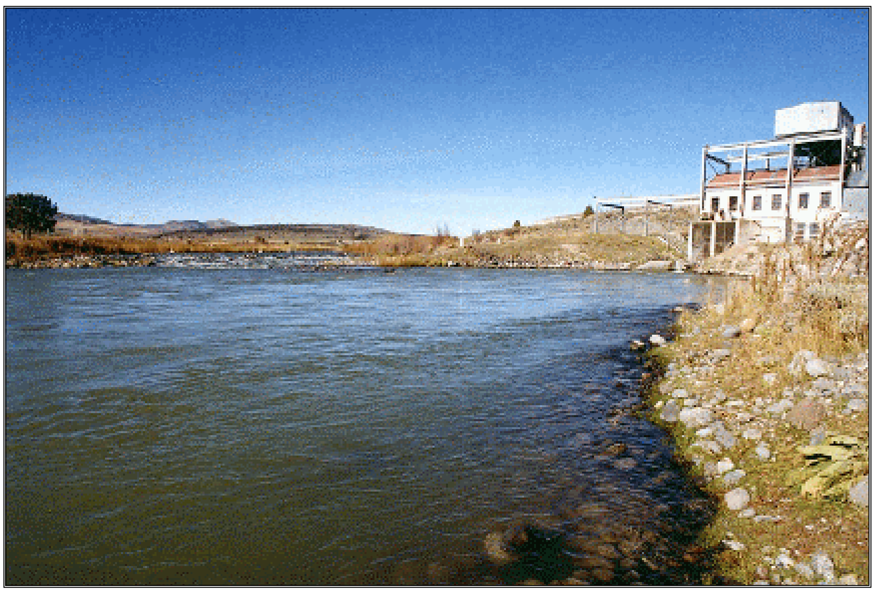
Bear River Hydroelectric Project (No. 20)
Grace-Cove Development

FINAL DRAFT 2005 Water Quality Summary



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Version: January 2006

EXECUTIVE SUMMARY

A water quality monitoring study was undertaken on the Bear River within PacifiCorp's Grace/Cove hydroelectric complex (Development) during July, August, and September 2005. This study was implemented to define water quality conditions at four separate locations within this reach of the Bear River. Continuous monitoring probes gathered data for a minimum of seven continuous days during the months of July, August and September at four locations on the Bear River including: above and below Grace Dam, at the mouth of Black Canyon, and below the Cove Hydroelectric Plant. Water quality grab samples were collected at the same time the probes were checked and were analyzed for nutrients and suspended solids.

Hydrology during each of the sampling periods was different. During July, the range of flows was greater (219 cfs) than that recorded in August (134 cfs). September flows were considerably reduced. During the final four days of the September sampling period all flows in the Bear River were sent through Black Canyon.

Some instantaneous water quality data demonstrated distinctive daily patterns over all months. Diel variations were recorded for temperature and dissolved oxygen. Specific conductance and turbidity did not consistently show this same pattern. To further explore this variation, the data were divided into two twelve-hour data sets; midnight to noon (am) and noon to midnight (pm). This distinction separates the warmer and cooler periods of each day and reduces variation within each group ANOVAs were used to compare differences between sites. When differences were found, a Tukey test was used to evaluate pair-wise differences. In order to evaluate correlations between sites pair-wise linear regressions were calculated for each parameter.

Grab samples collected during this time indicated that nitrogen and phosphorus were in abundant supply throughout the complex. The highest phosphorus concentrations occurred during July at site GC03. Total inorganic nitrogen did not follow the same pattern, and nitrogen was consistently the highest at site GC03 and peaked in September. These results were consistent with the water quality conditions recorded during the 2004 instantaneous sampling efforts. In addition, a comparison with historical instantaneous sampling data obtained during the months of July, August, and September 1994-1996 indicates that with only two exceptions (NO3+NO2 at GC04 in September, and TSS at GC03 in July) all instantaneous water quality data collected in 2005 is within or below the range of historically recorded values for sites GC01, GC03, and GC04 (Figures 1-1 through 1-6). No data was obtained from site GC02 during the 1994-1996 monitoring effort.

A comparison of each site and sampling event to the IDAPA water quality standards was undertaken utilizing the continuous data collected in this investigation. The instantaneous temperature requirement for the prescribed beneficial use of this section of the Bear River was exceeded at sites during July and August, but at none of the sites in September. Average daily temperature was exceeded at every site in July and August. Instantaneous dissolved oxygen was lower than the standard only in July and August (GC02 and GC04 in July and GC01 in August). Additionally, dissolved oxygen (expressed as a percent of atmosphere) was exceeded at all sites during all months. Exceedences of IDAPA water quality standards during the 2005 monitoring period were fairly consistent with exceedences recorded in 2004. Given the poor water quality

conditions recorded in the Bear at the control site (GC01), it is unlikely that the operations of the project contributed to recorded exceedences of IDAPA standards at monitoring sites downstream where exceedences decrease relative to the control site. With the exception of GC02 in July, monitoring results indicate that the project had little effect on violations of water temperature criteria as set forth in the IDAPA.

In the case of dissolved oxygen (mg/l) site GC04's percent exceedence of IDAPA standards is greater than those recorded at the upstream monitoring locations in July, but during August and September downstream excedences of IDAPA standards for dissolved oxygen (mg/l) are not greater than those recorded at the control site (GC01). During all three monitoring periods dissolved oxygen (expressed as a percent of atmosphere) at sites GC02, GC03, and GC04's percent exceedence of IDAPA standards was greater than exceedences recorded at the control site (GC01). However, physical characteristics of the Bear River vary considerably from the control site as you move downstream to the other monitoring locations. Site GC01 is located in a fairly turbulent reach of the river, whereas the latter monitoring locations are located in areas with fairly laminar flows. Increased photosynthesis in these laminar reaches drives up percent saturation. Dissolved oxygen data (expressed as percent of atmosphere) recorded at sites GC02, GC03, and GC04 is fairly representative of this relationship. As with temperature, it is unlikely that project operations significantly contributed to violations of dissolved oxygen criteria as set forth in the IDAPA.

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1.0 INTRODUCTION

The primary objective of the Water Quality Monitoring Plan (WQMP) is to accurately define the water quality conditions above, within and below the Grace/Cove hydroelectric complex (Development). The secondary objective is to evaluate the data and determine if the Development has contributed to violations of water quality criteria as set forth in the Idaho Water Quality Standards and Wastewater Treatment Requirements (IDAPA 58.01.02). This report will review the parameters, locations, and frequency of sampling conducted during July, August, and September 2005. This report includes data collected and conclusions of the study. In addition, quality assurance/quality control requirements will be reviewed and evaluated in terms of data fitness.

1.1 Bear River Historical Water Quality

The Bear River spans over 550 miles, draining a 470,000-acre watershed which encompasses parts of three states. The river's flow and irrigation diversions are under the control of the Bear River Compact and regulated by the Bear River Commission. Water quality within the river falls under the jurisdiction of the states of Idaho, Utah, and Wyoming.

Precipitation within the Bear River basin is distributed unevenly with regards to both time and area. Most of the water within the basin is derived from winter snowfall. Data obtained at the U. S. Weather Bureau stations at Preston, Grace, and Montpelier show that the average monthly precipitation ranges from a high of 1.93 inches in April to a low of 0.65 inches in July. The range in precipitation at these stations is from about 8.5 inches to about 23 inches. The 50 percent exceedence value for Preston, meaning half the time one could expect total precipitation to exceed this value, is 16 inches per year while Grace and Montpelier are close to 14 inches annually. Over 50 percent of the surface area of the Idaho Bear River basin receives between 10-20 inches of annual precipitation. The areal distribution of precipitation is influenced by elevation and ranges from 10 inches at low elevations to over 50 inches at higher altitudes. Average precipitation over the entire Idaho Bear River basin is 3.3 million acre-feet annually.

On the mainstem Bear River in Idaho, there are six gaging stations (not including the two on the inlet and outlet to Bear Lake). An historical review of these data indicates that for the last 30-year period, maximum flows (1.75 to 2.0 million ac-ft) occurred in 1993, 1994 and 1996. Between 1988 and 1995, as well as 2000 to 2004, flows throughout the basin were low (less than 0.50 million ac-ft per year) For this 30-year period of record, an average of 432,000 ac-ft of water entered the Middle Bear River from Wyoming and 850,000 ac-ft exited at the Utah border. The Idaho portion of the Bear River yielded an average of 517,000 ac-ft of water. Although a large portion is produced within the watershed, the majority of the water entering Utah in the summer is from Bear Lake storage captured from upper basin sources during runoff and released for downstream irrigation in Utah. The storage of 1.42 million ac-ft of water in Bear Lake, represents the majority of storage above Alexander Reservoir near Soda Springs. Irrigation water used for agricultural represents the single largest consumptive use in the basin. A total of 90 irrigation companies serve 177,800 acres of irrigated land in the Middle Bear River. Bear Lake County has the largest number of companies (47) and the largest amount of acreage (75,680 acres), followed by Caribou, Franklin, and Oneida counties. Last Chance Canal, located immediately above this project, withdraws a significant amount of Bear River water during the summer irrigation season. Land is irrigated on both the north and south sides of the river throughout the project area (Last Chance down to Cove).

The Idaho Bear River basin has four major subbasins, or hydrologic units, all within the state of Idaho. The hydologic unit that this project is located in is HUC#16010202 which extends from below Alexander Reservoir to the Idaho-Utah border. This subbasin has 18 tributaries, of which four are found on Idaho's 303(d) list. The remaining three subbasins are coldwater and salmonid spawning designated. Recreation contact is primary or secondary for these three streams. The Bear River in this subbasin has five reaches, all of which are on Idaho's 303(d) list, including the reach containing this project. Nutrients, sediment and flow alteration are the reasons given for the 303(d) listing of the river, reservoir and tributaries in this subbasin.

Water quality studies on the Bear River date back to the 1950s. The Idaho Bear River reach (that portion downstream of the Wyoming-Idaho border) has been the subject of water quality investigations starting as early as 1953 (Clyde 1953). The studies focused on suspended sediments and flow. Several studies have also been conducted on the current condition of and influences on water quality in the reach above Bear Lake, extending as far as Woodruff Reservoir in Wyoming down to the Idaho-Utah stateline. Of the studies that have been conducted on Bear River water quality in the project reach (Wyoming-Idaho stateline to the Utah-Idaho stateline) the most extensive has been completed by ERI (1998) and will be described in detail later in this section. Prior to that discussion, a brief summary of historical water quality investigations on the Bear River system will be completed.

Early water quality studies focused on sediments and salinity in the river. Clyde (1953) evaluated sedimentation patterns in the Bear River between Oneida and Cutler reservoirs. Between 1910 and 1950, the riverbed raised six feet due to the deposition of over 110 million tons of sediment. Heimer (1978) measured turbidity and suspended sediments at sites from below Bear Lake to the Utah-Idaho stateline. Based on his 1975 data, sediment loads in the river increased from 98 tons/month (3,000 kg/day) at Soda Springs to 351 tons/month (10,600 kg/day) near Preston, then decreased to 171 tons/month (5,180 kg/day) at the stateline. Waddell (1970), Haws and Hughes (1973), and Hill et al (1973) all summarized water quality data collected in the late 1960s and early 1970s. Most analyses were for major anions and cations only. Over this time period, total dissolved solids (TDS) averaged about 375 mg/liter at the Bear Lake outlet, with little change throughout the Idaho reach.

The first extensive water quality study of the Idaho portion of the Bear River was conducted in 1975 and 1976 (Perry 1978), with samples collected every two weeks at 15 stations. Perry concluded that total suspended solids (TSS) and TDS concentrations responded differently in the reaches above and below Oneida. From Bear Lake to above Oneida, TSS and TDS decreased at higher flows due to a dilution effect. However, below Oneida, solids increased during runoff. He attributed this to high sediment inputs from tributaries below Oneida. High nitrate concentrations in Black Canyon, possibly from Grace wastewater treatment plant (WWTP), and fecal coliform contamination in the river near Preston were also identified as water quality problems.

In the late 1970s, the emphasis shifted to nutrient contamination in the river, with most data collected below Oneida Reservoir by Utah State University Water Research Laboratory.

Barker et al. (1989) summarized nutrient data collected from Bear Lake outlet to the Idaho-Utah stateline during 1987 and 1988. Average TP concentrations increased from 0.06 mg/liter at Bear Lake outlet to 0.100 mg/liter at the Idaho-Utah stateline. Average orthophosphorus increased from 0.008 to 0.037 mg/liter over the same reach, although on most dates the concentrations were low and relatively constant from site to site. Nitrate concentrations ranged from 0.140 mg/liter at the outlet to 0.860 mg/liter at the stateline.

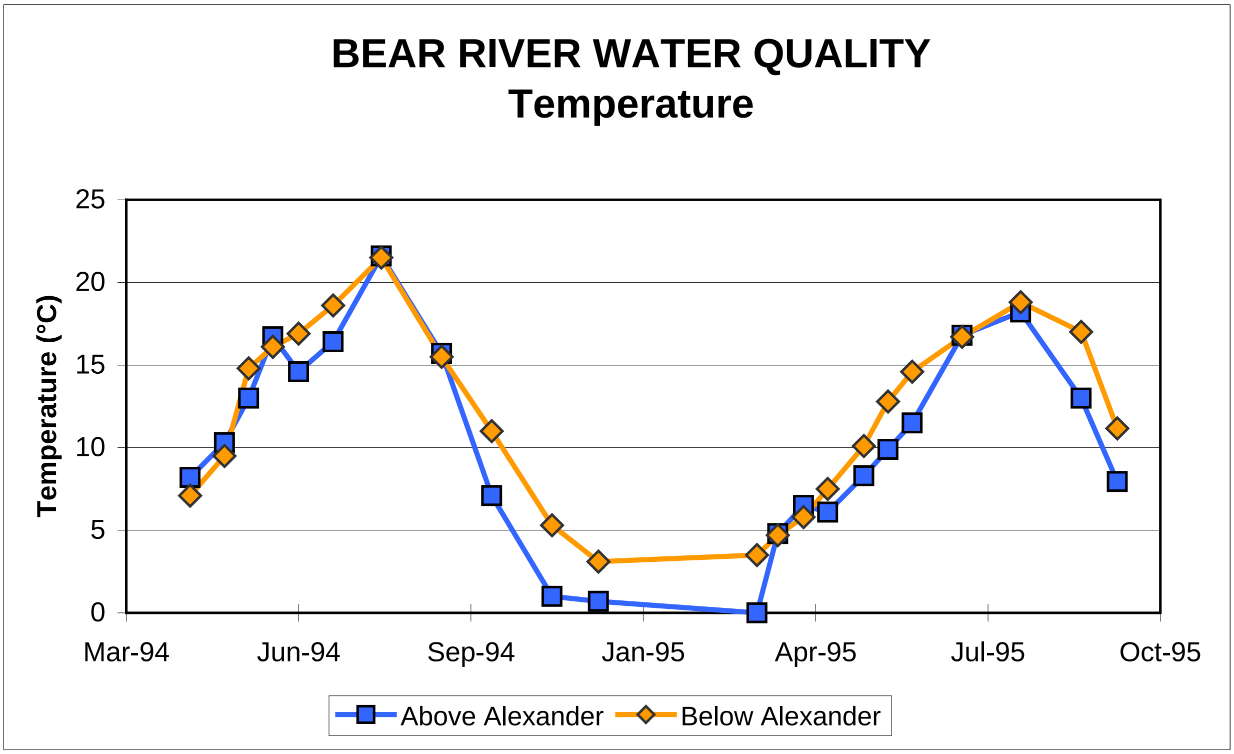
ERI (1998) conducted the most current and extensive water quality investigation on the mainstem Bear River. Twelve sites on the mainstem Bear River were sampled from April 1994 through September 1996 and in 1999-2000 including the inlet and outlet to Bear Lake as well as the outlet to Black Canyon below Grace, Idaho. In addition, several point sources, including the Soda Springs WWTP and the Clear Springs fish hatchery were also sampled. Several monitoring sites on the mainstem and tributaries were also monitored by PacifiCorp as part of their relicensing effort on three hydroelectric facilities in Idaho. Data from several of these sites have also been included in this review of available information. This study represents the basis for the summary and analysis of water quality conditions in the Middle Bear River watershed used to establish a Middle Bear River TMDL. (ERI 2004)

Temperatures within the Bear River at the study location have shown 20° to 22°C difference from the winter to the summer. In the data set from 1994 to 1995, the temperatures throughout the study area reflected the Bear River inflow to Alexander Reservoir. In this data set, the temperature criterion for the study section of the Bear River (Last Chance down to Cove) was exceeded in only 4 to 5 percent of the observations. These data for five stations in the Bear River can be seen in Figure 1-1.

Dissolved oxygen (Figure 1-2) was also measured at the same sites as temperature. The data reflect a grab sample measurement and not an electronic data collection. The number of exceedences of the coldwater concentrations at these sites was only 5 to 8 percent of the observations.

The concentrations of total suspended solids (TSS) were far more variable than for other parameters throughout the study reach. Alexander Reservoir, located downstream of the Bear Lake Marsh Outlet, receives Bear River water year round. TSS concentrations above Alexander Reservoir were similar to concentrations observed at the Bear Lake Marsh outlet, though there were more exceedences of the TSS criterion. Two out of the five runoff months exceeded the 60 mg/l criterion during the 1994-1996 study. There was only one base flow criterion exceedence, occurring during August. Highest concentrations occurred in June, July and August (73, 62, and 60 mg/L, respectively), with the lowest occurring in December, January and February (17, 8.8 and 7.0 mg/L, respectively). At the Bear River below Alexander Reservoir, the number of exceedences decreased to zero (Figure 1-3).

