										12.7			12.7					
	8										12.7			12.7					
											(8.1)12.7								
9APR91	0	12.5	12.5	12.4	12.5	12.4	12.4	12.4	12.4	12.3	12.4	12.5	12.4	12.7	12.5	12.4	12.9	12.8	12.9
	1	12.5	12.5	12.4	12.5	12.5	12.4	12.5	12.4	12.3	12.4	12.5	12.4	12.7	12.4	12.4	12.8	12.8	13.0
	2	12.4	12.4	(1.7)12.4	12.4	12.4	(1.4)12.3	12.4	12.4	(1.5)12.3	12.4	12.6	(1.8)12.4	12.7	12.4	(1.6)12.4	12.9	12.9	(1.9)12.9
	3	(2.1)12.5			12.5	12.4		12.4	12.3		12.4	12.5		12.7	(2.2)12.3		(2.1)12.9	(2.5)12.9	
	4				(3.2)12.4	(3.4)12.4		12.4	12.4		12.5	12.5		12.7					
	5							12.4			12.5	12.5		12.7					
	6							(5.4)12.4			12.4	12.5		12.7					
	7										12.4	(6.7)12.5		12.7					
	8										12.5								

Table A-2 (continued) Dissolved oxygen (ppm) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 100.7 to 111.1, 1991.

	DEPTH	RM 111.1			RM 108.8			RM 106.2			RM 103.5			RM 102.5			RM 100.7		
DATE	(m	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L
8MAY91	0	11.2	11.1	11.1	11.3	11.1	11.2	11.2	11.3	11.2	11.3	11.2	11.3	11.1	11.2	11.1	11.6	11.6	11.5
	1	11.2	11.2	11.1	11.3	11.1	11.3	11.3	11.3	11.2	11.3	11.2	11.2	11.2	11.1	11.1	11.6	11.5	11.5
	2	11.2	11.2	(1.2)11.1	11.3	11.2	11.3	11.3	11.3	(1.8)11.2	11.4	11.3	(1.2)11.2	11.1	11.1	(1.4)11.1	11.6	11.5	(1.9)11.4
	3	(2.8)11.2	11.2		(2.4)11.3	11.2	(2.9)11.2	11.3	11.4		11.4	11.3		11.1	(2.6)11.1		(2.1)11.5	(2.8)11.5	
	4		(3.2)11.2			11.3		(3.6)11.3	11.3		11.4	(3.9)11.3		11.2					
	5					11.2			11.3		11.4			11.2					
	6								(5.1)11.4		11.4			(5.1)11.2					
	7										11.4								
	8										11.4								
	9										11.4								
	10										11.4								
21MAY91	0	11.5	11.6	11.7	11.7	11.7	11.7	11.8	11.7	11.7	11.8	11.7	11.4	11.8	11.6	11.6	11.7	11.7	11.7
	1	11.5	11.5	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.8	11.7	11.4	11.8	11.6	11.6	11.7	11.8	11.7
	2	11.5	11.5	11.7	11.6	11.7	11.7	11.7	11.7	11.7	11.8	11.7	11.5	11.8	11.5	11.6	11.6	11.7	11.7
	3	11.5	11.5	11.7	11.6	11.7	(2.9)11.7	11.7	11.7	11.7	11.9	11.7	(2.8)11.5	11.8	11.6	(2.3)11.6	(2.9)11.6	11.7	(2.2)11.7
	4	(3.8)11.5	11.4	(3.4)11.7	11.6	11.8		11.7	11.7	(3.6)11.7	11.9	11.7		11.9	(3.2)11.6			(3.1)11.7	
	5				(4.2)11.6	(4.6)11.8		11.6	(4.8)11.7		11.9	11.7		11.9					
	6							11.6			11.9	11.7		11.9					
	7										11.9	(6.4)11.7		11.9					
	8										11.9			11.9					
	9										11.9			11.9					
	10										11.9			(9.1)11.9					
4JUN91	0	10.7	10.8	10.7	10.7	10.9	10.8	10.7	10.9	10.9	10.9	11.3	10.6	10.6	10.7	10.7	11.8	11.9	10.8
	1	10.7	10.9	10.7	10.7	10.9	10.8	10.7	10.9	10.9	10.9	11.3	10.5	10.6	10.6	10.7	11.8	11.8	10.8
	2	10.7	10.8	(1.6)10.6	10.7	10.9	10.7	10.7	10.9	10.9	10.9	11.3	10.5	10.6	10.5	10.7	(1.5)11.9	11.8	(1.7)10.9
	3	10.7	10.8		10.7	10.9	10.7	10.6	10.9	10.9	10.9	11.3	(2.3)10.6	10.6	10.5	(2.9)10.7		(2.2)11.8	
	4				(3.2)10.6	(3.8)10.8		10.5	10.9	(3.8)10.9	10.9	11.3		10.6	10.7				
	5							10.5	10.8		10.9	11.3		10.6					
	6							(5.5)10.5	(5.5)10.8		10.9	11.3		10.5					
	7										10.8	11.2		10.4					
	8										10.8	11.2		10.3					
	9										10.8			10.3					
	10										10.8								
											(10.6)10.8								
18JUN91	0	10.5	10.5	10.5	10.6	10.6	10.5	10.4	10.6	10.6	10.5	10.7	10.4	10.5	10.5	10.5	10.4	10.6	10.7
	1	10.5	10.5	10.4	10.6	10.6	10.5	10.4	10.6	10.6	10.5	10.7	10.3	10.5	10.5	10.4	(.9)10.4	10.5	10.7
	2	10.4	10.5	10.3	10.5	10.5	10.5	10.4	10.5	10.5	10.5	10.7	10.3	10.5	10.5	10.3		10.5	(1.2)10.6
	3	(2.8)10.4	10.4	(2.8)10.5	10.5	10.5	10.4	10.3	10.5	10.5	10.5	10.6	10.3	10.5	10.5	10.1		10.5	
	4		(3.1)10.5		(3.2)10.6	10.5	(3.2)10.5	10.2	10.4	(3.1)10.5	10.5	10.6	(3.1)10.5	10.5	10.4	(3.5)10.3			
	5					(4.5)10.6		10.2	10.3		10.4	10.6		10.4	(4.1)10.4				
	6							10.3	10.3		10.4	10.6		10.3					
	7								(6.2)10.4		10.3	10.5		10.2					
	8										10.3	10.4		10.1					
	9										10.3	10.4		10.3					
2JUL91	0	9.7	10.0	9.7	9.8	9.8	9.8	9.7	9.9	9.9	9.9	9.9	9.6	10.1	9.9	9.8	9.5	9.5	9.7
	1	9.7	10.0	9.7	9.8	9.8	9.7	9.7	9.9	9.9	9.9	9.9	9.4	10.1	9.8	9.7	9.5	9.5	9.6
	2	9.5	9.9	(1.9)9.6	9.7	9.8	9.6	9.7	9.9	9.8	9.9	9.9	9.3	10.0	9.8	9.7	9.4	(1.4)9.5	(1.1)9.6
	3	9.6	9.8		9.6	9.7	9.6	9.7	9.9	9.7	9.9	9.9	9.5	10.0	9.6	9.6			
	4		(3.1)9.7		(3.5)9.6	9.7	9.5	9.6	9.8	(3.1)9.8	9.9	9.9		10.0	9.6	(3.5)9.7			
	5					(4.2)9.7		9.6	9.8		9.8	9.9		9.9	(4.2)9.4				
	6							9.6	9.7		9.8	9.8		9.9					
	7							(6.1)9.6	(6.2)9.8		9.8	9.8		9.9					
	8										9.7	9.7		9.8					
	9										9.6	(8.4)9.7		10.0					

Table A-2 (continued) Dissolved oxygen (ppm) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 100.7 to 111.1, 1991.

	DEPTH	RM 111.1			RM 108.8			RM 106.2			RM 103.5			RM 102.5			RM 100.7		
DATE	(m	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L
16JUL91	0	8.1	8.1	7.9	8.0	8.0	8.0	7.8	7.9	7.9	8.0	8.1	8.0	8.2	8.1	7.8	8.5	8.7	8.8
	1	8.0	7.9	7.8	7.9	8.0	8.0	7.8	7.9	7.9	8.0	8.1	8.0	8.2	8.0	7.7	8.4	8.6	8.7
	2	7.9	7.8	7.8	7.9	7.9	7.9	7.8	7.9	7.7	8.0	8.0	7.9	8.2	8.0	7.7	(1.9)8.3	(1.4)8.6	(1.1)8.7
	3	7.8	7.8		7.8	7.8	7.8	7.6	7.9	(2.6)7.3	7.9	8.0	7.9	8.1	7.9	7.6			
	4				(3.5)7.8	7.7	(3.6)7.6	7.5	7.8		7.8	8.0	(3.2)7.5	8.1	7.7	(3.8)7			
	5					(4.3)7.6		6.3	7.8		7.8	7.9		8.0	(4.3)7				
	6								7.7		7.7	7.9		8.0					
	7								(6.2)6.9		7.7	7.9		8.0					
	8										7.6	7.7		7.8					
	9										(8.7)6.9	(8.7)7		6.6					
30JUL91	0	7.8	7.6	7.6	7.3	7.9	7.9	7.1	7.3	7.5	7.6	7.5	7.6	7.5	7.5	7.5	7.9	7.9	8.3
	1	7.7	7.5	7.5	7.3	7.8	7.9	7.1	7.3	7.4	7.6	7.5	7.5	7.4	7.5	7.4	7.8	8.0	(0.5)8.3
	2	7.6	7.4	(1.9)7.3	7.1	7.8	7.9	7.1	7.3	7.3	7.6	7.5	7.5	7.4	7.4	7.3	(1.3)7.8	(1.1)7.9	
	3	7.4	7.2		7.0	7.7	7.8	7.1	7.2	7.3	7.6	7.5	7.4	7.4	7.3	7.2			
	4		(3.2)7		(3.4)6.9	7.6	(3.3)7.6	7.1	7.2	(3.6)7.1	7.6	7.4	(3.4)6.8	7.4	7.1	(3.8)6.7			
	5					(4.6)6.9		6.9	7.2		7.5	7.4		7.4	(4.5)6.3				
	6							(5.9)6.9	7.2		7.5	7.3		7.3					
	7								(6.6)6.8		7.4	7.3		7.2					
	8										7.4	7.0		7.0					
	9										7.4	(8.2)7		6.1					
	10										7.2								
13AUG91	0	7.6	7.7	7.4	7.2	7.1	7.1	7.0	7.2	7.2	7.4	7.3	7.5	7.4	7.4	7.4	8.6	8.6	8.4
	1	7.6	7.7	7.4	7.1	7.1	7.1	7.0	7.1	7.1	7.4	7.4	7.5	7.4	7.4	7.4	8.6	8.5	8.4
	2	7.5	7.6	7.3	7.1	7.1	7.1	7.0	7.0	7.0	7.3	7.3	7.5	7.3	7.4	7.4	(1.9)8.6	8.5	(1.4)8.4
	3	(2.8)7.1	7.6	(2.1)7.2	6.9	6.9	6.9	7.0	6.9	(2.2)6.9	7.3	7.3	7.5	7.4	7.3	7.3		(2.1)8.4	
	4				(3.2)6.8	6.8		7.0	6.9		7.3	7.3	(3.3)7.3	7.3	7.1	(3.2)6.6			
	5					(4.2)6.5		6.9	6.9		7.3	7.3		7.3	(4.1)6.3				
	6							(5.3)4.8	6.6		7.2	7.2		7.2					
	7								(6.4)6		7.2	7.2		7.2					
	8										7.1	7.0		7.1					
	9										6.9	7.0		7.1					
	10										6.1	(9.5)6.2		(9.3)6.3					
27AUG91	0	7.8	7.7	7.7	7.5	7.5	7.7	7.5	7.5	7.9	7.3	7.4	7.7	7.0	7.3	7.7	7.8	8.0	7.8
	1	7.7	7.7	7.7	7.6	7.5	7.7	7.4	7.6	7.8	7.3	7.3	7.5	7.1	7.3	7.6	7.8	7.9	7.9
	2	7.7	7.7	7.8	7.6	7.5	7.7	7.4	7.5	7.8	7.3	7.4	7.6	7.1	7.2	7.6	(1.8)7.9	7.9	(1.6)7.9
	3	(2.9)7.6	7.7	(2.7)7.8	7.7	7.3	7.7	7.1	7.4	7.8	7.3	7.4	7.4	7.0	7.1	7.5		(2.1)7.9	
	4				(3.6)7.6	7.4	(3.2)7.8	7.3	7.4	7.8	7.3	7.3	(3.5)7.4	7.0	6.9	(3.4)7.6			
	5					(4.3)7.2		7.1	7.2		7.3	7.1		7.0	(4.1)4.1				
	6							6.9	7.2		7.3	7.1		7.0					
	7								(6.3)7.1		7.2	7.0		6.9					
	8										7.0	(7.3)6.5		6.7					
	9										6.6			5.9					
	10										4.9								
											(10.8)4.4								
10SEP91	0	7.8	8.1	8.2	8.1	8.3	8.0	7.6	7.8	8.2	8.0	7.9	8.1	7.8	8.1	8.0	8.1	8.2	8.2
	1	7.7	8.1	8.1	8.0	8.2	7.9	7.7	7.8	8.2	8.0	7.9	8.2	8.0	8.0	8.0	8.2	8.1	8.1
	2	7.6	8.1	8.1	8.0	8.2	7.8	7.7	7.7	8.2	7.9	7.9	8.4	7.8	8.0	8.0	(1.4)8	8.1	(1.3)8.1
	3	(2.9)7.5	8.1		8.0	8.2	7.6	7.7	7.7	8.2	7.9	7.8	8.5	7.8	8.0	7.9		(2.1)8.1	
	4		(3.2)8.1		(3.5)8	8.1	(3.7)7.6	7.7	7.7	(3.2)8.2	7.9	7.8	(3.2)8.5	7.8	8.0	(3.6)7.7			
	5					(4.4)8		7.7	7.8		7.9	7.8		7.9	(4.9)8				
	6							7.7	7.8		8.0	7.7		7.8					
	7							7.7	(6.7)7.7		7.9	7.7		7.6					
	8										7.9	7.5		7.4					
	9										7.9	(8.8)7		7.3					
	10										7.8			(9.3)6.9					

Table A-2 (continued) Dissolved oxygen (ppm) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 100.7 to 111.1, 1991.

	DEPTH	RM 111.1			RM 108.8			RM 106.2			RM 103.5			RM 102.5			RM 100.7		
DATE	(m	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L
24SEP91	0	8.2	8.2	8.2	8.5	8.4	8.5	8.2	8.3	8.4	8.1	8.1	7.8	8.2	8.2	8.3	8.7	8.9	8.6
	1	8.2	8.1	8.1	8.4	8.4	8.5	8.2	8.3	8.4	8.1	8.1	7.8	8.2	8.2	8.2	8.7	8.9	8.6
	2	8.1	7.9	7.9	8.3	8.3	8.3	8.2	8.2	8.5	8.0	8.1	7.7	8.1	8.2	8.2		(1.8)8.9	(1.9)8.5
	3	(2.3)8.2	(2.9)8.2	(2.2)8	8.3	8.3	8.2	8.1	8.1	8.5	8.0	8.0	7.5	8.1	8.3	8.1			
	4				(3.3)8.5	8.3	(3.1)8.4	8.0	8.0	(3.1)8.5	8.0	8.0	(3.2)7.7	8.1	8.3	(3.2)7.7			
	5					(4.1)8.5		7.9	8.0		8.0	7.9		8.0	(4.1)8.2				
	6							(5.8)7.9	8.1		8.0	7.9		8.0					
	7										8.0	7.9		7.9					
	8										7.8	7.8		7.9					
	9										7.9	(8.1)7.8		(8.9)7.8					
	10										7.9								
											(10.1)8								

Table A-3 Electrical conductivity (µmho) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 100.7 to 111.1, 1991.

	DEPTH	RM 111.1			RM 108.8			RM 106.2			RM 103.5			RM 102.5			RM 100.7		
DATE	(m)	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L
18DEC90	0	33	31	32	33	32	32	32	32	32	32	32	32	32	32	33	32	32	32
	1	33	31	33	35	33	32	33	32	32	32	32	32	32	33	33	32	34	35
	2	34	31	(1.2)33	35	33	33	33	33	(1.6)33	32	33	32	33	33	34	(1.3)32	(1.6)35	(1.1)35
	3	(2.4)34	(2.8)33		36	34	(2.3)34	34	33		33	33	(2.2)32	33	34	34			
	4					(3.8)35		35	34		34	34		34	34				
	5							35	35		34	35		34					
	6							(5.3)36	(5.5)36		35	36		35					
	7										36	36		36					
	8										36	(7.7)37		36					
	9										38			(8.5)37					
											(9.7)38								
15JAN91	0	30	30	31	31	30	30	31	30	30	30	31	31	31	31	31	30	28	29
	1	30	30	(0.9)31	31	30	31	31	31	30	31	31	31	31	31	31	30	26	30
	2	(1.8)31	(1.9)30		31	31	31	31	31	(1.7)31	31	31	(1.6)31	31	31	(1.8)31	(1.9)30	26	(1.3)30
	3				(2.4)3	32	(2.8)31	32	31		31	31		32	(2.4)31			(2.3)27	
	4							32	32		31	31		32					
	5							(4.7)32	(4.1)32		32	(4.2)32		32					
	6										32			33					
	7										32			33					
	8										33			(7.2)32					
											(8.8)34								
12FEB91	0	30	31	29	30	30	30	30	30	30	29	30	30	29	29	30	29	26	27
	1	30	31	30	31	30	30	30	30	30	29	30	30	30	30	30	29	26	28
	2	31	31	(1.2)30	31	31	30	30	31	(1.2)30	30	30	(1.5)30	30	30	31	(1.1)29	27	(1.5)29
	3				(2.2)3	(2.8)31	(2.9)31	31	31		30	31		30	30			(2.1)28	
	4							31	31		30	31		30	31				
	5							(4.8)31	(4.2)31		31	31		31					
	6										31	31		31					
	7										32	32		32					
	8										32	(7.1)32		(7.3)32					
12MAR91	0	29	30	30	29	29	29	60	30	29	29	30	29	29	29	29	33	33	32
	1	30	30	30	29	29	30	30	29	29	29	30	30	29	29	29	33	32	33
	2	30	30	(1.2)30	30	29	(1.5)30	30	30	(1.4)30	29	30	(1.2)30	29	30	(1.7)29	33	33	(1.9)33
	3	(2.1)30	(2.2)31		(2.2)3	(2.8)30		30	(3.1)29		30	30		29	(2.9)30		(2.1)32	(2.6)33	
	4							30			30	30		29					
	5							(4.2)30			30			30					
	6										30			31					
	7										31			31					
	8										31			31					
											(8.1)31								

Table A-3 (continued) Electrical conductivity (µmho) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 100.7 to 111.1, 1991.

	DEPTH	RM 111.1			RM 108.8			RM 106.2			RM 103.5			RM 102.5			RM 100.7		
DATE	(m)	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L
09APR91	0	29	30	30	30	30	30	29	30	30	27	29	28	28	29	29	29	30	30
	1	29	30	30	30	30	31	30	30	31	27	29	28	28	29	30	29	30	30
	2	30	30	(1.7)31	30	29	(1.4)31	30	29	(1.5)32	27	29	(1.8)28	29	29	(1.6)29	30	30	(1.9)30
	3	(2.1)30			31	30		30	30		28	30		29	(2.2)30		(2.1)30	(2.5)31	
	4				(3.2)3	(3.4)30		30	30		28	30		30					
	5							31			29	30		31					
	6							(5.4)31			30	30		31					
	7										30	(6.7)30		31					
	8										30								
											(8.6)30								
08MAY91																			
21MAY91	0	32	32	33	32	32	32	32	32	32	32	32	32	31	32	32	30	25	28
	1	32	32	33	32	32	32	32	32	32	32	32	32	31	32	32	30	28	30
	2	33	32	33	33	33	32	33	33	32	32	33	32	32	32	32	30	30	30
	3	34	32	33	34	33	(2.9)33	34	33	33	33	33	(2.8)33	32	32	(2.3)33	(2.9)30	30	(2.2)30
	4	(3.8)34	33	(3.4)33	34	33		34	34	(3.6)33	33	34		32	(3.2)34			(3.1)30	
	5				(4.2)3	(4.6)34		35	(4.8)34		33	34		32					
	6							35			33	34		33					
	7										33	(6.4)34		33					
	8										33			33					
	9										33			34					
	10										33			(9.1)35					
04JUN91	0	34	34	35	36	35	36	35	35	35	36	35	36	35	36	36	29	30	29
	1	35	35	35	36	35	36	36	36	35	36	35	37	36	36	36	30	30	29
	2	35	35	(1.6)35	37	35	37	37	36	35	36	36	37	37	37	37	(1.5)30	30	(1.7)30
	3	36	36		38	36	38	37	36	37	37	36	(2.3)38	38	37	(2.9)37		(2.2)30	
	4				(3.2)3	(3.8)38		38	37	(3.8)38	37	37		39	38				
	5							38	37		38	37		39					
	6							(5.5)38	(5.5)39		38	37		40					
	7										39	38		41					
	8										40	38		41					
	9										40			41					
	10										41								
											(10.6)41								

Table A-3 (continued) Electrical conductivity (µmho) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 100.7 to 111.1, 1991.

