WATER QUALITY STATUS AND TREND MONITORING SYSTEM FOR THE CLARK FORK-PEND OREILLE WATERSHED

Summary Monitoring Report 2004

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EXECUTIVE SUMMARY

This report summarizes water quality data collected in the Clark Fork-Pend Oreille Basin in 2004 by the Tri-State Water Quality Council. Analyses presented in this study describe the temporal and spatial variability in concentrations of algal nutrients, heavy metals and periphyton (attached algae) in the Clark Fork-Pend Oreille watershed.

The Tri-State Water Quality Council established seven priority water quality monitoring objectives for the Clark Fork-Pend Oreille watershed. These include:

1) Evaluating time trends in nutrient concentrations in the mainstem Clark Fork River and selected tributaries;
2) evaluating time trends for algal standing crops in the Clark Fork River;
3) monitoring compliance with established summer nutrient concentration target levels in the Clark Fork River;
4) estimating nutrient loading rates to Pend Oreille Lake from the Clark Fork River;
5) evaluating time trends for algal standing crops in near-shore areas of Pend Oreille Lake;
6) evaluating time trends for Secchi disc depth in Pend Oreille Lake; and
7) evaluating time trends for nutrient concentrations in the Pend Oreille River.

Nutrient constituents monitored included total phosphorus, total nitrogen (total Kjeldahl nitrogen plus nitrate + nitrite nitrogen), total soluble inorganic nitrogen (nitrate + nitrite plus ammonia nitrogen), and dissolved ortho-phosphorus (soluble reactive phosphorus). Metals constituents included total recoverable and dissolved fractions of copper, zinc, cadmium, lead and arsenic. Attached algae levels were measured in terms of chlorophyll *a* and ash-free dry weight from natural substrate samples. Water quality records from 15 river stations and 7 lake stations in a three-state area were analyzed. This study represents the sixth consecutive year of river and lake sampling.

This summary assessment report focuses on water quality status and spatial patterns reflected in instream concentrations of the selected monitoring variables. The report does not provide an in-depth assessment of long-term time trends in the data set, nor does it include an appraisal of nutrient loading to Pend Oreille Lake. Those monitoring objectives are addressed in separate reports, the first representing monitoring during the 1998-2002 time period (Land & Water 2004). The 2004 data described in this report will be analyzed for time trends as part of a planned second assessment report covering the years 2003-2007.

In general, concentrations of nitrogen constituents (total nitrogen and total soluble inorganic nitrogen) in 2004 were lowest at the Thompson River site. Nitrogen concentrations in the Clark Fork River from below Thompson Falls Dam to below Cabinet Gorge Dam tended to be higher than the Thompson River, but comparable to each other. Nitrogen concentrations in the Pend Oreille River in Washington were lower than in the Clark Fork River and comparable to the Thompson River. Total phosphorus concentrations were similar among the Thompson River and

Clark Fork River sites, but markedly lower in Pend Oreille River sites. Soluble reactive phosphorus concentrations were highest at the Thompson River site and decreased downstream.

Total recoverable and dissolved metal constituents were generally low during the 2004 calendar year, with median values often at or below the analytical detection limits. Concentrations above the limits of detection did occur, however, and these were usually associated with high flow events during the late-winter or spring periods. Median concentrations of dissolved copper and arsenic were above detection at the Clark Fork River below Thompson Falls, but below detection at the other two sampling sites.

Summer nutrient concentrations in the Clark Fork River during 2004 generally exceeded the established nutrient target levels. Median total nitrogen concentrations exceeded the instream target of 300 µg/L at five of nine monitoring stations, all upstream of Missoula. All five stations above Missoula exceeded the instream target of 20 µg/L for total phosphorus, but all stations below Missoula were below the target of 39 µg/L. Median total soluble nitrogen concentrations exceeded the instream target of 30 µg/L at four sites, and median soluble reactive phosphate concentrations exceeded the instream target of 6 µg/L at five sites in 2004. To achieve target level compliance, no more than one of ten samples can exceed the established target value. Target level compliance was met for total nitrogen at the Clark Fork above Flathead, for total phosphorus at Huson and above Flathead, for total soluble inorganic nitrogen at Bonita, and for soluble reactive phosphorus above Flathead.

Algal standing crops in the Clark Fork River in 2004, measured as chlorophyll *a*, were generally high compared to previous years at sites above Missoula, but comparable to previous years at sites below Missoula. The Clark Fork River above the Little Blackfoot had a higher mean chlorophyll *a* value in 2004 than in all previous years of monitoring (1998-2003). Mean chlorophyll *a* concentrations exceeded the instream summer mean target of 100 mg/m^2 at five of seven monitoring stations in August 2004 (Deer Lodge, above Little Blackfoot River, Bonita, above Missoula, and below Missoula) and at four of seven stations in September (Deer Lodge, above Little Blackfoot, Bonita, and below Missoula). Additionally, all sites except the Clark Fork River at Huson and above Flathead had at least one sample in August or September that exceeded the target maximum concentration (150 mg/m^2). In general, 2004 algal standing crops were higher in August than in September.

Open water Secchi depth readings were measured at only one location in 2004 (Granite). Secchi depth readings at Granite in 2004 were near the mid-range of values for the entire period of record. The lowest Secchi transparency in 2004 occurred in May, while the highest transparency occurred in August.

The 2004 monitoring program is the second year of a second five-year data collection cycle. A comprehensive analysis of water quality status, trends and nutrient loads will be performed following the 2007 monitoring year, similar to the analysis of the 1998-2002 data set.

1.0 INTRODUCTION

1.1 Background

1.1.1 History

The mission of the Tri-State Water Quality Council has been to develop a management strategy to restore and protect designated water uses within the Clark Fork-Pend Oreille Basin. The Tri-State Water Quality Council's Clark Fork-Pend Oreille watershed water quality monitoring program was begun in 1998 and employs a statistically-based sampling design derived from an analysis of previous nutrient and periphyton data collected for the watershed by the state agencies. Through this design approach, sampling frequencies and monitoring locations have been optimized to provide reliable information for watershed management decision-making while minimizing operational costs.

The 2003-2007 monitoring program represents the second five-year operational period of the Tri-State Water Quality Council's monitoring program. The initial five-year monitoring period (1998-2002), together with the preexisting agency data, provided the basis for a recently completed statistical analysis of water quality time trends in the Clark Fork-Pend Oreille Basin (Land & Water, 2003a). The results of this analysis have been used to optimize the existing 2003-2007 program.

1.1.2 Monitoring Program Goals

The Tri-State Water Quality Council's Water Quality Monitoring Committee has established seven primary monitoring goals for the Clark Fork-Pend Oreille Watershed, which conform to specific watershed management goals articulated in a tri-state management plan (EPA 1993). These monitoring goals include:

1) Evaluating time trends in nutrient concentrations in the mainstem Clark Fork River and selected tributaries;
2) evaluating time trends for algal standing crops in the Clark Fork River;
3) monitoring compliance with established summer nutrient concentration target levels in the Clark Fork River;
4) estimating nutrient loading rates to Pend Oreille Lake from the Clark Fork River;
5) evaluating time trends for algal standing crops in near-shore areas of Pend Oreille Lake;
6) evaluating time trends for Secchi depth in Pend Oreille Lake; and
7) evaluating time trends for nutrient concentrations in the Pend Oreille River.

1.2 Project Description

The study area includes 22 monitoring locations on the Clark Fork River, selected tributaries, Pend Oreille Lake, and the Pend Oreille River within the Clark Fork-Pend Oreille watershed of western Montana, northern Idaho and northeastern Washington (**Appendix A**). The locations selected for water quality monitoring provide distributed spatial coverage for evaluating the effects of point and non-point pollution sources, and the influences of major population centers and tributary inflows. This design provides for a cost effective and reasonably sensitive assessment of nutrient and metals inputs throughout the basin. A summary of monitoring locations, their rationale, and associated sampling frequencies are provided in **Table 1-1**.