Total phosphorus and orthophosphorus are pollution indicators and the mainstem Bear River has historically recorded high levels of both (ERI 1998). During ERI’s 1994-1996 studies, the Bear River flowing into Alexander Reservoir exceeded the 0.050 mg/L criterion eleven of the twelve months. For nine of those exceedences, average concentrations were two to three times the allowable level. With extremely high levels of phosphorous are entering Alexander Reservoir, it is not unexpected that the reservoir is also acting as a nutrient source for the soluble



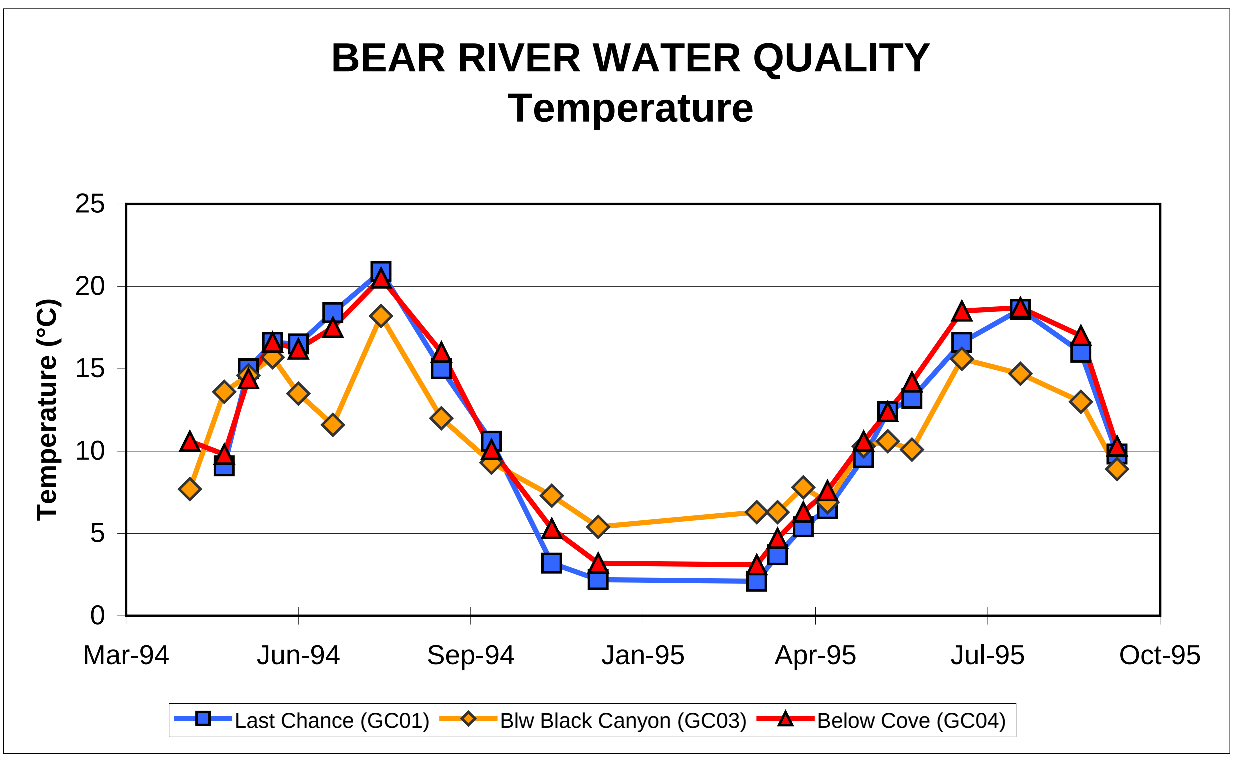
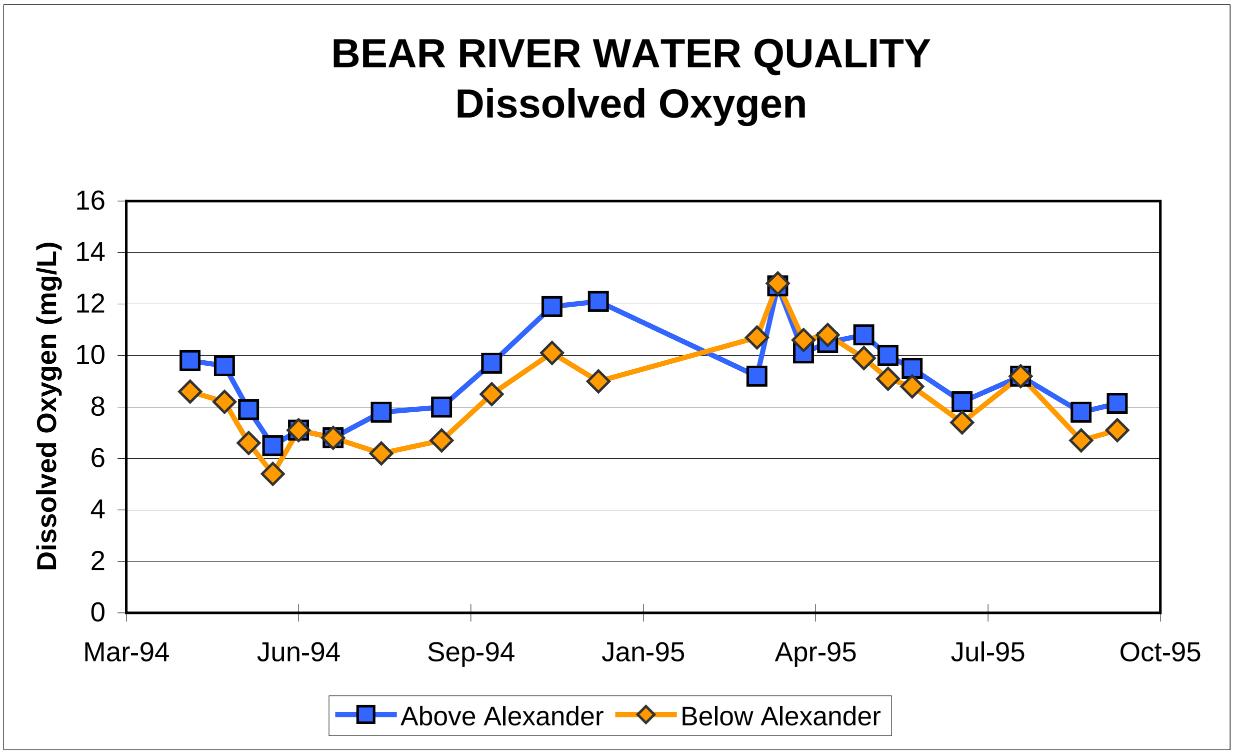


Figure 1-1. The water temperatures at five locations in the Bear River above Cove from 1994-1996.



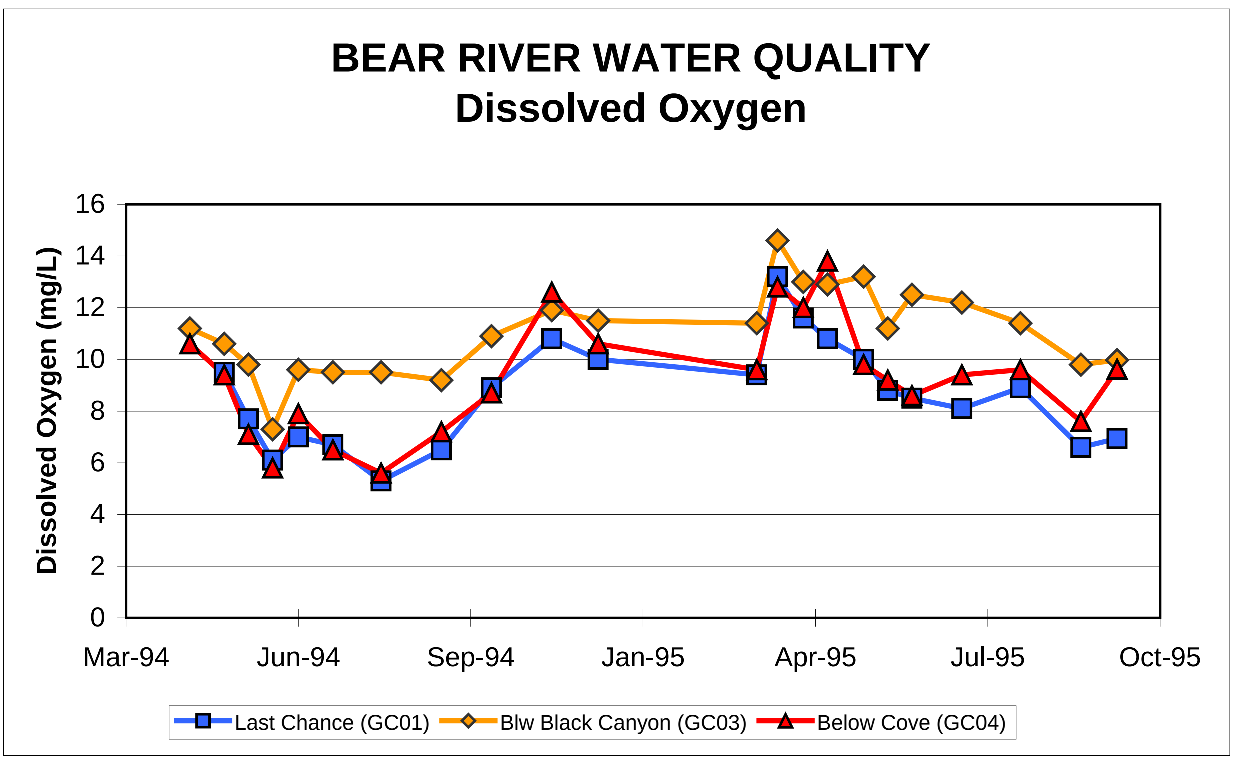
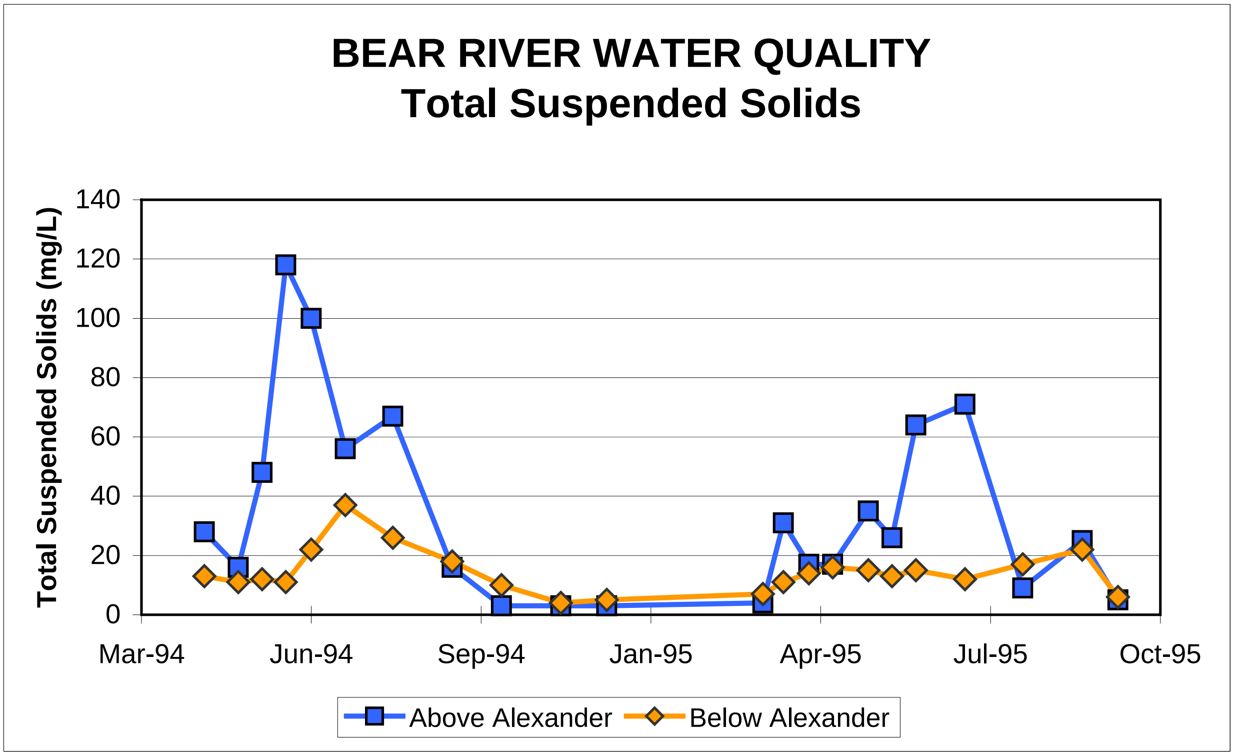


Figure 1-2. The dissolved oxygen concentrations at five locations in the Bear River above Cove from 1994-1996.



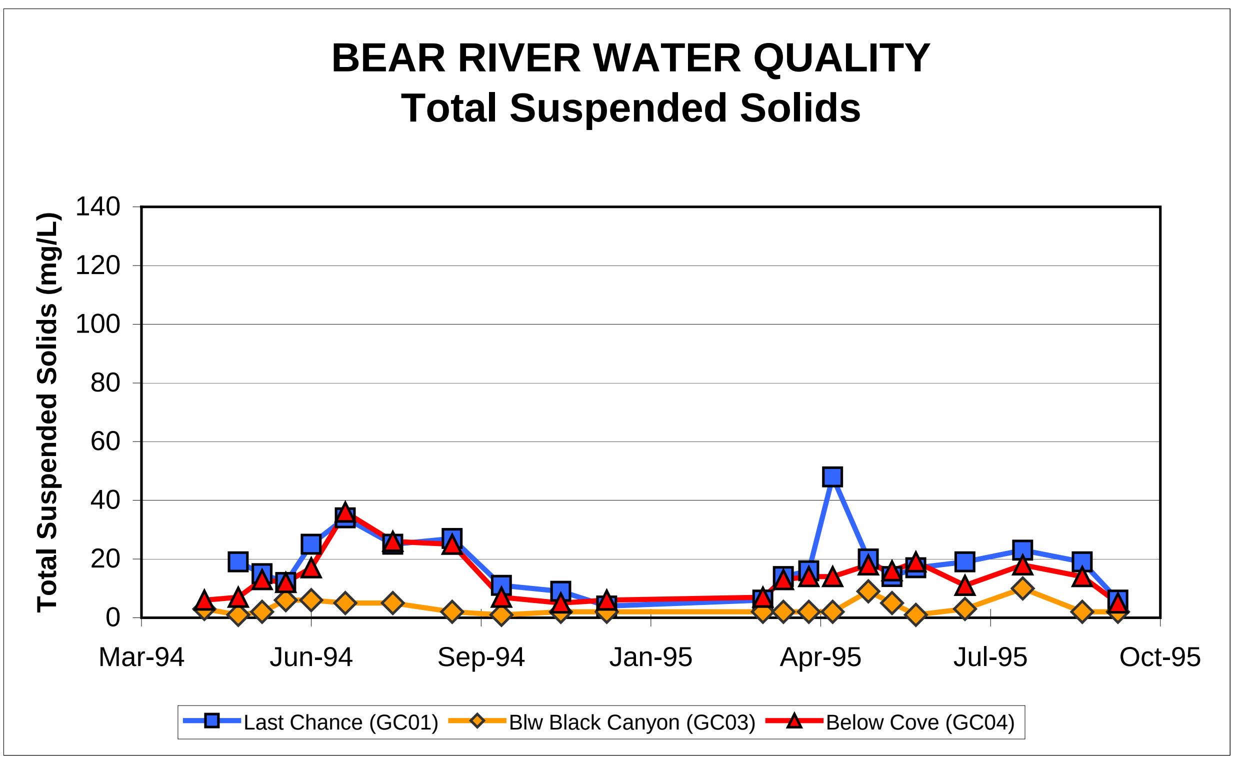
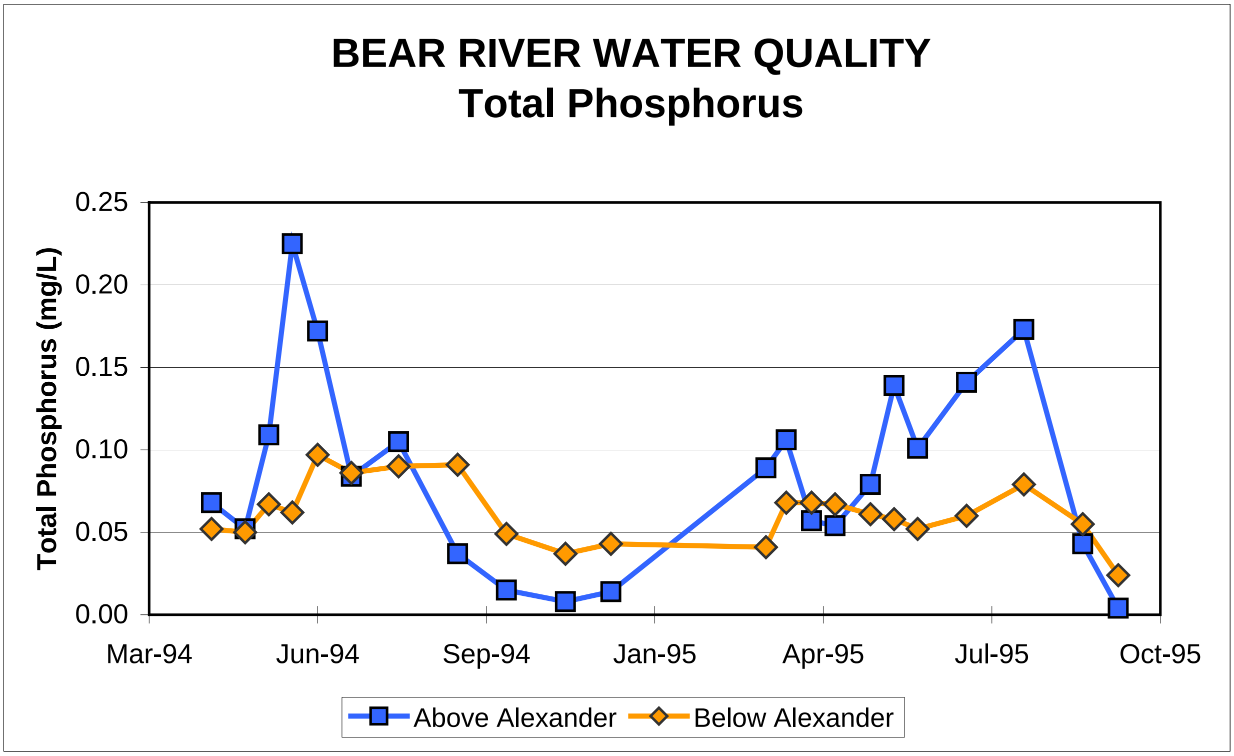


Figure 1-3. The total suspended solids concentrations at five locations in the Bear River above Cove from 1994-1996.



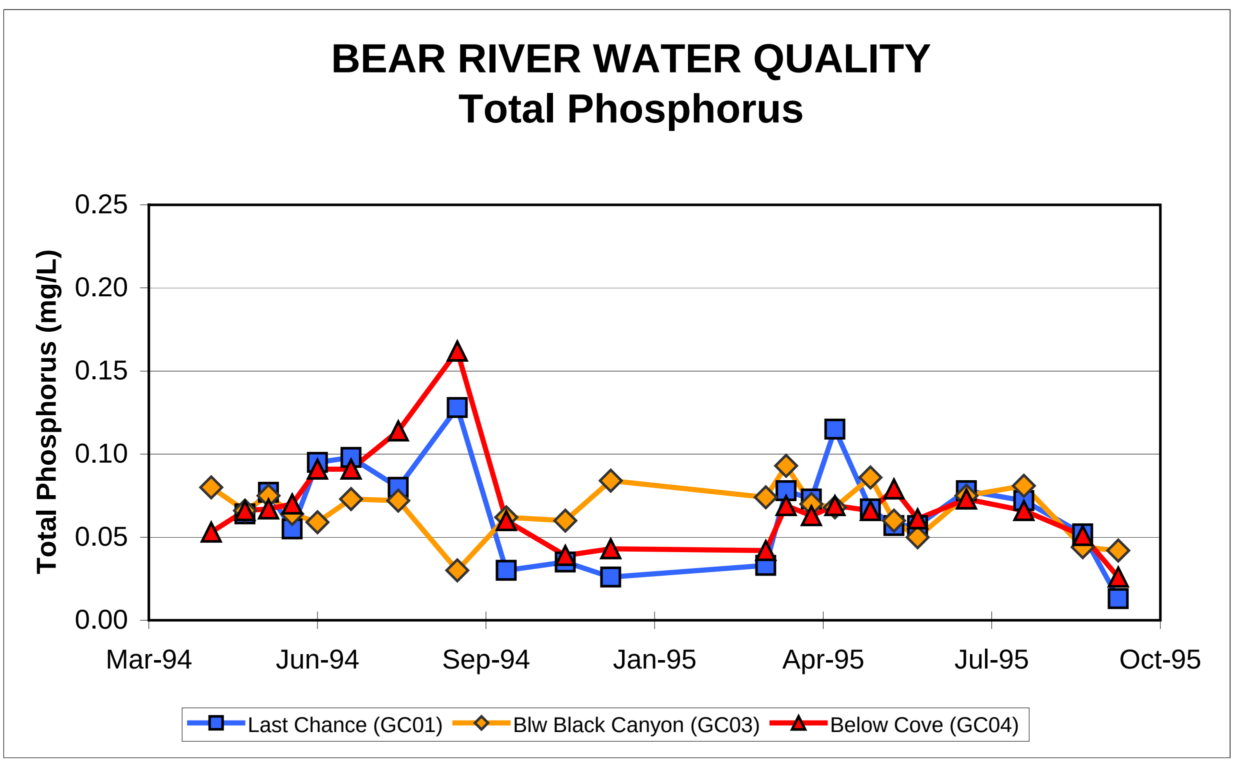
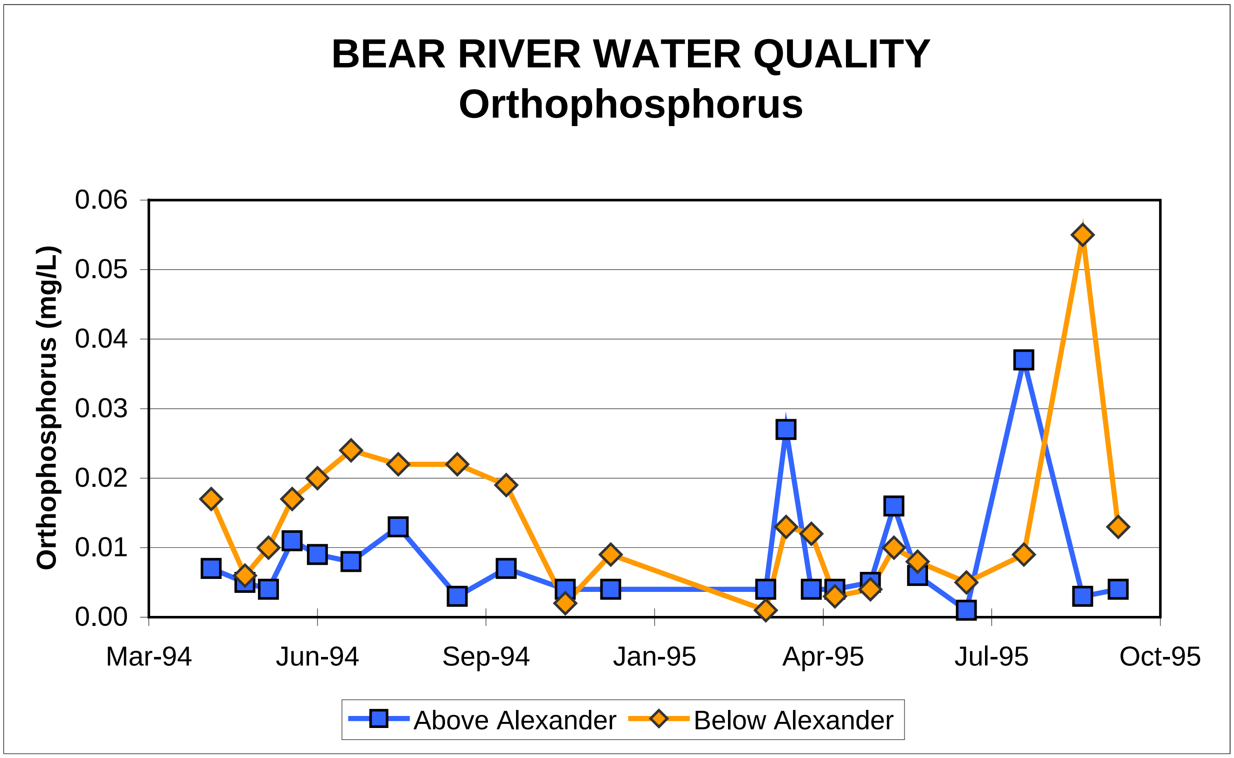


Figure 1-4. The total phosphorus concentrations at five locations in the Bear River above Cove from 1994-1996.



