Publication No. 99-03-101

Spokane River and Long Lake TMDL Study for Biochemical Oxygen Demand and Update of the Phosphorus Attenuation Model

Quality Assurance Project Plan

By
Bob Cusimano and Jim Carroll
July 1999

Washington State Department of Ecology
Environmental Assessment Program
Watershed Studies Unit

Approvals

Bob Cusimano 8/[illegible]
Project Lead
Watershed Studies Unit

Cliff Kirchmer 8/14/99
Ecology Quality Assurance Officer

Will Kendra 8/12/99
Section Supervisor
Watershed Ecology Section

Stuart Magoon
Lab Director
Manchester Laboratory

Karol Erickson
Unit Lead
Watershed Studies Unit

Carl Nuechterlein
Client Section Supervisor
Water Quality Program, ERO

Table of Contents

Project Description

Problem Statement

Ecology's Eastern Regional Office (ERO) is concerned about the pollutant loading capacity of the Spokane River system (including Long Lake). The Spokane River exhibits low dissolved oxygen levels during the summer months, in violation of Washington State water quality standards. The river is included on Ecology's 1996 303(d) list of impaired water bodies for dissolved oxygen, and is proposed to be listed on the 1998 list. The Clean Water Act requires Water Cleanup Plans, also known as Total Maximum Daily Loads or TMDLs, to be done for waterbodies on the 303(d) list. A TMDL for this water body was identified as a high priority during the water quality scoping process for the Spokane Water Quality Management Area (Knight, 1998). ERO has requested that Ecology's Environmental Assessment Program (EAP), Watershed Studies Unit determine minimum dissolved oxygen concentrations during critical conditions in the Spokane River, and establish TMDLs and allocations to control sources of oxygen consuming substances.

ERO has also requested that the Watershed Studies Unit reassess the nutrient loading to Long Lake, and if needed, update the Phosphorus (P)-Attenuation Model developed by Patmont *et.al.* (1985) for the river in the mid 1980s. Nutrient enrichment and eutrophication of Long Lake has been one of the major water quality concerns for the area. In the early 1980's Ecology established a total phosphorus TMDL for the lake. The P-Attenuation Model was developed to predict and allocate phosphorus loads into the lake from the river.

The two project requests are linked because BOD and nutrient loading both affect dissolved oxygen concentrations. Eutrophication increases plant growth and decreases dissolved oxygen during periods dominated by plant respiration and the increased decay of the organic material produced. The direct loading and decay of organic material from point and nonpoint sources can also decrease dissolved oxygen concentrations. Both of these water quality issues can be exacerbated during periods of low river flow and warm temperatures, especially in the deep slow moving water segments of the river system like Long Lake. The results of this study may require allocations for both BOD and nutrients to mitigate the impact of these pollutants on dissolved oxygen.

This project plan describes a technical study to determine what pollution controls are required to bring the Spokane River into compliance with state water quality standards.

Study Area

The Spokane River above Long Lake drains over 6,000 square miles of land in Washington and Idaho (Figure 1). Most of the people in the watershed live in the Spokane metropolitan area. The Spokane River flows west from Lake Coeur d'Alene in Idaho, across the state line to the City of Spokane. From Spokane, the river flows northwesterly to its confluence with the Columbia River at Lake Roosevelt. The proposed study area for this project extends from the Stateline Bridge at approximately river mile (RM) 96 to Long Lake Dam at RM 33.9. This project will complement a project that the Idaho, Spokane River Technical Advisory Committee has developed for the Spokane River in Idaho (Spokane River Technical Advisory Committee for Idaho called River TAC(a), 1998).

There are four hydroelectric dams located in proposed study area: Upriver dam (RM 79.9), Monroe Street dam (RM 73.4), Nine-Mile Dam (RM 57.6), and Long Lake Dam (RM 33.9). There is also a dam at Post Falls, Idaho (RM 100.8) that influences the hydrodynamics of the river. All of the Washington dams are run-of-the river types except Long Lake dam, which creates Long Lake (Lake Spokane), a 24-mile long reservoir.

Sources of Oxygen-Consuming Substances and Nutrients

The following facilities have National Pollutant Discharge Elimination System (NPDES) permits for discharging biochemical oxygen demand and/or ammonia to the Spokane River study area, in order of upstream to downstream:

Washington:

- Liberty Lake Publicly Owened Treatment Works (POTW)
- Kaiser Aluminum Industrial Wastewater Treatment Plant (IWTP)
- Inland Empire Paper Company IWTP
- City of Spokane AWTP

The following tributaries affect dissolved oxygen levels and nutrient concentrations in the Spokane River study area:

- Latah Creek (formerly Hangman Creek) (note – City of Cheney, Spangle, Rockford, Tekoa, and FairField all have small seasonal POTW discharges to creeks in the watershed.)
- Little Spokane River (note – Kaiser-Mead discharges to the Spokane River)
- Deep Creek (note – City of Medical Lake discharges to Deep Creek. In Knight, 1998 it was stated that "At current proposed design flows the discharge will probably not affect the Spokane River. However, as the system is expanded there may be some winter hydraulic

capacity issues in Deep Cr. and a potential for a new growing season P load to the Spokane River.")

The Spokane aquifer also potentially affects dissolved oxygen levels and nutrient concentrations in the river. The aquifer discharges to the river in some reaches, and is recharged by the river in other reaches (Patmont *et al.*, 1985).

In addition, nonpoint sources along the length of the river system may be contributing BOD and nutrients in some cases. However, other than the tributary loads, these sources are likely small during the period of concern for this project (see Study Design section for a discussion of the study period). The contributions of BOD and nutrients of the small discharges to the tributaries of the Spokane River will be included as part of the tributary loading to the river, and not assessed as "discrete" loads for this study.

Beneficial Uses

The Spokane River classifications and dissolved oxygen criteria are:

PORTION OF STUDY AREA	CLASSIFICATION	DISSOLVED OXYGEN CRITERION
Long Lake (from Long Lake Dam to Nine Mile Bridge	Lake Class	No measurable decrease from natural conditions
Spokane River (from Nine Mile Bridge to the Idaho border)	Class A	Dissolved oxygen shall exceed 8.0 mg/L

In addition, the Spokane River has the following specific water quality criteria (Ch. 173-201A-130 WAC):

- Spokane River from Long Lake Dam (river mile 33.9) to Nine Mile Bridge (river mile 58.0). Special conditions:
  - (a) The average euphotic zone concentration of total phosphorus (as P) shall not exceed 25 ug/L during the period of June 1 to October 31.
  - (b) Temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9). ("t" represents the maximum permissible temperature increase measured at a mixing zone boundary; and "T" represents the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.)
- Spokane River from Nine Mile Bridge (river mile 58.0) to the Idaho border (river mile 96.5). Temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9).

Historical Data Review

Hydrology:

Areas of aquifer inflow and outflow complicate the low river flow hydrology of the Spokane River. Patmont *et al.*, (1985, 1987) collected direct measurements of ground water flux on the river. Their studies included estimates of velocity and dispersion characteristics of the river system based on dye study results and morphometric measurements. Their work revealed a complex hydrologic system with alternating inputs and outputs of ground water to and from the river channel (including impoundment seepage from Upriver Dam, Post St. Dam, and Nine-Mile Dam). Pelletier (1998) developed equations to estimate the aquifer inflow and outflow to the river from Lake Coeur d' Alene outlet to RM 64.6 based on the Patmont *et al*, (1985, 1987) data.

Figure 2 presents box plots of the 1942-98 monthly flow data from USGS station #12422500 at Spokane (RM 72.9). The plots show that the lowest flows occur during the July-October summer period, which is the period of greatest concern for BOD and nutrient impacts. The summer period corresponds to low dissolved oxygen, high temperatures, and increased macrophyte and algae productivity. Assuming a seasonal design flow will be used for this study, the 7Q20 low flow calculated for the July-October period, using the Spokane station is 618cfs (estimated with Weibull distribution test in WQHYDRO—Aroner, 1994). One of the major assumptions in this test is that the distribution of the past flow data can be used to represent future flows. Figure 3 shows the difference in the median August flows between the Spokane station and the Post Falls station #12419000 (RM 100.7). A linear trend analysis (Spearman rho test) shows a significant decreasing trend in the August median data from 1942-98. Figure 4 is a plot of the difference between the stations as a percentage of the Post Falls gauge. The graph shows that a change in hydrologic conditions between the two stations occurred about 1967-68. A trend analysis for the 1968-98 did not identify a significant trend. This suggests that the hydrologic conditions were different between the two stations before and after 1968 (i.e., a step trend). These results also suggest that only data after 1967 should be used to calculate flow statistics for the river in this area to estimate critical conditions. Recalculating the 7Q20 flow for the Spokane station using data from 1968-98 yields an estimated flow of 526 cfs, which is 92 cfs less than using the whole period. Establishing an appropriate design flow(s) for the river will be reviewed in more detail in the draft and final reports for this project.