Table 1-1. ***Monitoring Locations, Rationale, and Sampling Frequency***

Station	STORET ID	Name	Rationale	Sampling Frequency
2.5	3225SI05	Silver Bow Creek at Opportunity	below mixing zone for Butte WWTP	S10
07	3326CL02	Clark Fork below Warm Springs Creek	upstream control site, start of Clark Fork River	S10
09	3526CL01	Clark Fork at Deer Lodge	upstream control site for Deer Lodge, upper river indicator site	P10, S10
10	3726CL01	Clark Fork above Little Blackfoot River	below mixing zone for Deer Lodge WWTP	P10, S10
12	3919CL01	Clark Fork at Bonita	upper river site, between significant tributaries	P10, S10
15.5	4116CL01	Clark Fork above Missoula	below Blackfoot drainage, control site for Missoula	P10, S10
18	4115CL01	Clark Fork below Missoula (Shuffields)	below mixing zone for Missoula WWTP	P10, S10
22	4313CL01	Clark Fork at Huson	lower river site, downstream of Missoula	P10, S10
25	4710CL01	Clark Fork above Flathead	lower river site, upstream control for the Flathead River	P10, S10
27.5	4907TH01	Thompson River near mouth	lower river tributary, sponsored on annual basis by Plum Creek	N12
28*	5005CL01	Clark Fork below Thompson Falls	lower river site, downstream of Flathead River and TF WWTP	NM12
29*	5403CL01	Clark Fork at Noxon Bridge	lower river site, reflects reservoir influence	NM12
30*	5538CL01	Clark Fork below Cabinet Gorge Dam	estimation of nutrient loading to Pend Oreille Lake	NM18
		Pend Oreille River at Newport, WA	represents outflow of Pend Oreille Lake	N12
		Pend Oreille River at Metaline Falls, WA	downstream control site	N12
		Pend Oreille Lake: Kootenai	nearshore site, indicator of near-shore nutrient loading	P10
		Pend Oreille Lake: Springy Point	near Sandpoint and outflow of Pend Oreille Lake	P10
		Pend Oreille Lake: Sunnyside	nearshore site, indicator of near-shore nutrient loading	P10
		Pend Oreille Lake: Trestle Creek	nearshore site, near mouth of Pack River	P10
		Pend Oreille Lake: Bayview	open water site, south end of Pend Oreille Lake	P10, SD
		Pend Oreille Lake: Hope	nearshore site, over shallow north end of Pend Oreille Lake	SD
		Pend Oreille Lake: Granite Point	open water site, over deepest portion of Pend Oreille Lake	SD

N12 = Nutrient and field constituents, 12 monthly samples
NM12 = Nutrient, metal and field constituents, 12 monthly samples
NM18 = Nutrient, metal and field constituents, 12 monthly samples and 6 peak flow samples
P10 = Periphyton, 10 replicates per site, August and September
S10 = Summer nutrient and field constituents, 10 samples during 3 weeks in summer
SD = Secchi Depth, 12 monthly samples (if available)
* These sites sponsored by Avista Corp., pursuant to 401 certification requirement

Currently, the 2003-2007 program includes a basic monitoring component and several annual or periodic rotational add-on elements. The basic program consists of the highest priorities for annual monitoring, while the add-ons represent options for additional monitoring that are contingent on annual funding availability. The 2004 program included each of the tasks described below, which constitute the basic monitoring program:

1. monthly collection of nutrient and heavy metals samples and field constituents at three Clark Fork River sites, monthly collection of nutrient samples and field constituents at one Thompson River site and two Pend Oreille River sites;
2. summer collection of periphyton standing crop samples at seven Clark Fork River sites (August and September);
3. summer collection of nutrient samples and field constituents at nine Clark Fork River sites (10 samples over 3 months);
4. collection of nutrient and heavy metals samples at the Clark Fork River below Cabinet Gorge Dam during spring peak flow (six samples over a one-month period, May to June);
5. monthly Secchi depth readings at one Pend Oreille Lake site.

Nutrient constituents included: total phosphorus (TP), total Kjeldahl nitrogen (TKN) or total persulfate nitrogen (TPN, Washington sites only), nitrate + nitrite nitrogen (NO_2+NO_3-N), total ammonia nitrogen (NH_3+NH_4-N), and soluble reactive phosphorus (SRP). Heavy metal constituents included dissolved and total recoverable fractions of copper (Cu), zinc (Zn), cadmium (Cd), lead (Pb) and arsenic (As). Values for total nitrogen (TN) and total soluble inorganic nitrogen (TSIN) were calculated as follows:

$$TN = TKN \text{ plus } NO_2+NO_3\text{-N} \qquad TSIN = NO_2+NO_3\text{-N plus } NH_3+NH_4\text{-N}$$

Field constituents included: water temperature (˚C), dissolved oxygen (mg/l), pH (standard units), redox potential (mv), specific conductance (µs/cm), total dissolved solids (mg/l), and turbidity (NTU). Stream flow (instantaneous, cubic feet per second (cfs)) and river stage (ft) were also recorded where gauging stations were available.

Periphyton samples from natural substrates were analyzed for chlorophyll *a* (mg/m^2) and ash-free dry weight (g/m^2). Secchi depth was recorded in meters (m).

This report provides a brief summary of water quality and algae data collected during the 2004 calendar year. No detailed study was undertaken for analysis of time trends in water quality, nor were statistical comparisons made of water quality between stations. These types of detailed analyses are conducted once every five years on a complete five-year data set. The 2004 calendar year monitoring data will be evaluated for time trends together with 2003-2007 data during 2008.

1.3 Sampling Methods

1.3.1 Field Constituents – Clark Fork and Pend Oreille Rivers

Field variables measured in the Clark Fork and Pend Oreille rivers using a hand-held water quality probe included water temperature (˚C), dissolved oxygen (mg/l), pH (standard units), redox (mv), conductivity (µs/cm), and total dissolved solids (mg/l). Turbidity (NTU) levels were measured using a portable turbidimeter.

1.3.2 Nutrients and Metals – Clark Fork and Pend Oreille Rivers

Water samples for total phosphorus (TP), total Kjeldahl nitrogen (TKN), total persulfate nitrogen (TPN), nitrate plus nitrite-nitrogen (NO_2NO_3), total ammonia-nitrogen (NH_4), soluble reactive phosphorus (SRP), total recoverable and dissolved copper (Cu), zinc (Zn), cadmium (Cd), lead (Pb) and arsenic (As) were collected using a grab sampling technique by wading in a well-mixed portion of the river. Samples were taken in the upstream direction to avoid entrainment of sediment disturbed by wading.

Water samples for TP, TKN, Cu, Zn, Cd, Pb and As were collected directly in acid washed, wide-mouthed polyethylene bottles. Bottles were rinsed twice with native water prior to sampling. Samples were acidified to a pH of less than 2 by adding concentrated sulfuric acid (H_2SO_4) for nutrient samples and concentrated nitric acid (HNO_3) for metal samples.

Water for soluble nutrients constituents ($NO_{2+}NO_3$, NH_4 and SRP) and soluble metals (Cu, Zn, Cd, Pb, As) were filtered in the field through a 0.45 µm filter into acid-washed polyethylene bottles. A small volume of filtrate (30-50 ml) was discarded before the sample was collected. Nutrient samples (NO_2NO_3 and NH_4) were frozen or acidified to a pH of less than 2 with concentrated sulfuric acid. Soluble reactive phosphorus (SRP) samples were filtered into polyethylene bottles, but were not preserved. SRP samples were cooled to 4°C or less, or frozen.

Samples were clearly labeled with a waterproof marker or pre-printed labels. Label information included the site identification number, date and time, sample type, preservative, and sampler's initials. Each bottle was recorded on a chain-of-custody form before leaving the site. All samples were stored in coolers and chilled to 4°C or less (or frozen for SRP) for transport to the lab. A summary of sampling protocols used during 2004 is provided in **Table 1-2**.