	DEPTH	RM 111.1			RM 108.8			RM 106.2			RM 103.5			RM 102.5			RM 100.7		
DATE	(m)	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L
18JUN91	0	37	37	37	38	37	38	38	38	38	38	38	39	38	39	39	39	37	39
	1	37	38	38	39	38	38	38	38	38	39	38	39	38	39	39	(0.9)39	38	39
	2	38	38	38	39	38	38	38	38	38	39	39	40	38	39	40		38	(1.2)39
	3	(2.8)38	38	(2.8)38	40	38	39	38	39	39	39	39	40	39	40	40		(2.1)38	
	4		(3.1)39		(3.2)4	38	(3.2)40	39	40	(3.1)39	40	40	(3.1)40	39	40	(3.5)40			
	5					(4.5)39		40	40		40	40		40	(4.1)40				
	6							40	41		40	41		40					
	7								(6.2)41		41	41		40					
	8										41	40		41					
	9										42	41		42					
											(9.3)43	(9.2)42							
02JUL91	0	41	41	41	42	41	41	41	41	41	41	41	42	40	41	41	41	40	40
	1	41	41	41	42	41	41	41	41	41	41	41	42	40	41	42	41	40	40
	2	42	41	42	43	41	42	42	42	41	41	42	42	41	41	42	41	(1.4)41	(1.1)40
	3	42	41	42	43	41	42	43	42	41	42	42	43	41	42	42			
	4		(3.1)42		(3.5)4	42	42	43	43	(3.1)42	42	43		42	42	(3.5)42			
	5					(4.2)42		43	43		42	43		42	(4.2)43				
	6							43	43		43	43		43					
	7							(6.1)43	(6.2)43		43	43		43					
	8										44	44		44					
	9										45	(8.4)46		45					
16JUL91	0	44	44	44	49	45	45	45	46	45	45	46	46	44	45	46	45	45	45
	1	45	44	45	50	45	45	46	46	45	45	46	47	45	46	46	46	46	46
	2	45	44	45	50	46	45	47	46	46	46	47	47	46	46	47	(1.9)47	(1.4)47	(1.1)46
	3	45	45		50	46	45	47	47	(2.6)46	47	47	47	47	47	48			
	4				(3.5)5	46	(3.6)47	48	47		48	48	(3.2)48	47	48	(3.8)49			
	5					(4.3)47		48	48		48	48		48	(4.3)49				
	6								48		48	49		48					
	7								(6.2)49		49	49		49					
	8										49	49		49					
	9										(8.7)50	(8.7)49		50					

Table A-3 (continued) Electrical conductivity (µmho) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 100.7 to 111.1, 1991.

	DEPTH	RM 111.1			RM 108.8			RM 106.2			RM 103.5			RM 102.5			RM 100.7		
DATE	(m)	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L
30JUL91	0	48	49	49	50	49	49	49	49	50	49	49	50	50	49	49	49	49	49
	1	49	49	49	50	49	50	49	50	50	49	49	50	50	49	50	49	49	(0.5)49
	2	49	49	(1.9)49	50	50	50	50	50	50	49	50	50	50	50	50	(1.3)49	(1.1)49	
	3	49	49		50	50	50	50	50	50	49	50	50	50	50	50			
	4		(3.2)49		(3.4)5	51	(3.3)50	50	50	(3.6)50	50	50	(3.4)50	50	50	(3.8)50			
	5					(4.6)51		51	51		50	50		50	(4.5)52				
	6							(5.9)51	51		50	50		51					
	7								(6.6)51		51	51		51					
	8										52	51		51					
	9										52	(8.2)52		52					
	10										52								
											(10.5)53								
13AUG91	0	49	49	49	50	50	49	50	50	50	49	50	50	49	50	50	49	50	50
	1	49	49	49	50	50	49	50	50	50	50	50	50	50	50	50	49	50	50
	2	50	49	50	50	50	49	50	50	50	50	50	50	50	50	50	(1.9)49	50	(1.4)50
	3	(2.8)50	49	(2.1)50	50	50	49	51	51	(2.2)50	50	51	51	50	51	50		(2.1)50	
	4				(3.2)5	51		51	51		50	51	(3.3)50	50	51	(3.2)50			
	5					(4.2)51		51	52		51	51		51	(4.1)51				
	6							(5.3)51	52		51	52		51					
	7								(6.4)52		52	52		52					
	8										52	52		52					
	9										53	53		53					
	10										53	(9.5)53		(9.3)53					
27AUG91	0	48	48	48	55	56	52	51	52	52	51	51	51	52	51	51	56	56	59
	1	48	48	49	56	56	53	52	52	52	51	51	52	52	52	51	56	57	58
	2	49	49	49	56	56	52	52	52	52	52	53	52	53	52	52	(1.8)60	58	(1.6)58
	3	(2.9)49	49	(2.7)49	53	53	52	52	53	53	52	54	52	53	53	53		(2.1)58	
	4				(3.6)5	52	(3.2)52	53	53	53	52	55	(3.5)52	53	53	(3.4)54			
	5					(4.3)53		53	54		53	55		53	(4.1)53				
	6							53	55		53	56		54					
	7								(6.3)57		53	56		55					
	8										55	(7.3)56		56					
	9										56			58					
	10										56								
											(10.8)58								

Table A-3 (continued) Electrical conductivity (µmho) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 100.7 to 111.1, 1991.

	DEPTH	RM 111.1			RM 108.8			RM 106.2			RM 103.5			RM 102.5			RM 100.7		
DATE	(m)	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L	R	M	L
10SEP91	0	47	48	47	49	49	49	50	49	48	50	50	50	50	50	50	54	50	52
	1	48	48	48	50	49	49	50	49	48	50	50	51	50	50	51	53	50	52
	2	48	48	48	50	49	49	50	49	49	50	50	51	50	50	50	(1.4)53	50	(1.3)51
	3	(2.9)48	48		50	50	49	50	49	49	51	51	51	50	50	50		(2.1)51	
	4		(3.2)48		(3.5)5	50	(3.7)49	50	50	(3.2)49	51	51	(3.2)51	50	51	(3.6)50			
	5					(4.4)50		50	50		51	51		50	(4.9)52				
	6							51	50		51	52		51					
	7							51	(6.7)50		51	52		51					
	8										52	52		52					
	9										52	(8.8)52		52					
	10										53			(9.3)54					
											(10.5)54								
24SEP91	0	47	47	47	48	48	48	47	47	47	47	47	48	46	47	48	49	48	48
	1	47	47	47	48	48	47	48	47	48	48	48	48	46	47	47	48	48	49
	2	47	47	48	49	48	48	48	48	48	48	48	48	46	47	47		(1.8)48	(1.9)50
	3	(2.3)47	(2.9)48	(2.2)48	49	48	47	48	48	48	48	48	49	47	48	48			
	4				(3.3)5	49	(3.1)47	49	48	(3.1)48	48	48	(3.2)49	47	48	(3.2)48			
	5					(4.1)49		49	49		48	49		48	(4.1)48				
	6							(5.8)50	49		49	49		49					
	7										49	49		49					
	8										49	49		49					
	9										50	(8.1)50		(8.9)50					
	10										50								

Table A-4 Temperature (C) and dissolved oxygen (ppm) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 111.1, 103.5, and 102.5 during the diel study of August 12-13, 1991. Only the right 1/3 section was measured at RM 111.1.

		RM 111.1		RM 103.5						RM 102.5					
TIME	DEPTH	TEMP.	O2	TEMP.	O2	TEMP.	O2	TEMP.	O2	TEMP.	O2	TEMP.	O2	TEMP.	O2
		R	R	R	R	M	M	L	L	R	R	M	M	L	L
1500	0	22.6	7.5	22.9	8.0	22.6	7.8	22.8	8.2	23.1	7.9	23.1	7.9	23.2	8.0
1500	1	22.6	7.6	22.9	8.0	22.6	7.9	22.8	8.2	23.1	7.9	23.1	7.9	23.1	8.0
1500	2	22.7	7.6	22.9	7.9	22.6	7.9	22.8	8.0	23.1	7.9	23.1	7.8	23.1	8.1
1500	3	22.7	7.4	22.9	7.9	22.5	7.7	22.7	8.0	23.0	7.7	23.0	7.7	23.0	8.1
1500	4			22.9	7.9	22.5	7.9			23.0	7.7	23.0	7.7	23.0	8.2
1500	5			22.9	7.8	22.4	7.9			23.0	7.6	22.9	7.8		
1500	6			22.8	7.8	22.3	7.9			22.9	7.5				
1500	7			22.8	7.7	22.3	7.8			22.9	7.3				
1500	8			22.6	7.7	22.3	7.7			22.9	7.3				
1500	9			22.5	7.7	22.3	7.7			22.8	6.8				
1500	10			22.4	7.5	22.2	7.6								
1800	0	22.7	7.9	22.9	8.4	22.9	8.3	22.9	8.5	23.1	8.4	23.2	8.2	23.1	8.3
1800	1	22.7	7.8	22.9	8.4	22.9	8.3	22.9	8.4	23.2	8.4	23.2	8.2	23.1	8.2
1800	2	22.8	7.8	22.9	8.4	22.9	8.2	22.9	8.3	23.2	8.4	23.2	8.0	23.1	8.3
1800	3	22.8	7.1	22.9	8.4	22.9	8.3	22.9	8.2	23.2	8.3	23.2	8.0	23.1	8.2
1800	4			22.9	8.3	22.9	8.2			23.0	8.2	23.1	7.9		
1800	5			22.9	8.2	22.8	8.2			23.0	8.3	23.0	7.3		
1800	6			22.9	8.2	22.8	8.1			23.0	8.0				
1800	7			22.8	8.2	22.8	8.1			22.9	8.0				
1800	8			22.8	7.9	22.8	8.0			22.9	7.8				
1800	9			22.8	8.0	22.8	8.0			22.9	7.4				
1800	10			22.8	7.9	22.7	7.8								
2100	0	22.5	8.3	22.8	7.9	22.7	7.7	22.8	7.8	22.9	7.5	22.9	7.4	23.0	7.5
2100	1	22.5	8.4	22.8	7.8	22.7	7.6	22.8	7.7	22.9	7.4	22.9	7.6	23.0	7.4
2100	2	22.6	8.5	22.8	7.7	22.7	7.7	22.8	7.7	22.9	7.6	23.0	7.4	23.0	7.4
2100	3	22.5	8.2	22.8	7.6	22.8	7.7	22.8	7.7	23.0	7.4	23.0	7.4	23.0	7.3
2100	4			22.7	7.6	22.8	7.7			23.0	7.4	23.0	7.3		
2100	5			22.7	7.6	22.8	7.6			23.0	7.3	22.9	7.1		
2100	6			22.7	7.6	22.8	7.5			22.9	7.2				
2100	7			22.7	7.5	22.8	7.5			22.9	7.2				
2100	8			22.6	7.4	22.7	7.4			22.8	7.1				
2100	9			22.6	6.7	22.7	7.1			22.9	6.9				

Table A-4 (continued) Temperature (C) and dissolved oxygen (ppm) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 111.1, 103.5, and 102.5 during the diel study of August 12-13, 1991. Only the right 1/3 section was measured at RM 111.1.

		RM 111.1		RM 103.5						RM 102.5					
TIME	DEPTH	TEMP.	O2	TEMP.	O2	TEMP.	O2	TEMP.	O2	TEMP.	O2	TEMP.	O2	TEMP.	O2
		R	R	R	R	M	M	L	L	R	R	M	M	L	L
2400	0	22.4	7.1	22.6	8.0	22.5	7.7	22.4	7.6	22.6	8.1	22.8	7.8	22.8	7.8
2400	1	22.4	7.0	22.6	7.9	22.5	7.7	22.4	7.5	22.7	8.1	22.9	7.8	22.8	7.8
2400	2	22.4	7.2	22.7	7.9	22.5	7.7	22.4	7.4	22.7	8.0	22.8	7.7	22.8	7.8
2400	3	22.4	7.3	22.7	7.8	22.5	7.6			22.7	8.0	22.8	7.6	22.8	7.8
2400	4			22.7	7.8	22.4	7.8			22.8	8.0	22.8	7.3	22.8	7.7
2400	5			22.4	8.0	22.5	7.6			22.8	7.9				
2400	6			22.7	7.6	22.5	7.7			22.8	7.8				
2400	7			22.7	7.5	22.4	7.6			22.8	7.6				
2400	8			22.6	7.3	22.4	7.6			22.8	7.2				
2400	9			22.6	7.3	22.4	7.6			22.8	6.2				
2400	10			22.6	6.4	22.5	6.6								
300	0	22.2	7.3	22.4	7.7	22.5	7.7	22.5	7.5	22.4	7.4	22.5	7.4	22.6	7.2
300	1	22.2	7.1	22.5	7.7	22.5	7.7	22.5	7.5	22.5	7.4	22.5	7.4	22.5	7.2
300	2	22.2	7.2	22.5	7.7	22.5	7.7	22.4	7.5	22.6	7.4	22.5	7.4	22.6	7.0
300	3	22.2	7.1	22.5	7.7	22.6	7.7	22.4	7.3	22.6	7.4	22.6	7.3	22.5	7.0
300	4			22.5	7.7	22.6	7.6			22.6	7.4	22.6	7.0	22.3	6.0
300	5			22.5	7.7	22.6	7.7			22.6	7.4	22.6	6.0		
300	6			22.5	7.7	22.6	7.6			22.6	7.4				
300	7			22.5	7.6	22.6	7.5			22.6	7.3				
300	8			22.5	7.5	22.6	7.4			22.6	7.2				
300	9			22.5	7.1	22.6	7.2			22.6	7.0				
300	10					22.5	6.6								
600	0	21.9	7.3	22.3	7.3	22.4	7.3	22.3	7.1	22.5	7.2	22.5	7.1	22.3	7.1
600	1	22.0	7.4	22.4	7.3	22.5	7.3	22.3	7.1	22.6	7.2	22.5	7.1	22.3	7.0
600	2	22.0	7.4	22.5	7.3	22.6	7.3	22.3	7.0	22.6	7.2	22.5	7.0	22.3	6.9
600	3	21.0	7.0	22.5	7.3	22.6	7.3	22.3	6.9	22.6	7.2	22.5	6.9	22.3	6.6
600	4			22.5	7.3	22.5	7.3			22.7	7.2	22.4	6.8	22.2	6.0
600	5			22.5	7.2	22.5	7.2			22.7	7.2	22.4	4.5		
600	6			22.5	7.2	22.5	7.1			22.6	7.2				
600	7			22.5	7.2	22.5	7.2			22.6	7.1				
600	8			22.5	7.2	22.5	7.2			22.6	7.1				
600	9			22.5	7.2	22.5	6.9			22.6	6.9				
600	10			22.5	6.9					22.6	6.3				

Table A-4 (continued) Temperature (C) and dissolved oxygen (ppm) profiles at the right (R), middle (M), and left (L) 1/3 sections of the Spokane River, River Mile (RM) 111.1, 103.5, and 102.5 during the diel study of August 12-13, 1991. Only the right 1/3 section was measured at RM 111.1.

		RM 111.1		RM 103.5						RM 102.5					
TIME	DEPTH	TEMP.	O2	TEMP.	O2	TEMP.	O2	TEMP.	O2	TEMP.	O2	TEMP.	O2	TEMP.	O2
		R	R	R	R	M	M	L	L	R	R	M	M	L	L
900	0	21.9	7.9	22.6	7.3	22.5	7.3	22.6	7.3	22.8	7.3	22.8	7.2	22.9	7.3
900	1	22.0	7.9	22.6	7.3	22.5	7.4	22.6	7.2	22.8	7.3	22.8	7.2	22.9	7.3
900	2	22.0	8.1	22.5	7.3	22.5	7.3	22.6	7.2	22.8	7.3	22.8	7.2	22.9	7.2
900	3	22.0	7.5	22.5	7.3	22.5	7.3	22.5	7.1	22.8	7.3	22.7	7.2	22.9	7.2
900	4			22.5	7.3	22.5	7.3			22.8	7.2	22.6	7.1	22.8	7.0
900	5			22.5	7.3	22.5	7.3			22.8	7.1	22.5	6.6		
900	6			22.5	7.2	22.4	7.3			22.8	7.2				
900	7			22.4	7.1	22.4	7.2			22.8	7.2				
900	8			22.4	7.0	22.4	7.2			22.7	7.1				
900	9			22.5	6.0	22.4	7.1			22.7	6.9				
900	10														
1200	0	22.4	8.3	22.7	7.4	22.7	7.3	22.6	7.5	23.0	7.4	23.0	7.4	23.1	7.4
1200	1	22.4	8.3	22.6	7.4	22.6	7.4	22.6	7.5	23.0	7.4	23.0	7.4	23.0	7.4
1200	2	22.2	7.9	22.5	7.3	22.6	7.3	22.6	7.5	23.0	7.3	22.9	7.4	22.9	7.4
1200	3	22.2	8.0	22.5	7.3	22.6	7.3	22.6	7.5	22.9	7.4	22.8	7.3	22.8	7.3
1200	4			22.5	7.3	22.6	7.3			22.8	7.3	22.8	7.1	22.8	6.6
1200	5			22.5	7.3	22.5	7.3			22.8	7.3				
1200	6			22.5	7.2	22.4	7.2			22.8	7.2				
1200	7			22.5	7.2	22.3	7.2			22.7	7.2				
1200	8			22.4	7.1	22.3	7.0			22.7	7.1				
1200	9			22.4	6.9	22.3	7.0			22.6	7.1				
1200	10			22.4	6.1	22.3	6.2								
1500	0	22.4	8.0	22.9	7.6	22.7	7.6	22.7	7.6	23.0	7.6	23.2	7.9	23.7	7.9
1500	1	22.4	7.9	22.9	7.6	22.7	7.6	22.8	7.6	23.1	7.8	23.2	7.9	23.5	7.9
1500	2	22.4	8.2	22.8	7.6	22.7	7.6	22.9	7.6	23.0	7.7	23.2	7.9	23.3	8.0
1500	3	22.3	8.0	22.8	7.5	22.8	7.6	22.7	8.0	22.8	7.7	23.0	7.9	23.1	8.0
1500	4			22.7	7.5	22.8	7.5			22.8	7.7	23.0	7.9	23.0	7.8
1500	5			22.7	7.6	22.7	7.5			22.8	7.6	23.0	7.6		
1500	6			22.6	7.5	22.6	7.4			22.7	7.6				
1500	7			22.6	7.5	22.5	7.4			22.7	7.5				
1500	8			22.5	7.5	22.3	7.3			22.7	7.4				
1500	9			22.5	7.4	22.3	7.3			22.7	6.6				
1500	10														

APPENDIX B

QA / QC Raw Data

Spokane River pH Quality Control.

Date	Station	Field model 47	Lab model 7	Lab Model 3500
9/10/91	1	6.2	6.4	N/A
	2	6.2	6.4	N/A
	3	6.4	6.3	N/A
	4	6.3	6.7	N/A
	5	6.2	6.6	N/A
	6	6.3	6.5	N/A
	PF	6.7	7.3	N/A
	CDA	6.4	6.9	N/A
5/12/91	1	6.1	5.7	N/A
	2	6.5	5.9	N/A
	3	6.6	6.1	N/A
	4	6.7	6.3	N/A
	5	6.7	6.2	N/A
	6	6.7	6.3	N/A
	PF	7.0	6.9	N/A
	CDA	7.2	7.0	N/A
7/2/91	1	5.9	5.7	N/A
	2	5.3	6.0	N/A
	3	5.5	6.1	N/A
	4	5.6	6.2	N/A
	5	5.8	6.3	N/A
	6	5.9	6.3	N/A
	PF	NA	NA	N/A
	CDA	6.3	6.0	N/A
3/12/91	1	7.3	7.7	N/A
	2	7.3	7.7	N/A
	3	7.4	7.7	N/A
	4	7.5	7.9	N/A
	5	7.4	7.9	N/A
	6	7.5	7.9	N/A
	PF	7.1	7.5	N/A
	CDA	8.0	8.2	N/A

5/7/91	1	5.0	5.1	5.3
	2	5.2	5.2	5.3
	3	5.5	5.4	5.4
	4	5.6	5.5	5.5
	5	5.6	5.7	5.6
	6	5.7	5.8	5.7
	PF	6.8	6.9	6.9
	CDA	7.4	7.2	7.1
10/1/90	1	6.9	7.0	7.1
	2	6.9	7.1	7.1
	3	7.0	7.1	7.0
	4	7.1	7.1	7.0
	5	3.5	3.3	3.3
	6	6.4	6.3	6.5
	PF	7.1	7.1	7.0
	CDA	7.9	7.9	7.8

	Grand Mean	Mean of Ranges
River (1 - 6)	6.3	0.3
PF	7	0.3
CDA	7.2	0.3

Spokane River Nutrient Quality Control.