The 1968-1998 median August data also suggest that the hydrologic data and model developed by Patmont *et al.,* (1985) can be used for this study to represent the changes in river flow between the State Line and Nine Mile Dam, because their work was based on post-1968 data.

Whereas the hydrology of the mainstem of the Spokane River is complicated by the inflow/outflow of groundwater, the hydrology of Long Lake corresponds almost singularly to surface water inflows/outflows. A diagnostic study of Long Lake (Soltero, 1992) found that surface water inflows and outflows to the lake accounted for approximately 98.5% of the hydrologic input/ouput during their study year. This diagnostic study included a detailed groundwater characterization using residuals from water budgets, as well as piezometers (used to measure hydraulic gradients and conductivity of the aquifers surrounding Long Lake), to determine the groundwater influence on the lake. The results amounted to minor, hydrologic contributions of 1.4% and 1.1% for groundwater inflows and outflows, respectively, in the annual water budget.

Soltero (1992) calculated a relatively rapid annual hydraulic retention time in Long Lake of 0.4 years during his study year, corresponding to a flushing rate of approximately 25 lake volumes per year. Monthly retention time variability ranged from 7 days in May 1991, during the highest inflows, to 56 days in August 1991, during the lowest inflows, emphasizing the flow-through response of the reservoir in connection to the magnitude of inflows. The retention time for June was 10 days and the average retention time for July-October was 44 days. The retention time and data presented in Figure 2 suggest that the hydrology in June is not representative of the other months used to establish the phosphorus TMDL for the lake.

Nuisance algae populations and hypolimnetic oxygen depletions within Long Lake have occurred during the summer growing season between July and October when inflows and corresponding flushing rates are low (Patmont, 1987). In addition to the reduced flow-through characteristic of Long Lake during this time, lake stratification during the growing season creates a complex mixing regime in which inflows are partially separated from lake surface and bottom waters. This is due to an apparent interflow of incoming waters through the metalimnion to the penstock tube openings in Long Lake dam. The compartmentalization due to these complex hydrodynamics results in non-steady state relationships between nutrient loading and in-lake water quality conditions (Patmont, 1987).

Water Quality:

Water quality (and quantity) data through 1985 was synthesized and evaluated in two documents produced in the late '80s: *Phosphorus Attenuation in the Spokane River* (Patmont *et al.,* 1985) and *The Spokane River Basin: Allowable Phosphorus Loading* (Patmont *et al.,* 1987). The major problem these studies were designed to address was the eutrophication of Long Lake and its effects on water quality. As noted above, these studies showed that there are complex ground water and surface water interactions that affect the water quality of the Spokane River and ultimately Long Lake. From their studies, a predictive model was developed to simulate phosphorus attenuation in the Spokane River and predict loads to Long Lake. Patmont et al's, design flow (1-in 20-year low flow) modeling resulted in about 38 percent of the phosphorus loading to the river being attenuated upstream of Nine Mile Dam.

Patmont *et al., (1985, 1987)* found that about two-thirds of the phosphorus attenuation was due to in-river removal processes and the remainder due to hydraulic attenuation (i.e., leaves the river via irrigation withdrawals or seepage to the aquifer). They estimated that design loading to Long Lake was 21 percent lower than the allowable 248 Kg/day load established by Ecology through an earlier study (Singleton, 1981). Year-to-year variation in phosphorus loading (for design year conditions) to Long Lake was found to be small, representing a coefficient of variation of only 11 percent.

Although the focus of the Patmont *et al.* studies were on nutrients, dissolved oxygen data were included in many of the analyses. Low hypolimnetic dissolved oxygen levels in Long Lake were reported and related to influent total phosphorus concentrations. Diurnal fluctuations in dissolved oxygen concentrations were noted in the river due to photosynthetic production and respiration, but phosphorus concentrations were not found to vary diurnally. Phosphorus concentrations were found to increase below the wastewater treatment plants at Coeur d'Alene and Spokane (Patmont *et al.*, 1985). Total phosphorus concentrations near the Stateline Bridge were 11.8-28.5 µg/L and 23.0-58.1 µg/L below the Spokane treatment plant during the summer of 1984.

Dissolved oxygen levels downstream of the Inland Empire Paper Company were analyzed as part of a wasteload allocation study for that company (study area from RM 83.5 to 72.8). Summary data are presented in Pelletier (1994, 1997). Background dissolved oxygen levels were found to be less than 8.0 mg/L for critical conditions, and attributed to ground water inflows with dissolved oxygen less than 8.0 mg/L and high summer river temperatures. Therefore, the wasteload allocation for Inland Empire Paper Company was derived based on the BOD load that caused no more than a 0.2 mg/L depletion of dissolved oxygen (considered to be a de minimus impact). Total phosphorus values were reported to be 10-15 µg/L in the study area (10 µg/L was the laboratory reporting limit). The values reported by Patmont (1985) for the same general area ranged between 10.6-25.9 µg/L. Pelletier also examined the concentrations of cadmium, lead, and zinc in the river system (Pelletier, 1998). Both of Pelletier's studies relied on hydrologic data compiled for the phosphorus attenuation model developed by Patmont *et al.*, (1985, 1987); specifically, the estimated Spokane Aquifer inflows and outflows to the river.

Figure 5 presents box plots of the monthly dissolved oxygen concentration from Ecology's ambient monitoring station 57A150 located at the Stateline Bridge for the period of record (December 1993 to April 1999). These data were collected during late morning to early afternoon. The plots show that the summer period can violate the dissolved oxygen criterion for the river. Figure 6 shows *in situ* diurnal data for one week periods during July, August, and September 1998 on the Spokane River above the Spokane AWTP (Data collected by Ecology's Ambient Monitoring Section). Although the data do not violate the dissolved oxygen criterion, they show a 1.5 to 2.0 mg/L diurnal change with the lowest concentrations occurring at night and early morning. The diurnal data suggest that the minimum dissolved oxygen concentrations in Figure 5 would be lower if the data represented nighttime values. The pH values exceed the upper limit of the criteria of 8.5 in July and August during the late afternoon through early evening which corresponds to the period of maximum photosynthetic activity. (Note: Dissolved oxygen and pH data presented in Figure 6 were corrected to offset with check standards measured by Winkler Method and Orion pH meter, respectively.)

Table 1 contains monthly statistics for total persulfate nitrogen, ammonia, total phosphorus, ortho-phosphate, and nitrite-nitrate for station 57A150 (located at the Stateline Bridge). The summary statistics show that total phosphorus concentrations for the summer period range from 10 to 35 µg/L at the state line. (It should be noted that the reporting limit for the total phosphorus ambient monitoring data was 10 µg/L. Approximately 45% of the data were reported at the limit. In order to assess the P-attenuation model, lower reporting limits must be met.)

Patmont *et al.* (1987) revised the total phosphorus TMDL to Long Lake from 248 kg/day to 259 ± 43 kg P/day during a seasonal median river flow condition (June-October). The TMDL was based on meeting the lake standard of 25 µg/L total phosphorus. They reported that the 1985 phosphorus loading to the lake during a median river flows is 255 ± 23 kg P/day, and concluded that existing phosphorus levels in the Spokane River basin were meeting the TMDL.

A diagnostic study of Long Lake was completed in 1992 as part of the Lake Spokane Phase I Restoration Project. The study, *Assessment of Nutrient Loading Sources & Macrophyte Growth in Long Lake (Lake Spokane), WA and the Feasibility of Various Control Measures* (Soltero *et al.,* 1992), provides a limnological assessment of Long Lake while focusing on the chief water quality concerns of algae blooms and increasing large stands of aquatic macrophytes in the lake. Annual water and phosphorus budgets were completed, the aquatic macrophyte community was assessed and restoration control measures were evaluated. They found that the Spokane River contributed over 90% of the phosphorus load to the reservoir. Groundwater was estimated to be contributing approximately 5% of the phosphorus load while the standing crop of macrophytes during senescence were estimated to be contributing less than 1% of the phosphorus load. A 90% sedimentation loss was used in the macrophyte phosphorus release estimate, but the contribution would still have been less than 1% of the total phosphorus load even if a 50% sedimentation loss value was used in the estimate.