Table 1-2. *Sampling Protocol*

Constituent	Sample Volume	Container	Preservation	Holding Time
TP and TKN	250 ml	Acid-washed polyethylene	H_2SO_4, cool to 4°C	28 days
Total Recoverable Cu, Zn, Cd, Pb, As	250 ml	Acid-washed polyethylene	HNO_3	6 months
Dissolved Cu, Zn, Cd, Pb, As	250 ml	Acid-washed polyethylene	Filter, HNO_3	6 months
NO_2NO_3 and NH_4	250 ml	Acid-washed polyethylene	Filter, add H_2SO_4 and cool to 4°C, or freeze	28 days

SRP	250 ml	Acid-washed polyethylene	Filter, cool to 4°C or freeze	48 hours

1.3.3 Periphyton – Clark Fork River

Two types of periphyton samples were collected: hoop samples (a bulk sampling method) and template samples (a rock scraping method). Hoop samples were collected for filamentous green algae (*Cladophora)* dominated sites (sites above Missoula) and template samples were collected for diatom dominated sites (sites below Missoula). Both chlorophyll *a* and ash-free dry weight (AFDW) were measured from the hoop and template samples. Clark Fork River periphyton samples were collected on two separate sampling events, once in August and again in September, in an attempt to document peak algal standing crops.

1.3.4 Secchi Depth – Pend Oreille Lake

For Secchi depth monitoring, a standard 20 cm Secchi disc was used. Secchi depth readings were taken on the side of the boat with the least amount of surface roughness. Water transparency was evaluated by lowering the Secchi disc over the side of the boat until the markings were no longer visible. The depth was read after the disc was lowered past the extinction point, and then raised until just visible. Depth was recorded in meters. The sampler also noted time of day, weather, water surface conditions, and any other variables that may have affected the reading.

1.4 Analytical Methods

State-certified laboratories, including the Montana Department of Public Health and Human Services chemistry laboratory, the Missoula wastewater treatment plant laboratory, and the Washington Department of Ecology Manchester laboratory performed all nutrient and metals analyses using standard methods. The University of Montana biology laboratory performed the periphyton sample analyses.

The analytical methods listed in **Table 1-3** represent standard analytical procedures. Details regarding these methods are not included in this document but are described in *Standard Methods for the Examination of Water and Wastewater, 20th Ed* (APHA 1999) and various EPA documents.

Table 1-3. ***Analytical Methods and Detection Limits***

Analyte	Method	Detection Limit
Total Phosphorus (TP)	EPA 365.3	1 µg/l
Total Kjeldahl Nitrogen (TKN)	EPA 351.2	100 µg/l
Nitrate + Nitrite-Nitrogen (NO_2NO_3)	EPA 353.2	100 µg/l
Total Ammonia-Nitrogen (NH_4)	EPA 350.1	10 µg/l
Soluble Reactive Phosphorus (SRP)	EPA 365.3	1 µg/l
Total Recoverable Copper (Cu)	EPA 200.7	1 µg/l
Total Recoverable Zinc (Zn)	EPA 200.7	0.5 µg/l
Total Recoverable Cadmium (Cd)	EPA 200.7	0.1 µg/l

Total Recoverable Lead (Pb)	EPA 200.7	1 µg/l
Total Recoverable Arsenic (As)	EPA 200.7	1 µg/l

1.5 Statistical Methods

This report includes summary statistics and boxplots for visual comparisons of water quality. Summary statistics include median, mean, minimum, maximum, standard deviation, and variance. Boxplots compare water quality and algae data from different monitoring station locations (i.e. spatial comparison) or at the same station for different sampling years (i.e. temporal comparison).

The shapes of the boxplots are based on median, interquartile, and extreme values of the data. The box encloses the interquartile range, which contains the middle 50 percent of the values. The median value is displayed as the centerline of the box. The top and bottom whiskers display the maximum and minimum observed values, excluding outliers and extreme values. Outliers, defined as values that are 1.5 to 3 times greater than or less than values in the interquartile range, are displayed as circles (○). Extreme values, or those more than 3 times the values in the interquartile range, are displayed with an asterisk (*). The boxplot construction is shown graphically in **Figure 1-1**.

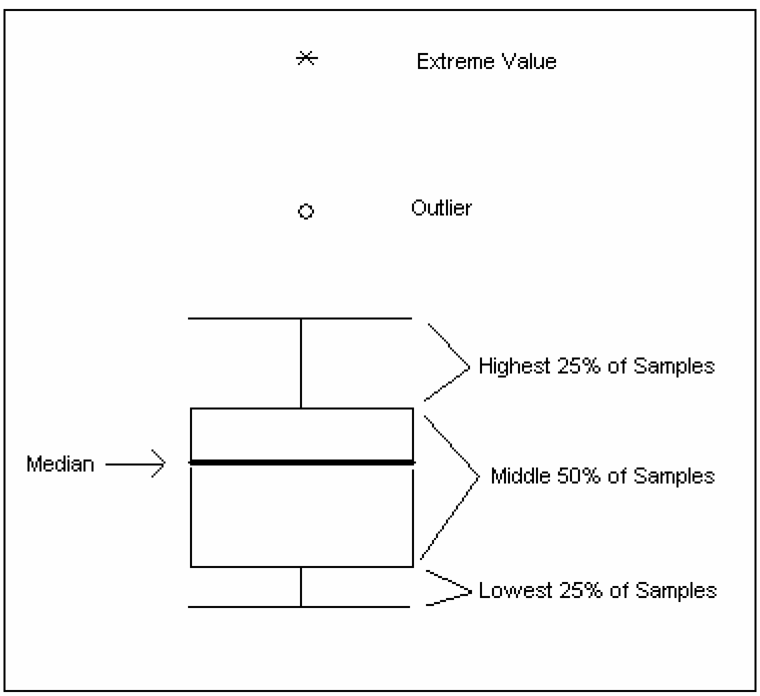

Figure 1-1. ***Boxplot Construction***

2.0 WATER QUALITY STATISTICS

2.1 Algal Nutrients Spatial Comparison

Nutrients concentrations tend to vary spatially throughout the Clark Fork-Pend Oreille watershed. Boxplots were used to provide a visual comparison of spatial patterns in nutrient concentrations during 2004 (**Appendix B**). Summary statistics including mean, median, minimum, maximum, standard deviation, and variance values, as well as the number of samples are provided in **Appendix C**. For boxplot presentations, stations were ordered (left to right) in the upstream to downstream direction.

2.1.1 Total Nitrogen

Median total nitrogen (TN) concentrations were highest in the Clark Fork River at Noxon (0.150 mg/L) and decreased in a downstream direction (0.055 mg/L in the Pend Oreille River at Metaline Falls). Median TN at the Thompson River site (0.055 mg/L) was lower than at the three Clark Fork River sites, but similar to the Pend Oreille River sites. The Clark Fork River site below Cabinet Gorge Dam yielded the lowest median TN concentration of the three Clark Fork sites (0.098 mg/L), yet all three Clark Fork River sites were very similar (0.098 – 0.150 mg/L). Peak flow samples collected from below Cabinet Gorge Dam yielded a slightly lower median concentration (0.082 mg/L), indicating a dilution effect during high water.

2.1.2 Total Soluble Inorganic Nitrogen

Median total soluble inorganic nitrogen (TSIN) concentrations were lowest in the Thompson River (0.010 mg/L). TSIN concentrations tended to increase in the Clark Fork River from below Thompson Falls Dam (0.0324 mg/L) downstream to the Clark Fork River below Cabinet Gorge Dam (0.0451 mg/L). Pend Oreille River sites at Newport and Metaline Falls (0.010 mg/L for both sites) showed median TSIN concentrations that were similar to the Thompson River. Median concentration of samples collected during peak flow below Cabinet Gorge Dam were slightly higher than the monthly median (0.0667 mg/L).

2.1.3 Total Phosphorous

Median total phosphorus (TP) concentrations were lowest at Clark Fork River below Thompson Falls (0.007 mg/L) and highest below Cabinet Gorge Dam (0.0091 mg/L), but median concentrations varied very little among the Clark Fork River sites and Thompson River . Median TP concentrations in the Pend Oreille River (0.0035 mg/L at Newport and 0.0048 at Metaline Falls) were lower than those measured at the lower Clark Fork River sites. The median concentration of peak flow samples from below Cabinet Gorge Dam was higher than the monthly median (0.010 mg/L), indicating a positive correlation with flow.

