Grace Hydroelectric Project

Boater Flow Water Quality Study

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1.0 INTRODUCTION

This report summarizes water quality monitoring conducted for the purpose of evaluating operations of the Grace Hydroelectric Project on the Bear River, Idaho from 2008 through 2010. As a license condition, the hydroelectric project is required to shut down the Grace Plant up to sixteen times and divert water to the Black Canyon when flows above 700 cfs are available between April 1 and July 15 on weekends. Concerns were raised during the first flows in 2008 over the potential effects of these releases on water quality, primarily the potential for mobilization of sediments within Black Canyon. Adverse effects on water quality have the potential to impact the trout fishery.

The objectives of this study were to collect detailed spatial and temporal data in Black Canyon of the Bear River for temperature, dissolved oxygen (DO), and turbidity and, based on those results, to evaluate the potential risk of these releases on aquatic life.

2.0 RELEVANT WATER QUALITY STANDARDS AND POTENTIAL ISSUES

2.1 Temperature

2.1.1 IDEQ Standard

According to the Idaho Surface Water Quality Standards set forth by the Idaho Department of Environmental Quality (IDEQ), temperature standards vary by the designated beneficial use classification (IDEQ 2008). The Bear River at Black Canyon has been designated COLD/SS, meaning it is a cold body of water with salmonid spawning. As stated in Section 250.02(b), the standard for cold water is:

> *Water temperatures of twenty-two (22) degrees C or less with a maximum daily average of no greater than nineteen (19) degrees C.*

However, during the spawning season the standard is more restrictive, as indicated under Section 250.02(f)(ii):

> *Water temperatures of thirteen (13) degrees C or less with a maximum daily average of no greater than nine (9) degrees C.*

Spawning and incubation periods for rainbow have been generally listed as March 15 to July 15 (Grafe et al. 2002). Spawning periods for Bonneville Cutthroat vary depending on elevation and temperature (May et al. 1978). But generally have been listed as spawning from May to June.

2.1.2 Issue

Whitewater releases could alter water temperature in a manner that adversely affects developing rainbow trout eggs.

2.2 Dissolved Oxygen

2.2.1 IDEQ Standard

Under Section 250.02(f)(i)(2)(a), the dissolved oxygen (DO) criteria for salmonid spawning are:

One (1) day minimum of not less than six point zero (6.0) mg/l or ninety percent (90%) of saturation, whichever is greater.

2.2.2 Issue

Potential release of buried organic matter during whitewater releases could produce a short-term, localized increase in the biological oxygen demand if the material remained in Black Canyon, potentially resulting in a decrease in DO. However, this case is considered unlikely because high flows through Black Canyon would likely transport most organic matter out of the reach.

2.3 Turbidity

2.3.1 IDEQ Standard

Turbidity standards are described by IDEQ (2008) under Section 250.02(e) as follows:

Turbidity, below any applicable mixing zone set by the Department, shall not exceed background turbidity by more than fifty (50) NTU instantaneously or more than twenty-five (25) NTU for more than ten (10) consecutive days.

2.3.2 Issue

Within Black Canyon, required minimum flow releases from the Grace Forebay are set at a minimum of 65 cfs or inflow if less. The Bear River is known for elevated levels of suspended solids arising from various sources; thus, accumulation of sediments could occur over the long term. Periodic flow spikes have the potential to mobilize sediment from stream banks and quiescent areas of the river. This sediment could have adverse effects on aquatic organisms. An example of this would be re-deposition over mainstem trout spawning redds.

3.0 METHODS

3.1 Hydrology

All hydrologic data for Grace Forebay flow releases into Black Canyon were obtained from PacifiCorp. Management of these flows was solely for whitewater releases.

3.2 Monitoring

To determine compliance with IDEQ water quality criteria during whitewater events, the two sites described below were monitored for temperature, DO and turbidity using YSI 6920 sondes. Data were collected beginning 12 hours prior to releases and until flows returned to normal.

The “Grace Forebay” site was located above Black Canyon to reflect background environmental conditions. The “Black Canyon” site served as the compliance point during whitewater releases and was located immediately downstream of the fisherman's bridge in the Black Canyon (Figure 1).

Steel cylinders were built to house, conceal and protect probes. These casings were perforated for water circulation with holes ranging from 1 to 2 inches in diameter. Values were recorded at 15-minute intervals throughout the study period. Calibration of field equipment was done in accordance with YSI® guidelines, immediately prior to each use in the field.

3.3 Loading Analysis

The intent of this analysis was to evaluate annual loading of sediments within the bypass reach. Turbidity data were obtained from several sources: 1) turbidity monitoring during whitewater releases, 2008-2010; 2) turbidity and TSS monitoring from the Bear River TMDL; and 3) turbidity monitoring from the Grace Hydroelectric Project, 2004-2007. Flow data acquired from PacifiCorp was used to estimate loading rates. The analysis focused on sediment transport into Black Canyon as measured at the lower monitoring site, but did not assess the fate of this material.

4.0 RESULTS

4.1 Hydrology

From April 1, through July 15 of each of three study years, scheduled and flow dependent releases were passed from the Grace Forebay into the Black Canyon (bypassing the Grace Flow Line and Plant). In each of the three years scheduled releases were run to conduct a fish stranding study that evaluated the effects of different down ramp rates in each of the three years. Flow dependent releases happened when calculated inflow to the Grace Forebay exceeded 700 cfs. Both scheduled and flow dependent releases happened on weekends exclusive of holiday weekends. This study measured water quality for the first five events each year regardless of type (scheduled or flow dependent). Average daily whitewater releases from 2008 to 2010 were plotted in relation to monitoring trip dates in Figure 2. Releases during the study were similar from year to year. Average flows for 2008, 2009 and 2010 were recorded at 1069, 907 and 1020 cfs, respectively. A total of 17 whitewater releases occurred over the study period. Four of the 17 events occurred within 24 hours of the previous event and 3 events were not measured. Minimum flow conditions through the Grace bypass (i.e., Black Canyon) are 65 cfs or inflow to the Grace Forebay if less, as specified under the project license conditions.

4.2 Temperature

Temporal patterns in water temperature at the two study sites are depicted in Figures 3 and 4. Temperatures were fairly similar between sites with the coldest temperatures occurring in April, typically from 5 to 10°C, and July temperatures reaching 19 to 22°C. Temperatures at the Grace Forebay exhibited much less of a diurnal pattern, while Black Canyon generally had more pronounced daily fluctuations and tracked ambient temperatures more closely. The greatest daily fluctuation in temperatures occurred during July.

Temperatures were higher at the Black Canyon site than in the Grace Forebay during whitewater releases (Figures 3 and 4). Figure 4 shows temperatures fluctuate <1°C on average during the initial surge, with the exception of July whitewater events. Temperatures increased in Black Canyon 2.6°C following the July 2008 whitewater release from the forebay.

4.3 Turbidity

Continuous monitoring in Black Canyon indicated that turbidity ranged between 1 and 7 NTU prior to whitewater events throughout the study period (Figures 5, 6 and 7). Higher pre-event turbidity values were observed typically during the spring.