NH3 DUP'S

location	# of dup's	mean	std dev.
river	21	0.141962	0.02283
pfwwtp	5	1.586	0.392602
cdawwtp	2	23.4725	0.015

NO3 DUP'S

Location	# of Dup's	mean	Std dev.
river	18	0.070139	0.009594
pfwwtp	2	12.735	0.48
cdawwtp	3	2.064683	0.11183

O-P DUP'S

Location	# of dup's	mean	std dev.
river	18	<.006	0.001329
pfwwtp	3	3.791667	0.153261
cdawwtp	2	3.985	0.05

TP DUP'S

Location	# of dup's	mean	std dev.
river	28	0.01281	0.002452
pfwwtp	3	3.014683	0.074962
cdawwtp	1	3.73	0.02

TKN DUP'S

Location	# of dup's	mean	std dev.
river	49	N/A	0.0137
pfwwtp	3	N/A	0.1367
cdawwtp	3	N/A	0.1367

Spokane River Chlorophyll a Quality Control.

		chlor a (mg'm3)			
Date	sta	Run 1	Run 2	mean	range
Aug 6, 1990	1	1.79	1.93	1.86	0.14
	2	2.08	1.85	1.965	0.23
	3	5.19	5.16	5.175	0.03
	4	7.37	7.25	7.31	0.12
	5	5.06	6.31	5.685	1.25
	6	0	0.24	0.12	0.24

Date	sta	Run 1	Run 2		
Apr 9, 1991	1	3.52	3.56	3.54	0.04
	2	3.87	3.94	3.905	0.07
	3	1.16	1.08	1.12	0.08
	4	4.66	4.93	4.795	0.27
	5	4.31	3.91	4.11	0.4
	6	5.3	5.24	5.27	0.06

Date	sta	Run 1	Run 2		
July 30, 1991	1	0.12	0	0.06	0.12
	2	0	0	0	0
	3	0	0.14	0.07	0.14
	4	2.12	2.01	2.065	0.11
	5	0	0	0	0
	6	0	0.04	0.02	0.04

	Grand Mean	Mean of Ranges
River (1 - 6)	2.6	0.19

NUTRIENT DUPLICATES - STD. DEVIATIONS

NH3 DUP'S

location	# of dup's	mean	std dev.
RIVER	21	0.14	0.02
PFWWTP	5	1.59	0.39
CDAWWTP	2	23.47	0.02

NO3 DUP'S

location	# of dup's	mean	std dev.
RIVER	18	0.07	0.01
PFWWTP	2	12.74	0.48
CDAWWTP	3	2.06	0.11

O-P DUP'S

location	# of dup's	mean	std dev.
RIVER	18	<.006	0.00
PFWWTP	3	3.79	0.15
CDAWWTP	2	3.99	0.05

TP DUP'S

location	# of dup's	mean	std dev.
RIVER	28	0.01	0.00
PFWWTP	3	3.01	0.07
CDAWWTP	1	3.73	0.02

TKN DUP'S

RIVER	49		0.01
PFWWTP	3		0.14
CDAWWTP	3		0.14

Spokane River 5-day BOD Quality Control.

			5-day BOD			
Date	**Station**	**Run 1**	**Run 2**	**Run 3**	**mean**	**range**
Aug 6, 1990	1	2.1	3.6	1.3	2.3333333	2.3
	2	3.3	5.3		4.3	2
	3	4.6	4		4.3	0.6
	4	4.8	6.6		5.7	1.8
	5	4.5	5.5		5	1
	6	3.3	5.7	4	4.3333333	2.4
	PF	12.6	15.4		14	2.8
	CDA *	>50	>50		N/A	N/A

* -- sample = < 2 mg/l after 5 days.

Date	Station	Run 1	Run 2	Run 3		
Jan 15, 1991	1	3	4	4.4	3.8	1.4
	2	2.7	3.3		3	0.6
	3	4	2.7		3.35	1.3
	4	3.3	2.7		3	0.6
	5	2.7	2.7		2.7	0
	6	3.3	3.5	3.7	3.5	0.2
	PF	7.7	10		8.85	2.3
	CDA	70.1	79.3		74.7	9.2

Date	Station	Run 1	Run 2	Run 3		
May 8, 1991	1	2	4	3	3	2
	2	3.3	3.3		3.3	0
	3	N/A	N/A		N/A	N/A
	4	2.4	3		2.7	0.6
	5	1.6	2.4		2	0.8
	6	2.2	4	2.8	3	1.8
	PF	13.6	10.4		12	3.2
	CDA	75	125		100	50

Date	Station	Run 1	Run 2	Run 3		
July 16, 1991	1	2.6	2.5	2.9	2.6666667	0.4
	2	0.6	0.8		0.7	0.2
	3	1.9	2		1.95	0.3
	4	3	10.4		6.7	7.4
	5	1.7	2.3		2	0.6
	6	3	2.8	3.2	3	0.4
	PF	10.5	10.9		10.7	0.4
	CDA	62.5	97.5		80	35

Date	Station	Run 1	Run 2	Run 3		
Sept 24, 1991	1	6.7	3.3	5	5	3.4
	2	6	6		6	0
	3	4.2	5.2		4.7	1
	4	4.1	3.9		4	0.2
	5	4.3	3.7		4	0.5
	6	2.5	6	9.5	6	7
	PF	10.8	11.8		11.3	1
	CDA	15	25		20	10

	Grand Mean	Mean of Ranges
River (1 - 6)	3.7	1.4
PF	11.4	1.9
CDA	68.7	26.1

No ultimate BOD samples were run in duplicate due to limitations on glassware.

Spokane River Bacteria Quality Control.

Feb 12, 1991.

	Fecal Coliform		Fecal Streptococcus		FC Mean	FC Range	FS Mean	FS Range
Sta	U of I	DEQ	U of I	DEQ				
1	0	1	0	1	0.5	1	0.5	1
2	10	7	4	7	8.5	3	5.5	3
3	5	3	0	3	4	2	1.5	3
4	2	2	1	4	2	0	2.5	3
5	5	5	0	2	5	0	1	2
6	0	1	1	2	0.5	1	1.5	1
PF	310	340	16	20	325	30	18	4
CDA	8	10	29	20	9	2	24.5	9

Sept 17, 1990.

	Fecal Coliform		Fecal Streptococcus					
	U of I (1)	U of I (2)	U of I (1)	U of I (2)				
1	1	3	14	8	2	2	11	6
2	11	14	13	8	12.5	3	10.5	5
3	7	9	11	6	8	2	8.5	5
4	10	9	1	4	9.5	1	2.5	3
5	12	16	6	5	14	4	5.5	1
6	32	30	11	14	31	2	12.5	3
PF	54	38	20	22	46	16	21	2
CDA	42	44	2	6	43	2	4	4

May 7, 1991.

	Fecal Coliform		Fecal Streptococcus					
	U of I (1)	U of I (2)	U of I (1)	U of I (2)				
1	<1	2	<1	<1	1.25	1.5	0.5	0
2	<1	<1	<1	2	0.5	0	1.25	1.5
3	<1	1	4	3	0.75	0.5	3.5	1
4	<1	<1	5	7	0.5	0	6	2
5	<1	<1	2	1	0.5	0	1.5	1
6	1	2	3	5	1.5	1	4	2
PF	<1	2	1	3	1.25	1.5	2	2
CDA	NA	NA	NA	NA	NA	NA	NA	NA

Fecal Coliform

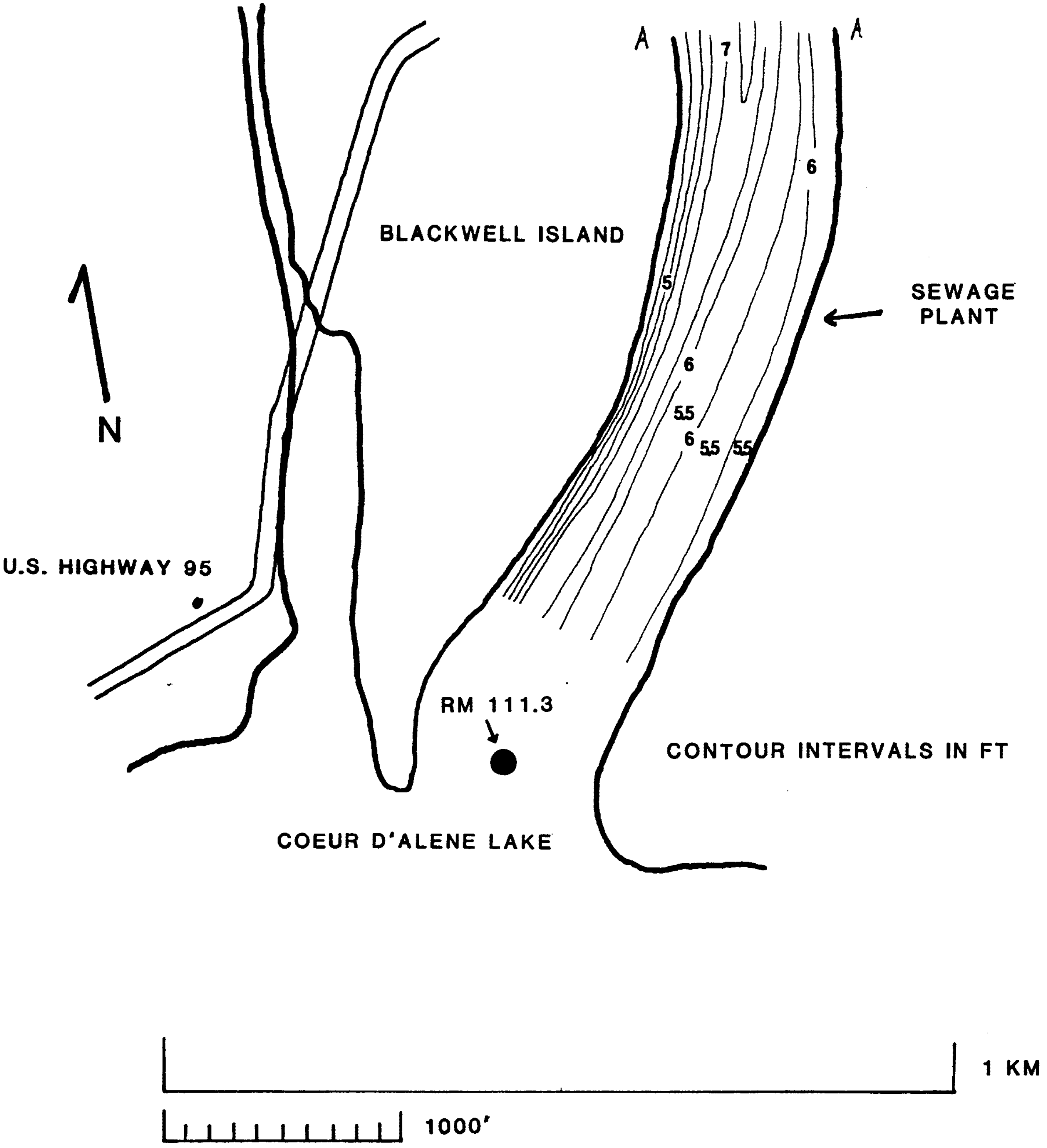
	Grand Mean	Mean of Ranges
River (1 - 6)	5.7	1.33
PF	124.1	15.8
CDA	26	2

Fecal Streptococcus

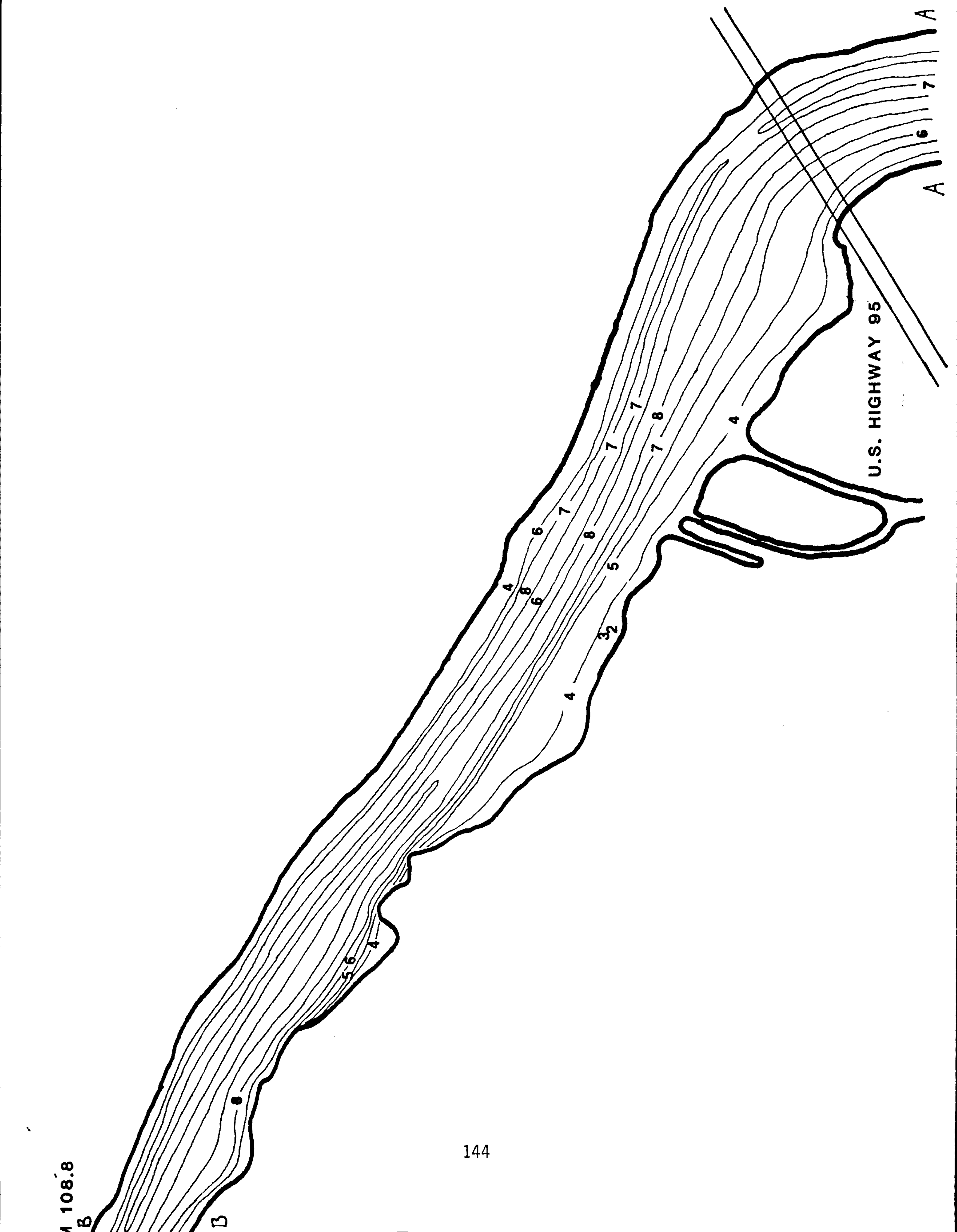
	Grand Mean	Mean of Ranges
River (1 - 6)	4.4	2.4
PF	13.7	2.7
CDA	14.25	6.5

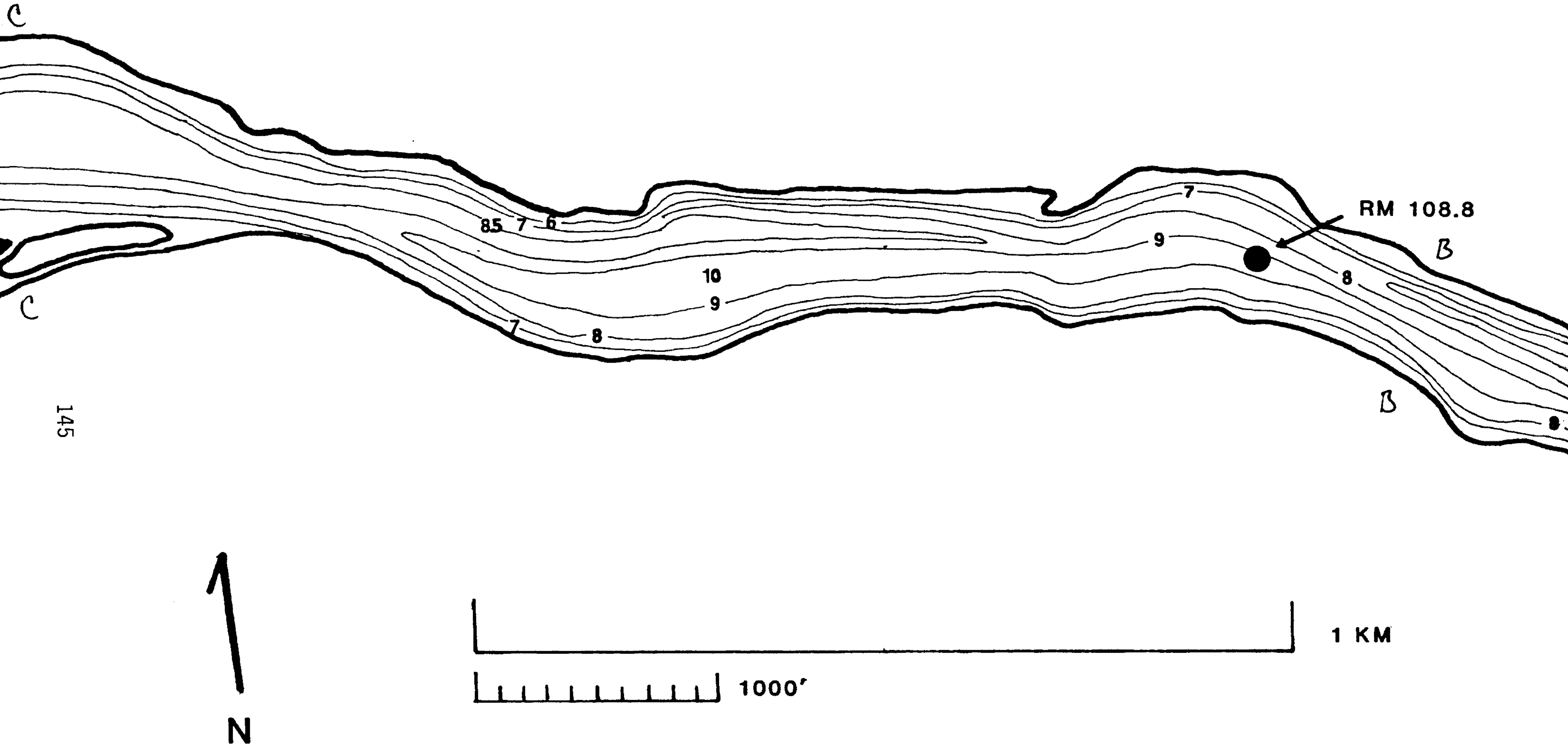
APPENDIX C

Morphometric Maps of the Spokane River

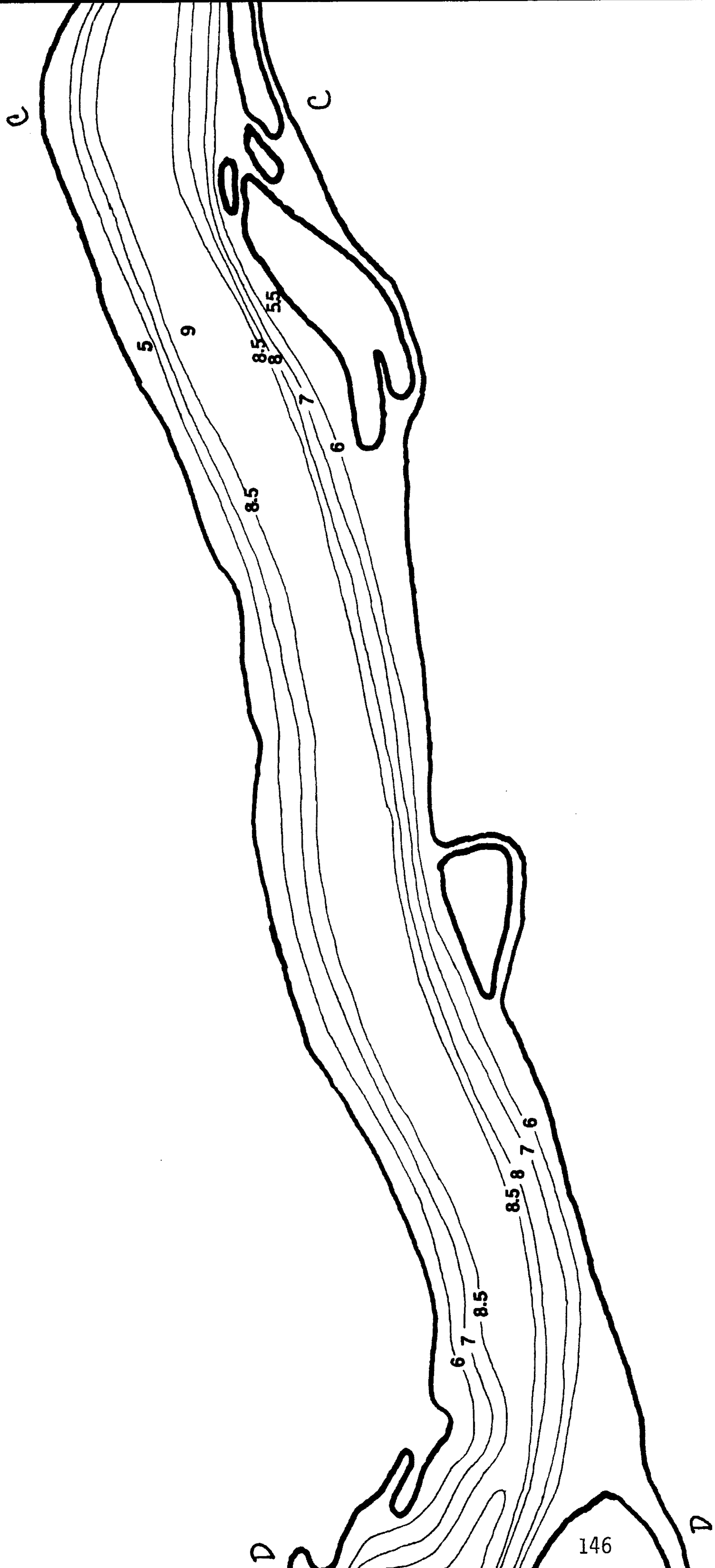


Morphometric map of the Spokane River (Idaho) at the Coeur d'Alene Lake outlet, May-October, 1980.