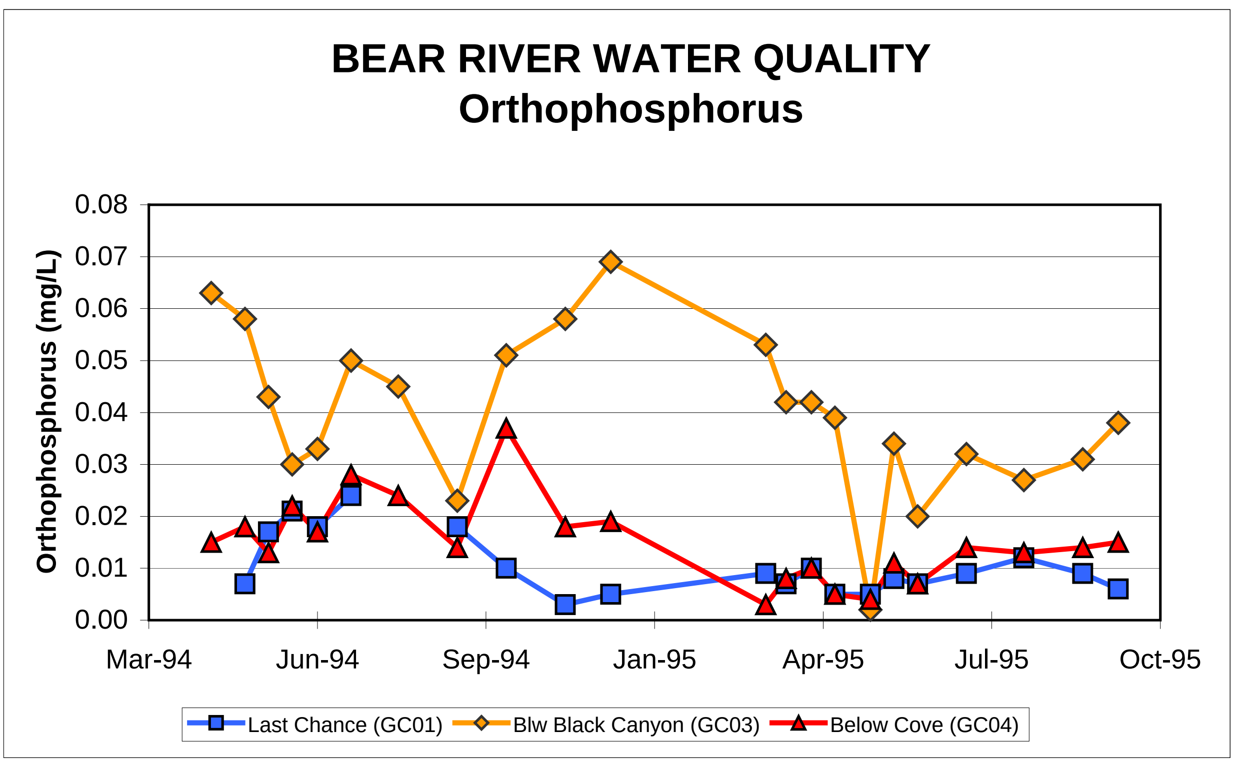
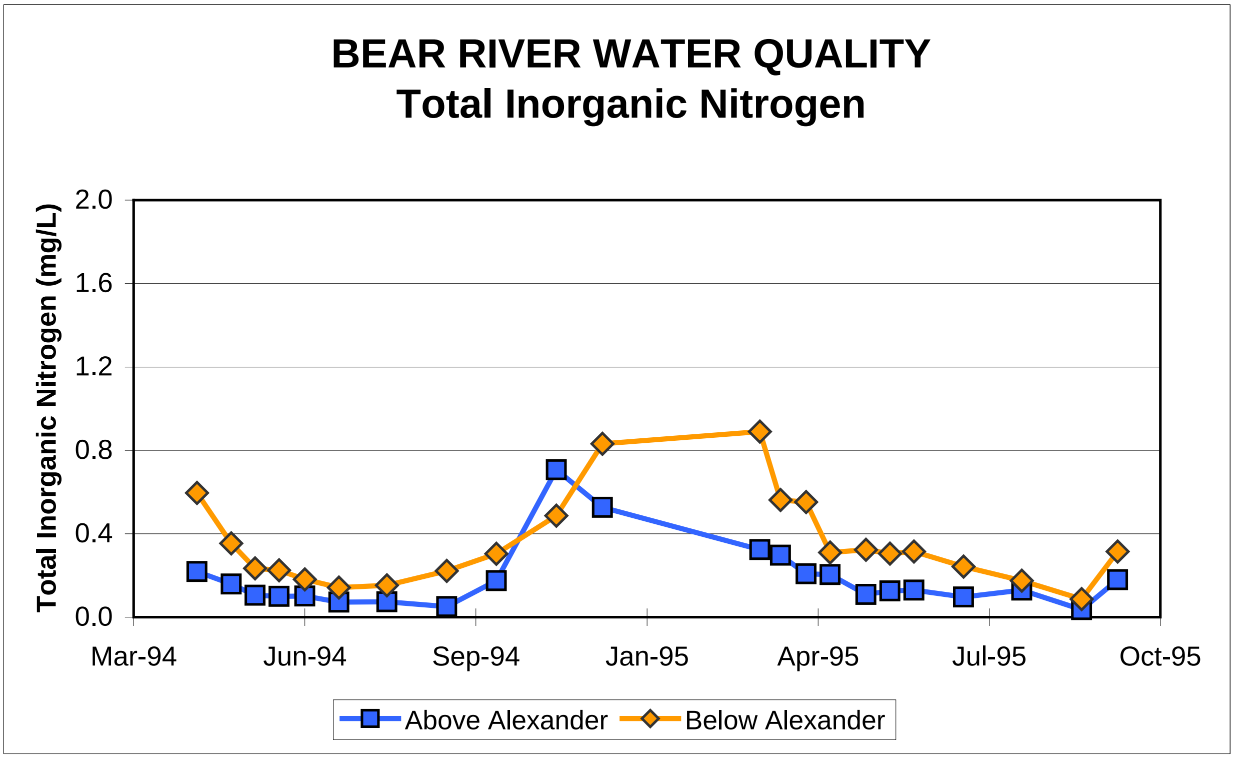


Figure 1-5. The orthophosphorus concentrations at five locations in the Bear River above Cove from 1994-1996.



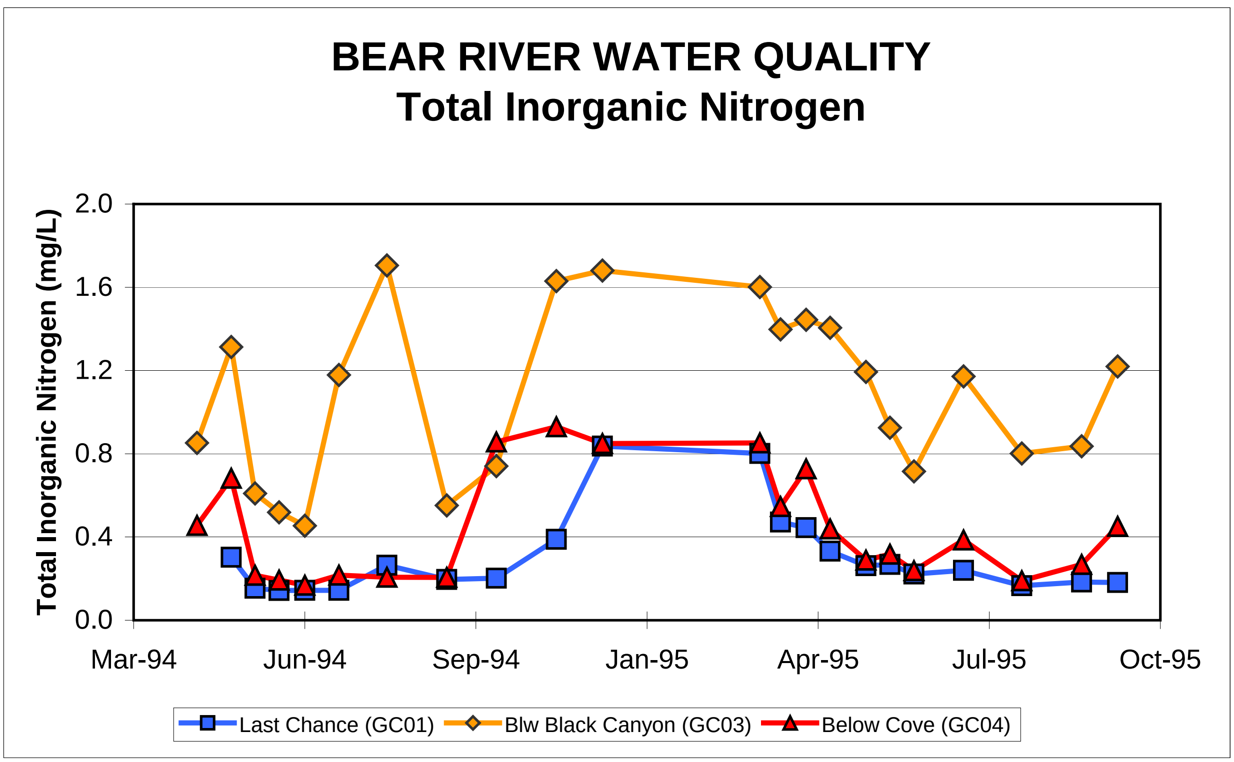


Figure 1-6. The total inorganic nitrogen concentrations at five locations in the Bear River above Cove from 1994-1996.

fraction of both phosphorous (ortho-phosphate) and nitrogen (nitrate, nitrite and ammonia). Historical data indicates that both these nutrients are leaving the reservoir in higher concentrations that are entering (Figures 1-4, 1-5 and 1-6). Although the overall effect is to remove vast amounts of nitrogen and phosphorous, the transformation below the reservoir has resulted in a clear (sediment removed) nutrient enriched ecosystem. This has resulted in an abundance of rooted macrophytes and attached algae in the downstream reaches of the Bear River. This area is within the study location of this project (Last Chance to Cove). In addition, an inspection of Figures 1-4 through 1-6 also shows that Black Canyon outflows contain significant concentrations of orthophosphorus and total inorganic nitrogen. The source of these nutrients is undocumented but surface irrigation is suspected to be a large part of the cause. In total, the subject reach of the Bear River that is reflective of a highly productive, riverine system with high densities of primary producers.

2.0 MONITORING LOCATIONS

The Grace WQMP include sampling at four locations. These sites were continuously monitoring with YSI probes during three periods in 2005. In addition to the continuous monitoring, water quality samples (grab) were collected. These locations can be seen in Figures 2-1 and 2-2 and are described below.

GC01: Located below the outfall of the Last Chance Hydroelectric Plant and above the influence of the Grace forebay. This site represents the upstream control which will define water quality conditions entering the Development.

GC02: Located below the Grace Diversion Dam at the head of Black Canyon. This site will define the water quality conditions at the head of the bypass reach and will also define water quality conditions of Grace Diversion Dam water releases.

GC03: Located at the exit of the Bear River from Black Canyon. This site will define the water quality conditions resulting from the combination of the Grace Diversion Dam flow releases and the inflowing springs or point sources accruing within Black Canyon.

GC04: Located below the outfall of the Cove Hydroelectric Plant. This site represents the water quality conditions leaving the Grace/Cove Hydroelectric complex and represents the cumulative effects of the Development and land uses between the upper forebay of the Grace Diversion Dam and the outfall of the Cove plant.

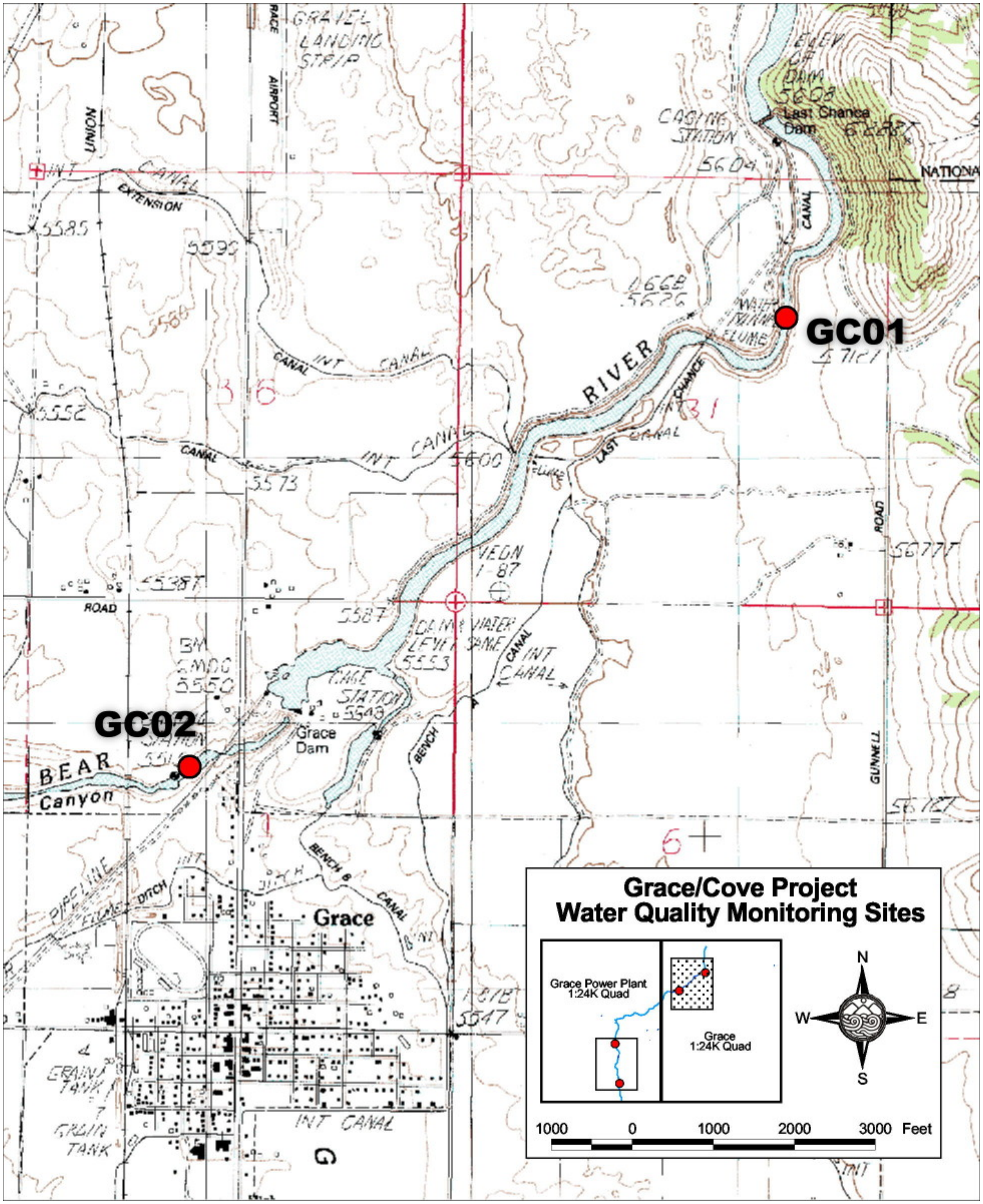


Figure 2-1. The location of the uppermost monitoring sites for the Grace/Cove WQMP.

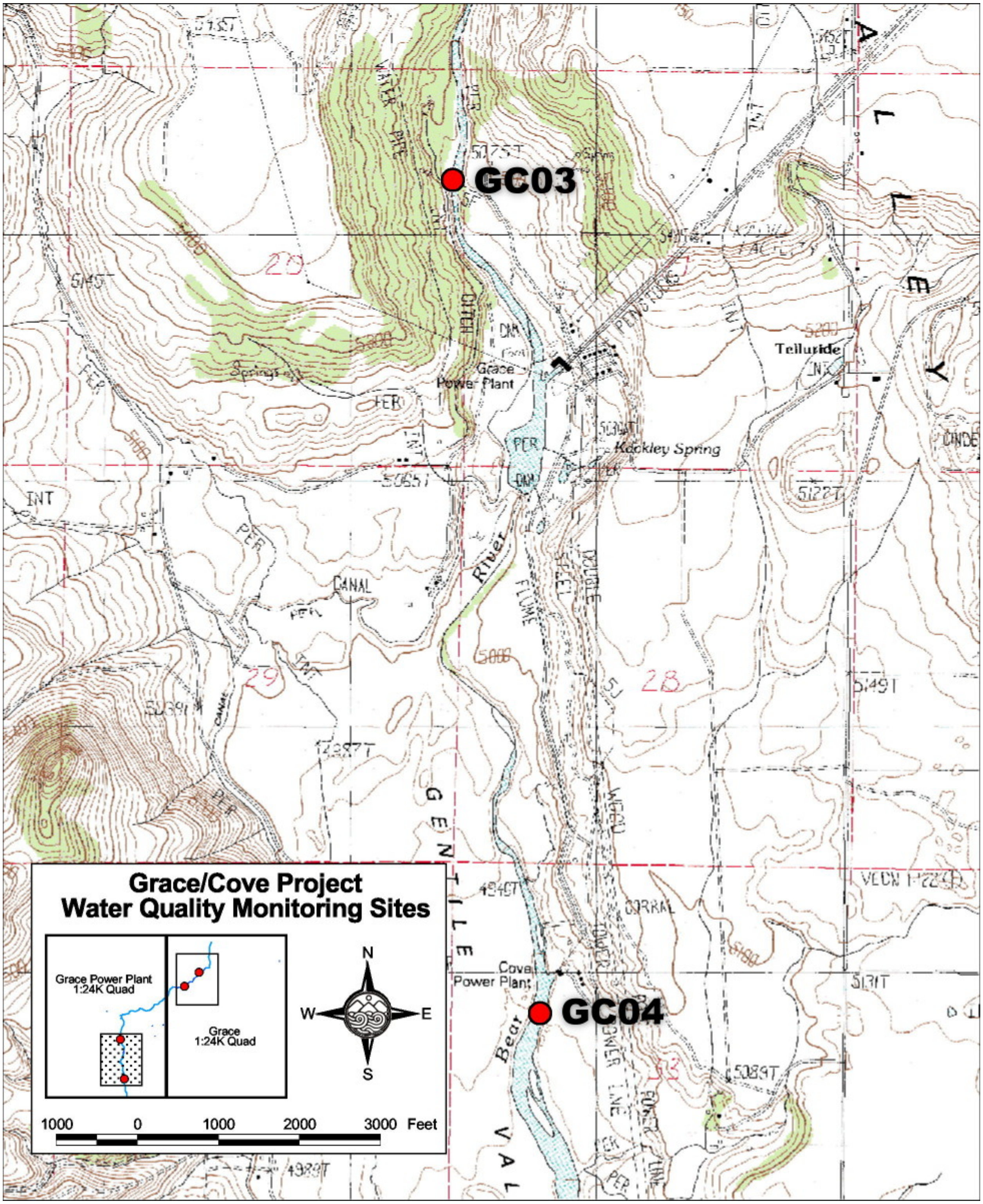


Figure 2-2. The location of the lowermost monitoring sites for the Grace/Cove WQMP.