Turbidity ranged from 5 to 40 during continuous monitoring in the Grace Forebay. Values at the forebay were lower in the spring and increased throughout each study season (Figures 8, 9 and 10). Increasing turbidity values could be caused by spring runoff, irrigation return or irrigation water deliveries from Bear Lake that increase river flows during the irrigation season. Effects of whitewater releases on turbidity are illustrated in Figures 8, 9 and 10. For graphical presentation, events were offset to exemplify the turbidity spikes associated with each release. The highest turbidity value measured during each whitewater release occurred during the initial surge of water. Maximum turbidity spikes ranged from 113 to 1189 NTU, with the lowest occurring in April 2009 and the highest in April 2010. During the first whitewater release in 2008, turbidity measurements spiked to 604 NTU with the second release spiking to 514 NTU (Figure 8). No grab samples were taken to compare field turbidity measurements to lab certified measurements throughout the study. In comparing the 2008 releases, a 100 NTU would be considered a considerable drop in measurements. A more notable observation is the duration at which turbidity remained above the IDEQ standard. During 2008 the first whitewater release maintained turbidity readings above the standard for 5 hours, while the second release maintained turbidity reading for 4 hours above standards.

In 2009, five whitewater releases were conducted through the Black Canyon. Turbidity spikes were similar to those observed in 2008 with the largest spike occurring during the initial surge. However, the magnitude of turbidity was at substantially lower levels than 2008 (Figure 9). The highest recorded turbidity in 2009 occurred in early June 2009 (450 NTU), while the lowest was recorded in April 2009 (124 NTU).

Turbidity increased throughout the year and declined to near April 2009 levels in late June 2009 during the last release. Average flows during each of the five events were similar, ranging from 845 to 954 cfs. It is interesting to note the increasing turbidity with each event. With each event, duration of turbidity exceeding Water Quality Standards increased. During the first release, exceedance occurred for 1.25 hours, increasing to 4 hours during the May event and returning to 2 hours in late June. Average exceedance for 2009 was 2.45 hours compared to 4.75 hours in 2008.

In 2010, three whitewater releases were conducted in Black Canyon. Turbidity spikes were at much higher levels than previous years (Figure 10). In April 2010, turbidity was higher than the previous eight releases. Turbidity levels reached a maximum of 1,189 NTU, following releases in 2010 were observed at 600 and 743 NTU in May and June respectively. The duration of turbidity exceeding the standard was also much higher with the maximum occurring in April at 10 hours, while May and June were observed at 4.5 and 9.25 hours, respectively. Average exceedance of the turbidity standard in 2010 was 7.9 hours.

This increase in turbidity in 2010 was likely due to work conducted in Alexander Reservoir during 2009. Reservoir elevation was lowered to perform maintenance on dam gate structures, providing opportunity to pass fine sediments downstream into Black Canyon. Considering the 65 cfs discharge into Black Canyon potentially large quantities could have been deposited. These loose fines could then be mobilized and transported through the system during the first whitewater release in 2010.

4.4 Dissolved Oxygen

Monitoring during 2008, 2009 and 2010 indicate that DO levels measured in Bear River sites were above the compliance standard of 6 mg/L throughout the study (Figures 11 and 12). Peak DO was reached typically during the spring and the lowest levels occurred during the summer. DO levels tend to be higher in Black Canyon than in the forebay. This may reflect accrual of DO from primary production in the clearer waters of the canyon.

Some diel patterns were revealed during the monitoring at both sites, primarily in Black Canyon prior to whitewater releases, with levels increasing from morning to the afternoon (Figure 11). Amplitudes of these fluctuations were similar during all events. This pattern reflects rates of photosynthesis in relation to the intensity of sunlight. DO in the forebay showed little or no diel pattern (Figure 12). This is likely due to increased turbidity and depth which reduce the potential for photosynthesis.

During whitewater releases, DO in the Black Canyon shows a rapid decrease (Figure 11). DO concentrations decreased over a one-hour period, ranging from 0.5 mg/L in April 2009 to 3.0 mg/L in May 2010. This rapid decrease in DO occurs as the initial surge of water from the forebay arrives at the Black Canyon site. Multiple factors may be responsible, such as: 1) higher turbidity suppressing photosynthesis; 2) organic material consuming oxygen; and 3) increased turbulence that releases excess gases held in suspension. Accordingly, percent saturation of DO in Black Canyon would be expected to be lower after the initial surge of water and this is what was observed (Figure 13).

Some minor sensor problems occurred during the study period and are noteworthy. In 2010, only a partial set could be qualified in July as sensor failure occurred midway through the monitoring. DO levels become erratic and may have been the result of a failing electrolyte or perforated membrane. Generally, however, the vast majority of the monitoring efforts were successful.

4.5 Loading

The Black Canyon reach of the Bear River receives substantially more water under the current FERC License Article 408 than it did historically. License conditions require 63 cfs of minimum flow plus two cfs leakage for a total of 65 cfs of Minimum Stream Flow or inflow if less. Prior to the issuance of the 2003 license there was no requirement for minimum flow in the Black Canyon. Prior to 2003 all inflows into the Grace Forebay were used for generation unless inflows exceed the plant capacity of approximately 1000 cfs. Monthly average flows for 2008, 2009 and 2010 can be seen in Figure 14. Average daily releases were 92, 95 and 104 cfs during the three study years.

Historical turbidity and total suspended solids (TSS) data were used to build a relationship between these two parameters (Figure 15). In addition, turbidity data collected during the Bear River TMDL and Grace Cove was used to predict the average turbidity value expected at the Grace Forebay site. Average turbidity recorded during the whitewater study averaged 14 NTU, while the average turbidity recorded near the Grace Forebay during the Grace Cove study averaged 33 NTU (ERI 2007). Historical observations suggest winter flows in the Bear River have a lower turbidity value, while summer time flows have higher NTU values (ERI 2004). The Grace Cove study was conducted in the summer months, so averages from our study should be consistent with annual average recorded turbidity values suspected at the forebay. Given the relationship between turbidity and TSS, average turbidity at the Grace Forebay can be converted to TSS with some statistical accuracy. Using an average turbidity, TSS on average would be expected to be 7.18 mg/L. Using the average annual flows for the above study period annual loading would be 650, 672 and 677 tons of sediment deposited into Black Canyon. This simple analysis would suggest over a period of years significant deposition would occur within Black Canyon. However, estimations for 2010 using historical average are underestimating the potential loading which occurred in summer and winter of 2009/2010. Given the high measurements in the turbidity readings in 2010, loading would probably be significantly higher than estimated.

5.0 SUMMARY

The purpose of this study was to document water quality conditions during whitewater releases through Black Canyon, thereby determining potential risks associated with such releases. Whitewater releases during 2008, 2009 and 2010 affected water quality in Black Canyon in several noteworthy ways. Of principal interest were the following:

1) Temperature levels in Black Canyon can increase markedly as water is released from the forebay during summer;
2) Turbidity levels spike quickly above the standard, but return to acceptable levels rapidly;
3) The magnitude of turbidity spikes do not appear to be flow dependent;
4) DO levels at both sites remained above the standard of 6 mg/L throughout all events; and
5) Annual sediment loading into Black Canyon may exceed 600 tons, but the degree of retention in the canyon is unknown.