2.1.4 Soluble Reactive Phosphorus

Median soluble reactive phosphorus (SRP) concentrations were highest at the Thompson River site (0.0042 mg/L) and decreased downstream to Pend Oreille River at Metaline Falls (0.0015 mg/L). Median concentrations at Clark Fork River below Cabinet Gorge Dam (0.0019 mg/L) were slightly higher than the Pend Oreille River sites. It should be noted that detection limits were higher for the Pend Oreille River sites (0.003 mg/L) than for the Clark Fork sites (0.001 mg/L) due to different analytical laboratories. Samples collected during peak flow from below

Cabinet Gorge Dam yielded a median concentration below the analytical detection limit (<0.001 mg/L), indicating a dilution effect during high flow.

2.2 Heavy Metals Spatial Comparison

Heavy metals constituents, including total recoverable and dissolved fractions of copper, zinc, cadmium, lead and arsenic were collected at three sites during 2004, including Clark Fork River sites below Thompson Falls, at Noxon, and below Cabinet Gorge Dam.

2.2.1 Total Recoverable Copper

Median total recoverable copper (Cu) concentrations were below detection (<0.001 mg/L) at all sample locations. The Clark Fork River site below Thompson Falls produced the most number of samples above detection, while the sites at Noxon and below Cabinet Gorge Dam had only one or two samples above the analytical detection limit.

2.2.2 Total Recoverable Zinc

Median concentrations of total recoverable zinc (Zn) were highest at the Clark Fork River below Thompson Falls (0.00135 mg/L) and decreased downstream to Clark Fork River below Cabinet Gorge Dam (0.0007 mg/L). The median concentration of peak flow samples collected below Cabinet Gorge Dam were lower than the monthly median (0.00038 mg/L).

2.2.3 Total Recoverable Cadmium

All total recoverable cadmium (Cd) samples from all sites were below the analytical detection limit of 0.001 mg/L during 2004.

2.2.4 Total Recoverable Lead

Median total recoverable lead (Pb) concentrations were below the analytical detection limit (<0.001 mg/L) for all sites in 2004. Clark Fork River stations at Noxon and below Cabinet Gorge Dam had one sample during 2004 that was measured at detection (0.001 mg/L), otherwise, all samples collected in 2004 were below the analytical detection limit.

2.2.5 Total Recoverable Arsenic

Median total recoverable arsenic (As) concentrations were below the analytical detection limit (<0.001 mg/L) for all sites in 2004. All sampling locations had several samples above the analytical detection limit, with a maximum concentration of 0.011 mg/L at all sites.

2.2.6 Dissolved Copper

Median dissolved copper (Cu) concentrations were highest below Thompson Falls (0.001 mg/L) and below detection (<0.001 mg/L) at Noxon and below Cabinet Gorge Dam. The Clark Fork River sites at Noxon and below Cabinet Gorge Dam had only one or two samples above the analytical detection limit. Samples collected during peak flow from below Cabinet Gorge Dam yielded a median concentration at the analytical detection limit (0.001 mg/L).

2.2.7 Dissolved Zinc

Median concentrations of dissolved zinc (Zn) were lowest at the Clark Fork River below Thompson Falls (0.0104 mg/L) and increased downstream to Clark Fork River below Cabinet

Gorge Dam (0.0145 mg/L). The median concentration of peak flow samples from below Cabinet Gorge Dam were much lower than the monthly median (0.0011 mg/L), indicating a dilution effect during high water.

2.2.8 Dissolved Cadmium

All dissolved cadmium (Cd) samples from all sites were below the analytical detection limit of 0.001 mg/L during 2004.

2.2.9 Dissolved Lead

Median dissolved lead (Pb) concentrations were below the analytical detection limit (<0.001 mg/L) for all sites in 2004. Each sample location had one sample during 2004 that was measured at detection, otherwise, all samples collected in 2004 were below the analytical detection limit.

2.2.10 Dissolved Arsenic

Median dissolved arsenic (As) concentrations were highest at Clark Fork River below Thompson Falls (0.0007 mg/L) and below the analytical detection limit (<0.001 mg/L) at Noxon and below Cabinet Gorge Dam in 2004. All samples collected from below Cabinet Gorge Dam during peak flow were below the analytical detection limit (<0.001 mg/L).

2.3 Field Constituents Spatial Comparison

2.3.1 Temperature

Median stream temperature increased from a low of 8.15 ^{o}C in the Thompson River to a high of 11.85 ^{o}C in the Pend Oreille River at Metaline Falls.

2.3.2 pH

Median pH values were highest in the Clark Fork River below Thompson Falls (8.40) and decreased steadily downstream to the Pend Oreille River at Newport (8.11). Median pH in the Thompson River (8.33) was comparable to the Clark Fork River below Thompson Falls.

2.3.3 Conductivity

Conductivity, an indirect measure of dissolved ion concentrations, was highest in the Clark Fork River below Thompson Falls (190 µs/cm) and decreased downstream to Pend Oreille River at Metaline Falls (141 µs/cm). The Thompson River site exhibited a median conductivity (160 µs/cm) lower than the Clark Fork River sites, but higher than the Pend Oreille River sites.

2.3.4 Dissolved Oxygen

Median dissolved oxygen concentrations (DO) in 2004 were highest at the Thompson River site (10.9 mg/L) and lowest in the Clark Fork River at the Noxon Bridge (10.0 mg/L). Median DO at Pend Oreille River sites (10.4 mg/L at both Newport and Metaline Falls) was between the Thompson River and the Clark Fork River sites. Differences in dissolved oxygen concentrations between sites is likely affected by time of sampling and diurnal fluctuations.

2.3.5 Turbidity

Median turbidity was highest at the Clark Fork River below Thompson Falls (2.04 NTU) and decreased downstream to Pend Oreille River at Metaline Falls (1.10 NTU). Median turbidity in the Thompson River (1.50 NTU) was similar to the Clark Fork River below Cabinet Gorge Dam (1.54 NTU).

2.4 Summer Nutrient Levels

Intensive summer nutrient monitoring to evaluate compliance with the established instream targets was conducted at one station on Silver Bow Creek and at eight Clark Fork River stations (**Appendix A, Figure 4**). The following stations were each sampled ten times beginning in May and continuing through September: Silver Bow Creek at Opportunity, Clark Fork River below Warm Springs Creek, Clark Fork River at Deer Lodge, Clark Fork River above Little Blackfoot River, Clark Fork River at Bonita, Clark Fork River above Missoula, Clark Fork River below Missoula, Clark Fork River at Huson and Clark Fork River above the Flathead River.

The following Clark Fork Basin nutrient targets were developed by the Tri-State Water Quality Council and subsequently adopted as standards by the State of Montana (ARM 17.30.631):

- Total nitrogen — Clark Fork River (headwaters to Flathead River) — 300 µg/L
- Total phosphorous — Clark Fork River (headwaters to Missoula) — 20 µg/L
- Total phosphorous — Clark Fork River (Missoula to Flathead River) — 39 µg/L

The Tri-State Council has established secondary target values for soluble inorganic forms of nitrogen and phosphorus in the Clark Fork River, as follows:

- Total soluble inorganic nitrogen — 30 µg/L
- Soluble reactive phosphorus — 6 µg/L

2.4.1 Summer Boxplots

Spatial comparisons of summer nutrient concentrations in Silver Bow Creek and the Clark Fork River are presented using statistical boxplots (**Appendix D**). Where appropriate, boxplots are displayed on two scales to better display the data. The relevant target values are shown as horizontal lines, where these are available.

The total nitrogen (TN) boxplots show that five stations above the confluence of the Blackfoot River had median values exceeding the target level (300 µg/L) in 2004. These sites include Silver Bow Creek at Opportunity (2717 µg/L) and the Clark Fork River sites below Warm Springs (305 µg/L), above Deer Lodge (498 µg/L), above the Little Blackfoot River (481 µg/L), and at Bonita (386 µg/L). Median summer TN was highest at the Silver Bow Creek site, and generally decreased in a downstream direction, although a slight increase is noted above Deer Lodge. The lowest median summer TN concentration was observed in the Clark Fork River above the Flathead River confluence (142 µg/L).