A
A
U.S. HIGHWAY 95
7
6
4
7
8
7
7
6
7
8
4
8
6
5
3
2
4
5
6
4
8
M 108.8
B
B



CONTOUR INTERVALS IN FT


C
C
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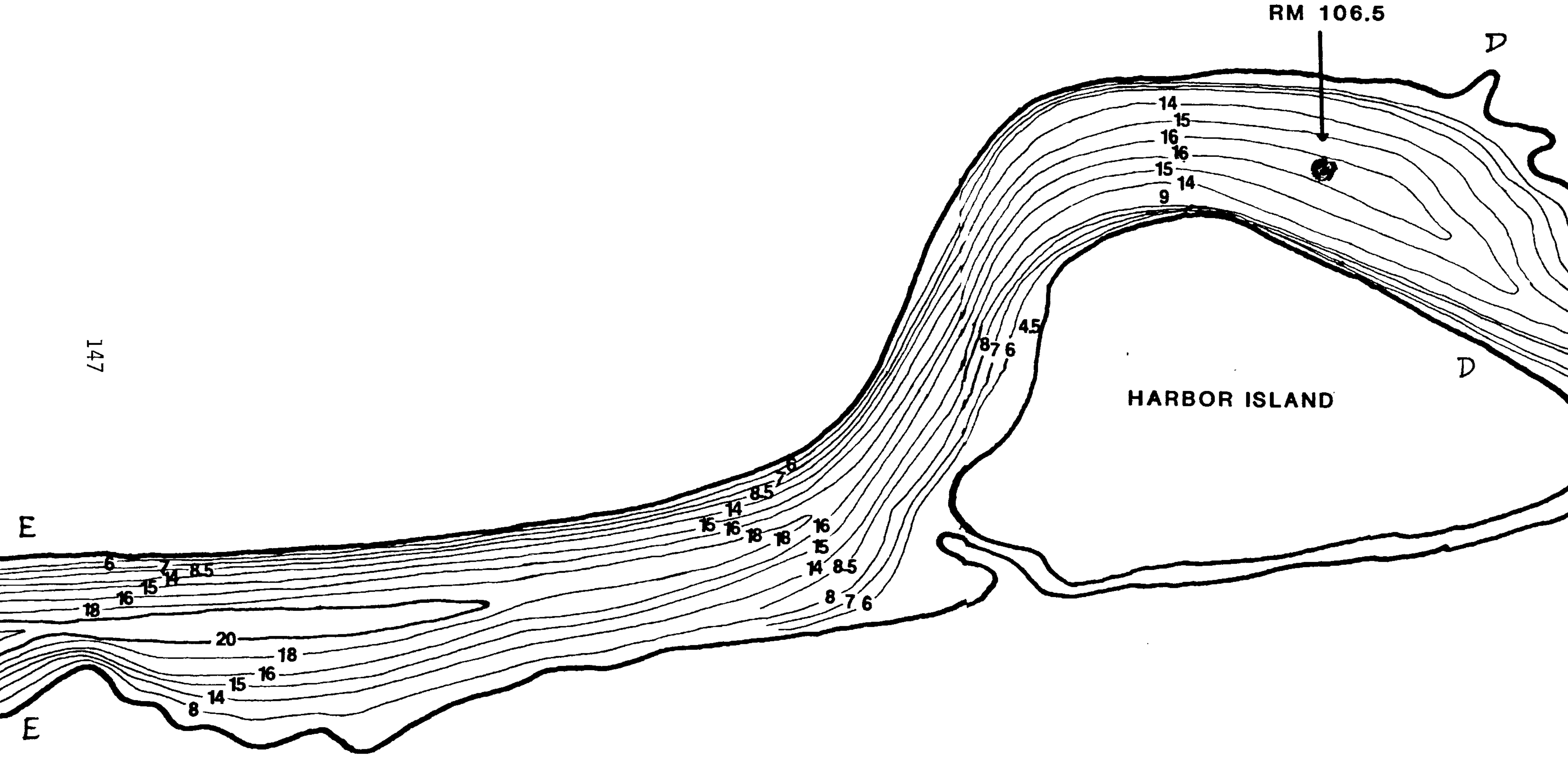
9
5
8.5
8
7
6
8.5
6
7
8
8.5
8.5
7
6
D
D


RM 106.5
D
D
HARBOR ISLAND
E
E
14
15
16
16
15
14
9
4.5
8
7
6
8
8.5
7
14
15
16
18
18
16
15
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8.5
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7
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16
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20
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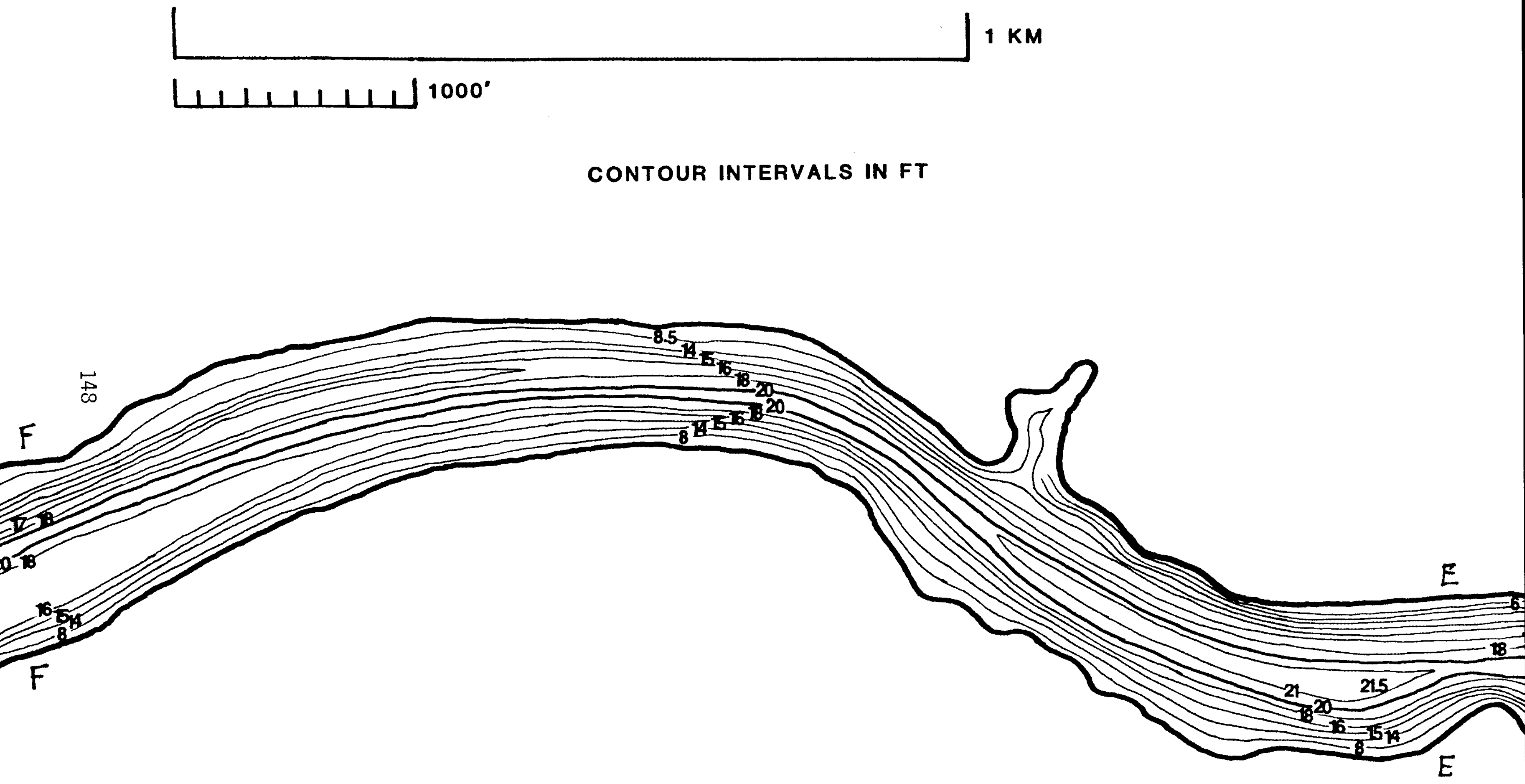
16
15
14
8


1 KM
1000′
CONTOUR INTERVALS IN FT
F
F
E
E
8.5
14
15
16
18
20
20
18
16
15
14
8
17
18
18
16
15
14
8
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21.5
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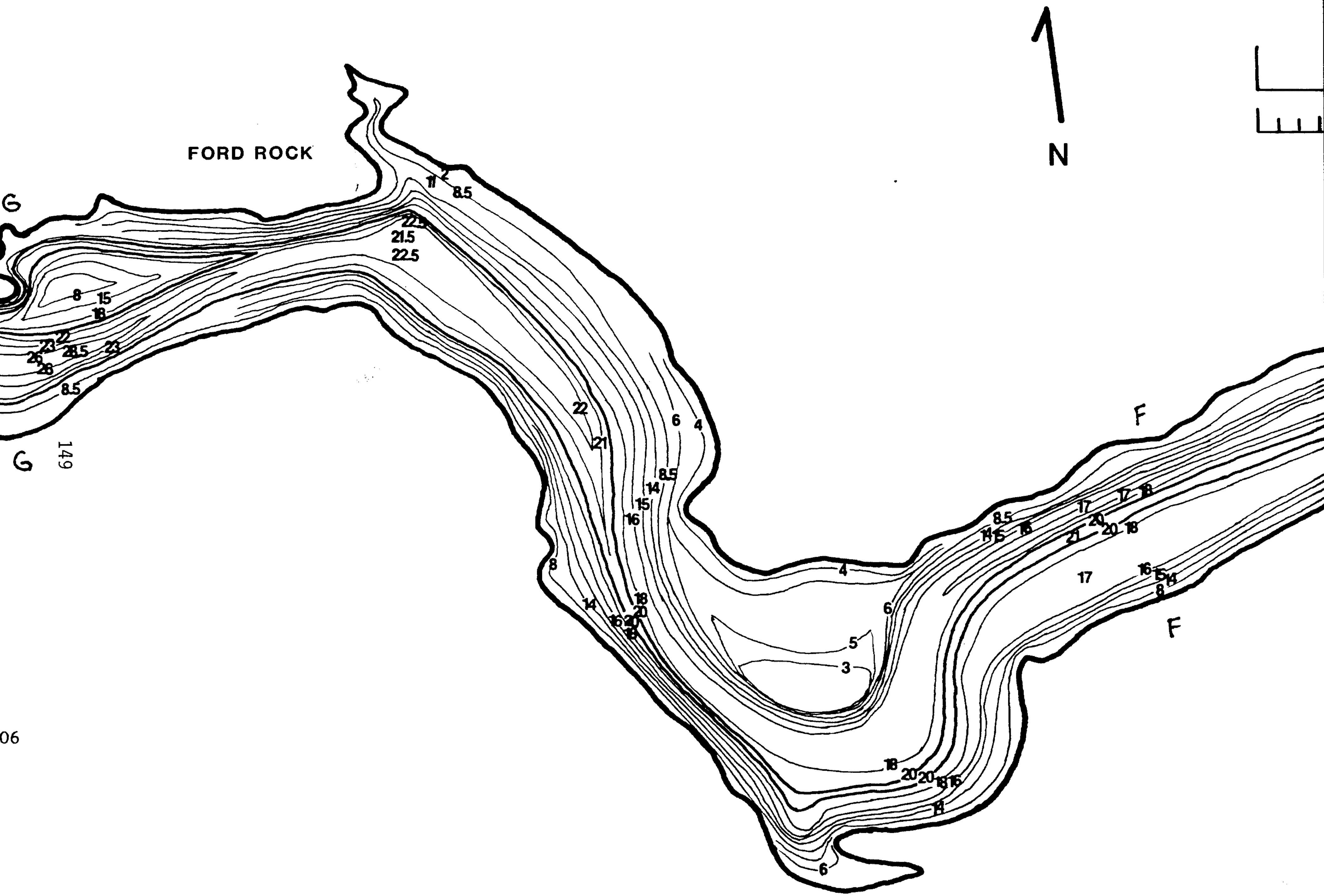
16
15
14
8
18


FORD ROCK
N
G
G
F
F
2
11
8.5
22.5
21.5
22.5
8
15
18
22
23
23
21.5
23
26
26
8.5
22
21
6
4
8.5
14
15
16
8
14
18
20
16
20
18
4
6
5
3
8.5
14
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8
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18
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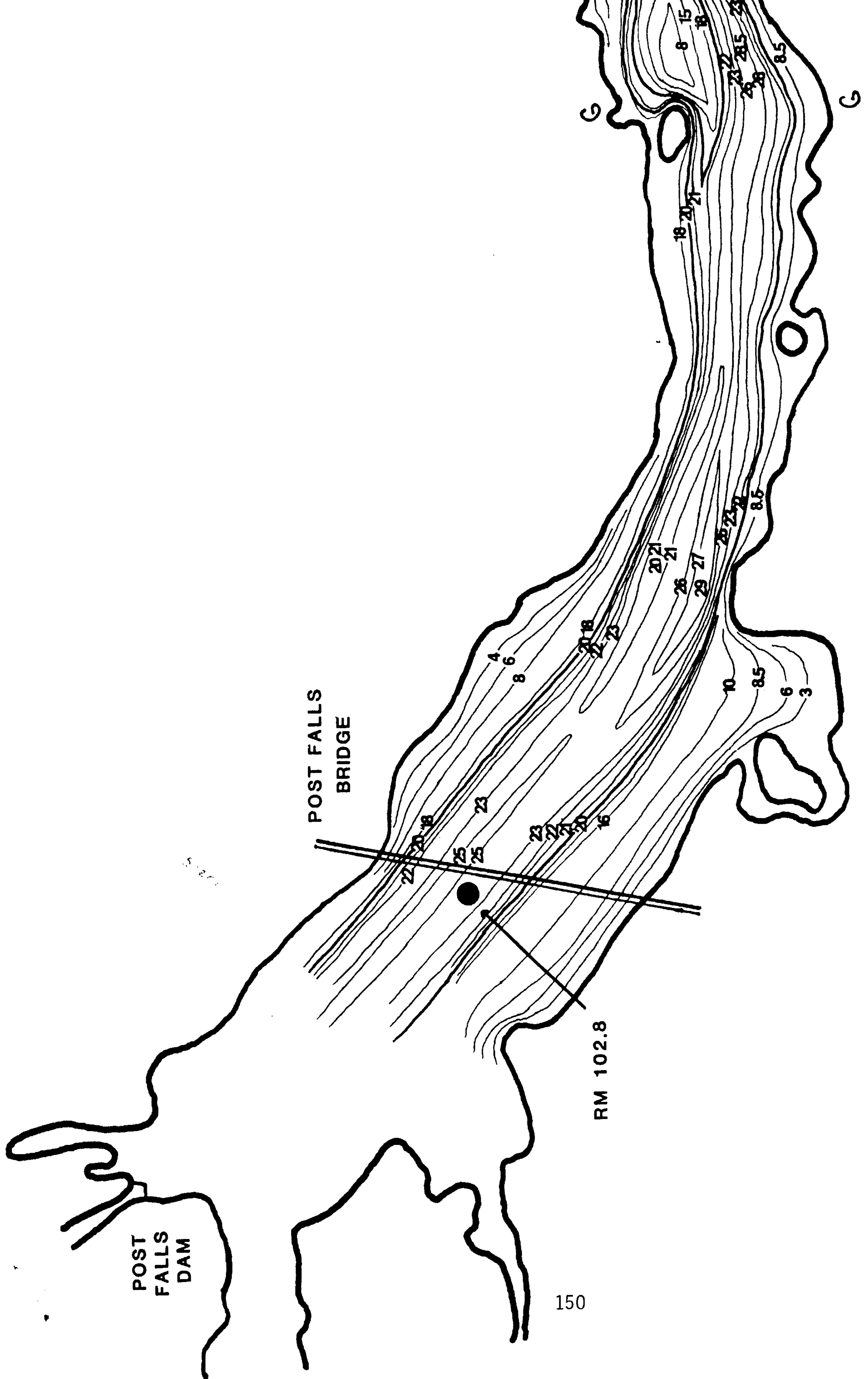
14
6


POST FALLS BRIDGE
RM 102.8
POST FALLS DAM
G
G
8
15
18
23
22
23
28.5
25
28
8.5
18
20
21
8.5
22
23
25
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29
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18
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10
8.5
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20
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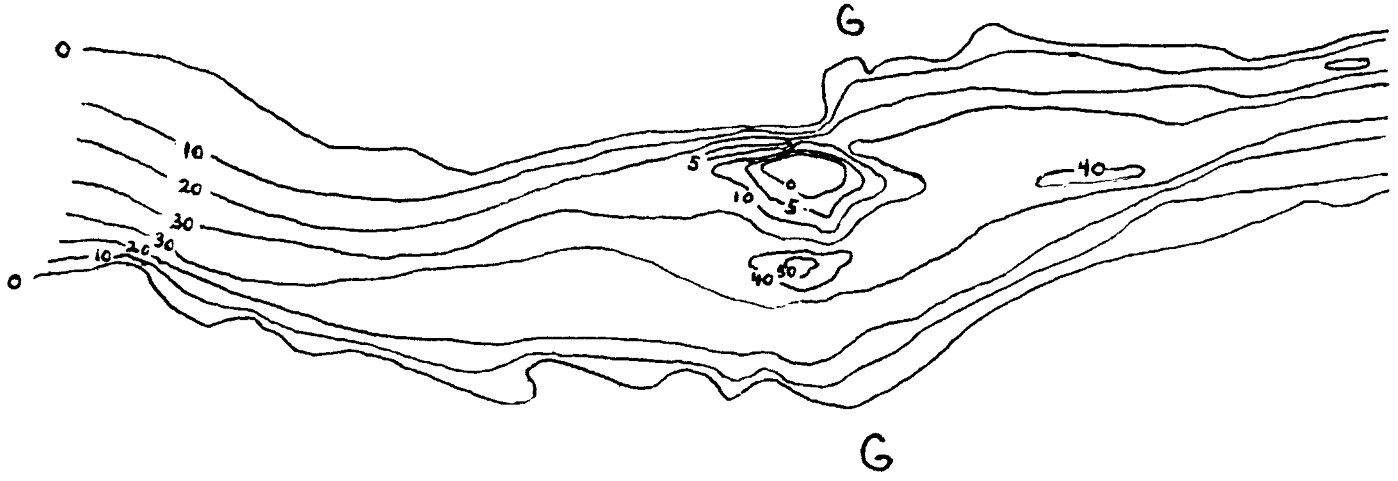

Vicinity of Ford Rock on the Spokane River with revised depth measurements of 1991.