Although whitewater releases affected temperature in Black Canyon, at times decreasing or increasing, such changes were relatively brief in duration (i.e., hours), before resuming a typical diel pattern. The greatest effect occurred during summer releases when temperatures increased by several Celsius degrees, but appeared to be within the acceptable standards.

Dissolved oxygen measured during the study remained within acceptable standards (>6.0 mg/L), although DO showed substantial decreases during most releases. A maximum of 3.0 mg/L decline was observed in May 2010. Because declines remained within acceptable levels and were very brief, we conclude that it is unlikely they were detrimental to aquatic life.

In 2009 turbidity was recorded at much lower levels during all events than in 2008, suggesting that some scouring and removal of fines from the system may have taken place during 2008. In addition to the reduced magnitude of turbidity spikes, the duration during which turbidity exceeded water quality standards was substantially reduced. These whitewater releases can also be viewed as flushing flows for sediments that have accumulated over time in the river.

Turbidity peaked during the initial water surge of each whitewater release, with the greatest spike occurring in April of 2010. However, unique conditions were present in Black Canyon prior to the 2010 releases. Sediments from Alexander Reservoir appear to have been mobilized when reservoir elevation was dropped for maintenance work on the dam outlet, creating a higher than normal loading within Black Canyon during the summer of 2009.

6.0 LITERATURE CITED

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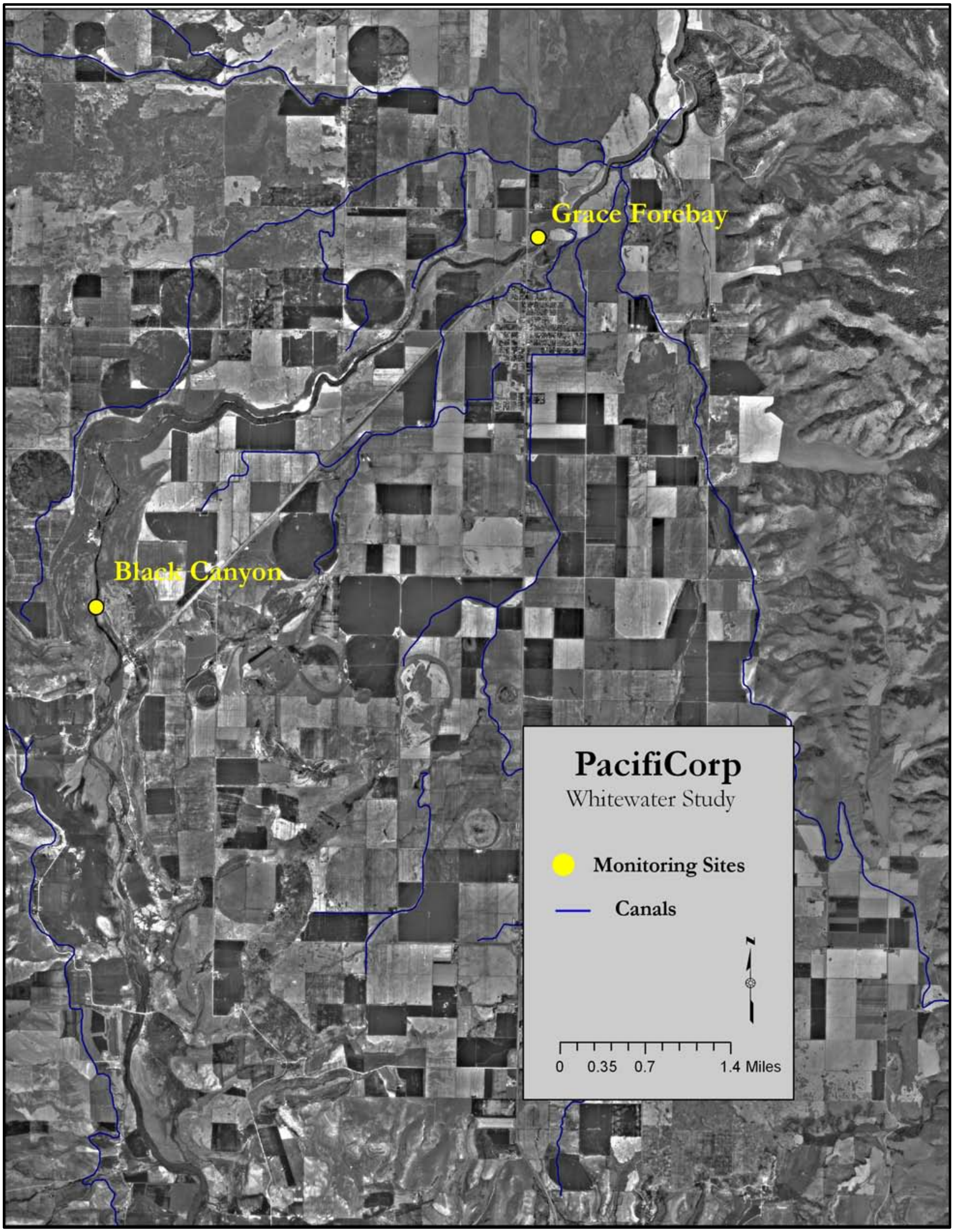

Figure 1. Locations of the monitoring sites for the whitewater releases.