Median summer total phosphorus (TP) concentrations exceeded the 20 µg/L target at all six sites above Missoula in 2004, including Silver Bow Creek at Opportunity (218 µg/L) and the Clark Fork River sites below Warm Springs (41 µg/L), above Deer Lodge (28 µg/L), above the Little Blackfoot River (53 µg/L), at Bonita (40 µg/L), and above Missoula (20.4 µg/L). Median summer TP concentrations at the three stations below Missoula all fell below the target (39 μg/L). As was observed for TN, the lowest median summer TP concentration was observed in the Clark Fork River above the Flathead River confluence (16 μg/L).

Median summer total soluble inorganic nitrogen (TSIN) concentrations in 2004 were above the target value of 30 μg/L at four stations. These include Silver Bow Creek at Opportunity (1733 μg/L) and Clark Fork River sites above Deer Lodge (151 μg/L), below Missoula (46 μg/L) and at Huson (35 μg/L). The lowest median summer TSIN value was exhibited at the Clark Fork River sites at Bonita (10 μg/L).

Median summer soluble reactive phosphorus (SRP) concentrations exceeded the target value of 6 μg/L at five of the nine monitoring stations, including Silver Bow Creek at Opportunity (97.3 μg/L), and the Clark Fork River sites below Warm Springs Creek (20 μg/L), above the Little Blackfoot River (14.5 μg/L), at Bonita (11.1 μg/L) and below Missoula (6.5 μg/L). The lowest median SRP concentration was in the Clark Fork River above the Flathead River (3.3 μg/L).

2.4.2 Summer Summary Statistics

Mean, median, minimum, maximum, standard deviation and variance values for 2004 for each of the nutrient constituents were calculated for the nine summer nutrient target stations (**Appendix E**). The Tri-State Water Quality Council's stated objective is to achieve a 95 percent compliance rate at the 95 percent confidence level for each of the summer target values. At a 95 percent confidence level, the allowable number of exceedances for 10 samples is 14.3 percent, or no more than 1 exceedance per 10 samples.

In summer 2004, compliance with the established total nitrogen target level was met only in the Clark Fork River above Flathead. The total phosphorus target was met only at the Clark Fork River sites at Huson and above the Flathead River. The secondary target for total soluble inorganic nitrogen was met only at the Clark Fork River at Bonita. The secondary target for soluble reactive phosphorus was met at only the Clark Fork River above Flathead. The number of samples exceeding the nutrient target levels during the ten sampling events and the associated percent compliance for each nutrient variable is shown by monitoring station in **Table 2-1**.

Table 2-1 ***Summer Sample Nutrient Target Compliance***

Station	TN (300 μg/L)		TP (20 and 39 μg/L)		TSIN (30 μg/L)		SRP (6 μg/L)	
	# above target	% compliance	# above target	% compliance	# above target	% compliance	# above target/	% compliance
SBC at Opportunity	9*	0	10	0	10	0	10	0
CFR bl Warm Springs	6*	33	10	0	2	80	10	0
CFR ab Deer Lodge	9*	0	7	30	10	0	2	80
CFR ab Ltl Blackfoot	8*	11	10	0	3	70	10	0
CFR at Bonita	6*	33	10	0	1	90	9	10
CFR ab Missoula	2*	77	5	50	2	80	3	70
CFR bl Missoula	2*	77	4	60	10	0	5	50

CFR at Huson	2*	77	0	100	7	30	4	60
CFR ab Flathead	0*	100	0	100	3	70	1	90

*one sample rejected from summer sampling period

3.0 PERIPHYTON STATISTICS

Seven Clark Fork River stations have been monitored for periphyton standing crops from 1998-2004 (**Appendix A, Figure 5**). Clark Fork River stations were sampled in August and September. Ten replicate samples were collected at each station and these were analyzed for two variables:

- Chlorophyll *a* (Chl *a*) (mg/m^2)
- Ash-free Dry Weight (AFDW) (g/m^2)

Pend Oreille Lake stations were traditionally sampled in September, however no periphyton samples were collected from Pend Oreille Lake in 2004. Instead, nutrient and periphyton sampling was conducted by Michael Falter in 2003 (Falter, 2004) to provide a trophic status assessment of Pend Oreille Lake. Sampling was conducted at 13 sites throughout Pend Oreille Lake to duplicate earlier studies conducted in 1989-90. A summary of conclusions derived from this study are provided in Section *3.2.2*. In addition, Secchi transparency (m) was measured in Pend Oreille Lake in 2004. The Granite site was the only station monitored for Secchi transparency in 2004.

3.1 Periphyton Temporal Comparison

Temporal boxplots for chlorophyll *a* and ash-free dry weight in periphyton samples from the Clark Fork River (**Appendix F**) were developed to show changes over the monitoring period.

3.1.1 Clark Fork River

Generally, algae samples collected from natural substrates in the Clark Fork River had higher mean chlorophyll *a* values in 2004 than in 2003. Five of the seven stations showed increased mean chlorophyll *a* values from the previous sampling year. These include Clark Fork River sites above Deer Lodge (186 mg/m^2), above Little Blackfoot (221 mg/m^2), at Bonita (192 mg/m^2), above Missoula (105 mg/m^2) and above Flathead (45 mg/m^2). One of the seven stations, Clark Fork River below Missoula (151 mg/m^2), showed decreased mean chlorophyll *a* values from the previous sampling year. Mean chlorophyll *a* values in the Clark Fork River at Huson (51.7 mg/m^2) were very similar to 2003 values. Overall, mean concentrations of chlorophyll *a* in 2004 were comparable to the entire period of record for most stations, although the Clark Fork River station above the Little Blackfoot displayed the highest mean chlorophyll *a* values in 2004 than any previous sampling year.

Mean algal biomass values, measured as ash-free dry weight (AFDW), increased from 2003 to 2004 at four of the seven monitoring stations. The stations that showed an increase in AFDW from 2003 were Clark Fork River stations above Deer Lodge, above Little Blackfoot, below Missoula and above Flathead. Clark Fork River stations at Bonita and above Missoula showed decreased algal biomass from 2003. AFDW in 2004 in the Clark Fork River at Huson was very similar to 2003 values.

3.2 Periphyton Spatial Comparison

Periphyton data for the Clark Fork River (**Appendix F**) are depicted as spatial boxplots for years 1998-2004. Clark Fork River chlorophyll *a* boxplots include horizontal lines that show the benthic algae chlorophyll *a* targets levels for both a summer mean (100 mg/m^2) and annual maximum (150 mg/m^2) instream concentration. These targets were developed by the Tri-State Water Quality Council and subsequently adopted as site-specific water quality standards by the State of Montana (ARM 17.30.631)

3.2.1 Clark Fork River

In August 2004, two of seven Clark Fork River monitoring locations had mean chlorophyll *a* values below the mean target level of 100 mg/m^2. These included sites at Huson (43.7 mg/m^2) and above the Flathead River (54.3 mg/m^2). In September 2004, three of seven monitoring sites produced mean chlorophyll *a* values less than the mean target level, including the Clark Fork above Missoula (89.0 mg/m^2), at Huson (59.8 mg/m^2) and above the Flathead River (36.2 mg/m^2). Additionally, five of the seven sites showed higher mean chlorophyll *a* values in August than in September, indicating that peak algae growth for 2004 likely occurred in the month of August.

If the measured 2004 chlorophyll levels for the Clark Fork River are averaged for the August and September sampling events to reflect a "summer mean" concentration, and these averages are compared to the summer mean state water quality standard for the Clark Fork River, 5 of 7 sites failed to attain the state standard for chlorophyll *a* in 2004 (100 mg/m^2). These monitoring locations are the Clark Fork above Deer Lodge, above the Little Blackfoot River, at Bonita, above Missoula and below Missoula. Additionally, the individual sample replicate data for chlorophyll *a* in the Clark Fork River during 2004 showed that at least one measurement value for either August or September surpassed the target for maximum growth (150 mg/m^2) at five of the seven sites. During September 2004, all samples collected at Clark Fork River stations at Huson and above Flathead were below the target maximum.