APPENDIX D

Appropriate Idaho Water Quality Standards

Legend	
	# Protected for General Use
	* Protected for Future Use
Legend	X Use Protected Above Mining Impact Area

DESIGNATED USES

Map Code	Waters	Domestic Water Supply	Agricultural Water Supply	Cold Water Biota	Warm Water Biota	Salmonid Spawning	Primary Contact Recreation	Secondary Contact Recreation	Special Resource Water	
	source to mouth									(1-1-85)
ii. PB-320S	ST.JOE RIVER-Calder to St.Maries River	#	#	#		#	#	#	#	(1-30-80)
jj. PB-321S	ST.MARIES RIVER - source to Fernwood	#	#	#		*	#	#	#	(1-30-80)
kk. PB-322S	ST.MARIES RIVER - Fernwood to mouth		#	*			#	#		(1-30-80)
ll. PB-3221S	SANTA CREEK - source to mouth		#	*		*	#	#		(1-30-80)
mm. PB-330S	ST.JOE RIVER - St. Maries to mouth		#	#			#	#		(1-30-80)
nn. PB-340S	PLUMMER CREEK		#					#		(1-30-80)
oo. PB-350S	FERNAN LAKE AND OUTLET to Coeur d'Alene Lake	#	#	#		#	#	#		(1-30-80)
pp. PB-40S	SPOKANE RIVER - Coeur d'Alene Lake outlet to Ida-Wash border	#	#	#		#	#	#		(10-15-85)
qq. PB-410S	SPIRIT LAKE	#	#	#		#	#	#	#	(1-30-80)
rr. PB-420S	TWIN LAKES	#	#	#		*	#	#		(1-30-80)
ss. PB-430S	HAYDEN LAKE	#	#	#		#	#	#	#	(1-30-90)
tt. PB-440S	HAUSER LAKE	#	#	#		*	#	#		(1-30-80)

1.2161 -- 01.2199 (RESERVED)

01.2200, GENERAL WATER QUALITY STANDARDS. The following general water quality standards will apply to waters of the State, both surface and underground, in addition to the water quality standards set forth for specifically classified waters. Idaho Department of Health and Welfare Rules and Regulations Sections 01.2200,04. -- 01.2200,06. will, however, apply only to surface waters. As a result of man-caused point or nonpoint source discharge, waters of the State must not contain: (1-30-80)

01. Hazardous Materials. Hazardous materials (see Idaho Department of Health and Welfare Rules and Regulations Section 01.2003,19.) in concentrations found to be of public health significance or to adversely affect designated or protected beneficial uses. These materials do not include suspended sediment produced as a result of nonpoint source activities. (1-1-85)

02. Deleterious Materials. Deleterious materials (see Idaho Department of Health and Welfare Rules and Regulations Section 01.2003,07.) in concentrations that impair designated or protected beneficial uses without being hazardous. These materials do not include suspended sediment produced as a result of nonpoint source activities. (1-1-85)

03. Radioactive Materials. Radioactive materials or radioactivity which:

a. Exceed one-third (1/3) of the values listed in Idaho Department of Health and Welfare Rules and Regulations, Title 1, Chapter 9, Section 01.9110,03.a.ii., "Rules Governing Radiation Control." (1-1-85)

b. Exceed concentrations required to meet the "Radiation Protection Guides" for maximum exposure of critical human organs recommended by the former Federal Radiation Council in the case of foodstuffs harvested from these waters for human consumption. (1-30-80)

04. Floating, Suspended or Submerged Matter. Floating, suspended, or submerged matter of any kind in concentrations causing nuisance or objectionable conditions or that may adversely affect designated beneficial uses. This matter does not include suspended sediment produced as a result of nonpoint source activities. (2-2-83)

05. Excess Nutrients. Excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated or protected beneficial uses. (1-30-80)

06. Oxygen-Demanding Materials. Oxygen-demanding materials in concentrations that would result in an anaerobic water condition. (1-30-80)

07. Suspended Sediment. Suspended sediment in concentrations that seriously injure a designated or protected beneficial use. (2-2-83)

01.2201 -- 01.2249 (RESERVED)

01.2250, WATER QUALITY CRITERIA FOR USE CLASSIFICATIONS

01. Primary Contact Recreation. Between May 1 and September 30 of each calendar year, waters designated for primary contact recreation are not to contain fecal coliform bacteria significant to the public health in concentrations exceeding: (1-30-80)

a. 500/100 ml. at any time; and (1-30-80)

b. 200/100 ml. in more than ten percent (10%) of the total samples taken over a thirty (30) day period; and (1-30-80)

c. A geometric mean of 50/100 ml. based on a minimum of five (5) samples taken over a thirty (30) day period. (1-30-80)

02. Secondary Contact Recreation. Waters designated for secondary contact recreation are not to contain fecal coliform bacteria significant to the public health in concentrations exceeding: (1-30-80)

a. 800/100 ml. at any time; and (1-30-80)

b. 400/100 ml. in more than ten percent (10%) of the total samples taken over a thirty (30) day period; and (1-30-80)

c. A geometric mean of 200/100 ml. based on a minimum of five (5) samples taken over a thirty (30) day period. (1-30-80)

03. Warm Water Biota. Waters designated for warm water biota are to exhibit the following characteristics: (1-30-80)

a. Dissolved oxygen concentrations exceeding 5 mg/l at all times. In lakes and reservoirs this standard does not apply to: (1-30-80)

i. The bottom twenty percent (20%) of the water depth in natural lakes and reservoirs where depths are thirty-five (35) meters or less. (1-30-80)

ii. The bottom seven (7) meters of water depth in natural lakes and reservoirs where depths are greater than thirty-five (35) meters. (1-30-80)

iii. Those waters of the hypolimnion in stratified lakes and reservoirs. (1-30-80)

b. Hydrogen Ion Concentration (pH) values within the range of 6.5 to 9.0. (1-30-80)

c. Water temperatures of 33° C or less with a maximum daily average not greater than 29° C. (1-30-80)

d. The total concentration of dissolved gas not exceeding one hundred ten percent (110%) of saturation at atmospheric pressure at the point of sample collection. (1-30-80)

e. Mean concentration of un-ionized ammonia at a level of 005. mg/l or less as based on a minimum of five (5) samples taken over a thirty (30) day period. (1-30-80)

04. <u>Cold Water Biota</u>. Waters designated for cold water biota are to exhibit the following characteristics: (1-30-80)

a. Dissolved Oxygen Concentrations exceeding 6 mg/l at all times. In lakes and reservoirs this standard does not apply to: (1-30-80)

i. The bottom twenty percent (20%) of water depth in natural lakes and reservoirs where depths are thirty-five (35) meters or less. (1-30-80)

ii. The bottom seven (7) meters of water depth in natural lakes and reservoirs where depths are greater than thirty-five (35) meters. (1-30-80)

iii. Those waters of the hypolimnion in stratified lakes and reservoirs.

(1-30-80)

b. Hydrogen Ion Concentration (pH) values within the range of 6.5 and 9.0. (1-30-80)

c. Water temperatures of 22° C or less with a maximum daily average of no greater than 19° C. (1-30-80)

d. The total concentration of dissolved gas not exceeding one hundred ten percent (110%) of saturation at atmospheric pressure at the point of sample collection. (1-30-80)

e. Mean concentration of un-ionized ammonia at a level of 004. mg/l or less as based on a minimum of five (5) samples taken over a thirty (30) day period if water quality characteristics are near optimal for the protected use. In all other cases, the mean concentration of un-ionized ammonia is to be 002. mg/l or less as based on a minimum of five (5) samples taken over a thirty (30) day period. (1-30-80)

05. Salmonid Spawning. Waters designated for salmonid spawning are to exhibit the following characteristics during the spawning period and incubation for the particular species inhabiting those waters: (1-30-80)

a. Dissolved Oxygen concentrations exceeding 6 mg/l or ninety percent (90%) of saturation, whichever is greater. (1-30-80)

b. Hydrogen Ion Concentration (pH) values within the range of 6.5 to 9.0. (1-30-80)

c. Water temperatures of 13° C or less with a maximum daily average no greater than 9° C. (1-30-80)

d. Total concentration of dissolved gas not exceeding one hundred ten percent (110%) of saturation at atmospheric pressure at the point of sample collection. (1-30-80)

e. Mean concentration of un-ionized ammonia at a level of 004. mg/l or less as based on a minimum of five (5) samples taken over a thirty (30) day period if water quality characteristics are near optimal for the protected use. In all other cases, the mean concentration of un-ionized ammonia is to be

002. mg/l or less as based on a minimum of five (5) samples taken over a thirty (30) day period. (1-30-80)

06. Domestic Water Supplies. Waters designated for domestic water supplies are to exhibit the following characteristics: (1-30-80)

TABLE

	Substance	Maximum Allowable Concentrations mg/l	Degrees Celsius	
a.	Arsenic	005.0		(1-30-80)
b.	Barium	1.000		(1-30-80)
c.	Cadmium	001.0		(1-30-80)
d.	Chromium	005.0		(1-30-80)
e.	Cyanide	0.200		(1-30-80)
f.	Fluoride*			
i.		2.400	Up to 12.0	(1-30-80)
ii.		2.200	12.1 - 14.6	(1-30-80)
iii.		2.000	14.7 - 17.6	(1-30-80)
iv.		1.800	17.7 - 21.4	(1-30-80)
v.		1.600	21.5 - 26.1	(1-30-80)
vi.		1.400	26.3 - 32.5	(1-30-80)
g.	Lead	005.0		(1-30-80)
h.	Mercury	0.002		(1-30-80)
i.	Nitrate (as N)	10.000		(1-30-80)
j.	Selenium	001.0		(1-30-80)
k.	Silver	005.0		(1-30-80)
l.	Endrin	0.0002		(1-30-80)
m.	Lindane	0.004		(1-30-80)
n.	Methoxychlor	0.100		(1-30-80)
o.	Sodium	No maximum established; 20 suggested as optimum		(1-1-85)
p.	Toxaphene	0.005		(1-30-80)
q.	Trihalomethanes	0.100		(1-1-85)
r.	2,4-D	0.100		(1-1-85)
s.	2,4,5-TP Silvex	001.0		(1-1-85)

* As determined by the average annual maximum daily air temperature for the area where the water is to be used.

t. Radioactive materials. Radioactive materials or radioactivity not to exceed concentrations specified in Idaho Department of Health and Welfare Rules and Regulations Title 1, Chapter 8, Section 01.8102,01., "Rules Governing Public Drinking Water Systems." (1-1-85)

APPENDIX E

Water Quality Characteristics of Other Northern Idaho Streams

Water quality characteristics of the Upper Spokane River, the Pend Oreille River below Box Canyon Dam, and the Palouse River near Potlatch, Idaho.*

Spring Water Quality Characteristics (April)

	Spokane R. (4/9/91)	Pend Oreille R. (4/90)	Palouse R. (4/20/76)
Temperature (C)	3.9	8.7	3.5
Dissolved Oxygen (mg/l)	12.5	11.05	11.9
Secchi (m)	2.4	1.7	N/A
pH	7.8	7.9	7.2
Total Phosphorus (mg/l)	0.018	0.022	0.26
Total Kjeldhal Nitrogen (mg/l)	0.15	0.29	1.2
Nitrate-nitrogen (mg/l)	0.089	0.04	1.07
Ammonia-nitrogen (mg/l)	0.14	0.21	0.07
Chlorophyll a (mg/m3)	3.8	4.1	N/A

Late-Summer Water Quality Characteristics (Aug.-Sept.)

	Spokane R. (8/27/91)	Pend Oreille R. (8/89 & 8/90)	Palouse R. (9/10/75)
Temperature (C)	25.6	21.7	18.5
Dissolved Oxygen (mg/l)	7.5	8.4	8.5
Secchi (m)	3.3	4.5	N/A
pH	6.7	8.3	7.2
Total Phosphorus (mg/l)	0.01	0.01	0.08
Total Kjeldhal Nitrogen (mg/l)	0.19	0.16	1.7
Nitrate-nitrogen (mg/l)	0.04	0.02	<.01
Ammonia-nitrogen (mg/l)	0.19	0.15	0.21
Chlorophyll a (mg/m3)	4.51	1.02	N/A

* -- Pend Oreille River data from WATER QUALITY, FISH AND WILDLIFE CHARACTERISTICS OF BOX CANYON RESERVOIR, WASHINGTON. C. M. Falter, C. Baines, and J. W. Carlson. 1991. Completion Report 1989-1990. University of Idaho.

Palouse River data from WATER QUALITY STATUS REPORT, PALOUSE RIVER. 1975-1976. Report No. 33. Idaho Department of Health and Welfare. Division of Environment.

REVIEW COMMENTS AND AUTHORS' RESPONSES
SPOKANE RIVER WATER QUALITY STUDY
JUNE, 1990 - OCTOBER, 1991

March 24, 1992

Note of the Authors: Many of following reviewers' questions and comments refer to points that were simply beyond the scope of this study. We point out that this study was not, nor was it ever intended to be, an exhaustive study of the Spokane River and Wastewater Treatment Plants. Nor did the project scope of work given us did not include the amount of intensive sampling that would have been required to answer many of reviewers' questions. Both the length of the study and amount of funding were insufficient to have answered so many of the river dynamics questions of what is happening at any given time in the Spokane River ecosystem. Most of these questions are great questions, but should have been posed as this study was being designed and funding appropriated. The funding of $25,000 a year was far below the funding level required to answer most of these concerns.

The Spokane River is a complex system with a diverse array of point and non-point pollution sources affecting it. The basic goal of this study was to collect a limited amount of data, as outlined in the study plan, and based on this data, try to define general trends which, when viewed and acted upon would lead to an overall improvement in water quality of the Spokane River in the future. We feel we accomplished the goal.

CITY OF COEUR D'ALENE
COMMENTS TO THE
WATER QUALITY STUDY
OF
THE UPPER SPOKANE RIVER CONDUCTED BY:

C.M. FALTER
B. RIGGERS
J.W. CARLSON
1990/91

Draft published December 1991.

Comments will be in numerical order by Section, Page Number and Paragraph Number.

Comments will be in numerical order by Section, Page Number and Paragraph Number.

No. 1, Abstract, Page xi, Paragraph I

> The authors in describing the upper reaches of the Spokane River state that: "this reach is typified by swift water currents and cobble bottomed channel in the upper section.." In fact, numerous field trips by our staff and others of the community have noted a tremendous amount of "wood product" debris all along the upper reaches of the river, both in mid-channel and along the shores. This is easily evidenced at the Cedars Floating Restaurant, where the entire area is littered with logging debris.

The statement was made based on extensive SCUBA studies by Falter & Mitchell (1982). We have no reason to believe that the bottom composition has changed significantly since that time. Wood debris is common along the entire river due to the log rafting throughout the year. The debris accumulates in the slower sections (the lower reaches) where it has a chance to settle to the bottom.

No. 2, Abstract, Page xi, Paragraph II

> The authors note that the flow of 340 cfs occurred in September, 1990. However, elsewhere within the report the low flow was noted as being in September of 1991. This information needs to be corrected.

No. 3, Abstract, Page xi, Paragraph II

> The authors report a range of median pH's of 5.7 to 7.8; not just a median pH. We are curious as to why a median pH range was reported rater than a mean or mode?

It is statistically inaccurate to calculate a mean based on a set of logarithmic data (pH values). The median value to be more significant than the modal value when left with these two options and is commonly used in water quality studies.

No. 4, Abstract, Page xi, Paragraph III

> The authors report a 73% increase of the mean year round chlorophyll *a* over the 7.6 mile reach. We are uncertain as to the significance of this statement and why the authors chose to report this. We would naturally expect a significant increase in the chlorophyll *a* content of any waters after it has exited a lake. Higher sunlight penetration combined with shallower waters and higher temperatures would naturally produce an increase; all other factors being equal.

We presented this chlorophyll *a* increase because it is a potential problem in the river. As chlorophyll *a* increases, water transparency decreases, thus detracting from the aesthetic quality of the water. Overall water quality is also reduced.

As to the assumptions that sunlight and warm temperatures alone cannot support phytoplankton as in any biological community, the population must have nutrients in order to grow and multiply. In the case of phytoplankton, these nutrients are mainly phosphorus and nitrogen. In this area, phosphorus is nearly always the number one limiting nutrient in determining the phytoplankton production in a body of water (*i.e.* the phosphorus level determines the phytoplankton level).

In the Spokane River, all other factors are not equal, as suggested in the comments. Concentrations of all nutrients measured in the study increased over the 7.6 mile reach. This correlates with the increase in chlorophyll a concentrations over the reach.

No. 5, Abstract, Page xi, Paragraph IV

The concentrations of chlorophyll *a* placed in the Spokane River in the Mesotrophic and the Meso-oligotrophic productivity ranges. These two terms indicate that river is in a quite healthy condition. We wonder why these terms were chosen to define the river quality without any further discussion.

These terms were obtained from tables by Wetzel (1983) based on various water quality parameters. The trophic status of a water body is a relative term. Studies done 10 years ago by Falter & Mitchell classify the Spokane River as extremely oligotrophic based on algal productivity. This suggests that either overall nutrient loading to the Spokane River is increasing or that inhibiting metals are on the decline.

No. 6, Abstract, Page xii, Paragraph I

The authors note a general trend of TKN increasing downstream through the study reach. This is contrary to results obtained by Soltero in his study. The Soltero study noted a decrease in the TKN between the lake outlet and the Spokane Industrial Park. We question whether the authors took into account either in-flow or out-flow to the Spokane/Rathdrum aquifer? What is this trend indicative of?

We claim no responsibility for Soltero's study nor his conclusions. The Spokane Industrial Park is ?? miles downstream of the study area. This makes comparisons questionable. Our study was not designed to determine sources and sinks of TKN below RM 100.7.

As far as trends are concerned, the increased downstream TKN concentrations are indicative of high TKN in WWTP effluent discharges, private drainfields, and other unknown sources, as pointed out in the report (pg. 15). It would be speculative to surmise further on the sources as they have not been assessed.

No. 7, Abstract, Page xii, Paragraph II

The authors note summer total phosphorus increased 87% between RM-111,1 and RM-108.8 over the entire study, 187% in 1991, but showed a 30% decline in 1991 after phosphorus removal in the Coeur d' Alene WWTP. This statement is quite confusing. How was the 87% figure arrived at: is this a mean between 187% increase in 1990 and 30% decrease in 1991? What is meant by summer total phosphorus increased over the entire study? The entire study period was for approximately 1 1/2 years and included winter. The authors note that beginning in June of 1991, total phosphorus in our effluent declined by 79%, This is incorrect inasmuch that for the period of June through October 1991, our average removal rate was 85.4% to an average discharge concentration of 0.93 mg/l. There is no mention of statistical meaning to these and other variations in nutrients and chlorophyll *a* in this report. If the author is using simple percentages to draw conclusions, he should include the normal ranges of deviations (in percent) that one would normally find in a river system of this category. (See Table #1).

No. 8, Abstract, Page xii, Paragraph III

The authors note that the wastewater treatment plant BOD_5 levels from the CD'A plant averaged 81.2 mg/l. This is incorrect. Our discharge permit prohibits us from discharging in excess of 30 mg/l BOD_5. We have not been in violation of this discharge permit. Using BOD_5 data from our records either on the same dates the study sampled, or the closest date to that, our average for the study period was 15.0 mg/l.

We reproduced the results of our independent tests on CDA WWTP effluent as they appeared. We are aware of the discrepancy between our results and those of your lab. Our river BOD values were in expected ranges; we can find no explanation in our data for the discrepancy on WWTP values.

No. 9, Abstract, Page xii, Paragraph IV

The authors are reporting median fecal coliform bacteria. Coliform data when used properly, can only show log differences, *i.e.*, geometric means are reported.

In many cases, the extreme variability in coliform counts can cause geometric means to be misleading and of little use (see Table 18). It is also inaccurate to compute a mean with values such as > 60. Therefore, we deemed the median value to have more significance.

No. 10, Introduction, Page 1, Specific Objectives No. 4

The authors claim that a specific objective of the study was to determine the effects of existing and proposed wastewater discharges on river water quality. We do not feel that this objective was adequately completed within the text of this study.

Objective 4 was written unclearly. See revision.

No. 11, Methods, Page 3, Paragraph II

The authors note that samples of municipal treatment effluent were taken from a 24 hour composite sampler located at each wastewater treatment plant. Such a composite sample should not be used to determine the presence of coliform bacteria. This is contrary to the Standard Methods, 1989 Edition.

We ran the samples given us by the WWTP personnel. Using a composited sample can increase variability of bacterial samples.

No. 12, Methods, Page 3, Paragraph IV

Water volumes between stations were determined by mechanical planimetry of morphometric data. This information was used to determine retention times. We question the completeness of the existing data bases to determine accurate river volumes by planimetry.

Falter & Mitchell (1982) conducted extensive depth transect studies on this reach and developed complete morphometric maps of the area. In addition, we ran depth transects at all sample stations and extensively in the Ford Rock area, as outlined in the Methods section of the report (pg. 5). Both of these resources were used in calculating river volumes, and we believe the calculations to be quite accurate. Planimetry is, of course, the accepted method of determining river and lake volumes. Other suggestions? Morphometric maps have been included in Appendix A1 and A2.

No. 13, Methods, Page 4, Paragraph II, Bacteria

In Paragraph I of this page, the authors say that the procedures used for analyses were outlined in Standard Methods, 1989 Edition. However, the authors indicate that coliform bacteria were analyzed using a membrane filter technique and colonies were counted with microscope at 100 power. This is contrary to Standard Methods procedures, which says that a microscope of 10-15 power should be used. (See also Comment No. 9, above.)

Standard Methods does suggest the use of 10-15 power microscopes in counting coliform bacteria. However, since the entire filter is counted for coliform colonies, the magnification makes no difference, and we found the counting to be even more accurate under the higher magnification. We know the difference between real colonies and the blue media specks and did not count anomaly.