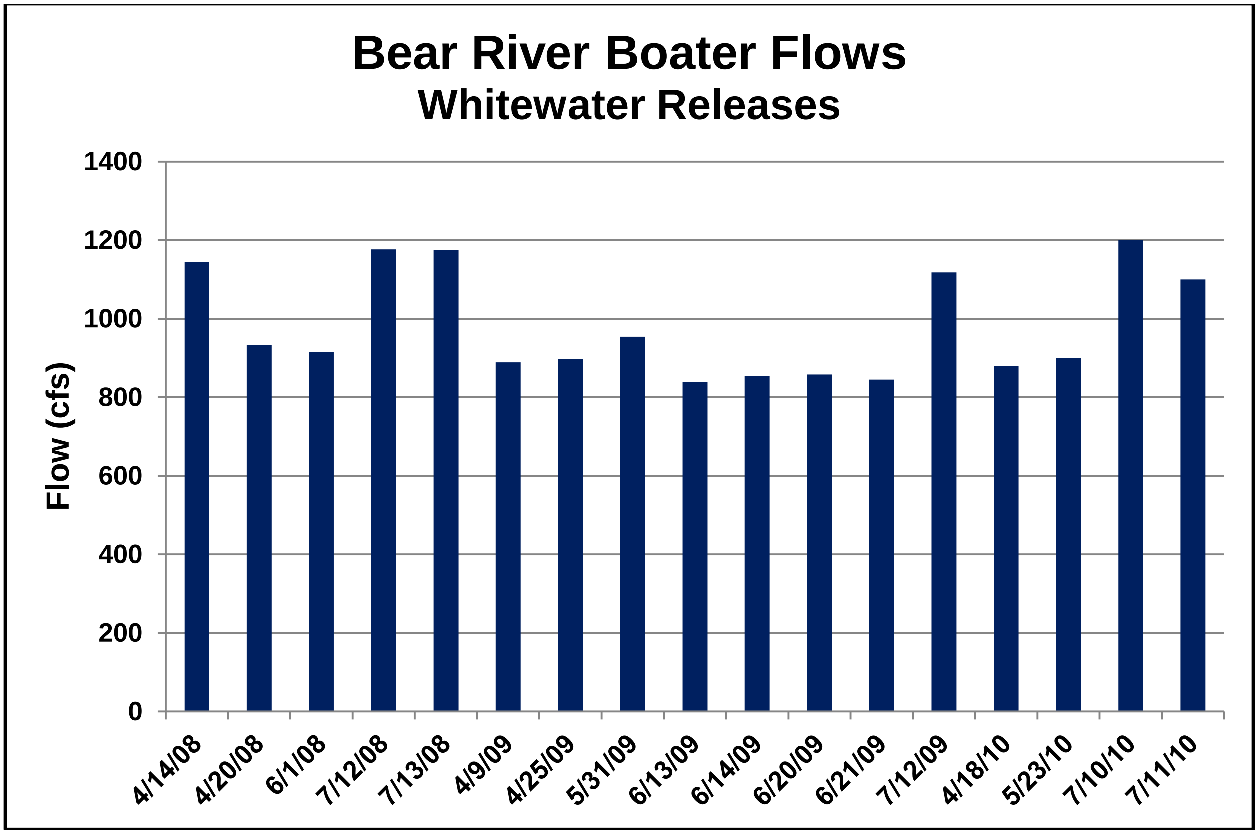

Figure 2. Average flows for each of the white water events for 2008, 2009 and 2010.

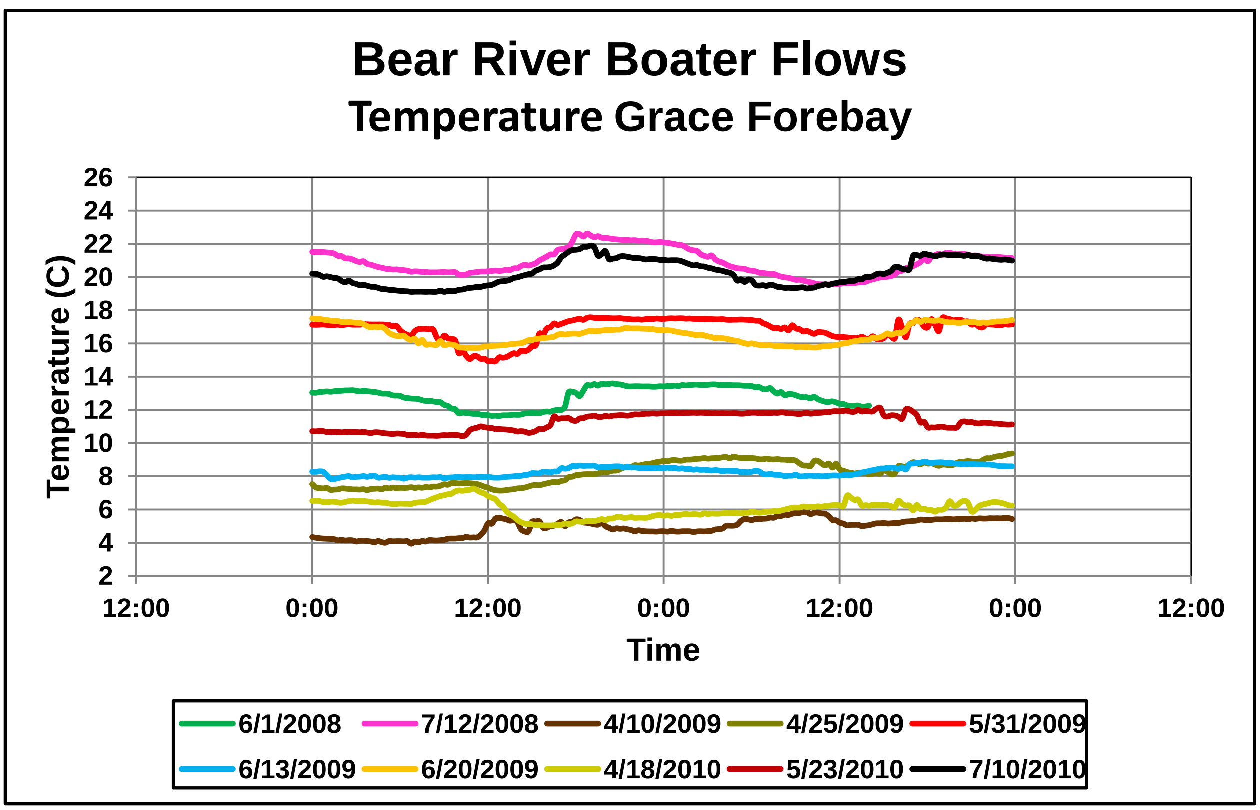

Figure 3. Temperatures during each whitewater event in the Grace Forebay, 2008-2010.