A shift in the make up of the phytoplankton community from diatom domination to blue-green domination in 1990 and 1991 was noted. Anoxic conditions in the hypolimnion were not observed during the study years, suggesting possible improvements as a result of AWT at the City of Spokane since December 1977, however Wagstaff and Soltero (1982) and Patmont et al. (1987) have documented continued hypolimnetic anoxia in Long Lake following AWT implementation.

In addition, a verification of the Spokane River Phosphorus Attenuation Model using 1990 through 1992 Long Lake data was accomplished. A separate publication: *Verification of Long Lake Water Quality as Predicted by the Spokane River Phosphorus Attenuation Model* (Soltero *et al.,* 1993) documents the statistical verification of the model. Model predictions of key water quality variables in Long Lake did not differ significantly from actual water quality measurements, which substatiated the use of the model. However, recommendations included a review of source loadings for the model input because of the lapse of time and change of conditions since the model was developed.

Project Goals

The ERO has requested a study of the Spokane River partly because the City of Spokane is currently finalizing their 20-year facility plan and the total assimilative capacity of the Spokane River to receive wastewater is not well understood. The major pollutants of concern that affects dissolved oxygen for NPDES permits are carbonaceous biochemical oxygen demand (CBOD) and ammonia. Nutrient loading is also of concern because of its indirect impact on dissolved oxygen through potential increased primary productivity and the resultant plant respiration and decay processes.

One of the major goals of this project will be to assess the assimilative capacity of the Spokane River system (including Long Lake) with respect to CBOD and ammonia from point and nonpoint loading sources. The effects of nutrient loading from point and nonpoint sources will also be assessed. In addition to evaluating the effects of pollutants, waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources will be recommended to meet dissolved oxygen criteria.

The second goal of this study will be to evaluate and update the P-attenuation model with respect to the original assumptions used to develop the model and its use to predict water quality responses in Long Lake. If the precision of the new water quality model developed for this project is confirmed, it could be used to replace the P-attenuation model.

Project Objectives

- Develop a model to determine the capacity of the Spokane River to assimilate point and nonpoint sources of oxygen consuming substances and meet water quality criteria. Conduct water quality sampling investigations for calibration and confirmation of the dissolved oxygen model.

- Use the model to determine the potential to violate water quality criteria during critical conditions. Identify potential WLAs and LAs to meet water quality standards.

- Assess the current conditions in the Spokane River and Long Lake, and the gain and loss of total phosphorus within the river system from the State Line to Nine Mile Dam.

- Evaluate and update the existing P-attenuation model used to predict water quality responses in Long Lake and compare prediction estimates to the water quality model developed for this project.

Study Design

Approach

Dissolved Oxygen Assessments

Based on an analysis of streamflow statistics, three seasons have been established. It is expected that wasteload allocations for NPDES permits will be applied seasonally.

- Summer -July through October. This season has the lowest streamflows and will have the lowest river assimilative capacity. The critical period for this season is late August to early September.
- Winter – November through March. This season will have a higher assimilative capacity than the summer, but may still require water quality-based discharge limits for point sources. The critical period for this season is November.
- Spring – April through June. This season has the highest streamflows and is least likely to experience dissolved oxygen problems. Technology based limits, rather than water quality based, are likely to determine wasteload allocations for this season.

At this time, water quality sampling and modeling for dissolved oxygen will be done only for the summer season.

Phosphorus Attenuation Assessments

- The surveys used to develop the P-Attenuation Model were conducted from mid-July to mid-September. In order to assess the performance and make modifications to the model, surveys for this study will also be conducted during this time frame. However, the critical period for P-loading to Long Lake was identified as June-November by Singleton (1991) and June-October by Patmont *et al.* (1985).

Three field sampling approaches will be used to achieve the objectives of this study: (1) a field measurement survey to collect discrete *in situ* water column data at all river and lake sampling stations and to collect continous data from two river and two lake stations over a 48 hour period, (2) synoptic sampling that consists of comprehensive sampling of mainstem river stations, tributaries, and major point source discharges, and (3) diagnostic limnological sampling of Long Lake. The historical data and data from these surveys will be used to calibrate and confirm a mechanistic water quality model that will then be used to predict dissolved oxygen levels during critical conditions. The water quality model will be based on eutrophication processes that include the interaction of nutrients, phytoplankton, carbonaceous material, and dissolved oxygen (see Water Quality Modeling section). If dissolved oxygen levels are predicted to be below 8 mg/L during critical conditions, the model will be used to determine the amount of pollutant loading reduction needed to meet the criterion. Pollution reductions will be identified for point sources in terms of WLAs, and for nonpoint sources in terms of LAs. The total phosphorus and limnological data collected will also be used to compare the performance of the existing P-attenuation model with that of the water quality model developed for this project.

Field Studies

One two-day field sampling survey will be conducted during August 16-17, 1999 to collect water column dissolved oxygen, temperature, pH, and conductivity data at all river and lake stations. One two-day synoptic survey will be conducted on August 23-25, 1999 to collect water quality data on the river, tributaries and major point sources. A lake diagnostic study will also be conducted on these days. Only one synoptic survey is proposed for the summer of 1999, because river flows are expected to be above the median daily flows for the summer period. Two additional surveys will be conducted during the summer of 2000.

Because the lowest assimilative capacity occurs in the summer, the surveys are scheduled during that season. The summer 1999 data will be used to calibrate a water quality model for the system and evaluate the P-attenuation model. One of the summer 2000 data collection surveys will be used to re-calibrate the model, and the other used to confirm the water quality model performance. The summer 2000-season data will also be used to assess and modify the water quality model to predict phosphorus loading and its effects on Long Lake.

Data Collection Requirements:

Reconnaissance Survey:

A reconnaissance survey will be conducted in July in order to identify specific sampling locations and evaluate the logistical requirements of the survey.

Stream Geometry and Hydraulic Data:

Hydrologic data are needed for transport calculations that are used to determine the movement of pollutants downstream. The historical data reported by Patmont *et al.,* (1985, 1987) and Pelletier (1994, 1998) will be used to establish the physical and hydrologic characteristics of the river and lake system (i.e., reach morphometry and discharge, including velocity and travel time estimates). The hydrologic conditions for the proposed study period will be based on flows measured at the current USGS gauging stations. Tributary flow data will be collected during each sampling survey. Design flows for the river and tributaries will be determined by using USGS gauging station data as reviewed in the "Historical Data Review" section.

EAP is also planning to conduct a study to assess the effect of aquifer recharge from the Spokane River on hydraulic heads in the aquifer and on ground-water quality (Garrigues, 1999). As part of this study, ground-water/surface-water interactions will be monitored and ground water chemistry will be measured including dissolved oxygen, nitrite-nitrate, and ortho-phosphorus. These data will be used in this study to establish the quality of ground-water inflow to the river.

Water Quality Data and Sample Collection:

Water quality data will be used to parameterize (set rates and constants for water column processes) and calibrate the water quality model. The sampling stations for this project will be the same as those sampled during the previous P-attenuation and Long Lake studies. The sampling sites and a schedule for field measurements and sample collection for laboratory analysis are presented in Table 2, 3, and 4, respectively.

During the field measurement survey on August 16-17, water column data will be collected at each of the river stations using a Hydrolab® Surveyor 2. At 2 stations (RM 96, 58.1) *in situ* data loggers (Datasonde 3) will be placed for 24 hours to record temperature, pH, conductivity, and dissolved oxygen. These data will be used to assess diel changes in the parameters measured. During the synoptic survey on August 23-25, grab samples will be collected twice a day for two days from the river and tributary stations. Samples will be collected by "time-of-travel" between the Stateline Bridge and Trent Rd. (RM 96.0 to 85.3) and between Monroe Street and Seven-Mile Bridge (RM 73.4 to 62.0). The schedule for collecting these samples will be based on river flow conditions during the survey and the "time-of-travel" estimates provided by Patmont *et al.*, (1985). Effluent grab and composite samples will also be collected during the synoptic survey.