2.1 Monitoring Frequency

Continuous monitoring probes (YSI Model 6920) collected dissolved oxygen, temperature, turbidity and specific conductance measurements at 15-minute intervals (reported hourly) over continuous periods from July 18 through July 25, August 4 through August 11 and September 9 through September 19, 2005. The Grace-Cove WQMP requires a minimum of continuous 7-day periods of hourly data for each month between July and September.

In addition to the continuous electronic data, water quality "grab" samples were also collected. Samples were returned to ERI's laboratory for analysis. Parameters analyzed are described in the following section. Samples were taken once during each of the continuous periods.

Flows in the Bear River immediately below the Grace Diversion Dam were monitored hourly and reported as average daily flows. This location corresponds to the continuous water quality station, GC02.

2.2 Monitoring Parameters

As noted above, two separate data sets were collected as part of the Grace-Cove WQMP. The parameters are defined below.

2.2.1 Continuously Monitoring Probes

YSI Model 6920 probes were installed by ERI at each of the four sites and were programmed to collect data at a 15-minute timestep over three 7-day periods. Parameters included:

1) specific conductance (µmhos/cm);
2) temperature (°C);
3) dissolved oxygen (mg O_2/L and % saturation); and,
4) turbidity (NTU).

2.2.2 Instantaneous Sampling

Grab samples were collected once during each of the three continuous monitoring 7-day periods. Samples were analyzed by ERI's EPA and state of Utah certified laboratory. Water quality parameters included:

1) total phosphorus (mg P/L);
2) orthophosphorus (mg P/L);
3) ammonia (mg N/L);
4) nitrate (mg N/L);

5) nitrite (mg N/L);

6) total suspended solids (mg/L); and,

7) turbidity (NTU).

3.0 MONITORING RESULTS

As noted in the previous sections, water quality data were instantaneously collected at four sites in the Bear River above, within and below the Grace-Cove Development. The collection and analysis of the data is intended to allow the major objectives of the program to be addressed. Those objectives are:

1) Characterize water quality conditions in the Grace bypass reach; and,

2) Help determine the Development's contribution, if any, to violations of water quality criteria as set forth in the Idaho Water Quality Standards and Wastewater Treatment Requirements, IDAPA 53.01.02 (Water Quality Standards).

3.1 Continuous Monitoring

3.1.1 Site Hydrology

Inspection of the flow data collected near Grace Cove Dam (Figure 3-1) demonstrates that the hydrology during each of the sampling episodes was different.

The first sampling period (July 18 through July 25) was characterized by flows ranging from 996 to 1218 cubic feet per second (cfs) at sites GC01 and GC04. Flow at site GC02 (the bypass reach) rising from 95 to125 cfs. Flow at GC03 is not gaged, but reflects those flows at GC02 plus the ungaged discharge from multiple springs in Black Canyon (Figure 3-1). Differences between stations reflect the conditions at the sites as a result of the diversion of water through the Grace powerplant (sites GC01 vs. GC02) and the subsequent mixing of bypass flows with groundwater discharge from Black Canyon.

The second sampling episode occurred between August 4-11. As in the first sampling period, the majority of water in the Bear River was diverted through the Grace powerplant. Flows at site GC01 were from 526 to 660 cfs, with 95 cfs bypassing the Grace plant and going into Black Canyon (site GC02). As in the July sample run, this data reflects the diversions and subsequent mixing between stations as a result of power generation.

The last sampling event occurred between September 9-19, when extremely low flows were evident throughout the study reach (Figure 3-1). For the first six days of the sampling event, the uppermost site, GC01, was subjected to flows of 413-465 cfs with 69-77 cfs going through the Grace powerplant. During the final four days of the sampling event, flows were reduced in the river to such a degree that all flows in the Bear River passing site GC01 were sent into Black Canyon (GC02, GC03 and GC04).

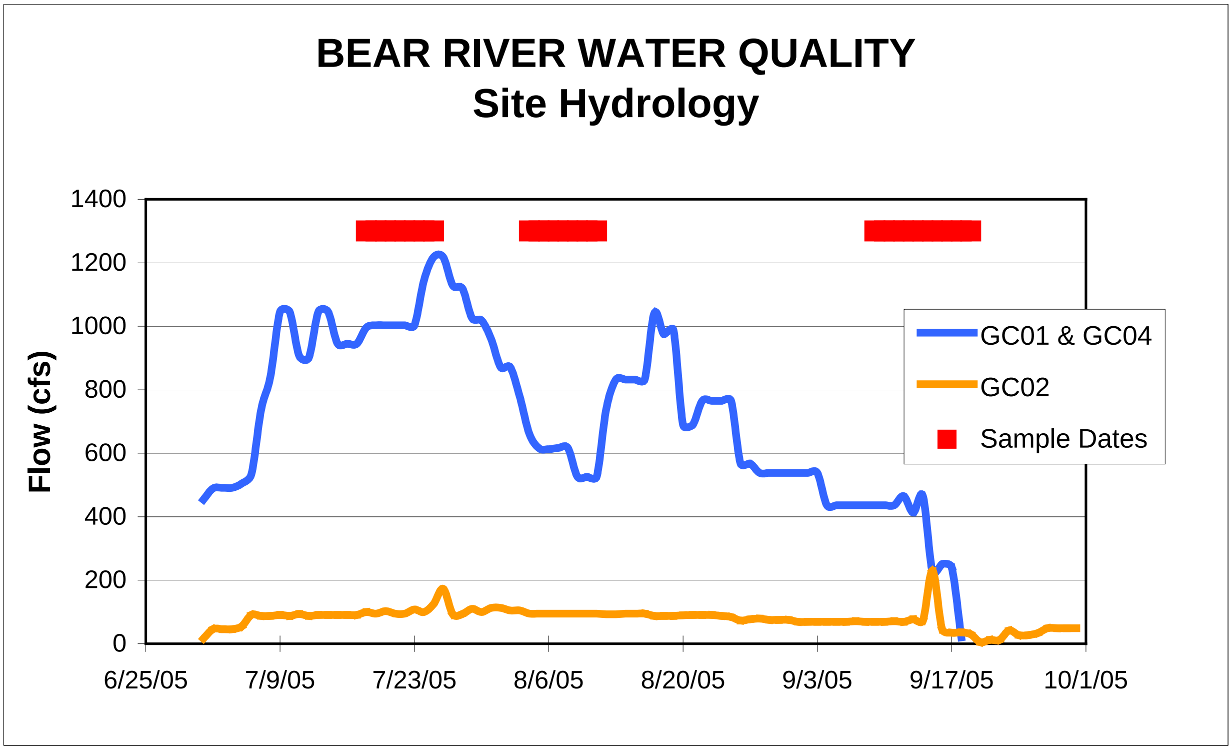


Figure 3-1. Flows recorded in the Bear River during the 2005 monitoring period.

3.1.2 Site Water Quality

3.1.2.1 July 2005 Water Quality

The water quality data collected continuously at the four stations are plotted in Figures 3-2 through 3-5. Temperature, dissolved oxygen, and to a certain extent specific conductance demonstrated a distinctive daily pattern. A summary of water quality attributes at each site during the sample period in July (July 18-25) is provided in Table 3-1. The table contains the number of observations, average, minimum and maximum values and variance statistics for each parameter.

At each station, for each day of measurement, maximum water temperatures (23.1-24.0°C) were reached between 3:00 and 5:00 p.m. Minimum temperatures (16.1-21.3 °C) occurred between 7:00 and 8:00 a.m. Dissolved oxygen expressed as mg/l (Figure 3-3) and percent saturation (Figure 3-4) followed similar diel patterns. Only a limited amount of dissolved oxygen data was collected from site GC04 (55 hours) in July due to the repeated failure of the dissolved oxygen sensor during the monitoring period. However, dissolved oxygen data that was successfully collected at GC04 was used for the July's water quality analysis. Specific conductance and turbidity did not have a consistent diel pattern for all sites. Turbidity levels varied between sites with GC02 and GC03 recording the greatest number of peak events (Figure 3-5). Large mats of periphytic algae were common throughout the study area and often lodged onto the probes, causing artificially high turbidity readings.

To characterize diel variation a one-way ANOVA was conducted for each parameter. The data were blocked by time of day so that observations within each hour (i.e. 6 p.m.) were compared to observations at every other hour. The analysis assumes that each hourly block includes at least 28 replicates (4 observations/hr over 7 days). The results of the one way ANOVA for each site and each parameter are shown in Table 3-2. The ANOVAs indicate that for temperature there are significant differences between times of day ($p\text{-value}<0.001$) at all four sites. There is also a significant difference in dissolved oxygen (percent saturation and concentration) at all four sites, with fewer sites showing significant differences among times of day for both turbidity and conductance.

In order to partition the daily variation confirmed by the ANOVAS, the data were divided into two 12-hour data sets; midnight to noon (a.m.) and noon to midnight (p.m.). This distinction separates the warmer and cooler periods of each day and reduces variation within each group. Two additional analyses were completed to detect statistically significant differences between sites for the monitored parameters. Tukey tests were completed to determine which pairs of sites were different for each parameter. In addition, paired linear regressions were run between sites to determine the degree of similarity.

The Tukey analysis tested for differences among all possible pairs of sites for each parameter (Table 3-3) The meaningful comparisons are those relative to the control site (GC01). The temperature at GC01 was significantly different only from GC03 ($p<0.05$). The GC01 a.m. and p.m. concentration and saturation of dissolved oxygen were significantly different from

Table 3-1. The descriptive statistics of the instantaneous data collected on the Bear River in July 2005.

	N	Range	Minimum	Maximum	Mean	Std. Error	Std. Deviation	Variance
Temperature (°C)								
GC01	723	2.73	21.26	23.99	22.48	0.03	0.72	0.52
GC02	721	2.69	21.27	23.96	22.56	0.02	0.49	0.24
GC03	719	7.11	16.10	23.21	20.28	0.06	1.7	2.9
GC04	269	2.65	20.35	23.00	21.73	0.04	0.73	0.53
Specific Conductance (µmho/cm)								
GC01	723	0.07	0.60	0.67	0.63	0.000	0.02	0.000
GC02	721	0.08	0.59	0.67	0.63	0.000	0.02	0.000
GC03	719	0.09	0.59	0.68	0.64	0.000	0.02	0.000
GC04	269	0.03	0.63	0.65	0.64	0.000	0.01	0.000
Dissolved Oxygen (%)								
GC01	723	40.90	68.7	109.6	82.64	0.44	11.78	138.88
GC02	721	85.4	68.2	153.60	98.09	0.79	21.27	452.20
GC03	719	87.1	98.6	185.70	119.19	0.69	18.57	344.74
GC04	269	39.6	52.9	92.5	74.6	0.62	10.1	102.22
Dissolved Oxygen (mg/l)								
GC01	723	3.24	6.00	9.24	7.14	0.03	0.92	0.85
GC02	721	7.37	5.86	13.23	8.47	0.07	1.83	3.34
GC03	719	7.45	8.78	16.23	10.75	0.06	1.6	2.55
GC04	269	3.35	4.66	8.01	6.54	0.05	0.84	0.70
Turbidity (NTU)								
GC01	723	26.0	14.4	40.40	31.97	0.24	6.5	42.2
GC02	721	253.6	5.30	258.9	15.36	0.47	12.53	157.06
GC03	719	330.6	0.8	331.4	4.61	0.54	14.36	206.33
GC04	269	22.0	7.3	29.3	11.1	0.15	2.45	5.98

Table 3-2. The ANOVA for determining if there is a significant difference between the parameter values over time of day. This analysis is assuming each hour (e.g. 6:00 p.m.) has seven replicates over the study in July 2005.

		Sum of Squares	df	Mean Square	F	Sig.
TEMPERATURE						
GC01	Between Groups	265.61	23	11.55	74.28	0.000
	Within Groups	108.67	699	0.16		
	Total	374.28	722			
GC02	Between Groups	113.52	22	5.16	58.33	0.000
	Within Groups	58.91	666	0.09		
	Total	172.43	688			
GC03	Between Groups	1749.24	23	76.05	157.09	0.000
	Within Groups	336.47	695	0.48		
	Total	2085.71	718			
GC04	Between Groups	225.25	23	9.79	99.93	0.000
	Within Groups	68.11	695	0.10		
	Total	293.36	718			
SPECIFIC CONDUCTANCE						
GC01	Between Groups	0.002	23	0.0001	0.32	0.999
	Within Groups	0.209	699	0.0003		
	Total	0.211	722			
GC02	Between Groups	0.010	23	0.0004	0.88	0.629
	Within Groups	0.338	697	0.0005		
	Total	0.348	720			
GC03	Between Groups	0.112	23	0.0049	22.54	0.000
	Within Groups	0.140	648	0.0002		
	Total	0.252	671			
GC04	Between Groups	0.004	23	0.0002	0.75	0.791
	Within Groups	0.173	695	0.0002		
	Total	0.178	718			
DISSOLVED OXYGEN (%)						
GC01	Between Groups	89110	23	3874	242.67	0.000
	Within Groups	11160	699	16		
	Total	100270	722			
GC02	Between Groups	184155	23	8007	39.46	0.000
	Within Groups	141431	697	203		

		Sum of Squares	df	Mean Square	F	Sig.
	Total	325586	720			
GC03	Between Groups	222152	23	9659	264.58	0.000
	Within Groups	25372	695	37		
	Total	247524	718			
GC04	Between Groups	18657	23	811	22.75	0.000
	Within Groups	8737	245	36		
	Total	27394	268			
DISSOLVED OXYGEN (mg/L)						
GC01	Between Groups	549.8	23	23.91	265.15	0.000
	Within Groups	63.0	699	0.09		
	Total	612.8	722			
GC02	Between Groups	1308.1	23	56.87	36.15	0.000
	Within Groups	1096.4	697	1.57		
	Total	2404.5	720			
GC03	Between Groups	1569.7	23	68.25	183.16	0.000
	Within Groups	259.0	695	0.37		
	Total	1828.7	718			
GC04	Between Groups	116.6	23	5.07	17.3	0.000
	Within Groups	71.8	245	0.29		
	Total	188.4	268			
TURBIDITY (NTU)						
GC01	Between Groups	341	23	14.82	0.34	0.998
	Within Groups	30129	699	43.10		
	Total	30470	722			
GC02	Between Groups	3939	23	171.27	1.09	0.346
	Within Groups	109141	697	156.59		
	Total	113080	720			
GC03	Between Groups	7366	23	320.26	1.58	0.041
	Within Groups	140781	695	202.56		
	Total	148147	718			
GC04	Between Groups	858	23	37.32	1.73	0.018
	Within Groups	14966	695	21.53		
	Total	15824	718			

Table 3-3. The results of the TUKEY tests to determine significant differences (p-value, 0.05) between means for different sample locations. The analysis has been grouped for the hours of midnight to noon and noon to midnight for hourly data collected in July of 2005.

	Mean	SE	Q	Qcrit	Sig
MIDNIGHT TO NOON					
Temperature					
GC01 vs GC02	0.214	0.357	0.599	3.685	not sig
GC01 vs GC03	3.019	0.357	8.449	3.685	significant
GC01 vs GC04	0.555	0.357	1.553	3.685	not sig
GC02 vs GC03	3.233	0.357	9.048	3.685	significant
GC02 vs GC04	0.769	0.357	2.152	3.685	not sig
GC03 vs GC04	2.464	0.357	6.896	3.685	significant
Specific Conductance					
GC01 vs GC02	0.001	0.009	0.123	3.685	not sig
GC01 vs GC03	0.018	0.009	1.972	3.685	not sig
GC01 vs GC04	0.025	0.009	2.739	3.685	not sig
GC02 vs GC03	0.017	0.009	1.848	3.685	not sig
GC02 vs GC04	0.024	0.009	2.616	3.685	not sig
GC03 vs GC04	0.007	0.009	0.768	3.685	not sig
Dissolved Oxygen (mg/l)					
GC01 vs GC02	1.377	0.558	2.467	3.685	not sig
GC01 vs GC03	3.939	0.558	7.058	3.685	significant
GC01 vs GC04	0.341	0.558	0.612	3.685	not sig
GC02 vs GC03	2.563	0.558	4.591	3.685	significant
GC02 vs GC04	1.718	0.558	3.078	3.685	not sig
GC03 vs GC04	4.281	0.558	7.669	3.685	significant
Dissolved Oxygen (%)					
GC01vs GC02	16.075	6.111	2.631	3.685	not sig
GC01 vs GC03	38.079	6.111	6.231	3.685	significant
GC01 vs GC04	5.023	6.111	0.822	3.685	not sig
GC02 vs GC03	22.004	6.111	3.601	3.685	not sig
GC02 vs GC04	21.098	6.111	3.453	3.685	not sig
GC03 vs GC04	43.102	6.111	7.053	3.685	significant
Turbidity (NTU)					
GC01 vs GC02	14.224	2.804	5.072	3.685	significant
GC01 vs GC03	24.071	2.804	8.584	3.685	significant
GC01 vs GC04	15.360	2.804	5.478	3.685	significant
GC02 vs GC03	9.847	2.804	3.512	3.685	not sig
GC02 vs GC04	1.136	2.804	0.405	3.685	not sig
GC03 vs GC04	8.712	2.804	3.107	3.685	not sig

	Mean	SE	Q	Qcrit	Sig
NOON TO MIDNIGHT					
Temperature					
GC01 vs GC02	0.081	0.267	0.304	3.685	not sig
GC01 vs GC03	1.257	0.267	4.710	3.685	significant
GC01 vs GC04	0.573	0.267	2.148	3.685	not sig
GC02 vs GC03	1.176	0.267	4.406	3.685	significant
GC02 vs GC04	0.492	0.267	1.844	3.685	not sig
GC03 vs GC04	0.684	0.267	2.562	3.685	not sig
Specific Conductance					
GC01 vs GC02	0.003	0.009	0.356	3.685	not sig
GC01 vs GC03	0.004	0.009	0.442	3.685	not sig
GC01 vs GC04	0.021	0.009	2.388	3.685	not sig
GC02 vs GC03	0.001	0.009	0.086	3.685	not sig
GC02 vs GC04	0.024	0.009	2.744	3.685	not sig
GC03 vs GC04	0.025	0.009	2.830	3.685	not sig
Dissolved Oxygen (mg/l)					
GC01 vs GC02	1.290	0.773	1.668	3.685	not sig
GC01 vs GC03	3.238	0.773	4.187	3.685	significant
GC01 vs GC04	0.891	0.773	1.152	3.685	not sig
GC02 vs GC03	1.949	0.773	2.519	3.685	not sig
GC02 vs GC04	2.181	0.773	2.820	3.685	not sig
GC03 vs GC04	4.130	0.773	5.340	3.685	significant
Dissolved Oxygen (%)					
GC01 vs GC02	14.766	9.033	1.635	3.685	not sig
GC01 vs GC03	34.688	9.033	3.840	3.685	significant
GC01 vs GC04	11.576	9.033	1.282	3.685	not sig
GC02 vs GC03	19.922	9.033	2.206	3.685	not sig
GC02 vs GC04	26.342	9.033	2.916	3.685	not sig
GC03 vs GC04	46.264	9.033	5.122	3.685	significant
Turbidity (NTU)					
GC01 vs GC02	16.077	2.318	6.937	3.685	significant
GC01 vs GC03	27.661	2.318	11.935	3.685	significant
GC01 vs GC04	16.628	2.318	7.175	3.685	significant
GC02 vs GC03	11.584	2.318	4.998	3.685	significant
GC02 vs GC04	0.551	2.318	0.238	3.685	not sig
GC03 vs GC04	11.033	2.318	4.760	3.685	significant

Table 3-4. The results of the paired linear regressions between the four sample sites on the Bear River during July 2005.