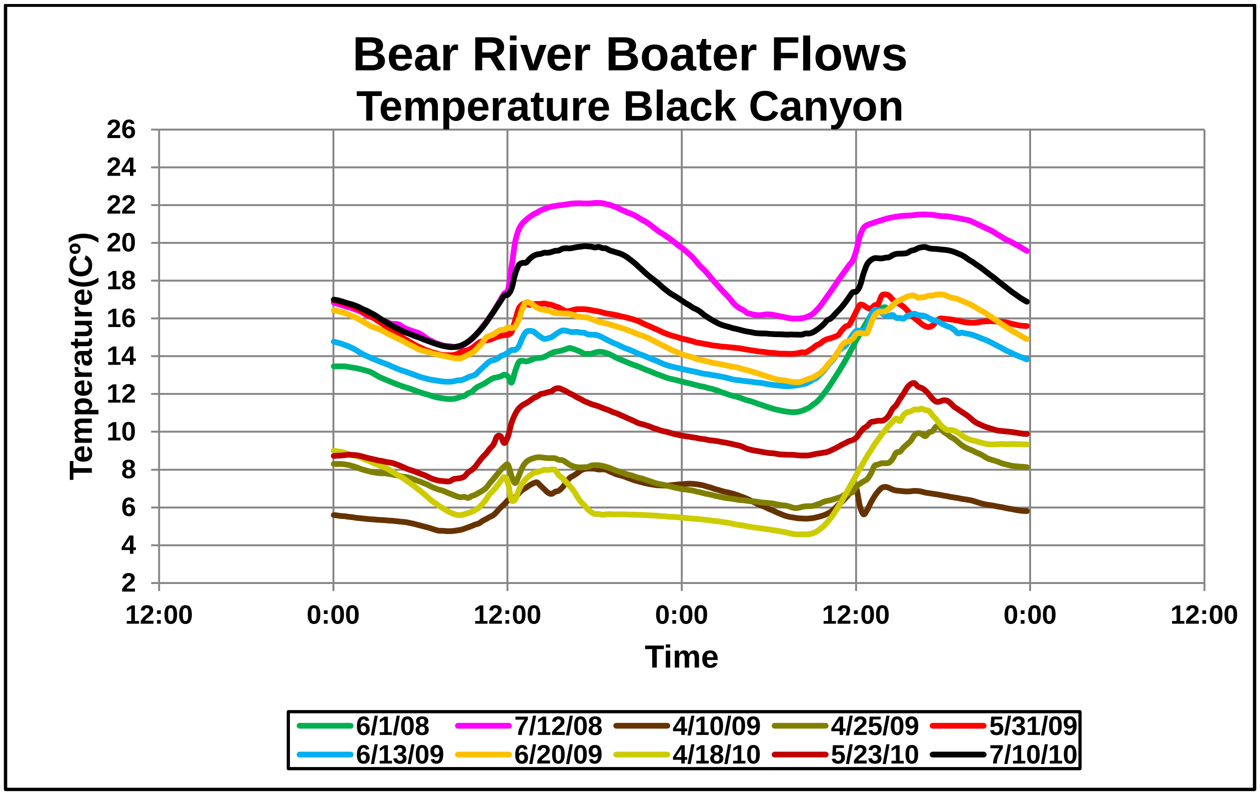

Figure 4. Temperatures during each whitewater event in Black Canyon, 2008-2010.

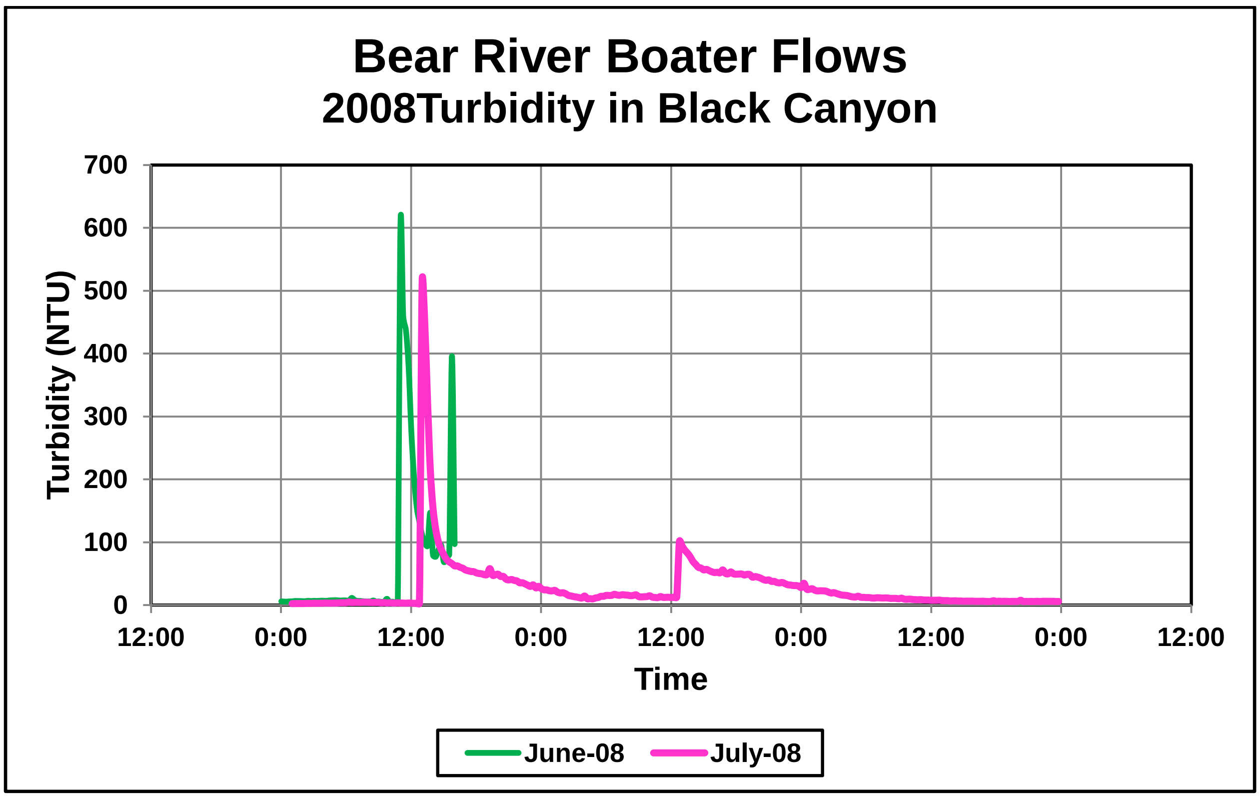

Figure 5. Turbidity in Black Canyon, 2008.

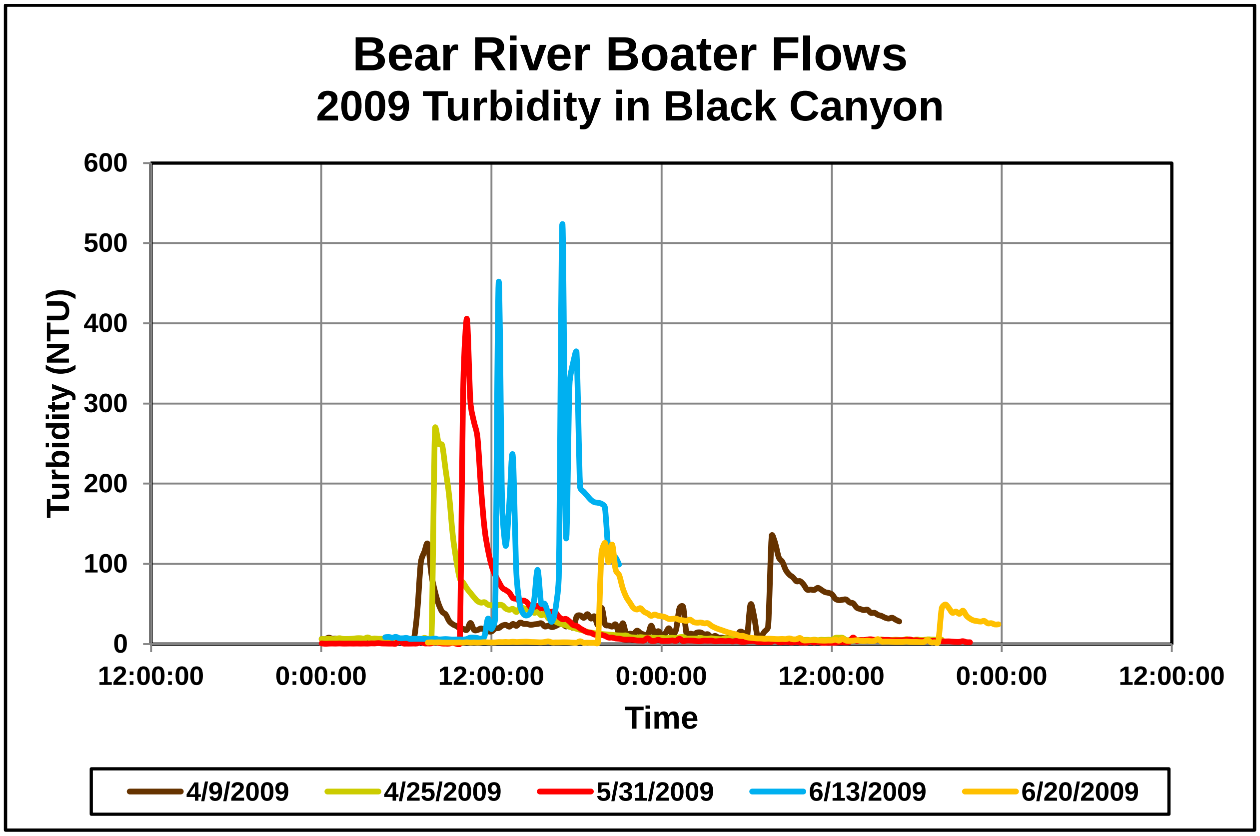

Figure 6. Turbidity in Black Canyon, 2009.