Phytoplankton samples will be collected at selected stations to provide data on species composition. Phytoplankton data will be used to select plankton growth rates from literature values based on species composition for modeling productivity.

Water quality samples will be collected from Long Lake during the surveys. The same stations will be used as those occupied by former studies outlined in Soltero et al. (1992). These established stations begin behind the Long Lake Dam (Station 0) and continue upstream at 5 mile intervals for 20 miles to Station 4. Ecology will sample one additional station 2.5 miles upstream of the Station 4. Water quality samples will also be collected at the Long Lake Dam outlet.

Field measurements on Long Lake during the August 16-17 survey will include temperature, pH, conductivity, and dissolved oxygen water column data at all stations using a Hydrolab Surveyor II. In addition, 24-hour deployment of two *in situ* data loggers (Datasonde 3) at two depths at stations 3 and 4 will be used to assess diurnal changes of temperature, pH, conductivity, and dissolved oxygen in the water column. Vertical profiles of light extinction will be measured at all stations and photosynthetic production and respiration will be measured using light and dark bottle tests of dissolved oxygen production and consumption (APHA et al., 1985). Light and dark bottles will be incubated at 1, 3, and 6-meter depths for approximately six hours at Station 3 and Station 4. Algal photosynthesis and respiration rates will be calculated by methods of APHA et al., (1985) and Thomann and Mueller (1987).

During the synoptic survey on August 23-25, grab samples will be collected using a Van Dorn sample bottle at 3-meter intervals from the top to the bottom at each station. Table 4 presents a summary of the chemical parameters to be sampled and the sampling strategy in the lake.

Data Quality Objectives and Analytical Procedures

Analytical methods and the reporting or precision limits for field measurements and laboratory analyses to be conducted during each monthly survey are listed in Table 5. Total precision (includes sampling and analytical precision) should be no more than 15% for all variables. Bias should not exceed the expected level for the specified analytical method.

Sampling and Quality Control Procedures

Collecting replicate samples will assess total variation for field sampling and laboratory analysis and thereby provide an estimate of total precision.. At least 10% of the total number of laboratory samples per parameter and field measurements will be replicate samples. In addition, field blanks will be collected to determine the presence of bias in the analytical method.

All water samples for laboratory analysis will be collected in pre-cleaned containers supplied by the Manchester Environmental Laboratory (MEL), except dissolved organic carbon and ortho-phosphorus, which will be collected in a syringe and filtered into a pre-cleaned container. The syringe will be rinsed with ambient water at each sampling site three times before filtering. All samples for laboratory analysis will be preserved as specified by Manchester Environmental Laboratory (MEL 1994) and delivered to MEL within 24 hours of collection. Laboratory analyses listed in Table 3 will be performed in accordance with MEL (1994).

Field sampling and measurement protocols will follow those specified in WAS (1993) for temperature (alcohol thermometer), pH (Orion Model 250A meter and Triode™ pH electrode), conductivity (Beckman Model RB-5 and YSI 33), dissolved oxygen (Winkler titration), streamflow (Marsh-McBirney 201 & 2000), and *in situ* temperature, dissolved oxygen, pH, and specific conductance (Hydrolab® multi-parameter meters). All meters will be calibrated and post-calibrated per manufacturer's instructions.

Effluent samples from the point sources listed in Table 2 will be collected in pre-cleaned ISCO 24-hour composite samplers. Effluent sampling will be conducted according to standard operating procedures for Class II inspections by Ecology as documented in Glenn (1994).

Data Assessment Procedures

Laboratory data reduction, review, and reporting will follow procedures outlined in MEL's Users Manual (MEL 1994). All water quality data will be entered into Ecology's Environmental Information Management (EIM) system. Data will be verified, and 100% of data entry will be reviewed for errors.

Data analysis will include evaluation of data distribution characteristics and, if necessary, appropriate distribution transformations. Estimation of univariate statistical parameters and graphical presentation of the data (box plots, time series, regressions) will be made using SYSTAT/SYGRAPH8, EXCEL, or WQHYDRO computer software.

The data from this project will be used to calibrate and confirm a water quality model of the river system.

Water Quality Modeling

Due to the physical differences between Long Lake and the Spokane River upstream of the lake, it may not be possible to easily use one model to simulate both systems. In order to model the river (State Line to Long Lake), the model must be able to simulate BOD decay, eutrophication processes, and inflows and outflows. At this time, the U.S. Environmental Protection Agency supported model QAUL-2E appears to be the most appropriate model for this reach (USEPA, 1987). Applying QUAL-2E to this reach would also be consistent with its application in other studies (Pellitier, 1994; River TAC(b), 1998). However, in QUAL-2E BOD is modeled as a single rate first-order decay process. Because of the differences in point source effluent quality, it may not be possible to use a single decay rate model. An alternative would be to use a model that allows BOD to be incorporated as different fractions of carbon.

In order to model Long Lake, the model must be able to simulate BOD decay, eutrophication processes, and reservoir characteristics (e.g., vertical and longitudinal variability). The Idaho Spokane River Water Quality Management Plan – Technical Advisory Committee is using the U.S. Army Corps of Engineers 2-dimensional model CE-QUAL-W2 to model the deep slow moving portion of the river between Lake Coeur d'Alene and Post Falls dam. This model may also be appropriate to apply to Long Lake. However, because computer water quality and hydrodynamic modeling techniques are developing rapidly, a review of existing models will be completed before selecting a model or models for this study.

Project Schedule and Laboratory Budget

The schedule for the proposed study is as follows:

Submit draft QAPP for internal review:	May 20, 1999
Submit draft QAPP for client review	June 5, 1999
Finalize QAPP:	July 15, 1999
Sampling Surveys begin	August 1999
Sampling Surveys end	September 10, 2000
Draft Report	March 31, 2001
Final Report	June 30, 2001

The laboratory budget is presented in Table 6.

Project Responsibilities

The following individuals and organizations will be involved in the project:

Bob Cusimano and Jim Carroll (Ecology): Principal Investigators responsible for preparation of Quality Assurance Project Plan (QAPP), project design, collecting and analyzing data, developing graphs and figures, writing and editing draft and final reports. (360-407-6688)

Will Kendra (Ecology): Section Supervisor of the Watershed Ecology Section of the Environmental Assessment Program. Responsible for approving the project QAPP, project budget, and project reports. (360-407-6698)

Karol Erickson (Ecology): Unit Lead of the Watershed Studies Unit of the Environmental Assessment Program. Responsible for internal review of the project QAPP and draft data summary reports. (360-407-6694)

Carl Nuechterlein, Ken Merrill and David T. Knight (Ecology): Client contacts for the Water Quality Program of Ecology, Eastern Regional Office. Responsible for review of draft QAPP and draft final report and interacting with the stakeholders and other interested public. (509-456-2926)

Stuart Magoon, and Pam Covey (Ecology). Manchester Environmental Laboratory (MEL) staff responsible for analysis and reporting of chemical data. (360-871-8860)

Stew Lombard (Ecology). Quality Assurance Section staff responsible for review of the project QAPP. (360-895-4649)

References

APHA, et al., 1985. Standard methods for the examination of water and wastewater. Sixteenth edition. American Public Health Association, American Water Works Association, and Water Pollution Control Federation. Washington D.C.

Aroner, E.R. 1994. WQHYDRO: Water Quality/Hydrology Graphics/Analysis System. April 1994. P.O. Box 18149, Portland, OR.

USEPA, 1987. The Enhanced Water Quality Models QUAL2E and QUAL2E-UNCAS: Documentation and users manual. EPA/600/3-87/007. U.S. Environmental Protection Agency.

Garrigues, R.S., 1999. Spokane River/Aquifer Interaction Project. Final Quality Assurance Project Plan (Draft). Washington State Department of Ecology, Environmental Assessments Program. Olympia, WA.

Glenn, N, 1994. Quality Assurance Project Plan for Basin Class II Inspections. Washington State Department of Ecology, Environmental Assessments Program. Olympia, WA.

Knight, D.T., 1998. Watershed Approach to Water Quality Management Needs Assessment for the Spokane Water Quality Management Area (WRIA 54-57). Washington State Department of Ecology, Water Quality Program. Spokane, WA.