Comparisons of the 1998-2004 algal standing crop data to the relevant target values/water quality standards for the Clark Fork River are shown in **Figures 3-1 to 3-7**. Mean values are displayed as points on the chart. The target mean (100 mg/m^2) and maximum (150 mg/m^2) chlorophyll *a* values are displayed as dashed lines.

3.2.2 Pend Oreille Lake

Mean chlorophyll *a* values for algae samples collected from natural substrates in Pend Oreille Lake were higher at developed sites (6.2 mg/m^2) than at undeveloped sites (2.1 mg/m^2) in 2003. These values are significantly lower than mean chlorophyll *a* values collected from developed and undeveloped sites during 1989 (11.7 and 6.4 mg/m^2, respectively). The highest mean chlorophyll *a* values in 2003 were at Ellisport Bay, Garfield Bay, Springy Point, Kootenai Bay and Bottle Bay. The lowest mean chlorophyll *a* values in 2003 were at Warren Island, Granite Point, Talache Landing and Lakeview.

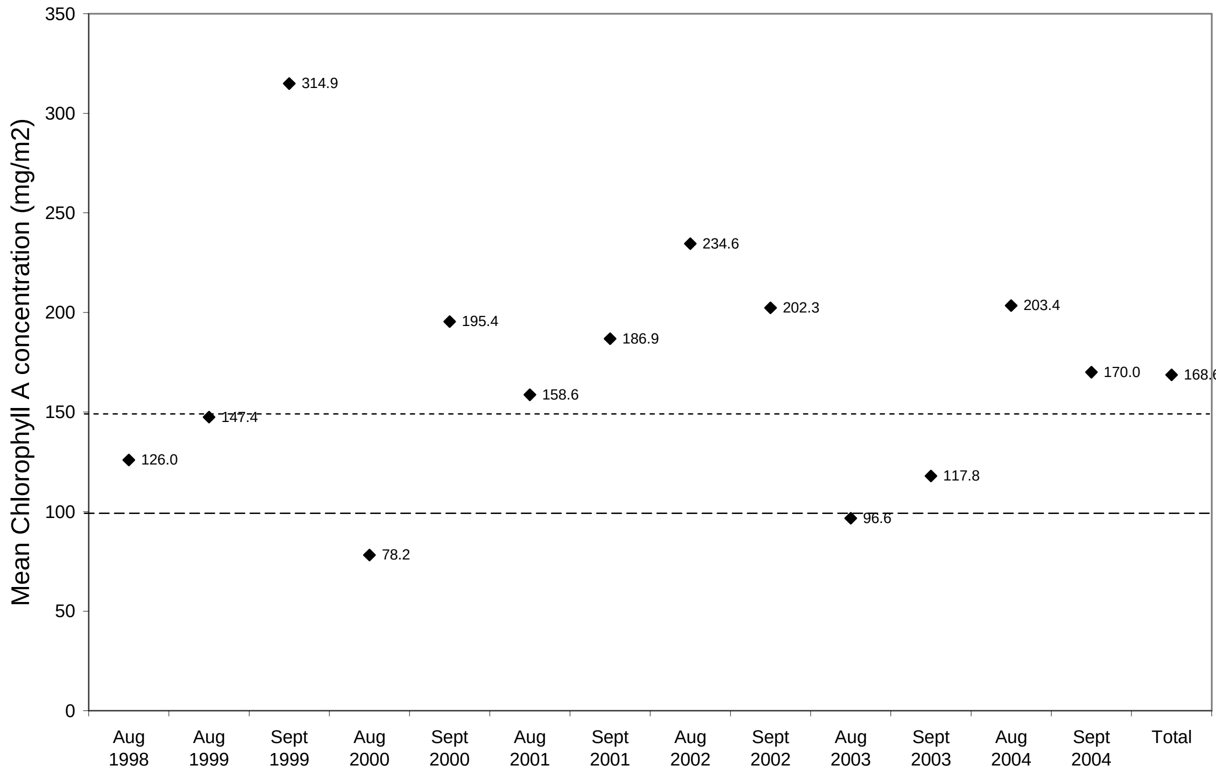

Figure 3-1. ***Clark Fork at Deer Lodge chlorophyll a values compared to instream target levels, 1998-2004***

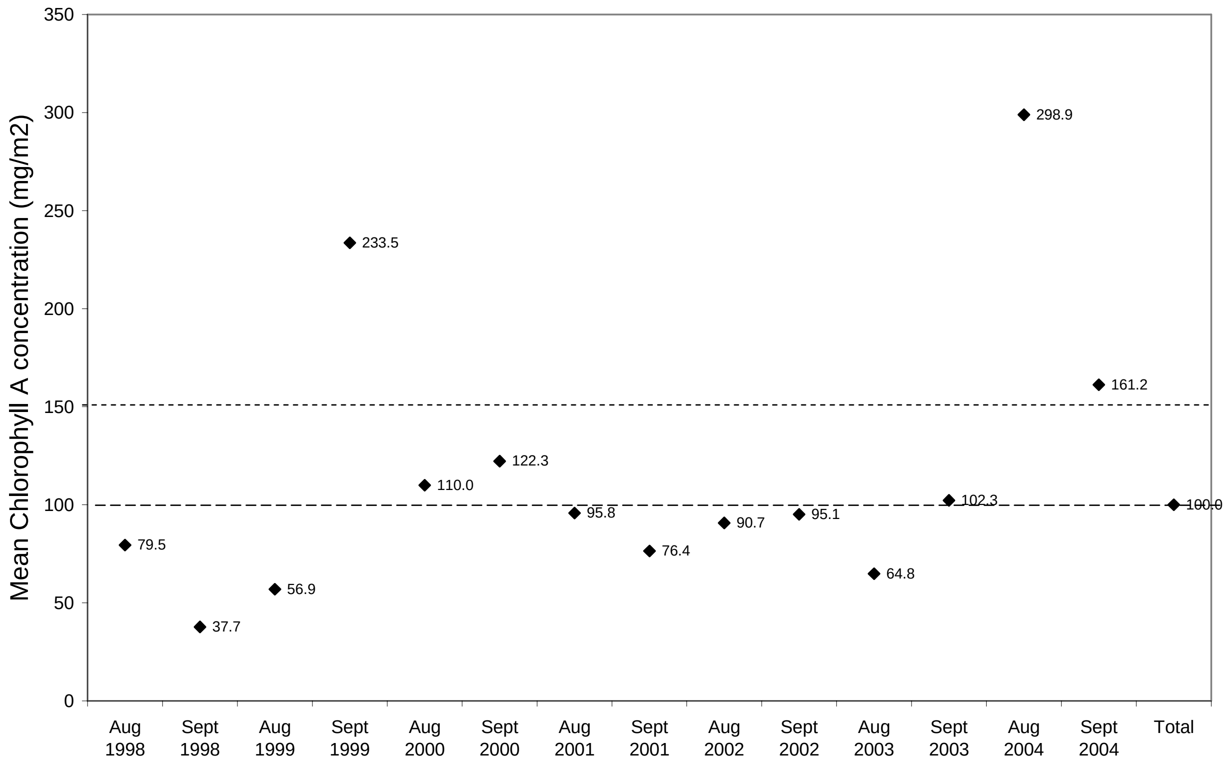

Figure 3-2. ***Clark Fork above Little Blackfoot chlorophyll a values compared to instream target levels, 1998-2004***