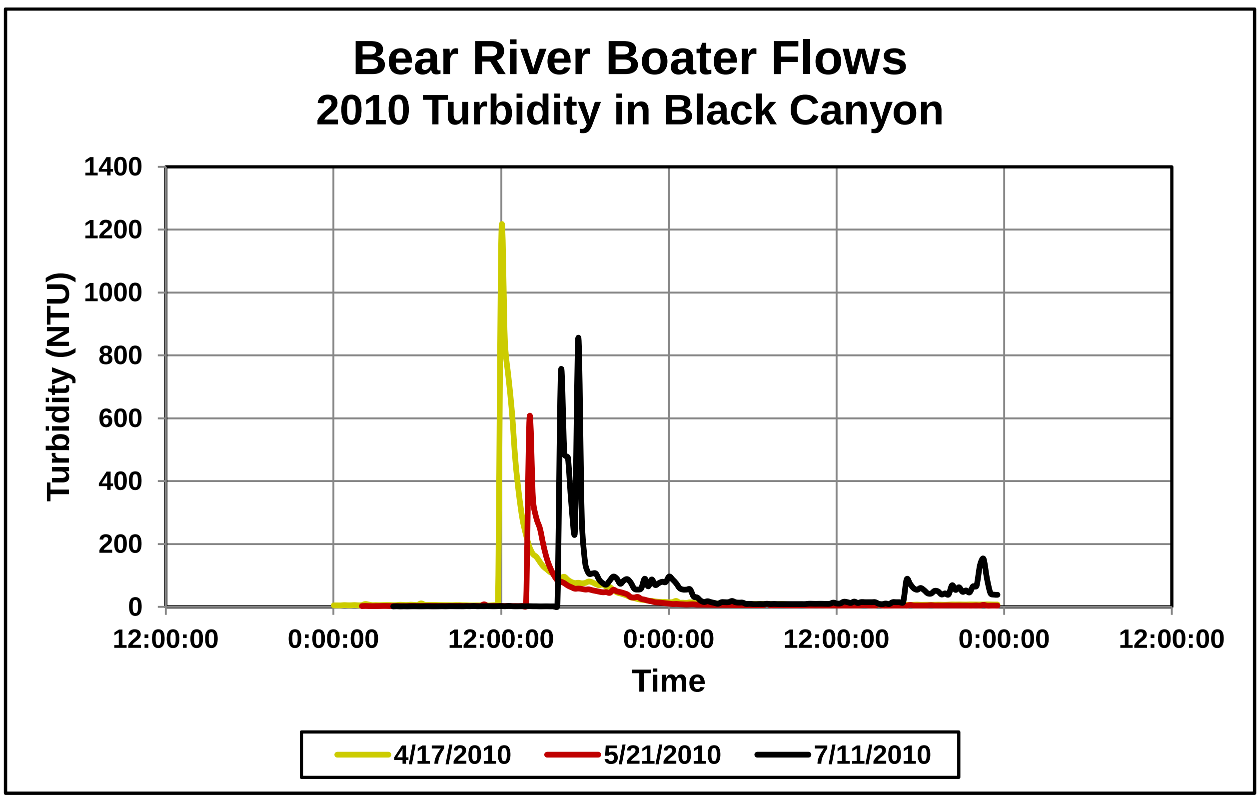

Figure 7. Turbidity in Black Canyon, 2010.

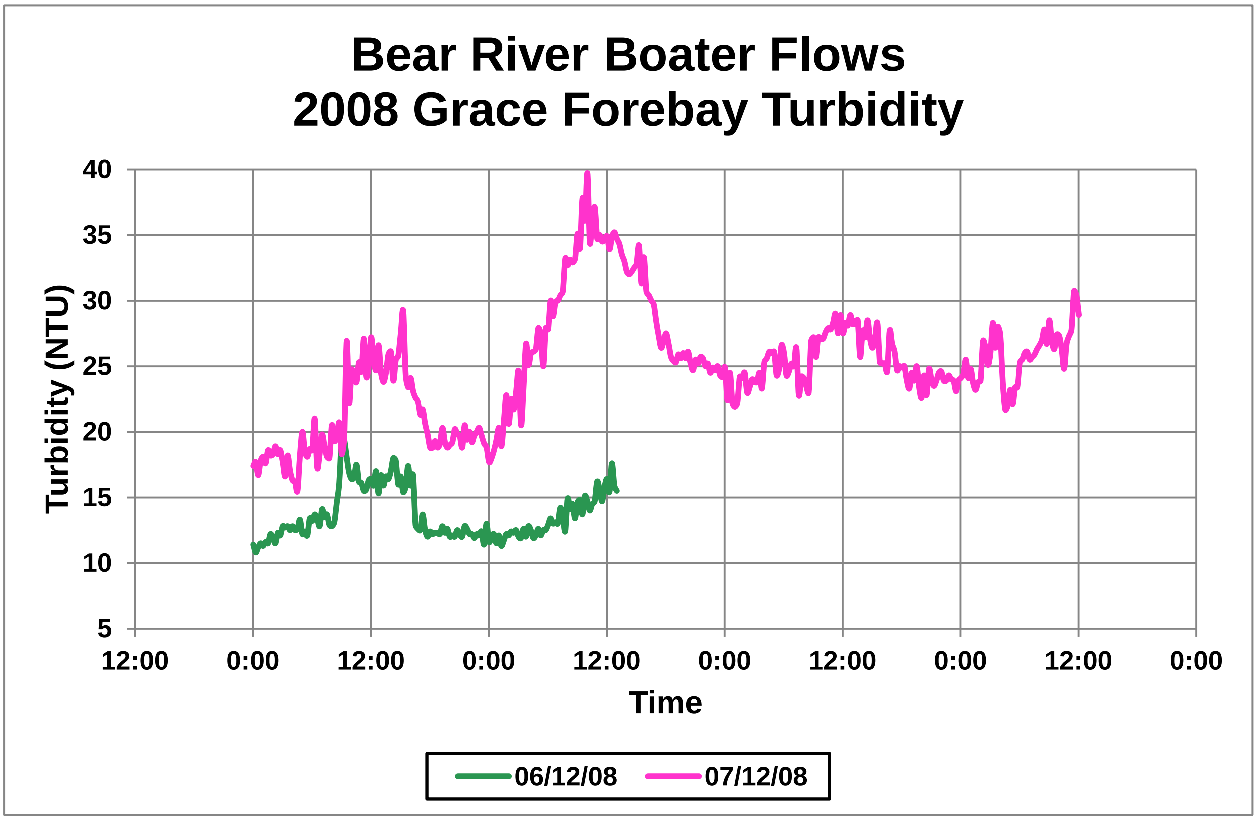

Figure 8. Turbidity in the Grace Forebay, 2008.