No. 14, Methods, Page 4, Biochemical Oxygen Demand

Several problems/conflicts with the authors' methods of determining BOD arise. Of particular concern is the determination of ultimate BOD's. Standard Methods do not include any procedures for determining ultimate BOD's. As a matter of fact, Standard Methods state that in doing a BOD test, at least 2 mg/l of oxygen should be consumed and that at least 2 mg/l of oxygen should remain. However, if the authors chose to do some sort of an ultimate BOD testing, time periods chosen should closely resemble those detention periods for the basins; assuming that these detention periods can be accurately calculated. At that, it is suggested that the protocol should include sufficient dilutions to ensure that at least 1 mg/l is consumed, and that at least 1 mg/l remains in the samples.

Effluents do not just remain in a receiving water for 5 days; They are in the receiving water until total degradation it reaches the sea, whichever comes first. The BOD_5 test originated in England where no WW source was more than 5 days' flow time from the sea, hence the use of BOD_5....The practice stuck. Ultimate BOD is a common diagnostic tool in larger countries (compared to England) to give a more realistic estimate of total BOD loading.

Our ultimate BOD testing did follow those residual oxygen guidelines. Measurement of ultimate BOD of an effluent stands by itself, independent of treatment time so similarity of assay times with detention times is meaningless.

No. 15, Methods, Page 6, Quality Control/Quality Assurance

Our single greatest concern is that of the authors' QA/QC program. The authors do detail how multiple instruments were used, and how duplicates were run on at least 10% of the samples throughout the study. They also mention that 39 samples were split and analyses performed by the UI Forestry Lab and the UI Analytical Lab for comparison. Did the results of the splits indicate good quality control? We are at significant variance with some of the analytical results being reported. We will deal with those individual parameters within the body of the comment concerning that individual analysis.

As is described in Section 1020 of Standard Methods, 17th Edition, QA and QC are two distinctly different approaches to laboratory control. It is assumed that the authors' laboratory procedures do, in fact, have a written QA plan. In some cases, however, we do question whether data validation is adequate.

Of single greatest concern is that of quality control. Quality control may be either internal or external; both are recommended. There are basically seven outlined steps for a effective quality control program. Nowhere in the authors' discussion of their QC program has it been stated that known additions are used as part of their regular analytical protocol. (Sometimes known as running "spiked" samples.) As is noted in this section of Standard Methods, at least 10% of the number of samples should be represented by known addition or spiked samples. We ask if this was done?

Another key factor of a good QC program is that of externally supplied standards. We are required to run a set of unknowns furnished by the EPA on an annual basis. The results of these are attached to these comments. (Tables #2 and #3).

Nor do the authors mention whether or not an analysis of reagent blanks has been performed as part of their QC program in addition to calibration with standards.

We feel that more discussion of the study's QA/QC program should be provided. Attached to these comments are Table 2, which is a comparison of our test results with that of the DEQ Lab in Coeur d' Alene for five (5) different parameters on influent and effluent samples. It can be noted that we are in very good statistical agreement. Attached also is Table 3, our analyses of EPA provided known quantities over the past three (3) years. It can be noted that our results are definitely within the acceptable limits and ranges of the EPA program.

Additional explanations provided in report.

No. 16, Results/Discussion, Page 11, Dissolved Oxygen, Para I

The authors refer to the Idaho Water Quality Standards for Cold Water Biota and Salmonid Spawning of DO levels being 6.0 mg/l. In addition, Idaho Water Quality Standards also indicate a saturation of 90% or 6 mg/l, whichever is highest. The authors do not mention which standard was used to determine saturation percentages; *i.e.*, was the actual Spokane River Water used to determine saturation concentrations?

The percent of dissolved oxygen saturation is usually calculated from standard tables assuming clean water with no salinity and no surface active agents. Field survey work should include testing to determine a "true saturation" concentration in the river water to permit accurate calculation of percent saturation from ambient dissolved oxygen measurements.

Yes. See text.

No. 17, Results/Discussion, Page 11, Dissolved Oxygen, Para II

The authors note that, "Percent saturation levels were somewhat low compared to other North Idaho streams, (Table 5)". However, no actual comparative data for other North Idaho streams are presented in any of the tables, including Table 5. What is the significance of this statement? How do other North Idaho streams compare with the Spokane River as to temperatures and atmospheric pressures?

See text.

No. 18, Results/Discussions, Page 11, Electrical Conductivity

The authors note ranges of conductivity tests taken throughout the study area. However, no significance or explanation of these results are offered. If they have no significance, why were they conducted?

The study plan provided us called for them.

No. 19, Results/Discussions, page 12, pH

The authors again report median values for pH. What is a median value and why are the results reported as median values? (See also comment No. 3)

A median is the middle value in a set of data that has been organized in ascending or descending order (see answer to Comment No. 3).

No. 20, Results/Discussions, Page 12, Turbidity, Paragraph II

The authors note that turbidity increased as flow did in the spring and note that turbidity appears to be directly related to flow and bottom sediments being stirred up and re-suspended. Not accounted for was the additional flushing of nutrients, BOD and suspended solids through the lake's system during spring runoff.

That was accounted for by comparison with the upstream station.

No. 21, Results/Discussion, Page 13 & 14, Chlorophyll a, Para V

The authors note that in the Falter and Mitchell study of 1982, the chlorophyll *a* results reported did not correct for pheophytin *a,* and that this tended to over-estimate the chlorophyll *a*. They further state that a doubling of chlorophyll *a* between 1980 and 1990/91 is probably a reasonable conclusion. However, the authors offer no substantial information to verify such a speculative conclusion.

That statement only applies to the two-year 1990-91 - one-year 1980 comparison. As such, it stands.

No. 22, Results/Discussions, Page 15, Nitrate-Nitrogen, Para II

The authors state that the Coeur d' Alene WWTP contributes very little nitrate/nitrogen to the Spokane River. This is in conflict with the graphs and text presented later in the study. Downstream tests indicate that the Cd'A NH_3 discharge is rapidly converted to NO_3.

The ammonia is converted to NO3, but not until at least after RM 108.8 (see correlating incline and decline of NO3 & NH3, respectively, in Figures 30 & 33).

No. 23, Results/Discussion, Page 16, Ammonia-Nitrogen, Para I

The authors note that the direct ammonia procedure used to analyze ammonia samples is no longer approved by the EPA because of the possibility of background interference. The authors indicate that they are using this direct method of measuring ammonia. They note that it is still a Standard Methods approved technique. They further state that, "values determined for WWTP'S, however, should be received with caution due to the possibility of background interference in those samples of high organic content". The statement concerning the direct ammonia procedure no longer being approved by EPA is correct. The use of the direct "probe" method has not been allowed by EPA for a good number of years. However, the Cd'A WWTP does not use this method. We use *Standard Method 350.2*, which is approved by the EPA as noted in the text, *EPA's Sampling and Analysis Methods*, edited by Lawrence H. Keith, copyright 1992. The authors obviously have not determined which methods each of the WWTP's use to determine ammonia.

The statement concerning WWTP values pertains to our methods and values, not the analysis methods of the WWTP's. Furthermore, our method for determining ammonia-nitrogen was not the direct probe method, it was the Direct Nesslerization procedure outlined by Standard Methods. We never indicated we used the probe method but will make this clarification the update of the report.

No. 24, Results/Discussion, Page 17, Total Phosphorus, Para III

The authors note increases in mean concentrations of total phosphorus between several RM Stations. Said presentations of percentage of increases in the river reach have little or no meaning. Actual loadings furnished by the respective treatment plants are not presented here. We offer the following information as attached Tables #4, #5 and Figures #1 and #2.

This study was designed by the Idaho DEQ as a characterization of this reach of the Spokane River, describing seasonal and spatial variation, not as a waste loading allocation study (See Objectives). Much of the criticism of the study originates from that mistaken expectation, of efforts to make it something it was not designed to do from the outset. Percentage increases do have a valuable role in the description of surface waters, responding to external factors.

No. 25, Results/Discussion, Page 18, Total Phosphorus, Para II & III

The authors note that a much reduced summer total phosphorus load occurred in 1991. They also state that this increase is significant, because it shows an overall deterioration in water quality of the Spokane River over the past 10 years. We are uncertain if the conjecture actually occurs, because the two statements appear to be in conflict. Is there still a deteriorating relationship even after phosphorus removal has begun at the Coeur d'Alene WWTP during the growing period?

Two different points are presented, and perhaps they should be clarified. First, the past 10 years have seen a general decline in overall river water quality, as evident in the total phosphorus trends over this period. Secondly, 1991 did see a reduction in TP compared to 1990, largely due to the efforts of CDA WWTP to remove phosphorus from treated effluent. This improved TP removal was significant to the river and the river's response was noted. The text has been clarified on that point.

No. 26, Results/Discussion, Page 19, N:P Ratio

Previous data obtained from the *Spokane River Basin: Allowable Phosphorus Loading*, C.R. Patmont of Harper-Owes, September, 1987, indicates that the Spokane River is clearly nitrogen limiting from the lake outlet to somewhere in Washington. (See attached Figure #3)

We have taken the information provided by the study from Stations No. 1, 2, and 3 and calculated an N:P Ratio. It appears that the N:P Ratio generally decreases between Sta. 1 and Sta. 2 until phosphorus removal began in 1991. During the phosphorus removal periods, the N:P Ratio increased greatly as a direct result of the WWTP's high ammonia-nitrogen discharge and low phosphorus discharge. This information is presented as Table #6.

Only partially true, but clarifications made in text.

No. 27, Results/Discussion, Page 19 & 20, Zinc

The authors note that there is a significant reduction in the concentration of zinc in the Spokane River over the past 10 years. They further state, "these lower levels may not be inhibiting phytoplankton growth to the extent that they were 10 years ago". However, we wonder if zinc concentrations in the bottom sediments are sufficient enough to inhibit bottom growth and does this have any significant impact to river water quality?

We conducted no studies to determine zinc concentrations in bottom sediments of the Spokane River and therefore cannot comment on growth inhibition of either algae or macrophytes. Our statements concerning zinc inhibition of phytoplankton growth are conjectural, based on past measurements and bioassays conducted on Spokane River water.

No. 28, Results/Discussion, Page 20, Biochemical Oxygen Demand, Paragraph II

The authors note that the interim results published in early 1991 were incorrect. They note in this discussion that they failed to adjust for 300 ml sample up to 1 l. Not knowing exactly how the miscalculated these results, we can make no other comment other than that that was noted in Comment No. 8, that shows that more than likely the study results reported for the Coeur d'Alene WWTP effluent is off by a factor in excess of 3. It is strongly suggested that the authors re-examine their calculations. We have taken our results on the date nearest to the test dates and provided the BOD_5 information. Attached is Table #7 showing the variations. As can be noted, the study results report and average BOD_5 for the effluent at Cd'A's WWTP as 81.2. We only had three test results that corresponded exactly with the study's test dates; the average of those three results was 14.2 mg/l. However, as can be noted, for the dates closest to the sampling dates of the study our overall BOD_5 effluent average was 15.0 mg/l. Some of the study results are as high as the plant's influent; indicating that no BOD_5 treatment occurred at the plant - highly unlikely.

We would request that the BOD's be re-taken and that split samples be performed by the study authors' lab, the City of Cd'A WWTP's lab and the DEQ lab at Coeur d'Alene.

We have reviewed our lab notes, data, and calculations and can find no explanation for error other than the discrepancy between the two labs. We cannot, therefore, change the numbers. The discrepancy can only be noted in interpretation of our data. If the UI does another study year in 1992, we would be happy to include BOD split sampling.

No. 29, Results/Discussion, Page 20, BOC, Paragraph V

The authors note that a portion of this downstream increase in BOD is secondary five day BOD from phytoplankton production in the lower reaches. They also note here, "but a significant portion is undoubtedly directly attributable to the Coeur d'Alene WWTP discharges". This statement indicates that the report is incomplete. We do not know how the authors came to the conclusion that a significant portion is due to Coeur d'Alene effluent, when no research data is provided. Sediment, algae, etc., deposits under low-flow will also increase BOD_5. This would appear to be an editorial statement not based on sound scientific evidence.

We are revising this section of the report to further elaborate, but our statements were reasonable conclusions based upon interpretation of our BOD data and therefore were not an editorial statement.

No. 30, Results/Discussion, Page 21, Ultimate BOD

As was noted in Comments No. 14 and No. 15, QA/QC procedures have to be rigidly defined in order to show any validity in reporting ultimate BOD determinations. In as much as the BOD_5 results have been misreported and still are incorrect, we question the validity of the ultimate BOD results.

There is question as noted above, with the BOD_5 data but they have **not** been misreported; our available data were accurately reported.

No. 31, Results/Discussion, Page 21, Fecal coliform Bacteria

Our Comment No. 13 is again referred to. Standard Methods indicate that with these high numbers, confirmation should be made with EC media. We wonder if this was done? (The study results do not indicate so.) Under the Section of "Methods", the authors state that they used the membrane filter technique for determining fecal coliforms and fecal streptococcus bacteria. Yet all the results are reported as Most Probable Number (MPN). These are two separate and distinct analytical methods. We wonder which procedure was actually used to determine coliform colony counts?

As was noted in previous comments, only the geometric means are used to report colony counts. Attached, please find our Table #87, which compares the study results for fecal coliform with Coeur d'Alene Wastewater Treatment Plant Lab results. As can be noted, we have considerable variation from that of the study results. We strongly recommend that the authors re-evaluate their testing procedure and particularly their method of calculating results. Again, we wonder whether or not confirmation of results were performed as prescribed by *Standard Methods, 17th Edition?* Finally as was previously noted, colony counts are made with a 10 to 15 power microscope, not a 100 power microscope.

Already addressed.

No. 32, Results/Discussion, Page 22, Paragraph I

The authors discuss fecal streptococcus MPN numbers (most probable number) for the Cd'A WWTP effluent. As we do not routinely run fecal streptococcus within our own laboratory, we have no way to verify or challenge the results reported here. (See also comments concerning fecal coliform bacteria, above.)

No. 33, Conclusions, page 23, No. 6

The authors report a low pH of 3.3. Even though the authors discuss the thoroughness and repeat testing done to verify a pH 3.3, we question these results. Noting the sampling locations for mid-depth of the Spokane River as displayed in "Figure 2", a pH of 3.3 would indicate that a large volume of the river water was represented by that number. It is hard to imagine that some aquatic life would endure a pH that acid. We wonder if replicate samples or re-sampling was done to verify this low of a number. Two possible explanations come to mind; could the sample bottle have a remnant trace of acid solution in it before collection? Why wasn't re-sampling done and why didn't subsequent sampling show similar results?

Acid contamination was possible but unlikely since we used the same bottles for pH determination repeatedly. The low pH was measured several hours after sampling, precluding going back to redo the sampling. The pH was taken on several meters, however.

No. 34, Conclusions, Page 24, No. 10

The authors conclude that high flows stirred up bottom sediments through the reach and combined with spring algae pulps to reduce secchi disk depth to 2.2 meters at those times. No mention of the effect of log traffic and/or log debris in the bottom of the river has been made here.

The study was not intended to address the effects of log traffic and/or log debris. We do, however, believe these to be insignificant in contributing to the decreased secchi depth, especially in the lower, deeper reaches of the river.

No. 35, Conclusions, Page 24, No. 10

The authors report that the TKN varied little with time of year or with water flows. We question these results as some of the draft data indicates it did, in fact, change. We would certainly expect the TKN to change in as much as that our total ammonia-nitrogen output in our effluent changes considerably with time of year. Therefore, in-river flows of TKN should likewise change.

The graphs show the data that we collected and analyzed. Results are results, whether or not they arrive at an expected conclusion.

No. 36, Conclusions, Page 24, No. 11

The authors state that at low flows WWTP's supplied 40% of the total nitrate load to the river. This is in contrast with the statement found in Comment No. 22, that the Coeur d' Alene treatment contributes very little nitrate-nitrogen to the Spokane River. Most of all the Coeur d' Alene WWTP's nitrogen discharges is in the form of ammonia. Therefore, this statement seems to be at odds with the scientific data.

Corrected in report.

No. 37, Conclusions, Page 24, No 12

The authors note that between RM-111.1 and RM-108.8 there was an average 75% increase in the total ammonia in the river, but less than 1/3 of that increase was from the Coeur d' Alene WWTP. The authors offer no suggestions as to where the other 2/3 of the ammonia load is coming from. Failure to provide this solution appears to be in conflict with the objectives of the study.

It would appear that a new river sampling station is highly desirable. We would strongly suggest that any further sampling and testing have a new station directly upstream of the Coeur d' Alene WWTP's outfall, and a sampling station be located immediately downstream.

Determining all point and non-point pollution sources was not an objective of the study as formulated by Idaho DEQ. To further elaborate on ammonia sources as called for in the comments would be unsupported speculation.

No. 38, Conclusions, Page 25, No. 13

The authors note a total phosphorus increase between RM-111.1 and RM-108.8 over the entire study. While their data does, in fact, indicate that this be the case, no mention of the fact that by RM-102.5 approximately the Post Falls Dam, the phosphorus level has decreased very significantly.

This is based on results from previous studies. It should be noted in the conclusions section that this total phosphorus increase only occurs during low-flow conditions.

We have clarified the statements so that they are more clear. Contrary to the comments, however, we do mention the net phosphorus sink by RM 102.5 (pg 25, No. 13). What one should be aware of is that the phosphorus doesn't just disappear. Much of it is converted into phytoplankton, attached algae, or macrophyte growth, resulting in the higher chlorophyll a values downstream (pg. 25, No. 9). Eventual fate may be in the sediments or removal from the aquatic system by insect emergence.

No. 39, Conclusions, Page 25, No. 14

The authors note that orthophosphorus averaged less than 0.006 mg/l in the river, but WWTP's effluent averaged 3.42 mg/l during this study. Two items of omittance should be noted here. First of all, we have noted that the Coeur d' Alene WWTP's effluent phosphorus is approximately 80% orthophosphorus. We also note that during the growing season, we are obligated to remove phosphorus to 85% removal or down to 1 mg/l. This was done during the summer of 1991 and continued through the fall growing season. No mention of this significant fact is noted.

We suggest a re-read of Conclusion 14, pg. 25, under the third sub-heading. We feel we have adequately addressed effluent phosphorus removal treatment.

No. 40, Conclusions, Page 25, No. 16

Again, we draw the readers' attention to the incorrect reporting of the Coeur d' Alene effluent average BOD_5 of 81.2 mg/l. (See previous comments).

Already addressed.

No. 41, Conclusions, Page 25, No. 17

Again, ultimate BOD levels were reported in the conclusions while they have very little, if any significance as a study result. Mean ultimate BOD increases of 11% in the lower reaches cannot necessarily be attributable to wastewater treatment plant effluent. No mention of possible log waste, log debris, or algae contributions is made here.

Nowhere in the conclusions do we state that the 11% increase is directly attributable to wastewater treatment plant effluent. However, an 11% increase in ultimate BOD throughout the reach is significant as a study result, no matter where it originates.

No. 42, Conclusions, Page 26, No. 18

Again, median fecal coliform counts were listed here. This is in direct conflict with reporting methods as detailed in Standard Methods.

See answers to Comment 9.

No. 43, Page F-1, Figure 1

In the map of the sampling sites for the upper Spokane River, the authors do not locate any of the large mill sites that may be considered almost as a significant point-source in themselves.

The scope of the study was not intended to directly address mill effluent.

No. 44, page F-7, Figure 8

This graphic depicting both Spokane River flow and wastewater treatment plant discharges is confusing at best and shows a bias on the part of the authors at the worst. WWTP discharges shown on the left of this graph are in units of cfs. An initial scanning of this graph gives the appearance that the treatment plants' flows are a very large percentage of the overall river flow; which, of course, is not the case. This graphic should be revised into two graphs, or at the least use one scale for both discharges.

We agree that this graph is misleading, and have deleted it.

No. 45, Page F-23, Figure 25

Please see our Comment No. 35. The authors, in their conclusions, state that TKN varied little with time-of-year, or with water flows.

See Figure 24.

No. 46, Page F-28, Figure 30

This graphic shows an extreme increase in the mean nitrate-nitrogen concentrations between RM-108.8 and RM-106.2. No conclusions or discussions of why this peaking occurred have been given. Are we to conclude that this increase in nitrate-nitrogen is a result of the Cd'A's WWTP effluent ammonia being oxidized to nitrate by RM-106.2, or is this indicative of a different source of nitrate-nitrogen?

Our thought is that this increase is, in fact, a result of ammonia being oxidized to nitrate in this section, as a similar decline in ammonia-nitrogen is seen (see Figure 33, pg. F-31). However, we do not have sufficient data to support this claim.

No. 47, Page F-33, Figure 35

This graphic is in error as the nitrate and ammonia bars should be reversed, i.e., the stripped bar should be marked ammonia and the solid black should be marked nitrate.

We have corrected this. Thank you.

No. 48, Page F-35, Figure 37

Not emphasized by this graphic is the fact that total phosphorus loading to the river varies between 0.01 and 0.025 mg/l. The flows of the river vary a great deal. During Spring run-off, tremendous amounts of phosphorus come down with these increased flows, so while the concentration of P does not vary a great deal, total phosphorus loading heading down-river to Long Lake does vary a great deal. No discussion of this phenomenon was presented.