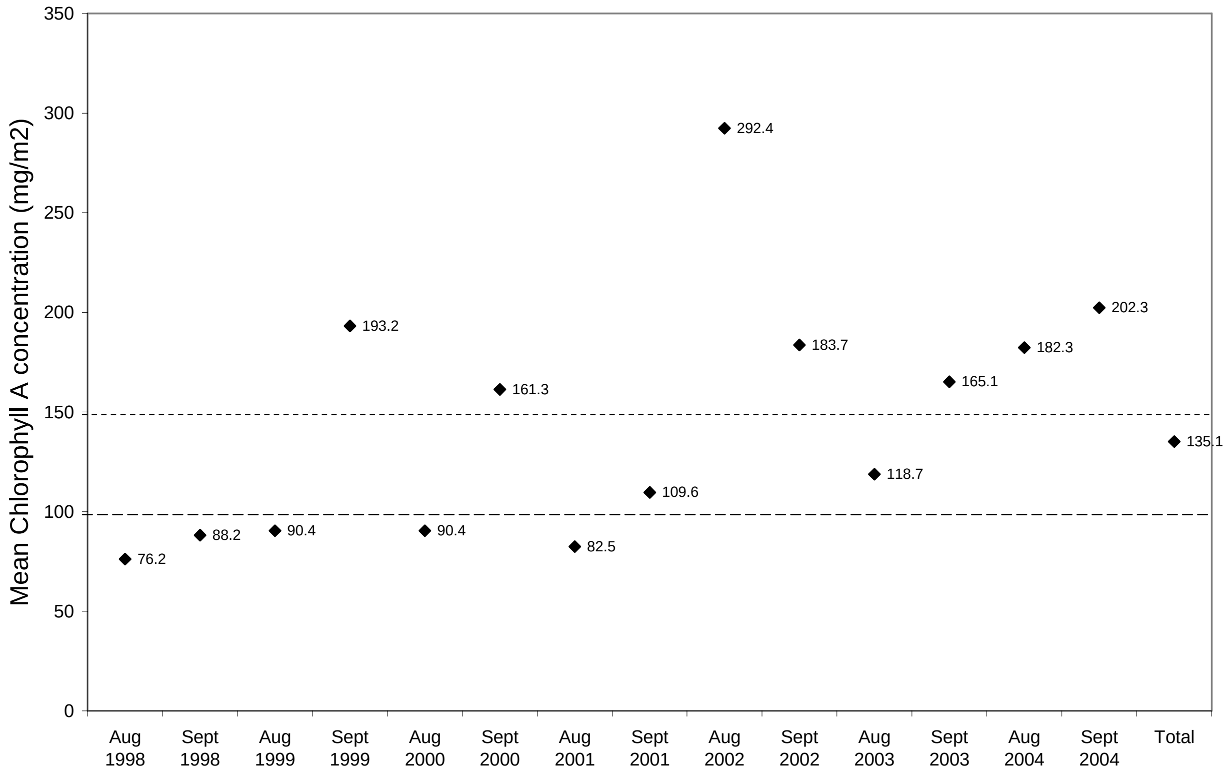

Figure 3-3. ***Clark Fork at Bonita chlorophyll a values compared to instream target levels, 1998-2004***

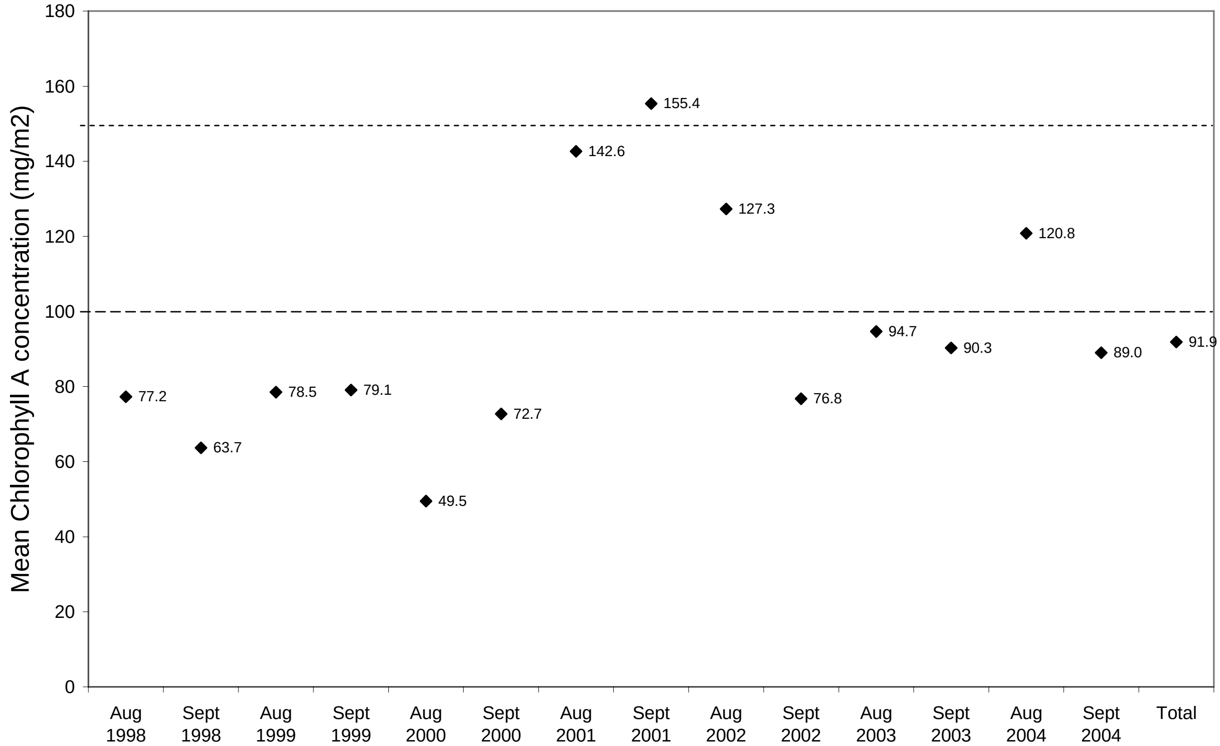

Figure 3-4. ***Clark Fork above Missoula chlorophyll a values compared to instream target levels, 1998-2004***

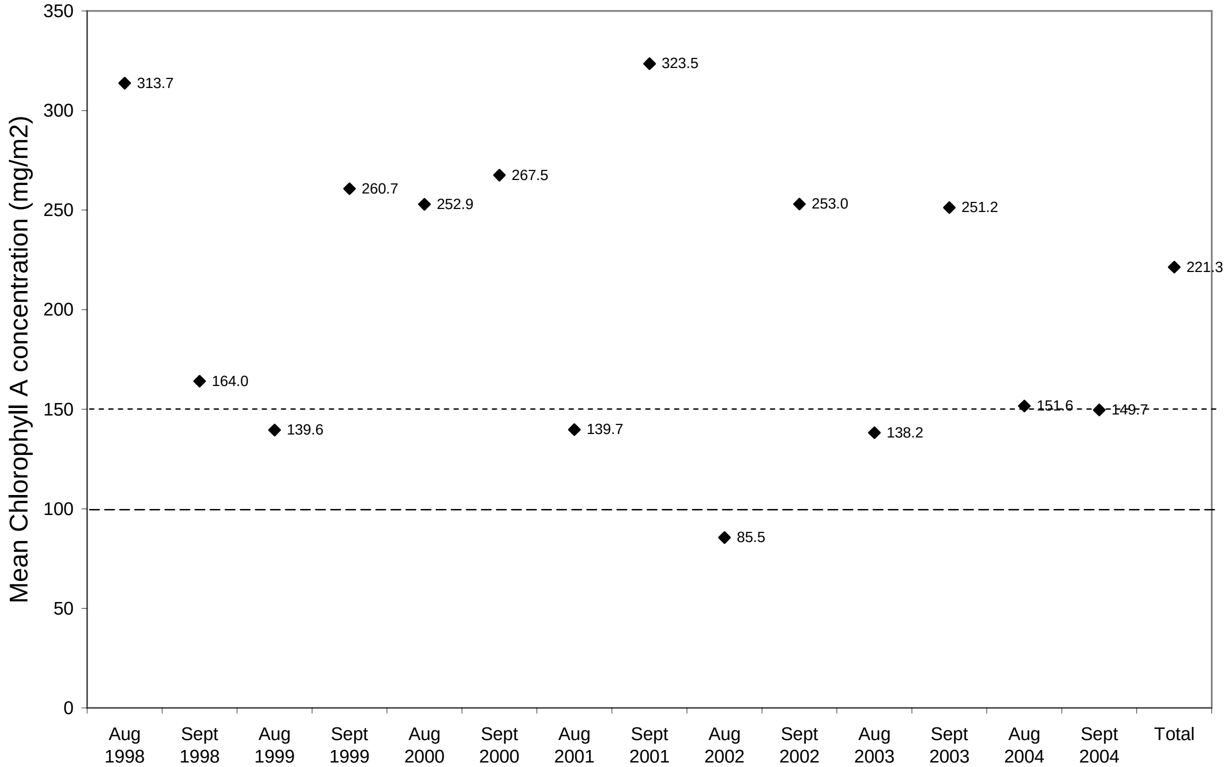

Figure 3-5. ***Clark Fork below Missoula chlorophyll a values compared to instream target levels, 1998-2004***