	N	R^2	Sig. Level
TEMPERATURE			
GC01 vs GC02	719	0.452	0
GC01 vs GC03	719	0.511	0
GC01 vs GC04	719	0.609	0
GC02 vs GC03	719	0.677	0
GC02 vs GC04	719	0.696	0
GC03 vs GC04	719	0.877	0
SPECIFIC CONDUCTANCE			
GC01 vs GC02	719	0.264	0
GC01 vs GC03	719	0.086	0
GC01 vs GC04	719	0.179	0
GC02 vs GC03	719	0.084	0
GC02 vs GC04	719	0.172	0
GC03 vs GC04	719	0.531	0
DISSOLVED OXYGEN (%)			
GC01 vs GC02	719	0.333	0
GC01 vs GC03	719	0.355	0
GC01 vs GC04	268	0.586	0
GC02 vs GC03	719	0.562	0
GC02 vs GC04	268	0.319	0
GC03 vs GC04	268	0.656	0
DISSOLVED OXYGEN (MG/L)			
GC01 vs GC02	719	0.333	0
GC01 vs GC03	719	0.355	0
GC01 vs GC04	268	0.633	0
GC02 vs GC03	719	0.519	0
GC02 vs GC04	268	0.393	0
GC03 vs GC04	268	0.425	0
TURBIDITY (NTU)			
GC01 vs GC02	713	0.043	0
GC01 vs GC03	714	0.019	0
GC01 vs GC04	714	0	0.783
GC02 vs GC03	713	0	0.941
GC02 vs GC04	713	0	0.571
GC03 vs GC04	714	0.004	0.094

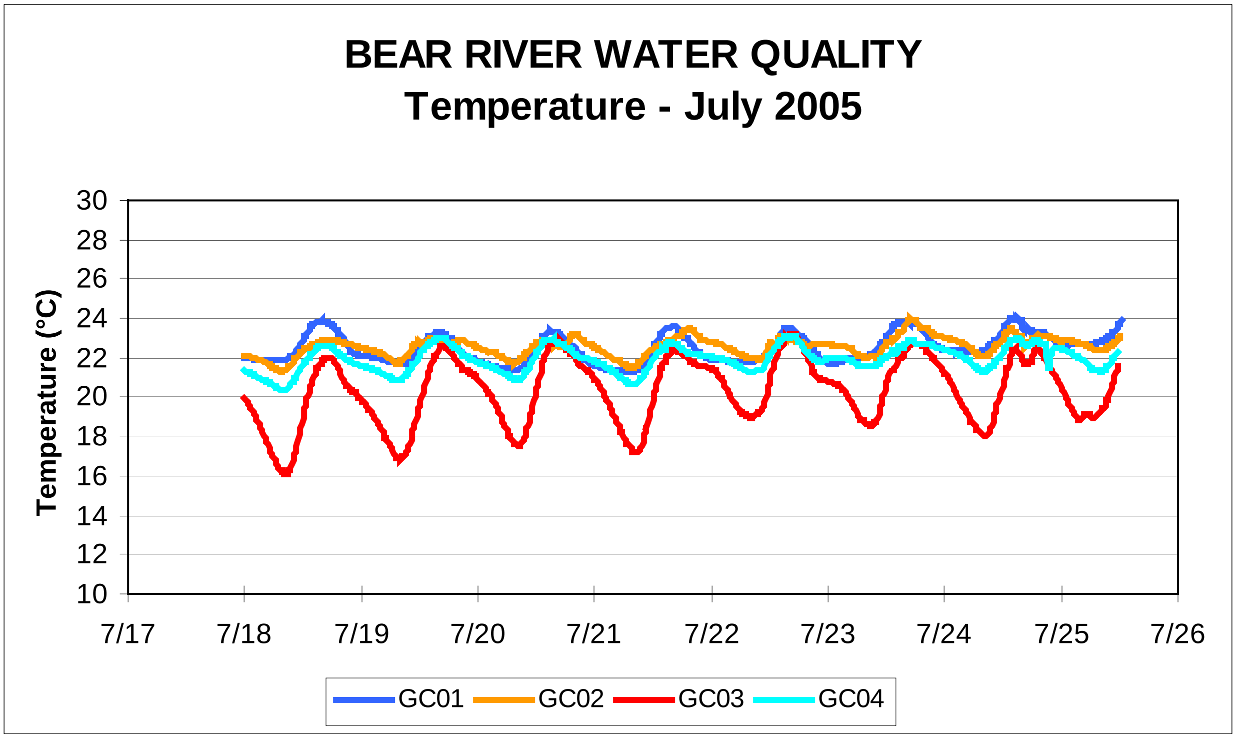


Figure 3-2. Temperature at four monitoring stations during July 2005.

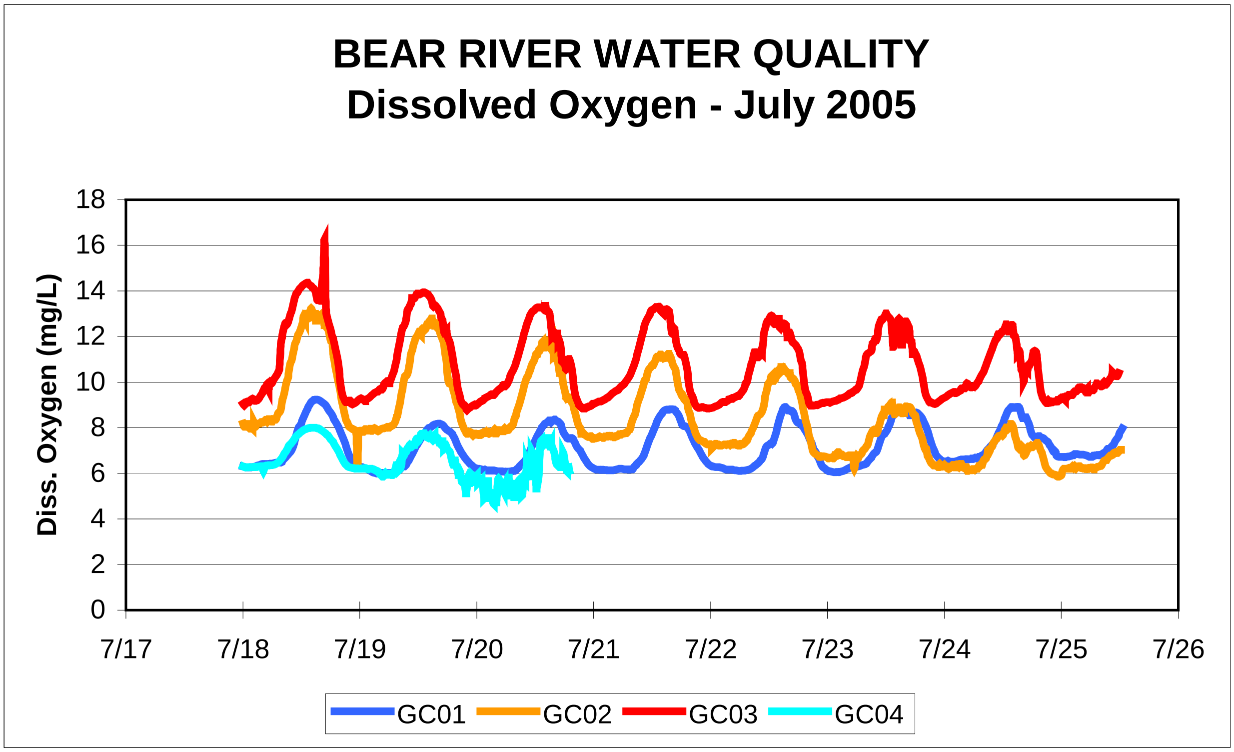


Figure 3-3. Dissolved oxygen at four monitoring stations during July 2005.

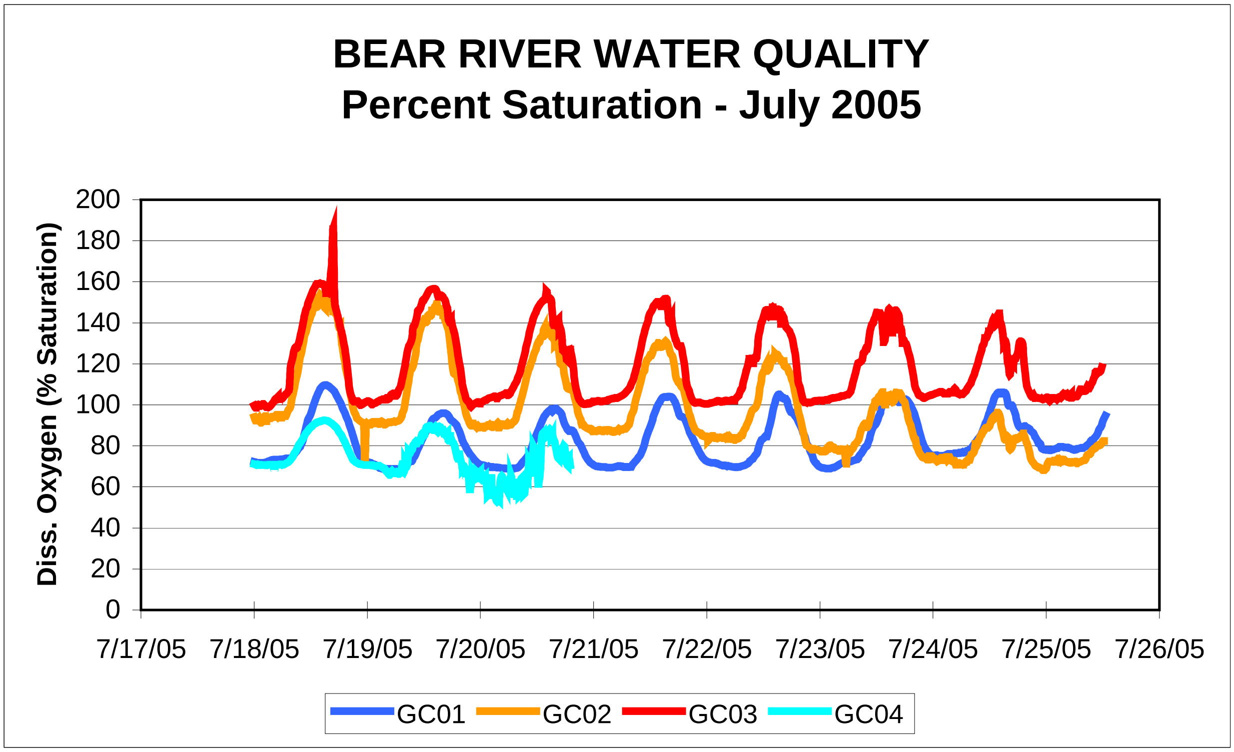


Figure 3-4. Percent saturation of dissolved oxygen at four monitoring stations during July 2005.

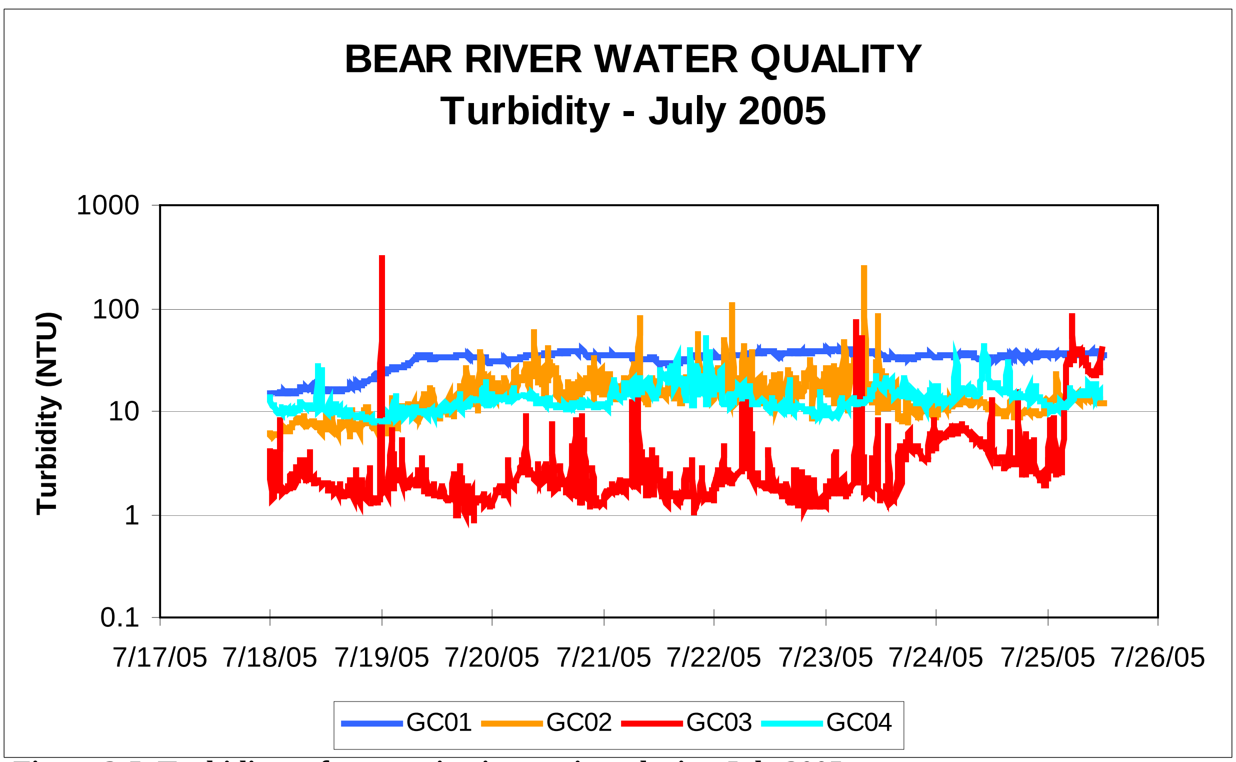


Figure 3-5. Turbidity at four monitoring stations during July 2005.

GC03. Turbidity was significantly different from GC01 at GC02, GC03, and GC04 during the a.m. hours but only at GC03 and GC04 during the p.m. hours.

By comparing the differences between adjacent sample sites (GC01 vs GC02; GC02 vs. GC03; GC03 vs.GC04) we can evaluate the systematic change in water quality parameters as water moves through the hydroelectric complex. In the case of temperature, GC02 and GC03 were significantly different from each other at all hours ($p<0.05$). Temperatures atGC03 and GC04 were significantly different during the a.m. hours. In the case of dissolved oxygen only GC03 and GC04 were significantly different for both am and pm hours. For turbidity the only pair with significant differences was GC02 and GC03 during the p.m. hours. As mentioned earlier, large mats of periphytic algae were common throughout the study areas and often lodged onto the probes, causing artificially high turbidity readings. To better observe significant relationships for both the Tukey analysis and the pair-wise linear regressions, turbidity observations above 200 NTU were treated as outliers and omitted from analysis.

Pair-wise linear regressions were used to determine if the same pattern of changes were occurring at each site for each parameter. In other words, can the parameter values at any site predict the values of another site. The regressions for the entire July data set (n=719) are shown in Table 3-4. The table includes the coefficient of determination (r^2) and the significance level of the regression relationship. Because of the large sample size (n=719 except GCO4 dissolved oxygen n=268), a large proportion of the regressions are significant. However, inspection of the r^2 value indicates what proportion of the variability at a site can be explained by the second site. For example, the variability in temperature at site GC01 can explain only 45 percent of the variability in temperature at GC02 ($p< 0.01$), but can explain 61 percent of the temperature variability at GC04 ($p < 0.01$). It is interesting to note that the highest coefficient of determination was found between GC03 and GC04 for temperature. The regression indicates that almost 88 percent of the variability in temperature at GC04 can be explained by temperatures at GC03. However, the dissolved oxygen (mg/l) at GC03 explains less than 43 percent of the variability in dissolved oxygen at GC04, so the relationships between sites are parameter specific.

3.1.2.2 August 2004 Water Quality

The water quality data collected continuously at the four stations are plotted in Figures 3-6 through 3-9. Similar to water quality attributes in July, temperature, dissolved oxygen and to a certain extent, specific conductance demonstrated a distinctive daily pattern. A summary of water quality attributes at each site during the sample period in August (August 4-11) can be seen in Table 3-5.

At each station for each day of measurement, maximum water temperatures (22.2-23.1°C) were reached between 3:00 and 5:00 p.m. with minimum temperatures (15.9-18.5°C) occurring between 6:00 and 8:00 a.m. Dissolved oxygen expressed as mg/l and percent saturation followed similar diel patterns. Specific conductance and turbidity did not have a consistent diel pattern for all sites. Turbidity levels varied between sites with GC02, GC03, and GC04 recording the greatest number of peak events.

Table 3-5. The descriptive statistics of the instantaneous data collected on the Bear River in August 2005.

	N	Range	Minimum	Maximum	Mean	Std. Error	Std. Deviation	Variance
Temperature (°C)								
GC01	676	6.62	16.52	23.14	21.21	0.04	0.97	0.94
GC02	674	1.83	20.54	22.37	21.33	0.02	0.40	0.16
GC03	670	6.26	15.94	22.2	19.14	0.06	1.64	2.69
GC04	672	4.25	18.47	22.72	20.45	0.04	1.05	1.09
Specific Conductance (µmho/cm)								
GC01	676	0.725	0.022	0.747	0.740	0.001	0.039	0.002
GC02	674	0.108	0.633	0.741	0.712	0.001	0.027	0.001
GC03	670	0.083	0.666	0.749	0.714	0.001	0.017	0.000
GC04	672	0.034	0.741	0.775	0.754	0.000	0.005	2.26E-05
Dissolved Oxygen (%)								
GC01	676	57.8	59.8	117.6	79.87	0.62	16.2	262.29
GC02	674	58	76.7	134.7	95.97	0.73	18.90	357.27
GC03	670	67.2	101.7	168.9	131.35	0.61	15.81	250.01
GC04	672	46	71.3	117.3	89.38	0.43	11.26	126.89
Dissolved Oxygen (mg/l)								
GC01	676	4.75	5.39	10.14	7.05	0.05	1.30	1.7
GC02	674	5.06	6.70	11.76	8.48	0.06	1.65	2.71
GC03	670	6.37	9.14	15.51	12.13	0.06	1.45	2.1
GC04	672	3.73	6.46	10.19	8.01	0.03	0.88	0.78
Turbidity (NTU)								
GC01	676	14.3	8.3	22.6	13.25	0.10	2.67	7.15
GC02	674	316	6.9	322.9	11.81	0.49	12.75	162.62
GC03	670	1860.5	0.9	1861.4	5.87	2.83	73.28	5370.43
GC04	672	18.7	4.2	22.9	9.12	0.10	2.61	6.84

Table 3-6. The ANOVA for determining if there is a significant difference between the parameter values over time of day. This analysis is assuming each hour (e.g. 6:00 p.m.) has seven replicates over the study in August 2005.