The area of concern in this study was the 11-mile outlet reach of the Spokane River, and while we do not pretend to ignore the effects of high flows and moderately high phosphorus concentrations entering Long Lake, neither do we address them. The comment question is simply not within the scope of this study.

No. 49, Page F-36, Figure 38

This graphic notes the phosphorus concentrations in the upper reaches of the Spokane River during the two test periods. All river concentrations are well below 0.02 mg/l; the threshold indicated as harmful to Long Lake. The significance of this has not been discussed.

See answer to Comment 48.

No. 50, Page F-39, Figure 41

This graphic shows mean total orthophosphorus concentrations. Again, at best this is an extremely confusing graphic that has very little significance and certainly no discussion about its significance of the data being represented here.

This graph shows that O-P concentrations were generally below detectable limits (.006 mg/l) in the Spokane River, and were extremely high in both WWTP's. A discussion of the significance of this is in the text (pg. 18, paragraphs 5 & 6).

No. 51, Page F-41, Figure 43

This graphic shows the percentage of total orthophosphorus loads from the Cd'A and Post Falls WWTP's versus the Spokane River background load at various times throughout the study period. The question arises as to what may occur to the orthophosphorus load during periods of little or no mixing. Does the river bottom have a high P up-take?

See pg. 18, paragraph 6. Chemical reactions occurring in the bottom sediments of the Spokane River were not addressed in this study.

No. 52, Page F-44, Figure 46

This graphic showing mean five (5) day BOD's in the Spokane River and both treatment plant effluents during the study period. We see no correlation in the fluctuations of river BOD_5. The graphic notes problems with dilutions of WWTP effluent resulted and no BOD_5 data in the early tests. We can furnish those results. The significance of this apparent lack of correlation between the concentrations has not been discussed.

Figure 46 was not intended to show a correlation between mean Spokane River BOD5 and effluent BOD5, and no inference of such correlation was made. The graph was referenced in an attempt to point out the period of highest BOD in the river, and to show fluctuations in river and effluent BOD throughout the study (see pg. 20, paragraph 4).

No. 53, Page F-46, Figure 48

Again, we refer to our comments concerning ultimate BOD's.

No. 54, Page F-47, Figure 49

We refer to our comments concerning reporting of median fecal coliform counts as being outside of the Standard Methods for examination of wastewater.

Addressed

No. 55, Page T-15, Table 16

The threshold of detectability for orthophosphorus concentrations appears to be 0.006 mg/l. Many concentrations are listed as being less than this threshold of detectability. How then, can one use the lower limits of detectability in averaging numbers? What is the statistical significance of averaging data below the Method's Detectability Limits (MDL)?

It is common limnological and water quality practice to use the mid-way point between 0 and the MDL as the value to average.

No. 56, Page T-16, Table 16

Refer to our attached Table #7.

No. 57, Page T-20, Table 18

This table tabulates results from fecal coliform tests. Please see our previous comments concerning result reporting. There is a difference between MPN and membrane filter methods. What, if any, differences in results can be expected?

Cannot say on the basis of our data.

No. 58, Page T-22, Table 20

Two items of significance are found here. First, the flows reported by the Cd'A treatment plant prior to September of 1991, were in significant error. After that date, a flow meter at the effluent end of the plant was put on-line. We estimate that flows can be off as much as 400,000 gpd. However, we have not adjusted previous reported results due to the uncertainty of the variation. Secondly, the fecal coliform count reported for April, 1991, in our self-monitoring data is reported incorrectly. The number should be 17.9 col./100 ml.

The flows we have reported were obtained directly from Coeur d'Alene WWTP Lab Personnel. If they were incorrect, we would like to know the correct values, as all nutrient loading calculations may be similarly biased.

We have copies of the report from the CDA WWTP lab which show this number to be 4,072.0, as we reported. However, we are making this change in the table, in view of the new data you have presented us with.

A review of the planning documents prior to the study being conducted indicates that several needs/requests for data inclusion were not done. The following comments are from planning documents reviewed by this office. In a memorandum dated November 6, 1989, from Irene Nautch of the Division of Environmental Quality to Ed Tulloch and Tim Eiler, through Susan Martin and Gwen Burr, the following suggestions were to be included within the study documents.

Note of Report Authors: These following items were not in our Scope of Work and, therefore, cannot be addressed by us (except for Comment # 68).

No. 59

Item No. 2 of this memorandum requested a discussion of why these sample sites and stations were good sites for the study. In addition, latitude, longitude, and elevation information was to be provided. This information is not contained within the body of the study.

In a letter to Mr. Ed Tulloch of the DEQ from the Honorable Richard C. Panabaker, Mayor, City of Hayden, dated February 20, 1990, the City requested several items to be included in the Spokane River Study.

No. 60

Referencing the above memorandum; the City of Hayden requested plume dispersion analyses of Coeur d' Alene and the proposed Hayden outfall to determine if the discharge adds to the DO problems in the hypolimnion. This was covered very cursory within the body of the study. Does additional analyses of such a plume dispersion need to be performed?

No. 61

It was suggested that bacteriological sampling stations should be expanded and include the slack water areas in Harbor Island and Greensferry areas to determine the impact of treated wastewater discharges on these areas in relation to non-point sources. A survey should be conducted after a stormwater event in August. Was this suggestion considered? Should it be separately addressed?

No. 62

It was determined that velocity profiles should be conducted to determine the flow distribution during August and October to verify the absence or presence of "dead" areas, and further define the area above the dam as a reservoir or river. No instream velocity measurements were reported within the body of the study. Should these be considered? What are their significances?

In a document transmitted to the Division of the Environmental Quality on April 5, 1990, entitled, Review of Spokane River Water Quality Survey Study Plan, prepared by Brown & Caldwell Consultants, and authored by M. Steve Merrill, PhD, several issues were brought out.

No. 63

It was noted on Page 2 of the report in Paragraph No. 4 that possible violations of the Idaho State 90% Saturation Criteria may occur out the outlet of Lake Coeur d'Alene, above the City of Coeur d' Alene discharge due to background oxygen demand. The data presented in the study seems to indicate that this, indeed, has occurred. What is the significance of this? How do the results compare to readings in the Cd'A and St. Joe Rivers?

No. 64

On Page 3 of the above-mentioned document, a question was raised; "What is the impact of oxygen concentrations below the 90% saturation criteria?" We also raise the same question.

No. 65

Item 2 on Page 3 reiterates our standpoint that oxygen saturation is usually calculated from standard tables, assuming clean water with no salinity and no surface active agents. It was suggested that survey work should include testing to determine the true saturation concentration in the river water to permit accurate calculation of percent saturation from ambient dissolved oxygen measurements. Our question is; Was this not done?

No. 66

Under item 4 on Page 3, the author again suggests current velocity measurements with depth during the stratification period be made. Although no stratification period was identified during the study, it would seem that current velocity measurements should have been taken. (See above).

No. 67

Under Item 4g, it was suggested that BOD testing be conducted with nitrification suppressed. The study indicates that no nitrification suppression was performed. What is the significance of not suppressing nitrification in the BOD testing; particularly ultimate BOD determination?

No. 68, Statistical Analysis of Results

Nowhere throughout this report are any examples of a statistical analysis of the data reported. No standard deviations are reported for any of the results that were used to form the conclusions. Likewise, no confidence limits for the data have been presented. Quantification and propagation of the uncertainty common to each term in the model is necessary in order to determine the degree of confidence which can be placed on any prediction. We question whether the authors did any uncertainty calculations or statistical analyses of their data?

As stated earlier, this study was designed by Idaho DEQ to be a time-series assessment of water quality at 6 sites in the upper Spokane River. Effort was put into sampling to obtain representative conditions across the river at each of the 5 above-dam sites rather than into replicating field samples. This study was not designed as a comprehensive Spokane R. TMDL study.

No. 69

Also attached for your information are Table #9 - #11; Shoreline P Results, P Results 1988-91, and comparisons of various parameters.

1. From the Spokane River Basin: Allowable Phosphorus Loading, C.R. Patmont of Harper-Owes, September, 1987.

USEPA
COMMENTS TO THE
WATER QUALITY STUDY
OF
THE UPPER SPOKANE RIVER:

The data presentation is questionable. Several checks of tables showed errors and inconsistencies in calculations and reporting.

1. Without reference to the water quality standard, any reported increase (percent or magnitude) can't be evaluated for environmental significance. Percent increases were confusing and did not always specify what value was the basis for the percent calculation.

   A State of Idaho Water Quality Standards Appendix has been added.

2. Was an error analysis done to determine confidence levels of measurements and calculated results?

   Few error analyses were done due to the lack of duplication of samples. Where data sets are sufficient for this type of statistical analysis, they have been computed and are in the attached appendix.

3. Was data analyzed to determine if changes, from one river location to another, or from year to year, were statistically significant?
   Example 1: "*From RM 111.1 to 108.8, there typically was an average 75% increase of total ammonia in the River.*" Table 13 shows a mean ammonia (NH_3 or NH_3-N?) concentration at RM 111.1 of 0.12 mg/L and at RM 108.8 a 0.17 mg/L concentration for water year (WY)91 and 0.19 mg/L for the entire study period. What calculation was used to give a 75% increase between the points?
   0.12 to 0.17 is a 41.6% increase
   0.12 to 0.19 is a 58.3% increase
   The worst case of ammonia increase (8/27/91) coincides with the most stringent NH_3-N water quality criterion, 0.8 mg/L (EPA "Quality Criteria for Water 1986" as referenced by Idaho State Water Quality Standards for this site specific temperature and pH data.) Theoretically, an 800% increase (0.10 mg/L to 0.8 mg/L) from RM 111.1 to RM 108.8 could be tolerated by the river without exceeding water quality standards, for the worst case situation. This example shows one of the drawbacks of presenting data as percent increases, and not referencing the water quality standards.
   Example 2: The bacteria data needs to be revisited in detail. Calculations

presented as "median" are really arithmetic means; neither of which are appropriate measures, because water quality standards are given in terms of geometric means.
Example 3: (Confusion about what value the percent increase is based upon) *"Concentrations of nitrate-nitrogen between sampling stations increased downstream, from RM 111.1 to RM 100.7. Mean nitrate values were much higher at RM 106.2 and RM 100.2 (a 150% and 75% increase, respectively)."* Do the percent increases occur from RM 111.1 or 100.7
Similar examples can be found throughout the document.

The data set is too limited for this. There is only one full year of data, so a year to year comparison is not valid, and there are too many variables between stations to determine statistical significance with respect to one another. We did not compare to Idaho Water Quality Standards because the Ammonia Standard for Warm Water Biota, Cold Water Biota, and Salmonid Spawning requires comparison to "...a level of ......mg/l or less as based on a minimum of five (5) samples taken over a thirty (30) day period." (Idaho Water Quality Standards, The sampling rigor of the Project Work Plan given us did not come close to this required sampling base number.

Ammonia was measured as NH3-N. All corrections in the report have been made.

The 75% ammonia increase between RM 111.1 and RM 108.8 was an error in our calculation, based on water volumes and total load. The text has been corrected.

The median calculations of bacteria data are exactly what they are labeled as - - Medians, not arithmetic means, as suggested by reviewers. We chose to compare median values, fully aware of what Standard Methods states concerning bacteria statistical analyses, because of the high occurrence of imprecise data. Numerous "greater than" and "less than" counts occur in the data sets for both fecal coliform and fecal streptococci, making both arithmetic and geometric mean calculations invalid (Tables 18 and 19).

The nitrate-nitrogen percent increase at RM 106.2 and RM 100.7 statements have been clarified in the text.

4. The stated objective of the diel temperature and dissolved oxygen study was to assess the data in terms of possible aquatic ecosystem stress. This was not done.

Copy comments to question 10 of DEQ comments address this one.

5. The authors' definitions of several important terms should be included in the report: *water year,* (and the associated time periods described by winter, summer, etc.), *other North Idaho streams, high and low relative flows.*

Water Year - October 1 thru September 30.

The terms winter and summer were used to indicate general periods throughout the study, not specific time frames. Similarly, high and low flows were general terms used to describe the discharge in the river over certain periods of time, relative to the rest of the hydrograph. Some other North Idaho Streams, with selected parameters, are included in an appendix for comparison with Spokane River parameters.

6. Value judgments, such as "poor mixing of wastewater effluent is not considered a critical issue" and "Nitrate is usually the most important form of nitrogen" are not appropriate in a technical report of this kind. Those decisions should be made by the State or appropriate regulatory agency. Describing these issues in terms of their probability of causing significant environmental impact would be more appropriate.

   Correct, and we have since tried to remove remaining ones from the report.

7. When expressing pollutant increases caused by wastewater treatment plants (WWTP), are the values calculated from effluent data only or from the increase observed between sampling stations upstream and downstream of the treatment plant (which would include any non-point or unauthorized point discharges)?

   Any references made to pollutant increases caused by wastewater treatment plants were calculated from effluent data only. Observed in-stream responses would, of course, have included other unidentified point- and nonpoint inputs.

8. There is no discussion of observed plant biomass growth in the river during the study. A narrative description of observations would be useful in assessing the water quality.

   The request for observations of plant biomass growth during the study seem to contradict earlier questions concerning the statistical validity of many of the data calculations. We refrained from including observations of parameters not measured.

   Nevertheless, we have incorporated some comments on this area into the report (See Results/Discussion).

ABSTRACT

9. Some discussion of pollutant sources besides WWTP's is also appropriate, even though the magnitude of the impact of those sources may not be known.

   See Introduction for a discussion of pollutants. Beyond that, we have no measurements. Again, this was not a TMDL study to provide a listing of inputs, but a study focused on in-stream conditions.

10. What data set does "mean summer D.O." describe? Water quality standards address instantaneous measurements for dissolved oxygen. Similarly, is "mean summer chlorophyll *a*" a reasonable reporting method for addressing water quality?

"Mean summer D.O." refers to the mean D.O. over the warm summer months (July through September) throughout the entire reach. The significance is that this is the time period in which D.O. levels are a potential problem (due to high temperatures, biological decomposition, etc.) and plant production maximal.

The same data sets and significance pertain to "mean summer chlorophyll *a*". Again, we were addressing trends and general reach water quality.

11. EPA is extremely interested in the average 5-day biochemical oxygen demand (BOD) value of 81.3 mg/L presented for Coeur d' Alene WWTP effluent. Was this data collected and analyzed using 40 CHR 136 methods and QA/QC? Please provide more specific information about dilutions, final titration values, and calculations. Data presented in Coeur d' Alene WWTP's discharge monitoring reports for the study period show a maximum instantaneous discharge of 15.4 mg/L. EPA has split samples with the WWTP for the past three years, and has not discovered any discrepancies of such a large magnitude. Any insight as to the nature of the discrepancies in this report, and measurement variability noted by the author in the Results section, would be appreciated.

5-day BOD's were calculated precisely as outlined in Standard Methods (15th Edition, pg. 483-489). Because of the high BOD of the CDA WWTP effluent, it was necessary to make large dilutions on the effluent samples. During each run, one effluent sample of 5 ml and one of 3 ml were diluted up to 300 ml to determine the 5 day BOD. These dilutions were arrived at after running a series of 20 effluent samples at different dilutions from 100% (300 ml) to .33% (1 ml) to determine the range. We realize that the large dilution of CDA WWTP causes measurement error to be high (as pointed out in the Results section), however consistently high readings seem to indicate to us that the BOD_5 of CDA WWTP is, in fact somewhat higher than values reported by the CDA lab. We direct your attention to the turbidity of the treated CDA WWTP effluent (Table 8.), which would support the the higher oxygen demand values. We also call attention to ammonia levels in CDA effluent, which are quite high. Generally, high ammonia levels go hand in hand with high BOD levels, which would support our findings. Calculations were done as outlined in Standard Methods, and were re-checked for accuracy.

METHODS

12. The sampling sites and compositing protocols are confusing. Text, figures and tables do not present a consistent picture of what was done. Were two vertical samples taken at each of the three cross channel sampling locations for each site, yielding six samples per site? Or were two samples taken at only the mid-channel? The text describes three mid-depth samples (and in another text location "standard...one meter increments") but Figures 2 and 3 show only a single vertical sample. The same question arises for stratified conditions.

One vertical sample was taken at mid-depth at each of the three cross channel sampling locations for each site. These samples were composited and subsamples were taken from this for composite measurements. Physical profiles of temperature, dissolved oxygen, and electrical conductivity were measured at one-meter increments, top to bottom, at each of the three cross-channel sampling locations per site. Figures 2 and 3 show the locations of water samples which were then composited. Under stratified conditions, we took an additional sample from the hypolimmion, kept it separate, and collected one additional grab sample at mid-depth from the epilimmion.

13. We understood that sampling at the left and right banks has been discontinued during the first summer because data was consistent across the river at each site. Is this really the case?

    No, cross-channel sampling and compositing continued throughout the study.

14. No discussion of detection limits is given. Can BOD_5 be measured to the 0.3 mg/L level, as presented in Results section, and 0 mg/L level, as presented in Table 16?

    Detection limits for Spokane River water BOD_5 were .33. Table 16 has been corrected. The following detection limits were determined on our samples:

	BOD_5	TP	OP	NH_3	NO_3
River	0.33	0.006	0.006	0.04	0.006
CDA WWTP	-	0.03	0.06	0.20	0.006
PF WWTP	-	0.03			

15. Chemical Analyses.
    Were orthophosphate samples frozen on collection day for later analysis? Don't orthophosphate samples need to be analyzed on day of collection? (We will check with EPA Region 10 Laboratory on this issue).

    Orthophosphate samples were frozen on collection day for later analysis. This is not a Standard Method or approved by EPA, but staffing constraints prevented us from running the lab analyses the next day.

16. Diel Study. The data in Table 4-A does not indicate a composite mid-depth sample being taken at the Cedar's dock site, as discussed in the text.

    The Cedars Dock Site is labeled as RM 111.1 in this table (see Diel Study, pg. 5).

17. QA/QC. Because of problems with calculations and results presentation, would like to see raw data presented in an appendix or made available through other means.

    Volumes of raw data are available by contacting us at:

    Mike Falter or Brian Riggers
    Dept. of Fish & Wildlife Resources
    University of Idaho
    Moscow, ID 83843

However, we have condensed all of the data into usable form and presented it in Tables and Appendices in the report.

18. Some discussion of the low number of duplicate samples analyzed should be presented. Isn't it standard to run duplicate samples for each parameter, except triplicate samples for BOD?

Duplicate sampling of each parameter was not addressed in the study plan. However, random samples were run in duplicate as a check, and most BOD samples were run in duplicate. (See QA/QC appendix).

19. How are the data for the duplicate samples presented? Are the two data points averaged and presented, or is the duplicate data not presented in this report in any form? Some analysis of what the duplicate samples showed would be appropriate. Example: The multiple chlorophyll a samples run on July 30, 1991. What data is presented, was there a statistically significant difference between the multiple samples?

The standard, first-run answers were presented in the report. Duplicate samples were purposely left out because of the randomness of the duplicate sampling schedule. Generally, (except with BOD_5's), duplicates were only ran as a check on measurements that seemed erroneous (as in the chlorophyll *a* samples of July 30, 1991). The random schedule and procedures whereby duplicates were analyzed makes them statistically invalid. However, they did serve as a good rough check on equipment and personnel performance, which is all they were intended to do. (See QA/QC Appendix).

20. There is no discussion to indicate that blanks were run when required. Were seed corrections done for BOD's? For ultimate BOD's was ammonia oxidation inhibited with thiosulfate? If so, how was the NBOD measured?

All blanks were run as required, and as outlined in Standard Methods (referenced in the report). Seed corrections were done for BOD's, as outlined in Standard Methods.

Ammonia oxidation was not inhibited in ultimate BOD's, and we have noted this in the report.

21. Data from Citizens Volunteer Monitoring Program and discharge monitoring data from wastewater treatment plants is presented, but how does it correlate with data collected in this study? There appear to be some significant differences in the data submitted by the WWTP's shown in the study and data submitted to EPA. EPA would be willing to work with the authors to determine the validity of the WWTP data sets.

The CVMP and WWTP data is presented simply as a comparison for the reader. Analysis of the outside data was not a part of the study plan...we did not want to tread on DEQ's territory since they ran the CVMP program.

RESULTS/DISCUSSION

22. Was any attempt made to integrate data of previous studies with the data from this study to present a comprehensive view of the water quality, as opposed to looking at each study individually?

Data from previous studies was referenced a number of times to show general trends in river water quality over the past 10-12 years. (See Figs. 5-7 & 29, Also noted in text).

23. There is no discussion of the interactive effects of the various nutrients, as related to plant biomass growth and dissolved oxygen (D.O.) depletion.

See Observations section.

24. Water discharge What is the "ameliorating effect of Lake Coeur d' Alene" that is referred to? Which parameters does it affect?

Lake Coeur d' Alene is a storage basin for Spokane River water before it exits the lake and enters the river. This causes peaks and troughs in the hydrograph to be less volatile in the Spokane River than in the tributary rivers which feed the lake. Flashiness of most water chemistry parameters would also be expected to be tempered in the River below the Lake.