Patmont, C.R., G.J. Pelletier, and M.E. Harper, 1985. Phosphorus attenuation in the Spokane River. Project Completion Report. Contract C84-076. Washington State Department of Ecology. Olympia, WA.

Patmont, et al., 1987. The Spokane River Basin: Allowable Phosphorus Loading. Final Report. Prepared for State of Washington State Department of Ecology, Contract No. C0087074. Harper-Owes, Seattle, WA.

River-TAC, Idaho(a), 1998. Spokane River Water Quality Assessment Project Quality Assurance Plan. Idaho Spokane River Water Quality Management-Technical Advisory Committee. Prepared by Limno-Tech, Inc. Ann Arbor, MI.

River-TAC, Idaho(b), 1998. Preliminary Model Calibration and Evaluation Report. Idaho Spokane River Water Quality Management-Technical Advisory Committee. Prepared by Limno-Tech, Inc. Ann Arbor, MI.

Soltero, et al., 1992. Assessment of Nutrient Loading Sources and Macrophyte Growth in Long Lake (Lake Spokane), WA and the Feasibility of Various Control Measures. Departments of Biology and Geology, Eastern Washington University, Cheney, WA.

Soltero, et al., 1993. Verification of Long Lake Water Quality as Predicted by the by the Spokane river Phosphorus Attenuation Model. City of Spokane, Clerk's No. OPR93-236, Public Works File #14099. Department of Biology, Eastern Washington University, Cheney, WA.

Thomann, R.V. and J.A. Mueller, 1987. Principles of surface water modeling and control. Harper and Row Publishers, Inc. New York, NY.

Wagstaff, W.H. and R.A. Soltero, 1982. The Cause of Continued Hypolimnetic Anoxia in Long Lake Lake, Washington Following Advanced Wastewater Treatment by the City of Spokane. Final Progress Report, Contract No. 82-031, Eastern Washington University, Department of Biology. Cheney, WA.

WAS, 1993. Field Sampling and Measurement Protocols for the Watershed Assessments Section. Ecology Manual, Washington State Department of Ecology, EAP Program. Olympia, WA.

Figures

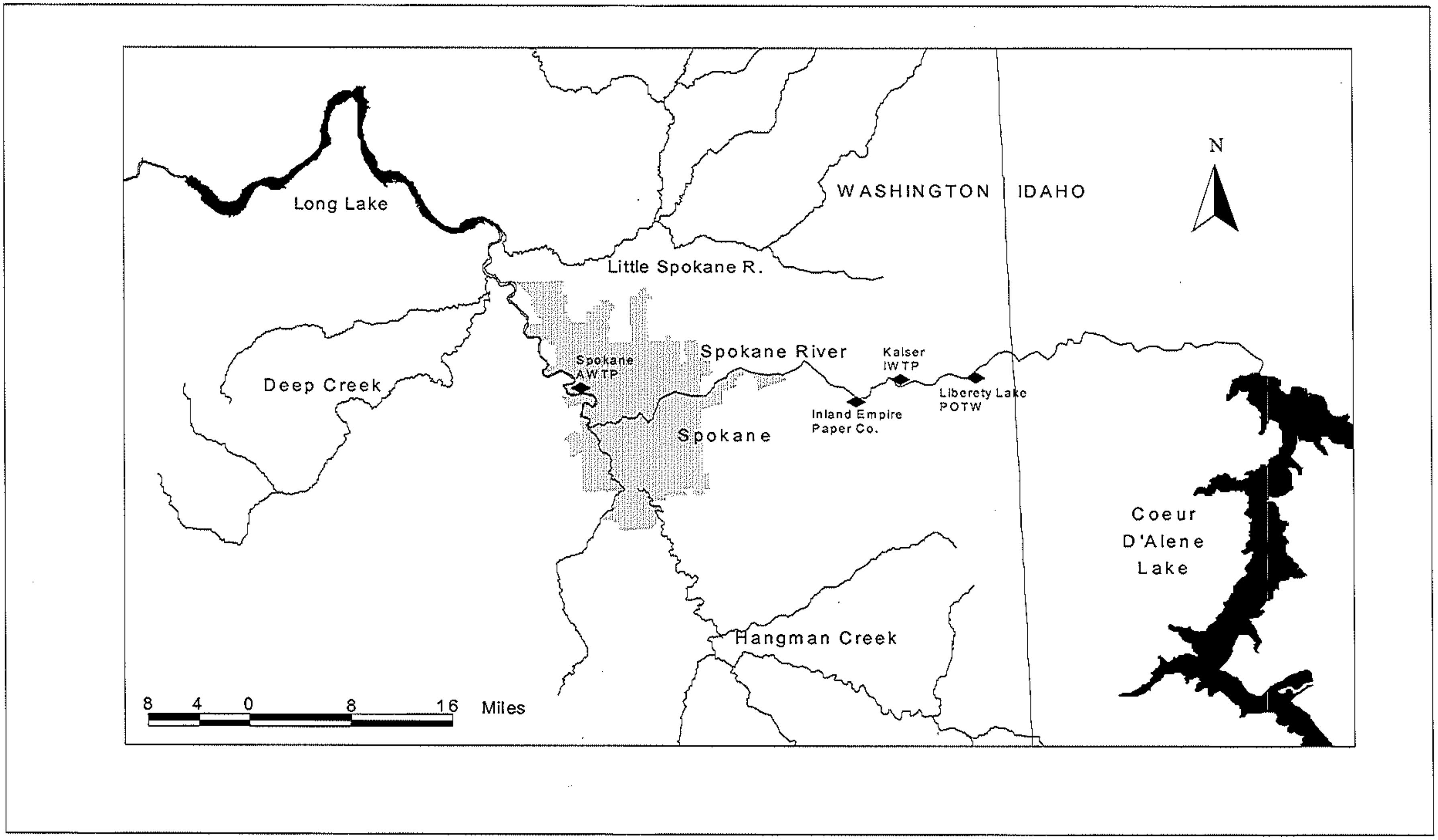


Figure 1. Study area map.

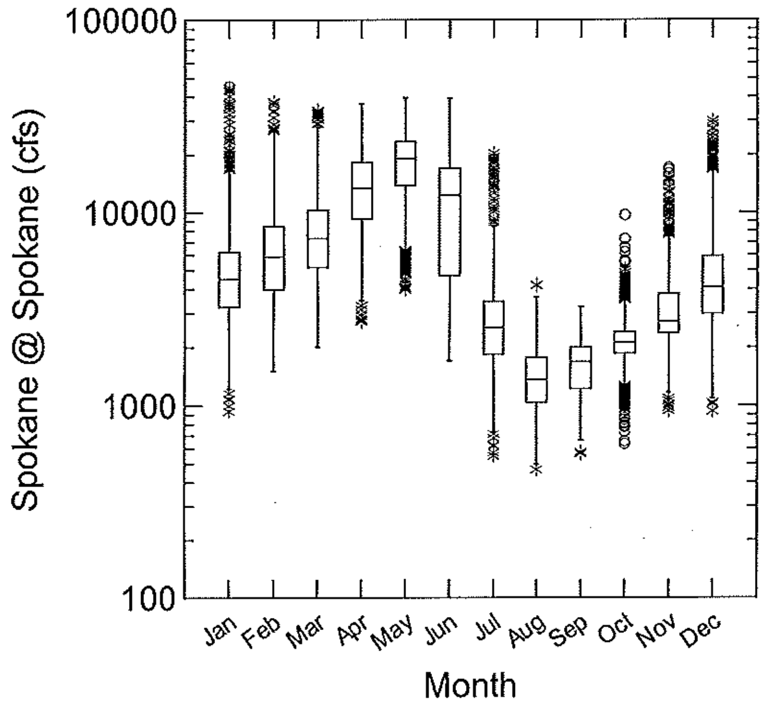


Figure 2. Box plots of monthly flow data from 1942-1998 for USGS station #12422500 at Spokane (RM72.9).