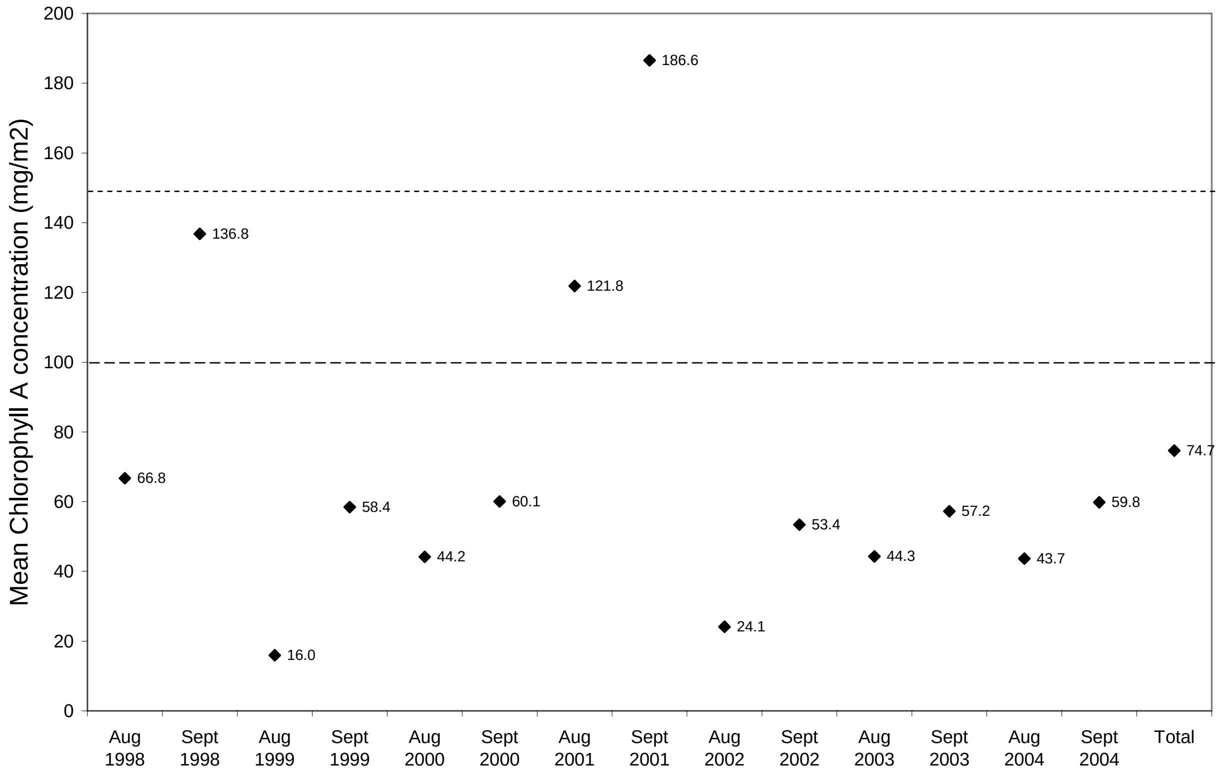

Figure 3-6. ***Clark Fork at Huson chlorophyll a values compared to instream target levels, 1998-2004***

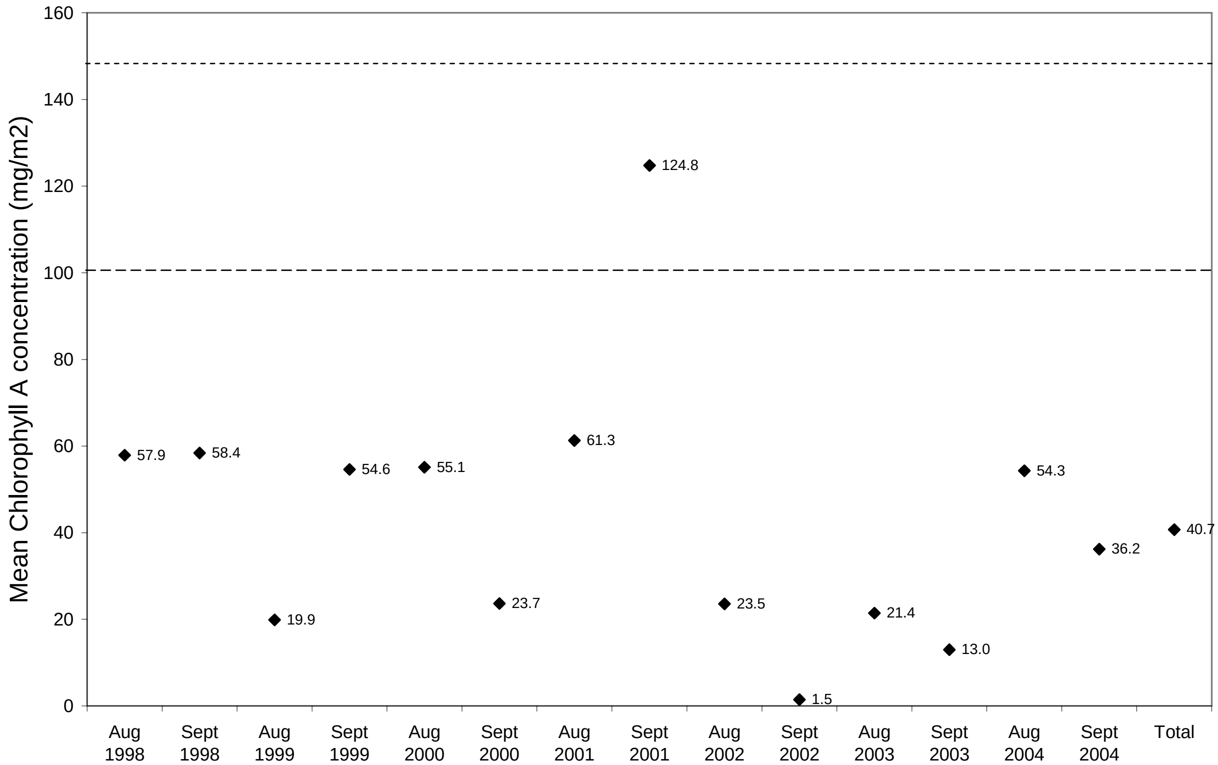

Figure 3-7. ***Clark Fork above Flathead chlorophyll a values compared to instream target levels, 1998-2004***

3.3 Secchi Transparency

Secchi disc transparency measurements have been collected on Pend Oreille Lake periodically since the 1950s. The Bayview, Hope and Granite stations have over 10 years of historical data (**Appendix A, Figure 5**). Only the Granite station was sampled during 2004. Boxplots (**Appendix G**) show fluctuations in median Secchi depth throughout the period of record. When data for the Bayview, Hope and Granite sites are pooled, the highest median value (or highest water transparency) was documented in 2003, with the lowest median value found in 1999. Secchi depth readings are typically highest in winter, with lowest values recorded in spring. The Bayview station has displayed the high median Secchi transparency, while the Hope site had the lowest median Secchi transparency for the period of record.

Secchi disk depth measurements were collected seven times in 2004 at the Granite site. Data from the Granite station for 2004 were near the mid-range of values for the entire period of record. The lowest Secchi transparency recorded in 2004 was experienced in May (5.4 m), with the greatest visibility occurring in August (14.6 m).

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