		Sum of Squares	df	Mean Square	F	Sig.
TEMPERATURE						
GC01	Between Groups	575.8	23	25.04	512.84	0.000
	Within Groups	31.6	648	0.05		
	Total	607.5	671			
GC02	Between Groups	32.6	23	1.42	12.06	0.000
	Within Groups	75.8	646	0.12		
	Total	108.4	669			
GC03	Between Groups	1599.3	23	69.53	221.37	0.000
	Within Groups	202.9	646	0.31		
	Total	1802.2	669			
GC04	Between Groups	600.3	23	26.10	126.89	0.000
	Within Groups	133.3	648	0.21		
	Total	733.6	671			
SPECIFIC CONDUCTANCE						
GC01	Between Groups	0.020	23	0.001	1.105	0.330
	Within Groups	0.502	648	0.001		
	Total	0.522	671			
GC02	Between Groups	0.048	23	0.002	3.118	0.000
	Within Groups	0.435	646	0.001		
	Total	0.483	669			
GC03	Between Groups	0.136	23	0.006	73.092	0.000
	Within Groups	0.052	646	0.000		
	Total	0.188	669			
GC04	Between Groups	0.002	23	0.000	4.047	0.000
	Within Groups	0.013	648	0.000		
	Total	0.015	671			
DISSOLVED OXYGEN (%)						
GC01	Between Groups	160148	23	6963.0	287.3	0.000
	Within Groups	15703	648	24.2		
	Total	175850	671			
GC02	Between Groups	219139	23	9527.8	345.2	0.000
	Within Groups	17830	646	27.6		
	Total	236969	669			
GC03	Between Groups	31633	23	1375.4	6.6	0.000

		Sum of Squares	df	Mean Square	F	Sig.
	Within Groups	135625	646	209.9		
	Total	167258	669			
GC04	Between Groups	76208	23	3313.4	240.3	0.000
	Within Groups	8935	648	13.8		
	Total	85143	671			
DISSOLVED OXYGEN (MG/L)						
GC01	Between Groups	1018.8	23	44.30	244.19	0.000
	Within Groups	117.6	648	0.18		
	Total	1136.4	671			
GC02	Between Groups	1717.3	23	74.67	214.64	0.000
	Within Groups	225.4	648	0.35		
	Total	1942.8	671			
GC03	Between Groups	250.4	23	10.89	6.10	0.000
	Within Groups	1153.1	646	1.78		
	Total	1403.5	669			
GC04	Between Groups	456.9	23	19.86	190.78	0.000
	Within Groups	67.5	648	0.10		
	Total	524.3	671			
TURBIDITY (NTU)						
GC01	Between Groups	703.3	23	30.6	4.9	0.000
	Within Groups	4081.0	648	6.3		
	Total	4784.3	671			
GC02	Between Groups	3293.6	23	143.2	0.9	0.640
	Within Groups	106119.8	646	164.3		
	Total	109413.4	669			
GC03	Between Groups	172688.0	23	7508.2	1.4	0.090
	Within Groups	3420132.1	646	5294.3		
	Total	3592820.1	669			
GC04	Between Groups	439.2	23	19.1	3.0	0.000
	Within Groups	4147.3	648	6.4		
	Total	4586.5	671			

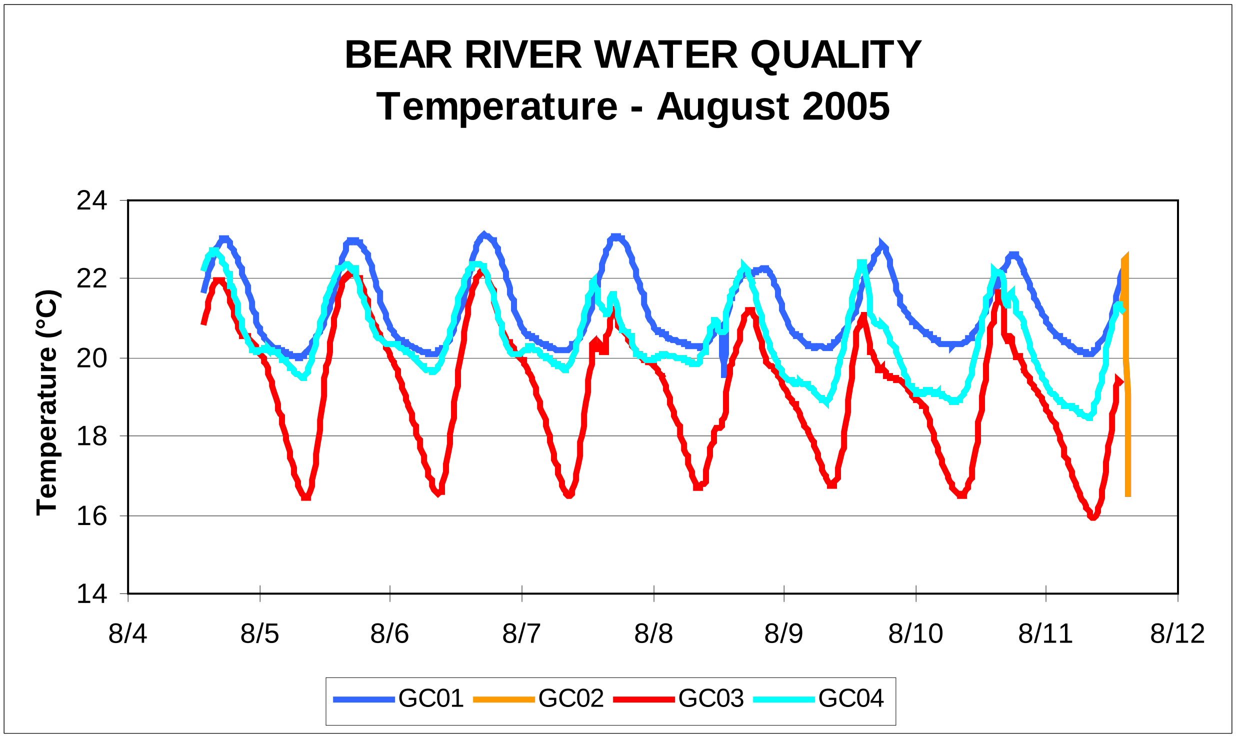


Figure 3-6. Temperature at four monitoring stations during August 2005.

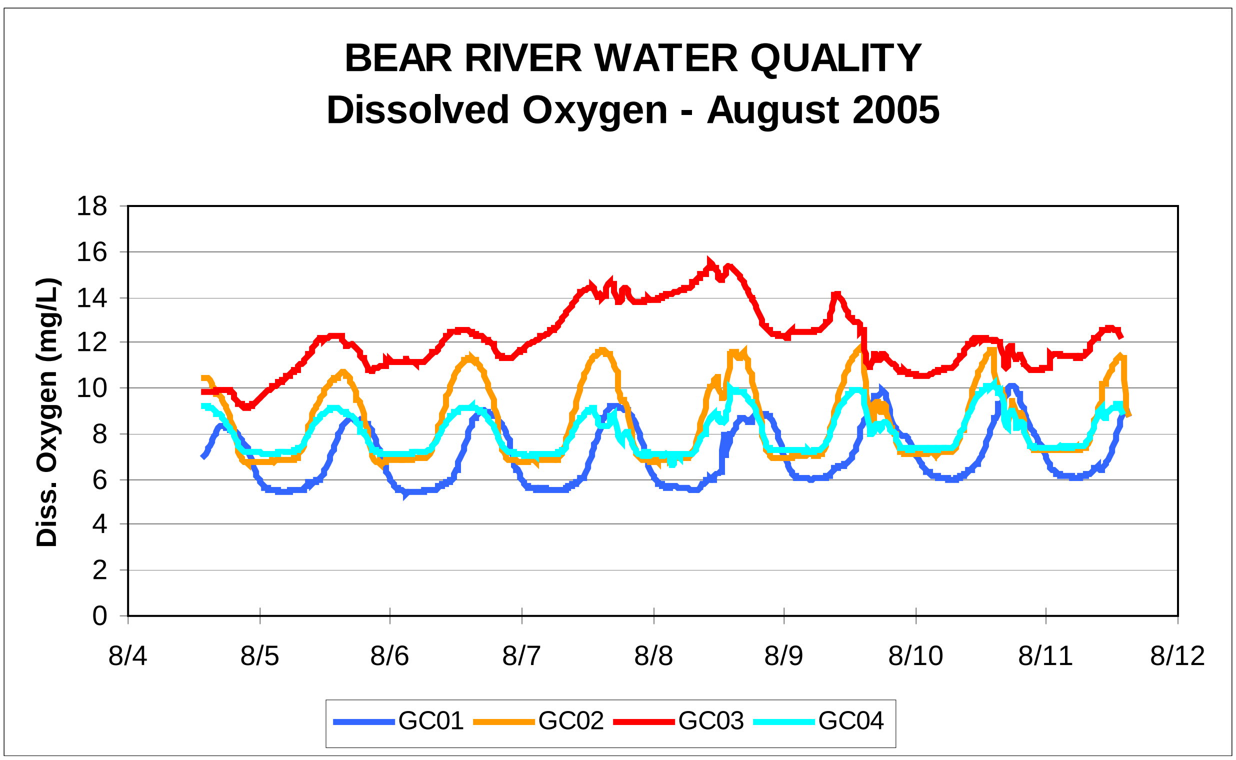


Figure 3-7. Dissolved oxygen at four monitoring stations during August 2005.

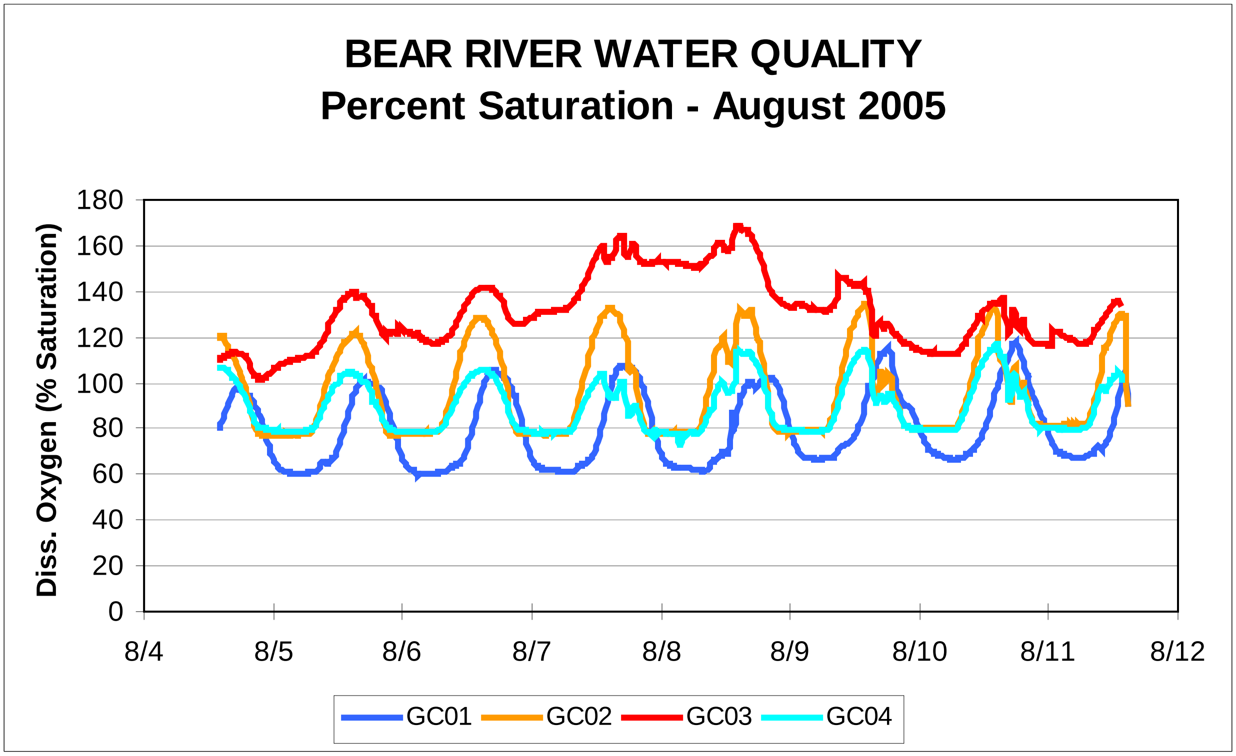


Figure 3-8. Percent saturation of dissolved oxygen at four monitoring stations during August 2005.

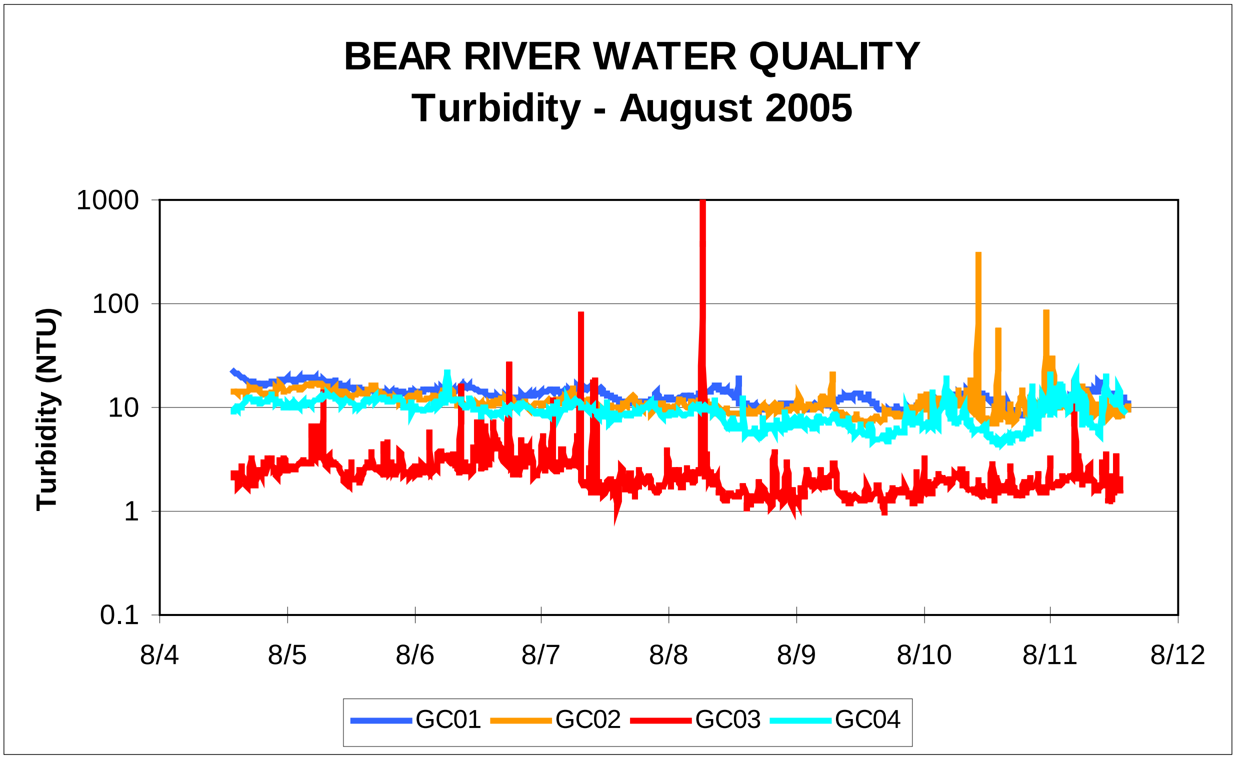


Figure 3-9. Turbidity at four monitoring stations during August 2005.

To characterize diel variation a one-way ANOVA was conducted for each parameter (Table 3-6). The ANOVAs indicate that for temperature there are significant differences between times of day (p-value<0.001). There is a significant difference in dissolved oxygen (percent saturation and concentration) between times of day for all four sites, with fewer sites showing significant differences among times of day for both turbidity and conductance.

In order to partition the daily variation, the data were divided into two 12-hour data sets; midnight to noon (a.m.) and noon to midnight (p.m.). Tukey tests were completed to determine which pairs of sites were different for each parameter. In addition, paired linear regressions were run between sites to determine the degree of similarity.

The Tukey analysis tested for differences among possible pairs of sites for each parameter (Table 3-7). The meaningful comparisons are those relative to the control site (GC01). The temperature at GC01 was significantly different only from GC03 ($p<0.05$). The GC01 a.m. and p.m. concentration of dissolved oxygen was only significantly different GC03. The GC01 percent saturation of dissolved oxygen was significantly different from GC02 and GC03 in the a.m. hours, but only GC03 in the p.m. hours. Turbidity was significantly different from GC01 at GC03 and GC04 during the a.m. hours, but only at GC03 during the p.m. hours.

By comparing the differences between adjacent sample sites (GC01 vs GC02; GC02 vs. GC03; GC03 vs GC04) we can evaluate the systematic change in water quality parameters as water moves through the hydroelectric complex. In the case of temperature, GC02 vs GC03 and GC03 vs GC04 were significantly different from each other during the a.m. hours. GC02 vs GC03 had significantly different temperatures during the p.m. hours. Adjacent sites that were significantly different in concentrations of dissolved oxygen included GC02 vs GC03 and GC03 vs GC04 during both the a.m. and p.m. hours. Adjacent sites that recorded significantly different percent saturation of dissolved oxygen included GC01 vs GC02 in the a.m. hours and GC02 vs GC03 and GC03 vs GC04 during both the a.m. and p.m. hours. In the case of turbidity GC03 vs GC04 had significantly different levels of turbidity during the am hours and GC03 vs GC02 had significantly different levels of turbidity during both the a.m. and p.m. hours.

Pair-wise linear regressions were used to determine if the same pattern of changes were occurring at each site for each parameter. The regressions for the entire August data set (n=670) are shown in Table 3-8. Because of the large sample size (n=670), a large proportion of the regressions are significant. However, inspection of the r^2 value indicates what proportion of the variability at a site can be explained by the second site. For example, the variability in temperature at site GC01 can only explain 58 percent of the variability in temperature at GC02 (p-value<0.01), but can explain 68 percent of the temperature variability at GC03 (p-value<0.01). It is interesting to note that the highest coefficient of determination was found between GC02 and GC04 for dissolved oxygen. The regression indicates that 86 percent of the variability in dissolved oxygen (mg/l) at GC04 can be explained by dissolved oxygen at GC02.

Table 3-7. The results of the TUKEY tests to determine significant differences (p-value, 0.05) between means for different sample locations. The analysis has been grouped for the hours of midnight to noon and noon to midnight for hourly data collected in August of 2005.

	Mean Diff.	SE	Q	QCrit	Conclusion
MIDNIGHT TO NOON					
Temperature					
GC01 vs GC02	0.773	0.323	2.397	3.685	not sig
GC01 vs GC03	2.564	0.323	7.950	3.685	significant
GC01 vs GC04	0.687	0.323	2.129	3.685	not sig
GC02 vs GC03	3.337	0.323	10.347	3.685	significant
GC02 vs GC04	1.460	0.323	4.526	3.685	significant
GC03 vs GC04	1.878	0.323	5.821	3.685	significant
Specific Conductance					
GC01 vs GC02	0.027	0.006	4.200	3.685	significant
GC01 vs GC03	0.018	0.006	2.835	3.685	not sig
GC01 vs GC04	0.012	0.006	1.848	3.685	not sig
GC02 vs GC03	0.009	0.006	1.365	3.685	not sig
GC02 vs GC04	0.039	0.006	6.048	3.685	significant
GC03 vs GC04	0.030	0.006	4.683	3.685	significant
Dissolved Oxygen (mg/L)					
GC01 vs GC02	1.823	0.497	3.670	3.685	not sig
GC01 vs GC03	6.242	0.497	12.562	3.685	significant
GC01 vs GC04	1.721	0.497	3.463	3.685	not sig
GC02 vs GC03	4.419	0.497	8.893	3.685	significant
GC02 vs GC04	0.102	0.497	0.206	3.685	not sig
GC03 vs GC04	4.521	0.497	9.099	3.685	significant
Dissolved Oxygen (%)					
GC01 vs GC02	21.564	5.466	3.945	3.685	significant
GC01 vs GC03	62.463	5.466	11.428	3.685	significant
GC01 vs GC04	17.989	5.466	3.291	3.685	not sig
GC02 vs GC03	40.899	5.466	7.483	3.685	significant
GC02 vs GC04	3.575	5.466	0.654	3.685	not sig
GC03 vs GC04	44.474	5.466	8.137	3.685	significant
Turbidity (NTU)					
GC01 vs GC02	2.494	1.205	2.069	3.685	not sig
GC01 vs GC03	11.526	1.205	9.561	3.685	significant
GC01 vs GC04	4.455	1.205	3.696	3.685	significant
GC02 vs GC03	9.032	1.205	7.492	3.685	significant
GC02 vs GC04	1.961	1.205	1.627	3.685	not sig
GC03 vs GC04	7.070	1.205	5.865	3.685	significant

	Mean Diff.	SE	Q	QCrit	Conclusion
NOON TO MIDNIGHT					
Temperature					
GC01 vs GC02	0.545	0.380	1.433	3.685	not sig
GC01 vs GC03	1.020	0.380	2.684	3.685	not sig
GC01 vs GC04	0.291	0.380	0.767	3.685	not sig
GC02 vs GC03	1.565	0.380	4.117	3.685	significant
GC02 vs GC04	0.836	0.380	2.199	3.685	not sig
GC03 vs GC04	0.729	0.380	1.917	3.685	not sig
Specific Conductance					
GC01 vs GC02	0.030	0.016	1.869	3.685	not sig
GC01 vs GC03	0.035	0.016	2.174	3.685	not sig
GC01 vs GC04	0.016	0.016	1.016	3.685	not sig
GC02 vs GC03	0.005	0.016	0.305	3.685	not sig
GC02 vs GC04	0.046	0.016	2.885	3.685	not sig
GC03 vs GC04	0.051	0.016	3.190	3.685	not sig
Dissolved Oxygen (mg/l)					
GC01 vs GC02	1.042	0.658	1.584	3.685	not sig
GC01 vs GC03	3.897	0.658	5.926	3.685	significant
GC01 vs GC04	0.215	0.658	0.327	3.685	not sig
GC02 vs GC03	2.855	0.658	4.341	3.685	significant
GC02 vs GC04	0.827	0.658	1.258	3.685	not sig
GC03 vs GC04	3.682	0.658	5.599	3.685	significant
Dissolved Oxygen (%)					
GC01 vs GC02	10.749	7.612	1.412	3.685	not sig
GC01 vs GC03	40.363	7.612	5.303	3.685	significant
GC01 vs GC04	0.963	7.612	0.127	3.685	not sig
GC02 vs GC03	29.615	7.612	3.891	3.685	significant
GC02 vs GC04	9.785	7.612	1.286	3.685	not sig
GC03 vs GC04	39.400	7.612	5.176	3.685	significant
Turbidity (NTU)					
GC01 vs GC02	1.311	1.725	0.760	3.685	not sig
GC01 vs GC03	10.166	1.725	5.892	3.685	significant
GC01 vs GC04	3.838	1.725	2.225	3.685	not sig
GC02 vs GC03	8.854	1.725	5.132	3.685	significant
GC02 vs GC04	2.527	1.725	1.465	3.685	not sig
GC03 vs GC04	6.327	1.725	3.667	3.685	not sig

Table 3-8. The results of the paired linear regressions between the four sample sites on the Bear River during August 2005.