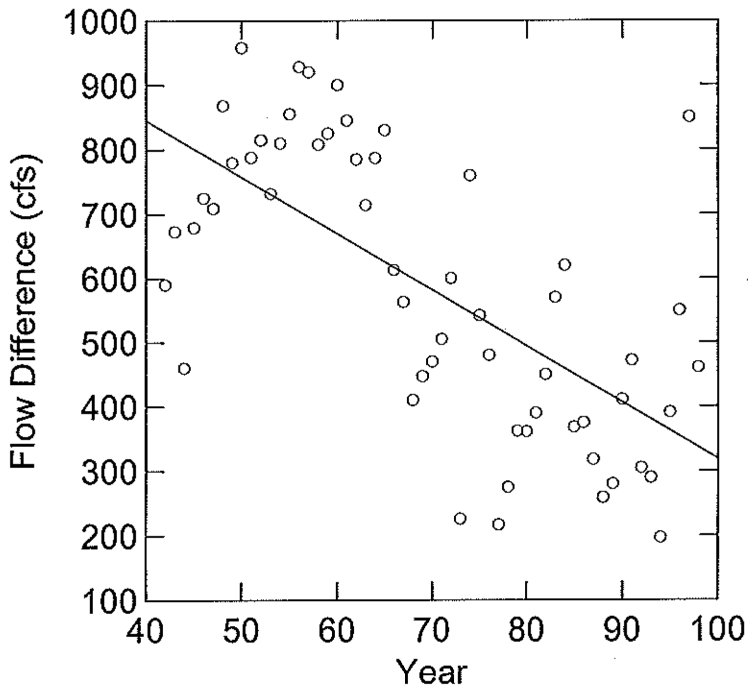


Figure 3. The median August flow difference between USGS station #12419000 (RM100.7) at Post Falls and #12422500 at Spokane (RM72.9) for 1942-1998.

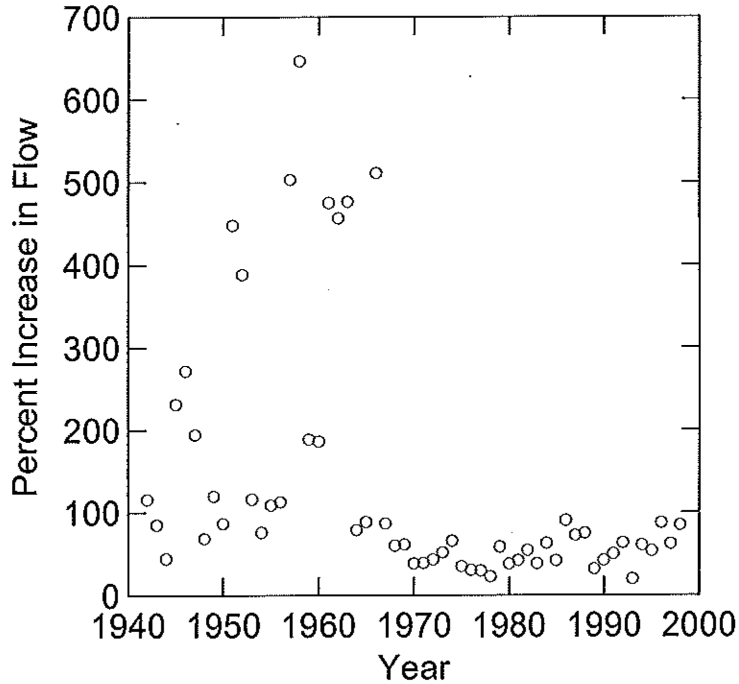


Figure 4. The median August flow difference between USGS station #12419000 (RM100.7) at Post Falls and #12422500 at Spokane (RM72.9) for 1942-1998 as a percentage of the Post Falls station.

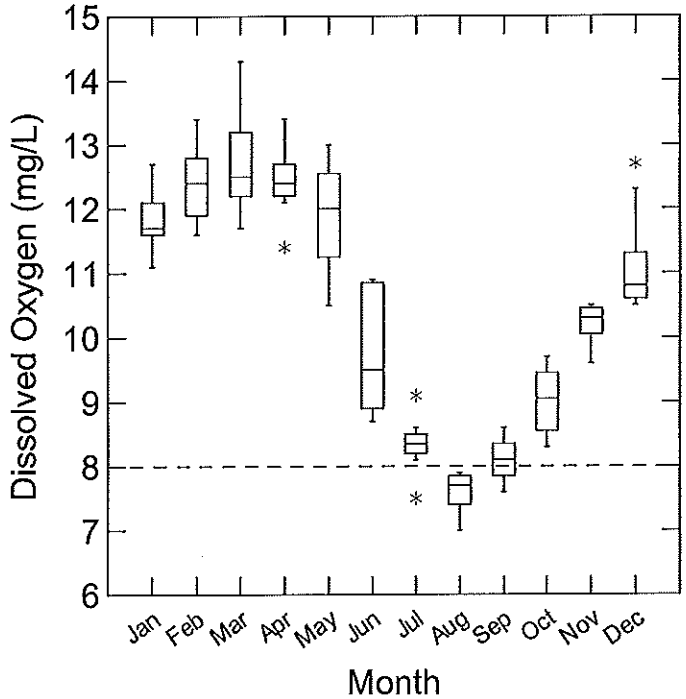
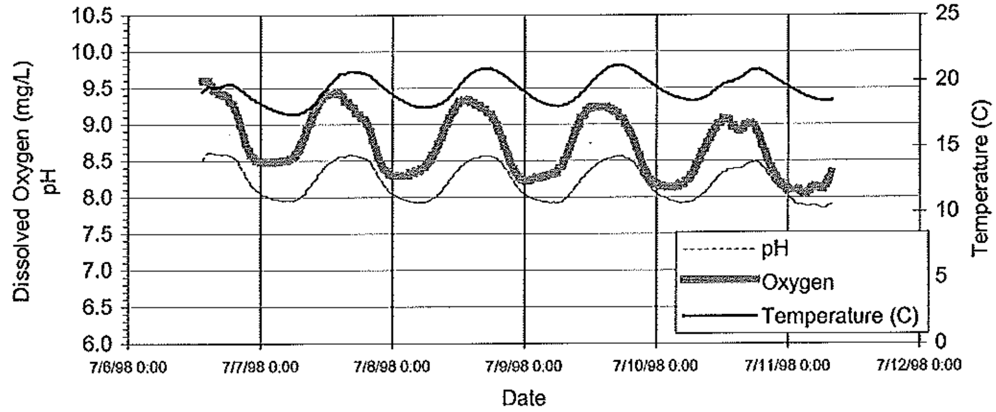
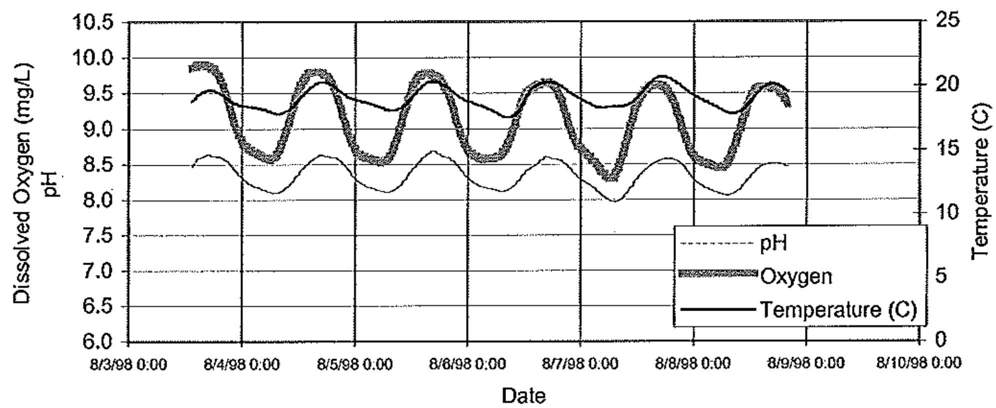


Figure 5. Box plots of monthly dissolved oxygen concentrations at Ecology's ambient monitoring station #57A150, located at the Stateline Bridge for the period of record, December 1993 – April 1999.