25. If Water Year 1991 was more "typical" than the entire study period, how is it being treated differently in results discussion? Figure 7 indicates that all data is similar during the low flow months, (the period of particular interest) except Yearsley's 1988 study.

Important differences between measurements in Water Year 1991 and the entire study are pointed out in the report. We did not make any effort to treat WY 1991 differently.

As shown in Figure 7, the mean monthly flows of all study years are similar from July to October (the period of interest). However, mean monthly flows in June are drastically different between studies (over 13,000 cfs difference between Yearsley's study and Water Year 1991). The flow during this "pre-summer" period is very important in that it sets the stage for the upcoming months by either flushing out the system or acting as an algae and weed incubator lengthening the summer high growth period. This issue was probably not sufficiently addressed in issuing the HARSB discharge permit period.

26. WWTP discharge. When discussing discharge flows from WWTPs as percent of total river flow, allowable mixing zones should at least be mentioned. Water quality parameters at the edge of the allowed mixing zones are an important feature of assessing the impact of the WWTP's on the water body.

The study plan did not include sampling at the edge the allowed mixing zone. It was an overall river water quality study plan with no effort to descern actual mixing zones, so we could not address their probable locations.

27. The conditions for Hayden Area Regional Sewer Board discharge stated in the report are possible limitations suggested by the author. Please clarify

that the current permit conditions prohibit discharge when river flow is less than 2000 cfs during the months of June through September.

Done.

28. Please include the Ford Rock Hole on the map or give its river mile location. Another potential area of oxygen reduction, which was not mentioned, is the area behind the dam. Was Site 5 chosen using previous research (which showed low D.O. behind the dam) to address this concern? Can the D.O. in this area be related to water quality standards?

Morphometric maps of the entire study area (except below Post Falls Dam), as well as detailed maps of the Ford Rock Hole, have been included in an Appendix. All sample sites were chosen and approved in the study plan, based on previous research done on the river. Site 5 was chosen in earlier years for its presumed great depth. Later studies simply adhered to the same site.

29. Flushing rates. What is "instantaneous mean flow", described in this section, and "instantaneous retention time", described in the Conclusions section? Isn't river flow data based on USGS daily mean flows?

River flow data is based on USGS daily mean flows. Corrections in the text on this point have been made.

30. Temperature. Is it reasonable to compare this water body to other North Idaho streams during summer, when the water body exhibits characteristics of a lake?

This reach of the Spokane River (or outlet arm of Coeur d'Alene Lake) has riverine characteristics at high flow and lacustrine characteristics at low flow. Belonging to each water body type then, it is certainly reasonable to compare this reach to either type, depending on the time of year. It is not a black or white issue.

31. Would the data from this study correlate with previous studies' assessments of characteristics which cause thermal stratification?

As pointed out in the report, we observed only one instance of slight thermal stratification. Stratification observed during other studies occurred at extremely low flows which did not occur during our study.

32. D.O. Can any discussion be made about the dam's effect on D.O., especially during periods of low D.O. above the dam?

The study was poorly designed to address the impacts of Post Falls Dam on dissolved oxygen. Site 6 should have picked up dam-enhanced deoxygenation, especially during early morning hours, but such stresses were not observed.

33. The D.O. standard of 6 mg/L does not apply to some lake/reservoir situations. What is the significance of 100% saturation, when the water quality criterion is 90%?

The equilibrium saturation level of oxygen in water is 100%. 90% is simply the minimum level the State has set in its water quality criterion.

34. Text indicates that data for North Idaho streams is presented in Table 5 for comparison with this water body.

Done.

35. Conductivity. Was the pocket of high conductivity verified with duplicate sampling or more than one sample at that site?

The pocket of high conductivity was verified by taking three sets of conductivity profiles at the station. All readings supported the initial observations.

COMPOSITE MEASUREMENTS

36. pH. Please clarify the meaning of *median pH range.*

See text.

37. Turbidity. Figure 20 does not illustrate the slight turbidity increase downstream of Lake Coeur d' Alene. How statistically significant is this increase to overall water quality and water quality standards?

See Table 8. The increase is averaged slightly greater than 10% (between RM 111.1 and RM 100.7) over the study period. The increase was not directly attributable to any defined source along the river

38. Chlorophyll a. Please expand on or explain the reference to "increased nutrient loading" in the fourth paragraph.

Done.

39. Could the high 1991 Chlorophyll a measurements with high flow be due to algae bloom(s) in Lake Coeur d' Alene being washed into this water body?

Certainly a possiblity, but with no data from Lake Coeur d'Alene at those times, we can't say.

40. Figure 21 indicates several rapid concentration decreases of similar magnitude to the "population crash" described on 9/17/90. Can this phenomenon be discussed?

Chlorophyll *a* levels are commonly sporadic, especially a data record with a two week interims between sampling dates. The population crash of 9/17/90 was notable in that the pheophytin content of the phytoplankton samples was extremely high, indicating an unhealthy or senescing population (See Figure 22). We probably caught the tail end of a bloom.

41. Figure 45 does not correspond with the statement that nitrogen is the limiting factor during August; does that statement only apply to Falter's 1982 study? The TMDL affecting this water body uses a different approach for determining which nutrient is limiting? For consistency, could that approach also be presented?

Figure 45 is an all-station composite of N:P ratios. In the composited data, the lake station tends to dominate with its very high N:P ratios. Station 2, below the CDA WWTP, had N:P ratios ≤16:1 every sampling date from June 29, 1990 through November 12, 1990. Following P removal in June, 1991, the N:P ratios soared to over 50:1. Figure 45 does indicate nitrogen limitation from August 8 to October 1, 1990 for the all-station data composite, as the text implies (See N:P ratio section in text). Calculating TMDL's for the Spokane River was not an objective of this study. We were not given that charge by DEQ and don't want to intrude on their turf.

42. Throughout this section there are references to mean river concentrations followed by WWTP contributions that appear to be a total yearly load. A direct comparison, using the same form for the data, would be more appropriate.

We reference both concentrations and total loading throughout the report for the river and WWTP's. Tables are provided for clarification.

43. There seems to be a general inconsistency when discussing nitrogen compounds by name. Text, figures, and tables go back and forth between the chemical compound name only and the compound name followed by "-nitrogen". This is especially confusing when numerical data is presented because it's not clear which convention is being followed in calculating the concentrations.

The labeling has been corrected but all of our data should be expressed as ....."...-nitrogen" or ...."...-phosphorus," etc.

44. The report discusses possible biological nitrate conversion to ammonia. Wouldn't this require anaerobic conditions in the river? Does the data, for D.O. and all nitrogen compound concentrations, support this theory? Is any ammonia being converted to nitrate downstream? If ammonia is being converted to nitrate and nitrites, does the Coeur d' Alene effluent have a more significant impact on nutrient concentration in the water body than discussed in this report?

Denitrification occurs both aerobically and anaerobically. Aerobic conditions in the mud or water permit higher rates of denitrification though. In the Spokane River, we suspect that most denitification occurs with photosynthetically-driven nitrate reduction and later release of reduced organic nitrogen or ammonia. In a well-aerated, ammonia-rich system such as the upper Spokane River, nitrification certainly must be occurring at a rapid rate. We didn't measure such nitrification and could not, therefore, conjecture on the rate of ammonia oxidation.

45. The Post Falls nitrate load is referred to as insignificant because of small effluent volume, then described as 25% of the summer load.

The Post Falls nitrate load is seen as an "insignificant" source of $N0_3$ compared to the total nitrate load." This refers to the entire study period. The 25% contribution refers to summer low flows only.

46. If the quality of the ammonia data for WWTP effluents is questionable, as described in the bold-faced note, why not use, or at least compare, data collected by the WWTP's using EPA approved methods?

Data collected by the WWTP's is presented in Table 20 for comparison.

47. Has the general increase in total phosphorus, which the author states has resulted in an "overall deterioration in water quality....over the last 10 years," changed the trophic state of the water body? Could a more thorough discussion of Figure 29 be given to explain its apparent conflict with the generally agreed upon statement that nutrient levels have been increasing over time in this water body? Why does this figure show only WY91? How does the entire study period, 6/90 through 9/91 compare with the other data?

The increase in TP is one factor which has led to a change in the Spokane River trophic status to mesotrophic. It is not the only one.

The legends on this graphic are in error. We apologize for this mistake. Corrections have been made.

Data for the entire study period includes two spring seasons, and would not be a realistic comparison to the 1980 study.

48. Is all measured total phosphorus reduction caused by plant biomass uptake? Were other possible phosphorus sinks considered, such as orthophosphate being adsorbed to particles containing iron and its hydroxy complexes, or sorbed to other metals? Could metals play an important role because of mining activities in the watershed?

We speculate that most of the reactive phosphorus was converted into plant biomass because of the relatively turbidity low carried by the river below the lake. Decreasing total phosphorus levels, however, were not solely a result of decreasing reactive phosphorus sink in this section. No metals were studied so conjecture can't be made, nor can we offer any more speculation as to the possibility of the orthophosphate absorption in the report. However, this seems to be a logical assumption.

49. Does the level of phosphorus measured in the water body show a statistically consistent decrease after Coeur d' Alene began phosphorus removal? (Figure 38 and Table 14 do not seem to support the conclusion of

the text). Can an estimate be made as to the effects of yearly variations and flow differences on total phosphorus?

The mean phosphorus level in the CDAWWTP effluent was 4.26 mg/l (n=16) before phosphorus removal, compared to a mean of 0.87 mg/l (n=9) after phosphorus removal. River mean phosphorus levels were .017 mg/l (n=16) before phosphorus removal and .011 mg/l (n=9) after phosphorus removal. These calculations were from data taken directly out of Table 14. This trend is apparent in Figure 38. WY 91 encompasses the phosphorus removal period, with fewer non-phosphorus removal measurements to bias the means.

CONCLUSIONS

50. No discussion of water quality standards.

State Water Quality Standards have been added.

FIGURES AND TABLES

51. For non-local readers, please add the river mile locator for Post Falls Dam to Figure 1.

52. The legend in Figure 6 is confusing.

53. Does the data set used for Figure 10 agree with a standard definition of low flow? Does Figure 11 compare the data (flow and WWTP effluent) for only Sept. 5, 1990, or is WWTP shown as the average of some larger data set?

The Figure 10 data set is over the lowest mean monthly flow during the period. In Figure 11, the river flow is a daily mean, whereas WWTP discharges are daily means based on an average daily flow throughout a one month period.

54. Although the trend of increasing nitrate concentration with increasing flow relationship still holds, can the author discuss the relatively low nitrate concentrations observed from 3/91 to 7/91 shown in Figure 24?

We don't know that we can say much more about the low nitrate values of 3-7/91. The minima seem to compare to the similar period in 1990, both times of annual chlorophyll *a* highs. Phytoplankton uptake is a reasonable explanation.

55. The figures using dual ordinate scales can be confusing. Was a standard methodology used to determine how much of a full scale should be used on each ordinate? Because the figures that use River Mile location on the abscissa are often trying to show effects of WWTP effluents, standardization seems necessary.

Dual ordinate scales were used because of the great difference in values between river water measurements and wastewater measurements. Scaling the WWTP ordinate down would cause the river measurements to be so low as to be unreadable.

56. There is a general confusion of EPA staff about nutrient data presented in figures 28, 32, 36, 40, and 43. What trends are being displayed in these figures and what is the data set "2000 cfs"? Does the nutrient load attributed to Spokane River include Lake Coeur d' Alene output, groundwater, and non-point source inputs?

These figures are not intended to illustrate trends. They illustrate the relative percentage loading from both wastewater treatment plants compared to loading from all other sources (Spokane River) during various time periods. The time period classifications were used to illustrate differing percentage inputs from each source under various flow conditions. Similarly, the 2,000 cfs data set is the relative loading from each source when flow in the river is equal to 2,000 cfs, the point below which Hayden is not allowed to discharge.

57. Figures 38 and 47 are very confusing. Are these supposed to be showing the same type of data as figures 25, 30 and 33? If not, what is being shown? Same question regarding Figure 18.

Figures 38 and 47 have been corrected. Figure 18 shows CDA and PFWWTP's median pH values in point values. This was the intent, and this figure remains unchanged.

58. The ordinates of Figure 46 do not indicate units for Coeur d' Alene WWTP scale or clearly specify that the river and Post Falls WWTP are measured on the left scale. Figure 48 is more clear but leaves out which scale should be used for Post Falls.

Fixed.

59. Table 3: Are these dissolved oxygen measurements? Averaging the data for right, middle, and left in Table 3, doesn't seem to match the means given in Table 4 for each site.

We assume the averages do not correlate because of the loss of accuracy involved with rounding such a large data set.

60. In Table 9, please explain the data presented as >x. Is this water depth?

In Table 9, >x indicates that the secchi disk was visible on the bottom, the maximum measured depth (x).

Specific Comments:

7) Page 1, Objectives.

Objective 4 was kind of a tag on item that the study design does not address. Qualification of this objective to assess POTW impacts to the extent data will allow may be in order.

See text, pg 1.

8). Page 1, Introduction, last line.

Reductions in Coeur d 'Alene River metals actually started prior to smelter shutdown. Construction of tailings impoundments in the late sixties stopped direct discharge of metals laden mill tailings and slimes to the river.

See text, pgs 1-2.

9). Page 2, Sampling.

Sample methods are appropriate for meeting Objective 1. Explain why reduction in winter sampling was statistically feasible, given Objective 2 to determine seasonal variability.

Winter is typically a time of low biological productivity, due to low water temperature, short photoperiod, etc. This was addressed in the study plan, and the sampling method used was approved.

10). Page 5, Diel Study.

Does the sampling method of only taking one diel series hold up statistically? How does one-day snapshot meet Objective 3?

If there were any diel fluctuations in D.O. and temperature, they would most likely occur during the summer, when water temperature and biological productivity is highest. We conducted the diel study at this time (mid-August) which we feel is adequate to develop a general river picture. A more thorough study would require more money and time.

11) Page 6, QA/QC.

There are no duplicate sampling results presented in an appendix for QA/QC. If there were some chemical constituents with overall poor duplication, then the Results section needs a qualifier for discussion of those parameters.

See Appendix B.

12) Page 9, Flushing Rates, 1st paragraph.

One exchange of a pool volume does not mean that all the water has physically exchanged. More like 65% has actually exchanged. It takes three or so volume exchanges before complete actual exchange has reached greater than 95%. Implying that one flushing rate indicates a complete exchange of water is misleading. Discuss.

See text, pg 9.

13) Page 9, Flushing rates, last paragraph.

Reference the line wherein a 15 day retention time is required.

This is a personal observation.

14) Page 10, Temperature, first paragraph.

Discussion of the role temperature may play on ammonia toxicity should be either here or in the ammonia section. Exceedence of the cold water biota criteria should also be discussed.

See text, pg 16.

15) Page 10, Temperature, last paragraph.

See general comment #4 regarding mixing.

The study was intended to address differences in water chemistry within the water column at each station only during thermally stratified conditions. All other water samples were to be composite samples from three sites at each station (See Methods, pg 3).Thermal stratification was defined in the project study plan as a change of >1 C within one meter of the water column. Thermal stratification was only observed once during the entire study period.

16) Page 11, Dissolved Oxygen, last paragraph.

Percent saturation levels are compared to other north Idaho streams. It is a dubious comparison, given that the outlet reach is fairly unique compared to most north Idaho streams. The table referred to (Table 5) does not give values for other streams. A more appropriate stream for comparison may be the river arm of Pend Oreille Lake.

See text, pg 11 and Appendix E.

17) Page 12, pH.

What do these pH levels mean with respect to beneficial uses? Specifically, ammonia toxicity may increase at higher pH levels. Given the seemingly high loads of ammonia being discharged from the POTWs, what are the consequences to cold water biota?

See text, pg 12.

18) Page 12, Turbidity.

If riverine character of the high flow period was important, separate the data and compare the data sets. Statistically, it should confirm or deny the statement. Also, how does background influence reach turbidity. If turbidity is related to flow, wouldn't the presence of fines in the lower reaches indicate a depositional zone?

We believe that the lower reaches are areas of deposition throughout most of the year, due to very little flow through this area. However, under high flows, the lower reaches experience significant water movement and consequential bottom sediment disturbance and re-suspension.

19) Page 12,13, Secchi.

The study reach is more lacustrine during the summer. The summer secchi disk transparency data shows the Spokane River to fall in the mesotrophic range of two to six meters.

20) Page 16, Ammonia-Nitrogen, 1st paragraph.

This first paragraph is a bold type qualifier, but again the QA/QC duplicate results are not shown or discussed for the reader. Throughout the report there is considerable discussion of ammonia and TKN values (and ammonia was 80% of the TKN), but what is the reliability? We have found from the IDEQ laboratory in Boise, that both ammonia and TKN duplicates can have very high average relative ranges (ARR's).

See Appendix B.

21) Page 16, Ammonia-Nitrogen, 2nd paragraph.

The last sentence contains two questionable statements, namely that the high percentage of ammonia is a toxicity and a eutrophication concern. First, toxicity of ammonia is due to the free form produced at higher temperatures and pH. Toxicity is also a function of concentration and time of exposure. How do these considerations affect this statement? Secondly, the comment about eutrophication contradicts other statements in the report that the system is mostly a P-limited system. Explain.

See text, pg 16.

22) Page 17, Total Phosphorus, 2nd paragraph.

The last sentence refers to lower TP levels in 1991. Could this also be related to the addition of phosphorus removal by the CdA WWTP? See general comment #1, regarding use of means of time series data.

See text, pg 17.

23) Same, 3rd paragraph.

A sentence notes that CdA contributed 3X the phosphorus load that Post Falls did. A deception lies here in that CdA has a much higher flow than Post Falls. See general comment #5, regarding use of load in the reach.

We are simply stating how much total phosphorus was added to the Spokane River from each WWTP. Because CDA WWTP is much more diluted is not a valid reason for dismissing the facts concerning how much total phosphorus is being added.

24) Same, 4th paragraph.

What is a "significant percentage"? Was significance tested statistically? See general comment #2, regarding use of percentages.

See text, pg 18.

25) Page 18, Total Phosphorus.

Figure 26 does not support the statement made about TP increase. Is the correct reference Figure 29?

Yes.

26) Page 19, N:P Ratio.

To better discuss the relationship of the WWTPs on water quality, a discussion of phosphorus removal implications may be appropriate here. P-removal may change N:P ratios. What impacts may result?

See text, pg 20.

27) Page 20, BOD, paragraph 3.

See comment #1 regarding use of means of time series data for comparisons.

The 5-day BOD means of this time series are compared to 5-day BOD means of another time series study which covered nearly a year. We feel the comparison, while probably not statistically valid, is a good reference to the general

28) Same, paragraph 4.

Is the increase in variability by the WWTPs reflected in increased sampling? Are comparisons to the river still statistically valid?

This paragraph, like many others, is an attempt to boil down some of the data into a usable, understandable form. We make no claim as to its statistical validity, however, we do feel that the statement is accurate. See text, pg 21.

29) Page 21, Ultimate BOD.

In discussion of Ultimate BOD effects in the Spokane River reach, it seems it becomes most important in the context of retention time. The earlier section indicated 15 days were needed for stratification to occur. It seems ultimate BOD would only be relevant during extreme retention times. Based on flow records, how many exceedences of the 15 day retention time have occurred? How does ultimate BOD reached in 27 or 35 days fit this scenario?

See text, pg 22.

30) Page 21, Fecal Coliform.

The methods indicate that FC was sampled using a pour plate technique. Most Probable Numbers of coliform bacteria are only reported when the MPN tube fermentation technique is used. Plate counts result in # colonies/ 100 ml. It is incorrect to report a combination of MPN colonies/ 100ml.

The plate count technique is typically used when turbidity of the sample is low. Excess turbidity as a result of sediment or algae may result in confluent growth patterns, and can contribute to extremely variable counts.

Again, a median of time series data was used for comparison of different river mile stations. See general comment #1 for this discussion.

A discussion of beneficial use impact is in order in this section. Permissible fecal coliform levels should be compared to the data. Statements that FC were high should be placed in context (ie: highest, high observed during study, etc.).

See text, pgs 22-23. We deemed the pour plate technique most useful in this study in light of the low turbidity of water in the Spokane River. We used the median calculation with the bacteria counts because of the relatively few outliers which would have skewed a mean calculation, and also because of the uncertainty as to the exact # of colonies/100 ml in some samples (i.e. >60, "Confluent Growth", etc) (Table 18-19). See Appendix D, Section 01.2250,01 for State of Idaho Water Quality Criteria concerning fecal bacteria.

31) Page 22, Diel study.

Accomplishment of Objective 3 was the goal of performing this experiment. Either here or in the conclusions, relate the results to the study goal; are there any indications of ecosystem stress?

Did one series of diel measurements accomplish the goal? One sample event provides little insight into variability. Was the sampling strategy sufficient to answer the question? How?

The last sentence of the second paragraph states that a minor sag was "deemed insignificant". rather than deem it, analyze it statistically.

See text, pg 23, and comments to question #10 above.