	N	R2	Sig. Level
TEMPERATURE			
GC01 vs GC02	670	0.067	0.000
GC01 vs GC03	670	0.681	0.000
GC01 vs GC04	670	0.494	0.000
GC02 vs GC03	670	0.226	0.000
GC02 vs GC04	670	0.22	0.000
GC03 vs GC04	670	0.541	0.000
SPECIFIC CONDUCTANCE			
GC01 vs GC02	670	0.014	0.002
GC01 vs GC03	670	0.001	0.321
GC01 vs GC04	670	0	0.869
GC02 vs GC03	670	0.041	0.000
GC02 vs GC04	670	0.035	0.000
GC03 vs GC04	670	0.096	0.000
DISSOLVED OXYGEN (%)			
GC01 vs GC02	670	0.481	0.000
GC01 vs GC03	670	0.036	0.000
GC01 vs GC04	670	0.275	0.000
GC02 vs GC03	670	0.173	0.000
GC02 vs GC04	670	0.871	0.000
GC03 vs GC04	670	0.141	0.000
DISSOLVED OXYGEN (MG/L)			
GC01 vs GC02	670	0.232	0.000
GC01 vs GC03	670	0	0.680
GC01 vs GC04	670	0.224	0.000
GC02 vs GC03	670	0.101	0.000
GC02 vs GC04	670	0.851	0.000
GC03 vs GC04	670	0.07	0.000
TURBIDITY (NTU)			
GC01 vs GC02	670	0.003	0.139
GC01 vs GC03	667	0.017	0.001
GC01 vs GC04	669	0.077	0.000
GC02 vs GC03	668	0.001	0.335
GC02 vs GC04	670	0	0.965
GC03 vs GC04	667	0.009	0.014

3.1.2.3 September 2005 Water Quality

The water quality data collected continuously at the four stations are plotted in Figures 3-11 through 3-14. Temperature, dissolved oxygen, and to a certain extent specific conductance demonstrated a distinctive daily pattern. A summary of water quality attributes at each site during the sample period in September (September 9-19) is provided in Table 3-9.

At each station for each day of measurement, maximum water temperatures (17.2-18.2°C) were reached between 3:00 and 5:00 p.m. with minimum temperatures (9.2-11.9°C) occurring between 6:00 and 8:00 a.m. Dissolved oxygen expressed as mg/l and percent saturation followed similar diel patterns. Specific conductance and turbidity did not have a consistent diel pattern for all sites. Turbidity levels varied between all of the sites with GC02 and GC04, recording the greatest number of peak events. Large mats of periphytic algae were common throughout the study area and often lodged onto the probes, causing artificially high turbidity readings.

To characterize diel variation a one-way ANOVA was conducted for each parameter. The results of a one way ANOVA for each site and each parameter are shown in Table 3-10. The ANOVAs indicate that for temperature there are significant differences between times of day (p-<0.001). There is a significant difference in DO (percent saturation and concentration) between times of day for all four sites, with fewer sites showing significant differences among times of day for both turbidity and conductance.

In order to partition the daily variation, the data were divided into two twelve-hour data sets; midnight to noon (a.m.) and noon to midnight (p.m.). This distinction separates the warmer and cooler periods of each day and reduces variation within each group. Two additional analyses were completed to detect statistically significant differences between sites for the monitored parameters. Tukey tests were completed to determine which pairs of sites were different for each parameter. In addition, paired linear regressions were run between sites to determine the degree of similarity.

The Tukey analysis tested for differences among possible pairs of sites for each parameter (Tables 3-11). The meaningful comparisons are those relative to the control site (GC01). The temperature at GC01 was not significantly different from any of the other sites in either the a.m. or p.m. hours ($p<0.05$). The GC01 a.m. concentration and saturation of dissolved oxygen was significantly different from GC03. However, in the p.m. there was no significant difference. Turbidity was significantly different from GC01 at GC02, GC03, and GC04 during the a.m. hours, but only at GC02 during the p.m. hours.

By comparing the differences between adjacent sample sites (GC01 vs GC02; GC02 vs. GC03; GC03 vs GC04) we can evaluate the systematic change in water quality parameters as water moves through the hydroelectric complex. In the case of temperature, only GC02 and GC03 were significantly different from each other during the a.m. hours. None of the adjacent sample sites recorded significantly different temperatures during the p.m. hours. In the case of dissolved oxygen (mg/l) only GC03 and GC04 were significantly different from each other during the a.m. hours. None of the adjacent sample sites recorded significantly different amounts of dissolved oxygen in the p.m. hours. As mentioned earlier, large mats of periphytic algae were

Table 3-9. The descriptive statistics of the instantaneous data collected on the Bear River in September 2005.

	N	Range	Minimum	Maximum	Mean	Std. Error	Std. Deviation	Variance
Temperature (°C)								
GC01	969	6.13	11.94	18.07	14.58	0.05	1.49	2.21
GC02	969	6.42	11.78	18.2	14.69	0.04	1.21	1.46
GC03	969	8.00	9.22	17.22	12.92	0.05	1.64	2.68
GC04	969	8.65	9.37	18.02	13.76	0.05	1.7	2.88
Specific Conductance (µmho/cm)								
GC01	969	0.02	0.71	0.73	0.72	0.00	0.00	0.00
GC02	969	0.69	0.02	0.71	0.70	0.00	0.02	0.00
GC03	969	0.08	0.62	0.70	0.66	0.00	0.02	0.00
GC04	969	0.10	0.73	0.83	0.76	0.00	0.02	0.00
Dissolved Oxygen (%)								
GC01	969	40.9	66.6	107.5	83.01	0.3	9.35	87.42
GC02	969	80.5	78.2	158.7	97.35	0.52	16.31	265.94
GC03	969	85.6	82.7	168.3	104.92	0.38	11.90	141.57
GC04	969	80.9	62	142.9	91.89	0.57	17.61	310.27
Dissolved Oxygen (mg/l)								
GC01	969	3.73	6.54	10.27	8.44	0.03	0.97	0.93
GC02	969	8.16	7.58	15.74	9.86	0.05	1.61	2.6
GC03	969	7.54	9.3	16.84	11.04	0.03	1.05	1.1
GC04	969	7.38	6.92	14.3	9.48	0.05	1.67	2.78
Turbidity (NTU)								
GC01	969	12.2	6.4	18.6	11.75	0.09	2.74	7.5
GC02	969	1361.4	2.6	1364	11.61	1.42	44.26	1956.72
GC03	969	97.1	0.8	97.9	6.83	0.35	10.78	116.03
GC04	969	834.3	0.2	834.5	6.43	1.06	32.87	1080.17

Table 3-10. The ANOVA for determining if there is a significant difference between the parameter values over time of day. This analysis is assuming each hour (e.g. 6:00 p.m.) has seven replicates over the study in September 2005.

		Sum of Squares	df	Mean Square	F	Sig.
TEMPERATURE						
GC01	Between Groups	413.60	23	17.98	9.83	0.000
	Within Groups	1712.34	936	1.83		
	Total	2125.94	959			
GC02	Between Groups	260.27	23	11.32	9.22	0.000
	Within Groups	1149.28	936	1.23		
	Total	1409.55	959			
GC03	Between Groups	1384.47	23	60.19	47.59	0.000
	Within Groups	1183.80	936	1.26		
	Total	2568.27	959			
GC04	Between Groups	1321.50	23	57.46	37.06	0.000
	Within Groups	1450.98	936	1.55		
	Total	2772.478573	959			
SPECIFIC CONDUCTANCE						
GC01	Between Groups	0.001	23	0.000	7.350	0.000
	Within Groups	0.008	936	0.000		
	Total	0.009	959			
GC02	Between Groups	0.023	23	0.001	1.685	0.020
	Within Groups	0.546	936	0.001		
	Total	0.568	959			
GC03	Between Groups	0.011	23	0.000	0.994	0.470
	Within Groups	0.465	936	0.000		
	Total	0.476	959			
GC04	Between Groups	0.036	23	0.002	3.204	0.000
	Within Groups	0.454	936	0.000		
	Total	0.490	959			
DISSOLVED OXYGEN (%)						
GC01	Between Groups	38170	23	1660	34.4	0.000
	Within Groups	45095	936	48		
	Total	83265	959			
GC02	Between Groups	145036	23	6306	60.7	0.000
	Within Groups	97276	936	104		

		Sum of Squares	df	Mean Square	F	Sig.
	Total	242312	959			
GC03	Between Groups	62517	23	2718	34.4	0.000
	Within Groups	73985	936	79		
	Total	136501	959			
GC04	Between Groups	220069	23	9568	134.0	0.000
	Within Groups	66843	936	71		
	Total	286912	959			
DISSOLVED OXYGEN (MG/L)						
GC01	Between Groups	291.0	23	12.7	20.0	0.000
	Within Groups	591.5	936	0.6		
	Total	882.5	959			
GC02	Between Groups	1246.1	23	54.2	45.1	0.000
	Within Groups	1124.5	936	1.2		
	Total	2370.6	959			
GC03	Between Groups	411.4	23	17.9	25.6	0.000
	Within Groups	652.9	936	0.7		
	Total	1064.3	959			
GC04	Between Groups	1823.8	23	79.3	99.4	0.000
	Within Groups	746.4	936	0.8		
	Total	2570.2	959			
TURBIDITY (NTU)						
GC01	Between Groups	455	23	19.8	2.8	0.000
	Within Groups	6710	936	7.2		
	Total	7165	959			
GC02	Between Groups	42019	23	1826.9	0.9	0.570
	Within Groups	1851884	936	1978.5		
	Total	1893903	959			
GC03	Between Groups	3020	23	131.3	1.1	0.310
	Within Groups	109176	936	116.6		
	Total	112196	959			
GC04	Between Groups	24984	23	1086.3	1.0	0.470
	Within Groups	1020467	936	1090.2		
	Total	1045452	959			

Table 3-11. The results of the TUKEY tests to determine significant differences (p-value, 0.05) between means for different sample locations. The analysis has been grouped for the hours of midnight to noon and noon to midnight for hourly data collected in September of 2005.

	Mean	SE	Q	QCrit	Sig.
MIDNIGHT TO NOON					
Temperature					
GC01 vs GC02	0.229	0.644	0.356	3.685	not sig
GC01 vs GC03	2.218	0.644	3.443	3.685	not sig
GC01 vs GC04	1.319	0.644	2.047	3.685	not sig
GC02 vs GC03	2.447	0.644	3.799	3.685	significant
GC02 vs GC04	1.548	0.644	2.403	3.685	not sig
GC03 vs GC04	0.899	0.644	1.396	3.685	not sig
Specific Conductance					
GC01 vs GC02	0.023	0.009	2.686	3.685	not sig
GC01 vs GC03	0.062	0.009	7.214	3.685	significant
GC01 vs GC04	0.039	0.009	4.528	3.685	significant
GC02 vs GC03	0.064	0.009	7.499	3.685	significant
GC02 vs GC04	0.103	0.009	12.027	3.685	significant
GC03 vs GC04	0.041	0.009	4.812	3.685	significant
Dissolved Oxygen (mg/L)					
GC01 vs GC02	1.287	0.498	2.583	3.685	not sig
GC01 vs GC03	2.790	0.498	5.600	3.685	significant
GC01 vs GC04	0.800	0.498	1.605	3.685	not sig
GC02 vs GC03	1.503	0.498	3.018	3.685	not sig
GC02 vs GC04	0.487	0.498	0.977	3.685	not sig
GC03 vs GC04	1.990	0.498	3.995	3.685	significant
Dissolved Oxygen (%)					
GC01 vs GC02	13.116	4.641	2.826	3.685	not sig
GC01 vs GC03	22.344	4.641	4.814	3.685	significant
GC01 vs GC04	5.529	4.641	1.191	3.685	not sig
GC02 vs GC03	9.228	4.641	1.988	3.685	not sig
GC02 vs GC04	7.587	4.641	1.635	3.685	not sig
GC03 vs GC04	16.815	4.641	3.623	3.685	not sig
Turbidity (NTU)					
GC01 vs GC02	1.522	1.625	0.937	3.685	not sig
GC01 vs GC03	6.749	1.625	4.153	3.685	significant
GC01 vs GC04	6.977	1.625	4.293	3.685	significant
GC02 vs GC03	5.227	1.625	3.216	3.685	not sig
GC02 vs GC04	5.455	1.625	3.357	3.685	not sig
GC03 vs GC04	0.228	1.625	0.140	3.685	not sig

	Mean	SE	Q	QCrit	Sig.
NOON TO MIDNIGHT					
Temperature					
GC01 vs GC02	0.010	0.648	0.015	3.685	not sig
GC01 vs GC03	1.122	0.648	1.731	3.685	not sig
GC01 vs GC04	0.326	0.648	0.503	3.685	not sig
GC02 vs GC03	1.112	0.648	1.716	3.685	not sig
GC02 vs GC04	0.316	0.648	0.488	3.685	not sig
GC03 vs GC04	0.795	0.648	1.227	3.685	not sig
Specific Conductance					
GC01 vs GC02	0.024	0.011	2.170	3.685	not sig
GC01 vs GC03	0.062	0.011	5.617	3.685	significant
GC01 vs GC04	0.037	0.011	3.332	3.685	not sig
GC02 vs GC03	0.038	0.011	3.447	3.685	not sig
GC02 vs GC04	0.061	0.011	5.501	3.685	significant
GC03 vs GC04	0.099	0.011	8.948	3.685	significant
Dissolved Oxygen (mg/l)					
GC01 vs GC02	1.561	0.730	2.137	3.685	not sig
GC01 vs GC03	2.422	0.730	3.315	3.685	not sig
GC01 vs GC04	1.280	0.730	1.752	3.685	not sig
GC02 vs GC03	0.861	0.730	1.178	3.685	not sig
GC02 vs GC04	0.281	0.730	0.384	3.685	not sig
GC03 vs GC04	1.141	0.730	1.563	3.685	not sig
Dissolved Oxygen (%)					
GC01 vs GC02	15.540	7.492	2.074	3.685	not sig
GC01 vs GC03	21.482	7.492	2.868	3.685	not sig
GC01 vs GC04	12.176	7.492	1.625	3.685	not sig
GC02 vs GC03	5.942	7.492	0.793	3.685	not sig
GC02 vs GC04	3.364	7.492	0.449	3.685	not sig
GC03 vs GC04	9.307	7.492	1.242	3.685	not sig
Turbidity (NTU)					
GC01 vs GC02	1.522	1.624	0.938	3.685	not sig
GC01 vs GC03	6.744	1.624	4.153	3.685	significant
GC01 vs GC04	6.978	1.624	4.298	3.685	significant
GC02 vs GC03	5.222	1.624	3.216	3.685	not sig
GC02 vs GC04	5.456	1.624	3.360	3.685	not sig
GC03 vs GC04	0.234	1.624	0.144	3.685	not sig

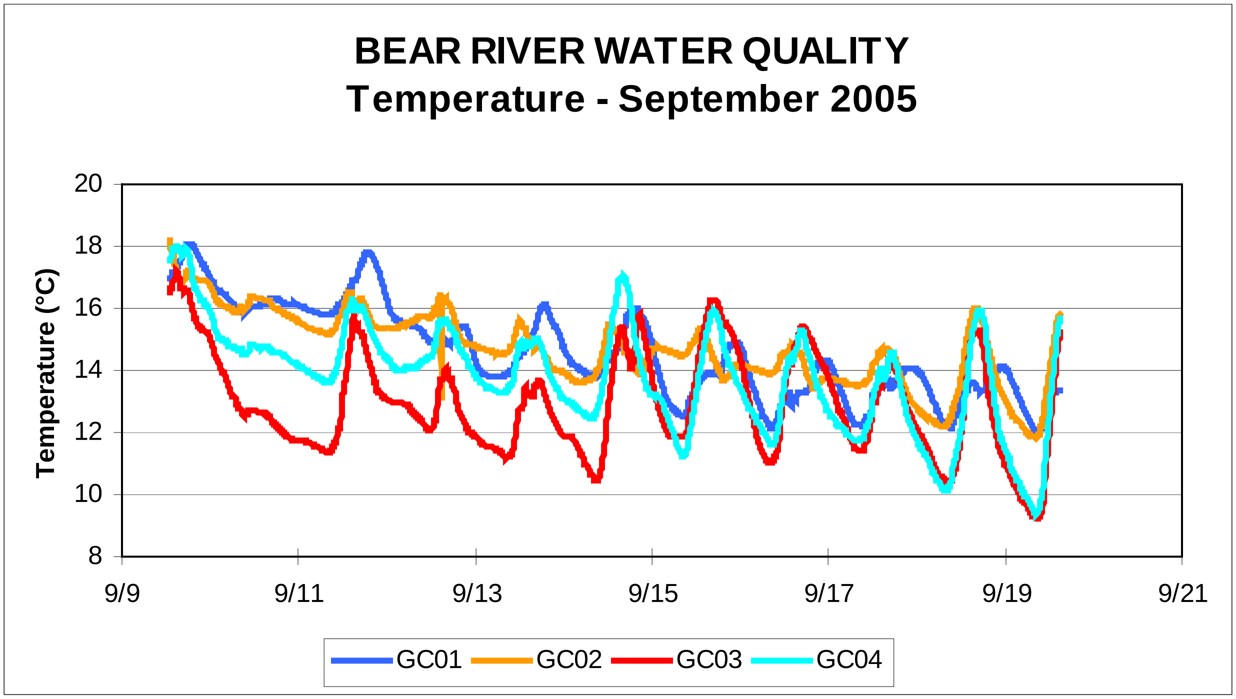


Figure 3-10. Temperature at four monitoring stations during September 2005.