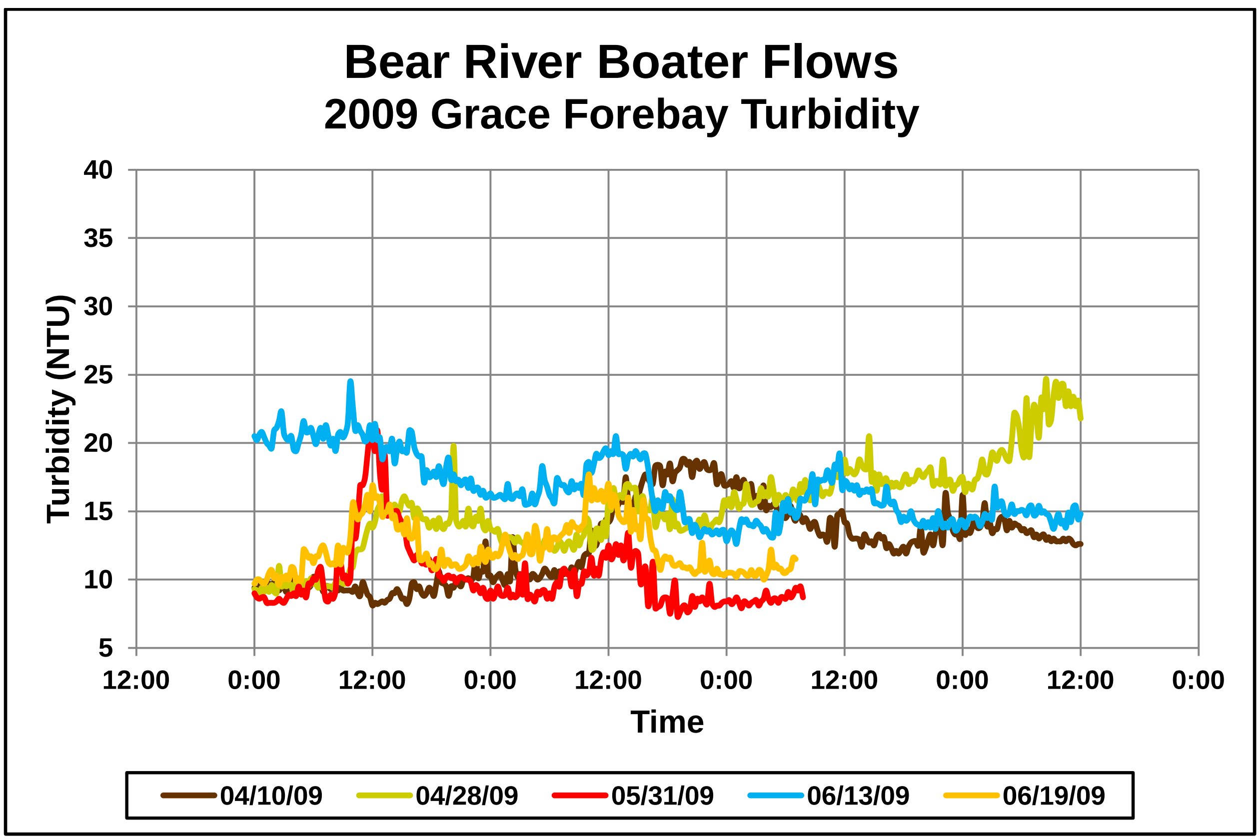

Figure 9. Turbidity in the Grace Forebay, 2009.

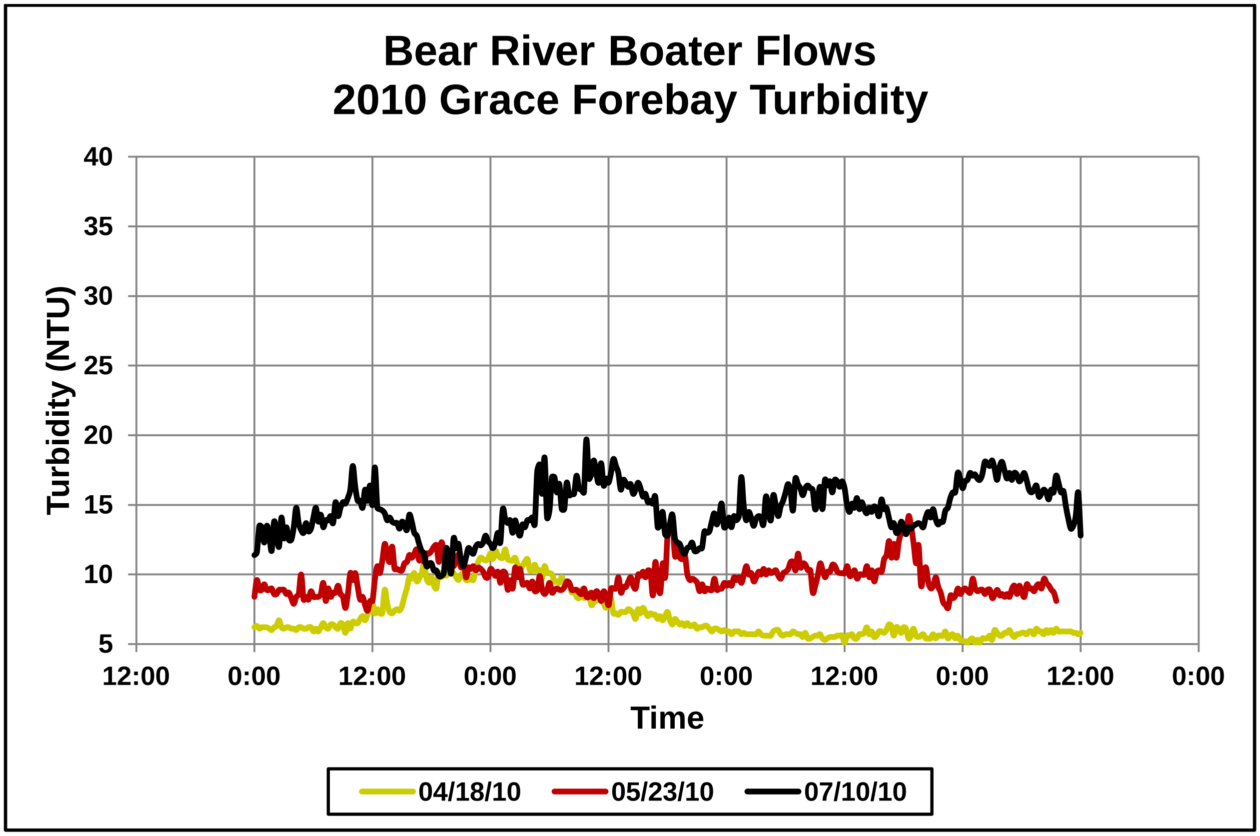

Figure 10. Turbidity in the Grace Forebay, 2010.