July



August



September

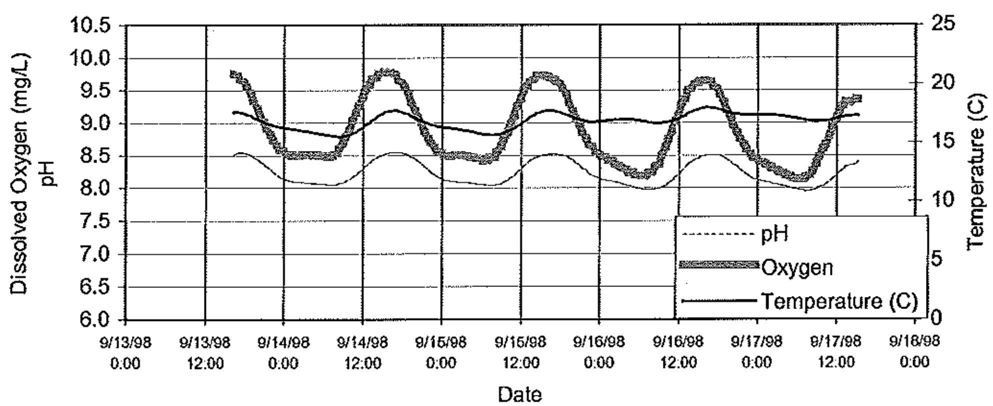


Figure 6. Spokane River diel data from upstream of the Spokane AWTP.

Tables

Table 1. Statistics for total persulfate nitrogen (TPN), ammonia (NH3_N), total phosphorus (TP_P), ortho-phosphate (OP_DIS), and nitrite-nitrate (NO2_NO3) for Ecology's ambient monitoring station 57A150 located at the Stateline Bridge. Values as mg/L.

Month	Statistic	TPN	NH3_N	TP_P	OP_DIS	NO2_NO3
Jan	N of cases	6	9	9	9	9
Jan	Minimum	0.105	0.010	0.010	0.005	0.036
Jan	Maximum	0.190	0.046	0.038	0.013	0.082
Jan	Mean	0.159	0.023	0.020	0.008	0.058
Jan	95% CI Upper	0.190	0.033	0.028	0.011	0.071
Jan	95% CI Lower	0.127	0.014	0.012	0.006	0.044
Jan	Standard Dev	0.0297	0.0123	0.0104	0.0032	0.0180
Feb	N of cases	6	9	8	9	9
Feb	Minimum	0.165	0.010	0.010	0.005	0.032
Feb	Maximum	0.220	0.040	0.030	0.015	0.106
Feb	Mean	0.184	0.019	0.015	0.009	0.062
Feb	95% CI Upper	0.205	0.028	0.021	0.012	0.081
Feb	95% CI Lower	0.162	0.010	0.009	0.007	0.044
Feb	Standard Dev	0.0205	0.0114	0.0073	0.0035	0.0245
Mar	N of cases	5	8	8	8	8
Mar	Minimum	0.122	0.010	0.010	0.005	0.029
Mar	Maximum	0.238	0.032	0.044	0.010	0.144
Mar	Mean	0.186	0.014	0.020	0.008	0.077
Mar	95% CI Upper	0.249	0.021	0.030	0.010	0.109
Mar	95% CI Lower	0.124	0.007	0.009	0.006	0.045
Mar	Standard Dev	0.0501	0.0085	0.0122	0.0025	0.0378
Apr	N of cases	5	8	8	8	8
Apr	Minimum	0.120	0.010	0.010	0.001	0.010
Apr	Maximum	0.244	0.059	0.126	0.010	0.123
Apr	Mean	0.186	0.018	0.028	0.007	0.056
Apr	95% CI Upper	0.251	0.032	0.062	0.009	0.093
Apr	95% CI Lower	0.120	0.004	-0.005	0.004	0.019
Apr	Standard Dev	0.0531	0.0169	0.0398	0.0032	0.0443
May	N of cases	4	7	7	8	7
May	Minimum	0.074	0.010	0.010	0.005	0.010
May	Maximum	0.205	0.019	0.064	0.010	0.104
May	Mean	0.115	0.013	0.021	0.008	0.038
May	95% CI Upper	0.213	0.017	0.039	0.010	0.069
May	95% CI Lower	0.017	0.009	0.002	0.005	0.006
May	Standard Dev	0.0614	0.0042	0.0200	0.0027	0.0342
Jun	N of cases	5	8	8	8	8
Jun	Minimum	0.052	0.010	0.010	0.005	0.010
Jun	Maximum	0.134	0.015	0.040	0.010	0.021
Jun	Mean	0.091	0.011	0.017	0.008	0.013
Jun	95% CI Upper	0.133	0.012	0.027	0.010	0.016
Jun	95% CI Lower	0.049	0.010	0.008	0.005	0.009
Jun	Standard Dev	0.0339	0.0018	0.0112	0.0027	0.0038
Jul	N of cases	5	8	8	8	8
Jul	Minimum	0.053	0.010	0.010	0.005	0.010
Jul	Maximum	0.204	0.022	0.025	0.010	0.210
Jul	Mean	0.130	0.013	0.013	0.008	0.051
Jul	95% CI Upper	0.210	0.017	0.018	0.010	0.112
Jul	95% CI Lower	0.051	0.010	0.009	0.005	-0.010
Jul	Standard Dev	0.0639	0.0045	0.0054	0.0027	0.0729

Cont.- Appendix A.

Month	Statistic	TPN	NH3_N	TP_P	OP_DIS	NO2_NO3
Aug	N of cases	5	8	8	8	8
Aug	Minimum	0.094	0.010	0.010	0.005	0.017
Aug	Maximum	0.270	0.054	0.029	0.013	0.137
Aug	Mean	0.165	0.019	0.015	0.009	0.041
Aug	95% CI Upper	0.245	0.032	0.021	0.011	0.074
Aug	95% CI Lower	0.085	0.005	0.009	0.006	0.007
Aug	Standard Dev	0.0645	0.0159	0.0068	0.0031	0.0400
Sep	N of cases	5	8	8	8	8
Sep	Minimum	0.105	0.010	0.010	0.005	0.020
Sep	Maximum	0.301	0.024	0.035	0.010	0.200
Sep	Mean	0.183	0.013	0.021	0.008	0.060
Sep	95% CI Upper	0.272	0.018	0.029	0.010	0.109
Sep	95% CI Lower	0.094	0.009	0.014	0.005	0.011
Sep	Standard Dev	0.0717	0.0055	0.0091	0.0027	0.0584
Oct	N of cases	6	8	8	8	8
Oct	Minimum	0.096	0.010	0.010	0.005	0.014
Oct	Maximum	0.186	0.047	0.030	0.011	0.054
Oct	Mean	0.134	0.017	0.014	0.008	0.034
Oct	95% CI Upper	0.166	0.027	0.020	0.011	0.047
Oct	95% CI Lower	0.103	0.006	0.008	0.006	0.022
Oct	Standard Dev	0.0301	0.0128	0.0070	0.0027	0.0151
Nov	N of cases	6	8	8	8	8
Nov	Minimum	0.047	0.010	0.010	0.005	0.010
Nov	Maximum	0.164	0.017	0.016	0.010	0.064
Nov	Mean	0.115	0.012	0.011	0.008	0.029
Nov	95% CI Upper	0.162	0.014	0.013	0.010	0.045
Nov	95% CI Lower	0.067	0.009	0.009	0.006	0.012
Nov	Standard Dev	0.0450	0.0025	0.0021	0.0025	0.0199
Dec	N of cases	6	9	9	9	9
Dec	Minimum	0.010	0.010	0.010	0.005	0.027
Dec	Maximum	0.152	0.031	0.039	0.011	0.064
Dec	Mean	0.108	0.016	0.023	0.008	0.044
Dec	95% CI Upper	0.161	0.022	0.031	0.010	0.055
Dec	95% CI Lower	0.055	0.009	0.015	0.006	0.033
Dec	Standard Dev	0.0508	0.0082	0.0108	0.0023	0.0143

Table 2. River, tributary, and point source sampling sites

River Mile	Site Name	Location
111.7	CLK111.7	Lake Coeur d'Alene outlet
96.0	SPK96.0	Stateline bridge
93.0	SPK93.0	Harvard Rd. bridge
92.7	LIB92.7	Liberty Lake POTW
90.4	SPK90.4	Barker Rd. bridge
87.8	SPK87.8	Sullivan Rd. bridge
86.0	KIS86.0	Kaiser IWTP
85.3	SPK85.3	Trent Rd. bridge
82.6	INL82.6	Inland Empire Paper Co IWTP.
79.8	SPK79.8	Upriver Dam powerhouse
78.0	SPK78.0	Green St. bridge
73.4	SPK73.4	Monroe St. powerhouse
72.4	HNG72.4	Hangman Creek
69.8	SPK69.8	Fort Wright bridge
67.6	SPK67.6	Above Spokane AWTP
67.4	SKT67.4	Spokane AWTP
64.6	SPK64.6	Gun Club
62.0	SPK62.0	Seven Mile bridge
58.1	SPK58.1	Nine Mile Dam powerhouse
56.4	LSK56.4	Little Spokane River
33.9	LLK33.9	Long Lake outlet

Table 3. Sampling strategy for the Spokane River, August 23-25, 1999.