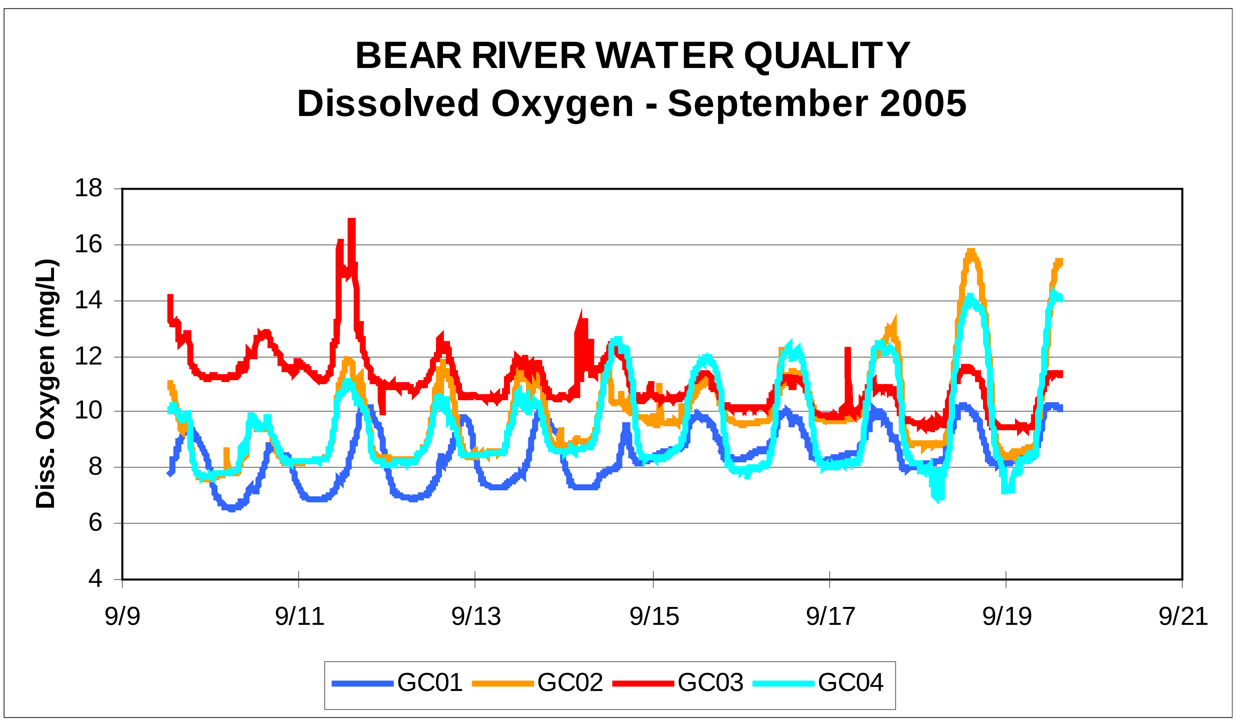


Figure 3-11. Dissolved oxygen at four monitoring stations during September 2005.

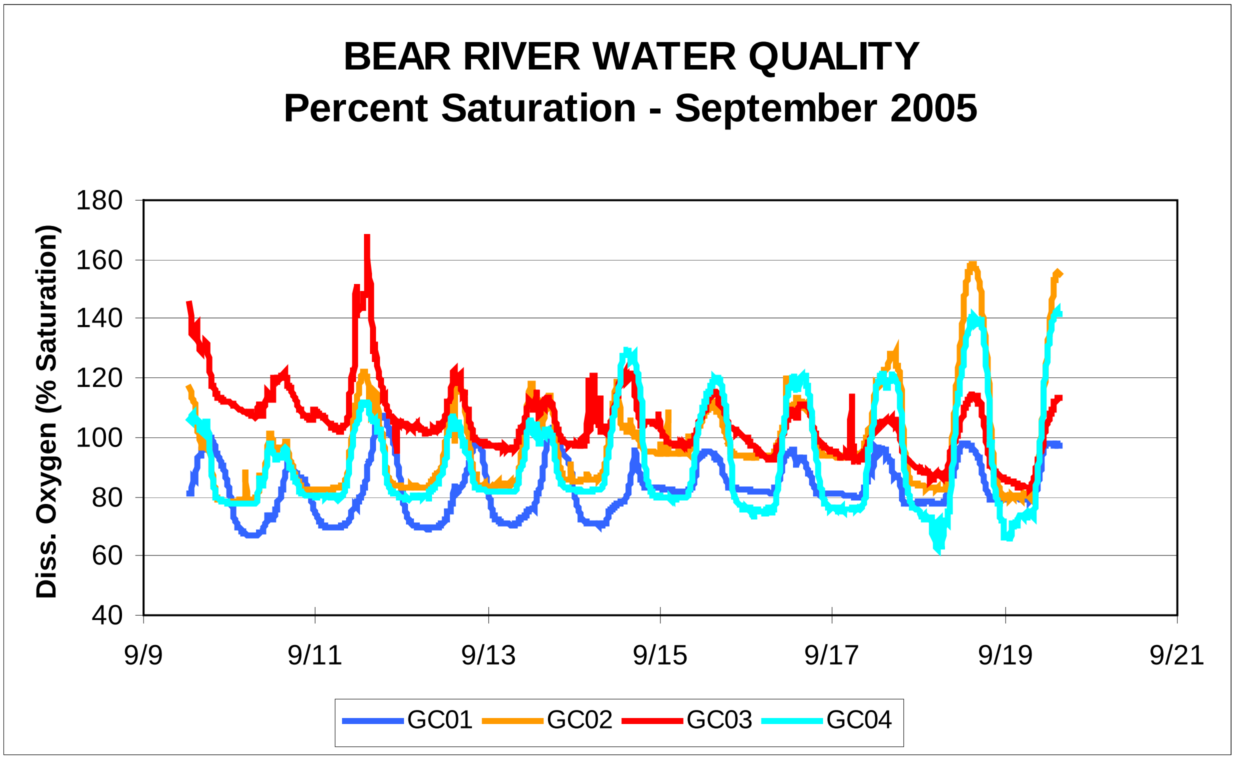


Figure 3-12. Percent saturation of dissolved oxygen at four monitoring stations during September 2005.

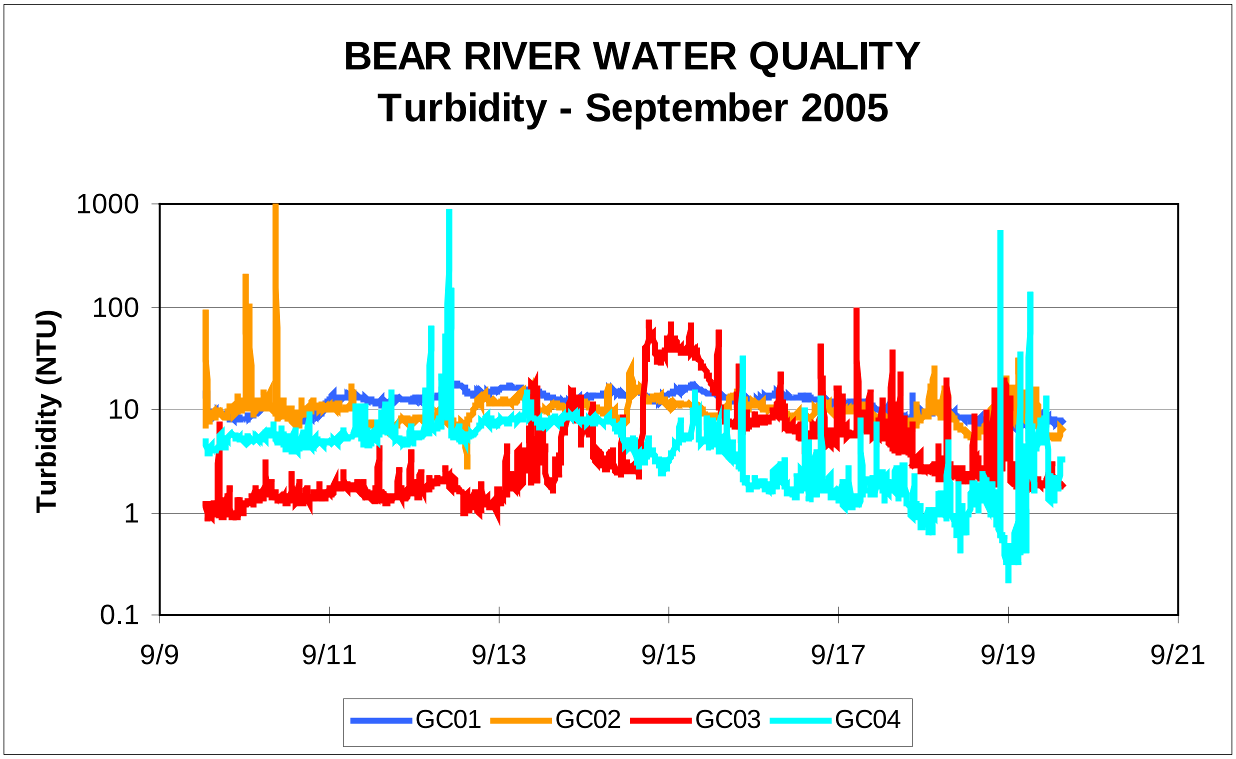


Figure 3-13. Turbidity at four monitoring stations during September 2005.

common throughout the study areas and often lodged onto probes, causing artificially high turbidity readings. To better observe significant relationships for both the Tukey analysis and the pair-wise linear regressions, turbidity observations above 200 NTU were treated as outliers and omitted from analysis.

Pair-wise linear regressions were used to determine if the same pattern of changes were occurring at each site for each parameter. The regressions for the entire September data set (n=969) are shown in Table 3-12. The table includes the coefficient of determination (r^2) and the significance level of the regression relationship. Because of the large sample size (n=969), a large proportion of the regressions are significant. However, inspection of the r^2 value indicates what proportion of the variability at a site can be explained by the second site. For example, the variability in temperature at site GC01 can only explain 21 percent of the variability in temperature at GC03 ($p<0.01$), but can explain 56 percent of the temperature variability at GC02 ($p<0.01$). It is interesting to note that similar to results in August, the highest coefficient of determination was found between GC02 and GC04 for dissolved oxygen.

3.2 Instantaneous Data

Grab samples were collected once during each of the continuous monitoring periods and analyzed by ERI's laboratory. The results of the instantaneous data collections can be seen in Table 3-13.

Total phosphorous was highest in the July at GC03 (0.069 mg/l) and lowest at GC02 (0.052 mg/l). In August, GC01 and GC04 had the highest concentrations of total phosphorus (0.033 mg/l) and the lowest at GC03 (0.023 mg/l). In September, GC04 had the highest concentrations of total phosphorus (0.035 mg/l) and the lowest were recorded at GC02 (0.020 mg/l).

The total inorganic nitrogen, which is made up of nitrate, nitrite and ammonia, did not display the same pattern as phosphorous. Total inorganic nitrogen concentrations in July more than doubled from 0.184 mg/L at GC02 to 0.424 mg/L at GC03. The same pattern was evident between these two stations in August (0.090 mg/L to 0.449 mg/L) and in September (0.125 mg/L to 0.607 mg/L). During all sampling events, the increases in concentrations of TIN were due to increases in nitrate. These results were consistent with the water quality conditions recorded during the 2004 instantaneous sampling efforts. In addition, a comparison with historical instantaneous sampling data obtained during the months of July, August, and September 1994-1996 indicates that with only two exceptions (NO3+NO2 at GC04 in September, and TSS at GC03 in July) all instantaneous water quality data collected in 2005 is within or below the range of historically recorded values for sites GC01, GC03, and GC04 (Figures 1-1 through 1-6). No data was obtained from site GC02 during the 1994-1996 monitoring effort.

3.3 Water Quality Compliance

The second objective of this investigation was to help determine the Development's contribution, if any, to violations of water quality criteria as set forth in the Idaho Water Quality Standards and Wastewater Treatment Requirements, IDAPA 53.01.02 (Water Quality Standards). A comparison of each site and sample event to the IDAPA Water Quality Standards was undertaken utilizing the hourly data collected in this investigation. The results of that

Table 3-12. The results of the paired linear regressions between the four sample sites on the Bear River during August 2005.

	N	R2	Sig. Level
TEMPERATURE			
GC01 vs GC02	969	0.559	0.000
GC01 vs GC03	969	0.217	0.000
GC01 vs GC04	969	0.542	0.000
GC02 vs GC03	969	0.297	0.000
GC02 vs GC04	969	0.715	0.000
GC03 vs GC04	969	0.651	0.000
SPECIFIC CONDUCTANCE			
GC01 vs GC02	969	0.02	0.000
GC01 vs GC03	969	0	0.744
GC01 vs GC04	969	0.137	0.000
GC02 vs GC03	969	0.02	0.000
GC02 vs GC04	969	0	0.835
GC03 vs GC04	969	0.266	0.000
DISSOLVED OXYGEN (%)			
GC01 vs GC02	969	0.256	0.000
GC01 vs GC03	969	0.066	0.000
GC01 vs GC04	969	0.268	0.000
GC02 vs GC03	969	0.167	0.000
GC02 vs GC04	969	0.781	0.000
GC03 vs GC04	969	0.29	0.000
DISSOLVED OXYGEN (MG/L)			
GC01 vs GC02	969	0.361	0.000
GC01 vs GC03	969	0.001	0.476
GC01 vs GC04	969	0.329	0.000
GC02 vs GC03	969	0.055	0.000
GC02 vs GC04	969	0.796	0.000
GC03 vs GC04	969	0.135	0.000
TURBIDITY (NTU)			
GC01 vs GC02	967	0.014	0.000
GC01 vs GC03	969	0.074	0.000
GC01 vs GC04	967	0.037	0.000
GC02 vs GC03	967	0.007	0.008
GC02 vs GC04	965	0	0.829
GC03 vs GC04	967	0.002	0.175

Table 3-13. The water quality data collected as grab samples within the Bear River during 2005.

Date	Time	Site	Log#	NH3 (mg/L)	NO2 (mg/L)	NO3+NO2 (mg/L)	TIN (mg/L)	OP (mg/L)	TP (mg/L)	TSS (mg/L)	TURB (NTU)
JULY											
7/25/05	12:35 pm	GC01	51052	0.056	0.016	0.111	0.168	0.016	0.053	15.329	7.5
7/25/05	12:25 pm	GC02	51053	0.063	0.015	0.120	0.184	0.015	0.052	12	7.6
7/25/05	12:00pm	GC03	51054	0.044	0.009	0.380	0.424	0.010	0.069	48.198	12
7/25/05	11:40am	GC04	51055	0.036	0.014	0.272	0.307	0.015	0.062	18.313	8.6
AUGUST											
8/11/05	2:40 pm	GC01	51180	0.051	0.006	0.094	0.146	0.007	0.033	7.548	5.4
8/11/05	2:40 pm	GC02	51181	0.056	0.008	0.134	0.190	0.009	0.025	5.594	4.9
8/11/05	1:20 pm	GC03	51182	0.037	0.004	0.410	0.449	0.011	0.023	5.310	1.3
8/11/05	2:05 pm	GC04	51183	0.094	0.006	0.296	0.391	0.012	0.033	7.94	5.1
SEPTEMBER											
9/7/05	1:50 pm	GC01	51341	0.038	0.007	0.113	0.151	0.011	0.029	11.949	7.2
9/7/05	1:30 pm	GC02	51342	0.033	0.004	0.091	0.125	0.006	0.020	4.063	4.5
9/7/05	1:00 pm	GC03	51343	0.032	0.004	0.575	0.607	0.021	0.032	1.770	<1
9/7/05	11:50 am	GC04	51344	0.043	0.004	0.553	0.596	0.018	0.035	5.32	3

analysis can be seen in Table 3-14. The instantaneous temperature requirement for the prescribed beneficial use of this section of the Bear River was exceeded at all sites during July and August. The second standard is average daily temperature. This parameter was exceeded at every site in July and August.

The second water quality standard parameter is dissolved oxygen. The instantaneous concentration was lower than the standard at GC02 (1%) and GC04 (71%) in July, and only GC01 (27%) in August. The additional associated parameter dissolved oxygen (expressed as a percent of atmosphere) exceeded water quality standards at all sites during all months. Exceedences were the lowest in July at GC03 (50%), in August at GC03 (5%) and in September at GC01 (72%). The highest exceedences in July were at GC01 and GC04 (100.0%), in August at GC03 (97%) and in September at GC02 (72%).

4.0 QUALITY CONTROL

This section will evaluate the quality assurance of sampling, sample handling, field techniques, field analyses, and data treatment. The procedures for calibration, maintenance, and downloading of the YSI Model 6920, used for the continuous monitoring task of this Development, will also be included in this section.

Specific data quality objectives for accuracy and precision of sampling are for measurements to fall within a 95 percent confidence interval around the true value. The confidence interval for each parameter is based on prior knowledge of the measurement system and is generated from the EPA publication "Estimation of Generic Acceptance Limits for Quality Control Purposes for Use in a Water Pollution Laboratory" (May 1991).

4.1 Continuously Monitoring Probes

Four YSI Model 6920 monitoring probes were installed at each of the stations. A backup probe was available in the case any problems were encountered with the equipment. Custom steel boxes were built in order to house, conceal and protect each probe. The probes were calibrated for each parameter according to the manufacturer's specifications (YSI 2001) before being placed in the field. Data were downloaded at the end of each continuous 7-day monitoring period using a laptop computer and the software EcoWatch for Windows. Each time the monitoring field crew was at the site, a grab sample was also taken. The probe was placed in a known calibration standard to record turbidity drift. This *in situ* measurement was compared to the standard and percent error was determined. The probe was then cleaned and calibrated in the field were run prior to and after the continuous 7-day sampling period. The QA/QC data is provided in Table 4-3. The program determined that no data was disqualified as per Table 4-2 for any site or time.

Table 3-14. The frequency of exceedences of relevant IDAPA 53.01.02 Water Quality Standards for the Bear River within the study site.

	Instant. Temp. (>22 C)		Daily Average Temp. (>19 C)		Instant. DO (< 6 mg/L)		DO, % of Atmosp. (>110%)	
	% Exceed	**N**	**% Exceed**	**N**	**% Exceed**	**N**	**% Exceed**	**N**
July								
GC01	65%	719	100%	8	0%	719	0%	719
GC02	85%	719	100%	8	1%	719	26%	719
GC03	19%	719	100%	8	0%	719	50%	719
GC04	45%	719	100%	8	26%	268	0%	268
August								
GC01	27%	670	100%	7	27%	670	3%	670
GC02	4%	670	100%	7	0%	670	28%	670
GC03	3%	670	71%	7	0%	670	95%	670
GC04	11%	670	100%	7	0%	670	6%	670
September								
GC01	0%	969	0%	10	0%	969	0%	969
GC02	0%	969	0%	10	0%	969	20%	969
GC03	0%	969	0%	10	0%	969	27%	969
GC04	0%	969	0%	10	0%	969	18%	969

Table 4-1. Rating continuous water quality records (Source: USGS, 2000. WRIR 00-4252, Table 9).

Measured physical property	RATINGS			
	Excellent	Good	Fair	Poor
Water temperature	≤ ± 0.2°C	> ± 0.2 to 0.5°C	> ± 0.5 to 0.8°C	> ± 0.8°C
Specific Conductance	≤ ± 3 %	> ± 3 to 10 %	> ± 10 to 15 %	> ± 15 %
Dissolved oxygen	≤ ± 0.3 mg/L	> ± 0.3 to 0.5 mg/L	> ± 0.3 to 1.0 mg/L	> ± 1.0 mg/L
pH	≤ ± 0.2 unit	> ± 0.2 to 0.5 units	> ± 0.5 to 0.8 units	> ± 0.8 units
Turbidity	≤ ± 5 %	> ± 5 to 10 %	> ± 10 to 15 %	> ± 15%

Table 4-2. Rejection criteria for continuous water-quality monitoring sensors.

Constituent	Manufacturer's Specifications[a]	Maximum Allowable Limits (USGS)[b]
Water temperature	> ± 0.15°C	> ± 2.0°C
Specific Conductance	> ± 0.5 %	> ± 30 %
Dissolved oxygen	> ± 0.2 mg/L or ± 2%, whichever is greater	> ± 2.0 mg/L or ± 20%, whichever is greater
pH	> ± 0.2 units	> ± 2.0 units
Turbidity	> ± 5% or 2 NTU whichever is greater	> ± 30%

[a] YSI Incorporated. 6-Series Environmental Monitoring Systems Operations Manual
[b] USGS, 2000. WRIR 00-4252, Table 8.

Table 4-3. Turbidity calibration data and percent error for continuous monitoring turbidity measurements taken during the summer of 2005. Ratings for turbidity were categorized as excellent, with the exception of the September dataset for station GC02, which was categorized as good.

	Standard: 40 NTU		Standard: 80 NTU		Avg % Error
	Turbidity	% Error	Turbidity	% Error	
July 25, 2005					
GC01	42.6	6.5%	78.3	2.1%	4.3%
GC02	40.3	0.7%	85.2	6.5%	3.6%
GC03	39.8	0.5%	76.2	4.7%	2.6%
GC04	42.1	5.3%	82.8	3.5%	4.4%
August 11, 2005					
GC01	38.9	2.8%	79.6	0.5%	1.6%
GC02	40.5	1.3%	84.3	5.4%	3.3%
GC03	42.6	6.5%	79.2	1.0%	3.8%
GC04	40.7	1.8%	83.6	4.5%	3.1%
September 19, 2005					
GC01	39.4	1.5%	84.5	5.6%	3.6%
GC02	43.2	8.0%	86.1	7.6%	7.8%
GC03	41.3	3.3%	82.1	2.6%	2.9%
GC04	41.3	3.3%	86.1	7.6%	5.4%

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