Sampling Station	Station Type	Aug 16-17 Hydrolab[b]	Temp.	pH	Cond.	DO	Flow	Alkalinity	Specific Cond.	Chloride	Nutrient 5	Chloro-phyll *a*	Total and Dissolved Organic C	Total Kjeldahl N	Phyto-plankton ID	BOD5	CBODU
CLK111.7	RIver		4	4	4	4					4						
SPK96.0	River	1	4	4	4	4		2	2	2	4	4	2				2
SPK93.0	River	1	4	4	4	4		2	2	2	4	4	2				
LIB92.7	Effluent[a]		2	2	2	2		2		2	2		2	2		1	1
SPK90.4	River	1	4	4	4	4		2	2	2	4	4	2				
SPK87.8	River	1	4	4	4	4		2	2	2	4	4	2		1		
KAS86.0	Effluent[a]		2	2	2	2		2		2	2		2	2		1	1
SPK85.3	River	1	4	4	4	4		2	2	2	4	4	2				
INL82.6	Effluent[a]		2	2	2	2		2		2	2		2	2		1	1
SPK79.8	River	1	4	4	4	4		2	2	2	4	4	2				
SPK78.8	River	1	4	4	4	4		2	2	2	4	4	2				
SPK73.4	River	1	4	4	4	4		2	2	2	4	4	2				
HAN72.4	Tributary		4	4	4	4	2	2	2	2	4	4	2			1	1
SPK69.8	River	1	4	4	4	4		2	2	2	4	4	2				
SPK67.6	River	1	4	4	4	4		2	2	2	4	4	2		1		
SPT67.4	Effluent[a]		2	2	2	2		2		2	2		2	2		1	1
SPK64.6	River	1	4	4	4	4		2	2	2	4	4	2				
SPK62.0	River	1	4	4	4	4		2	2	2	4	4	2				
SPK58.1	River	1	4	4	4	4		2	2	2	4	4	2		1		2
LSK56.4	Tributary		4	4	4	4	2	2	2	2	4	4	2				1
LLK33.9	River		2	2	2	2		2	2	2	2		2				
QA samples			8	8	8	8		5	4	5	14	7	5	2	3	2	2
Subtotal		13	82	82	82	82	4	45	36	45	88	67	44	10	6	7	12

[a] Effluent samples will be collected from an ISCO 24-hour composite sampler.

[b] Temperature, pH, conductivity, and dissolved oxygen data collected with a Hydrolab® Surveyor 2 at all stations and Datasonde 3 continous recorder at station SPK96.0 and SPK58.

Table 4. Sampling strategy for Long Lake (Lake Spokane) and summary of chemical parameters sampled at in-lake water quality stations.

Lake	<<===============sampling stations===============>>					
Depth (m)	0	1	2	3	4	5
0.5	3	2	3	2	3	2
3	3a	2	3a	2	3a	2
6	3	2	3	2	3	2
9	1a	1	1a	1		
12	1	1	1	1		
15	1a	1	1a	1		
18	1	1	1			
21	1	1	1			
24	1a	1	1a			
27	1	1				
30	1					
33	1a					

1) core nutrients (TP, Ortho-P, TPN, NO2-NO3, NH3)
conductivity, chloride

2) core nutrients
Conductivity, chloride
Chlorophyll a

3) core nutrients
Conductivity, chloride
Chlorophyll a, phytoplankton biovolume

a) TOC, DOC

Note: DO, temperature, pH, and conductivity profiles will be completed at all stations.

Table 5. Summary of field and laboratory measurements, target detection limits, and methods.

Parameter	Precision Limit (for field measurements and turbidity) or Reporting Limit (all others)	Method[a]
Field Measurements		
Velocity	± 0.05 f/s	Current Meter
Temperature (Temp)	± 0.2 /C	Alcohol Thermometer
pH	± 0.1 standard pH units	Field Meter/Electrode
Dissolved Oxygen (DO)	± 0.06 mg/L	Winkler Titration
Specific Conductivity (Cond)	± 20 μmhos/cm	Field Meter/Conductivity Bridge
Secchi Disc Depth	± 0.5 m	Secchi Disc
Light Attenuation	0.0014 $\mu W/cm^2$	Irradiameter
General Chemistry		
Specific Conductance	1 μmhos/cm	SM16 2510
Ammonia nitrogen (NH3)	0.01 mg/L	EPA 350.1
Nitrate + nitrite nitrogen (NO2-NO3)	0.01 mg/L	EPA 353.2
Total persulfate nitrogen (TPN)	0.01 mg/L	SM 4500 NO3-F Modified
Total Kjeldahl Nitrogen (TKN)	0.01 mg/L	SM 4500
Orthophosphate (Ortho-P)	0.005 mg/L	EPA 365.3
Total phosphorus[b] (TP)	0.003 mg/L	EPA 365.3
Chloride (Cl)	0.1 mg/L	EPA 300.0
Total Organic Carbon (TOC)	1.0 mg/L	EPA 415.1
Dissolved Organic Carbon[c] (DOC)	1.0 mg/L	EPA 415.1
5-day BOD[d] (BOD5)	2 mg/L	EPA 405.1
Ultimate Carbonaceous BOD (CBODU)	2 mg/L	NCASI (1987)
Phytoplankton ID/Biovolume	NA	SM18 10200F; Sweet (1987)
Chlorophyll *a* (Chloro-a)	0.05 μg/L	Fluorometer, SM 10200H(3)

[a] SM = Standard methods for the examination of water and wastewater. 20th edition (1998). American Public Health Association, American Water Works Association, and Water Environmental Federation. Washington, D.C.

[b] Low level phosphorus analysis.

[c] Filter in field with Whatman PURADISC™ 0.45 μm pore size syringe filter.

[d] Use unsensored data for readings below 2 mg/L.

[e] A procedure for estimation of ultimate oxygen demand. National Council of the Paper Industry for Air and Stream Improvement. Inc. Special Report No. 87-06. May 6, 1987.

Table 6 Lab cost for the proposed Spokane and Long Lake water quality study. Number of samples and cost are for each survey. One survey is planned for 1999 and two surveys for 2000.

Lab Measurement Parameter	Unit Cost	Number	Cost	
River and Tributaries				
Alkalinity	$14	36	$504	
Specific Conductance	$10	36	$360	
Chloride	$28	36	$1,008	
Nutrient 5 (include TPN)	$86	79	$6,794	
Chlorophyll *a*	$53	67	$3,551	
Phytoplankton ID/Biovolume	$56	6	$336	
Total Organic Carbon	$29	35	$1,015	
Dissolved Organic Carbon	$29	35	$1,015	
Ultimate Carbonacous Biochemical Oxygen Demand*	$663	6	$3,978	
Sub Total:				$18,561
Point Sources				
Alkalinity	$14	9	$126	
Chloride	$28	9	$252	
Nutrient 5	$63	9	$567	
Total Kjeldahl Nitrogen	$31	9	$279	
Total Organic Carbon	$29	9	$261	
Dissolved Organic Carbon	$29	9	$261	
5-day Biochemical Oxygen Demand	$46	7	$322	
Ultimate Carbonacous Biochemical Oxygen Demand	$663	6	$3,978	
Sub Total:				$6,046
Lake				
Specific Conductance	$10	88	$880	
Chloride	$28	88	$2,464	
Nutrient 5 (include TPN)	$86	92	$7,912	
Chlorophyll *a*	$53	24	$1,272	
Phytoplankton ID/Biovolume	$56	8	$448	
Total Organic Carbon	$29	34	$986	
Dissolved Organic Carbon	$29	34	$986	
Sub Total:				$14,948
Survey Total:				**$39,555**
Ambient Monitoring Long Lake Sampling				
Nutrient 5 (include TPN) for Jul, Aug, and Sep	$104	39		$4,056
Ground Water Sampling				
Total and Ortho-phosphorus	$46	52		$2,392
Total				**$46,003**
Grand Total for 3 Surveys				**$138,009**

Note: Laboratory cost may change for summer-2000 surveys.
[a] Low-level total phosphorus analysis