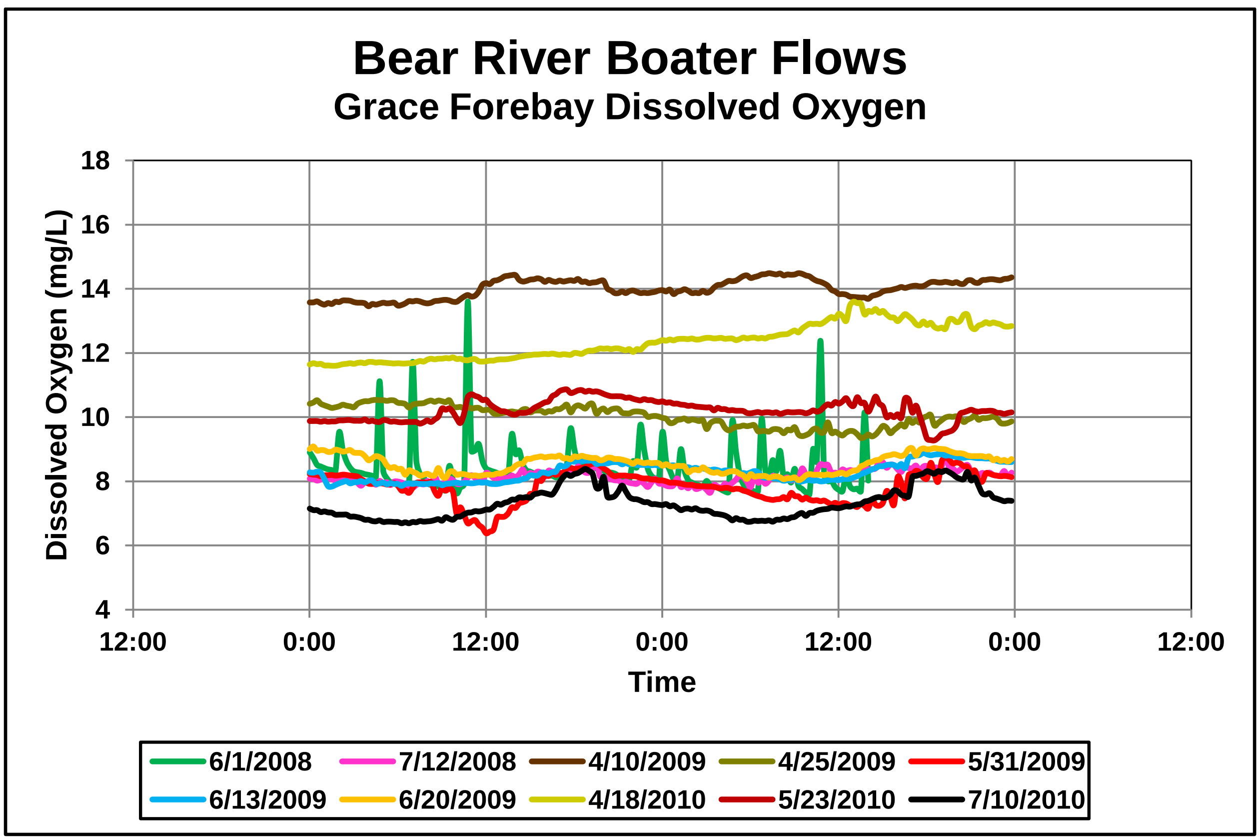

Figure 11. Dissolved oxygen in the Grace Forebay, 2008-2010.

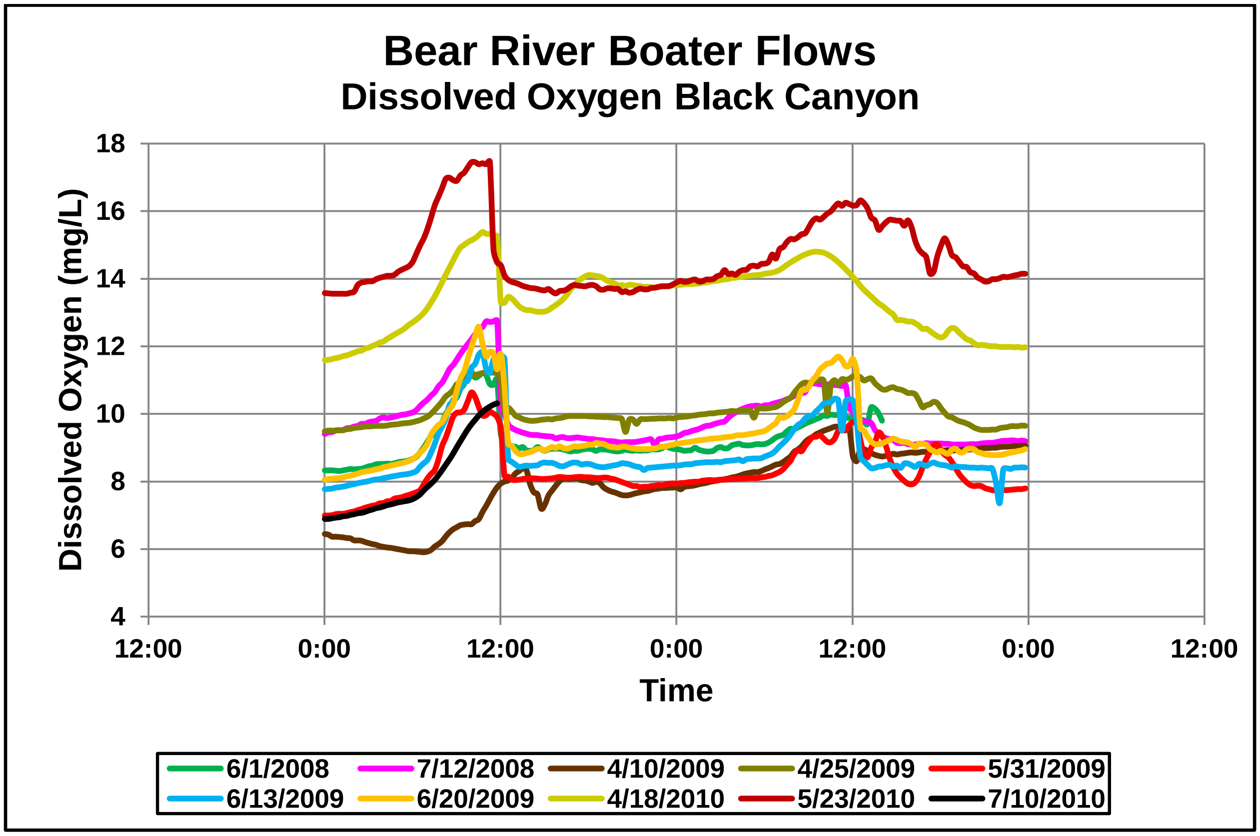

Figure 12. Dissolved oxygen in Black Canyon, 2008-2010.

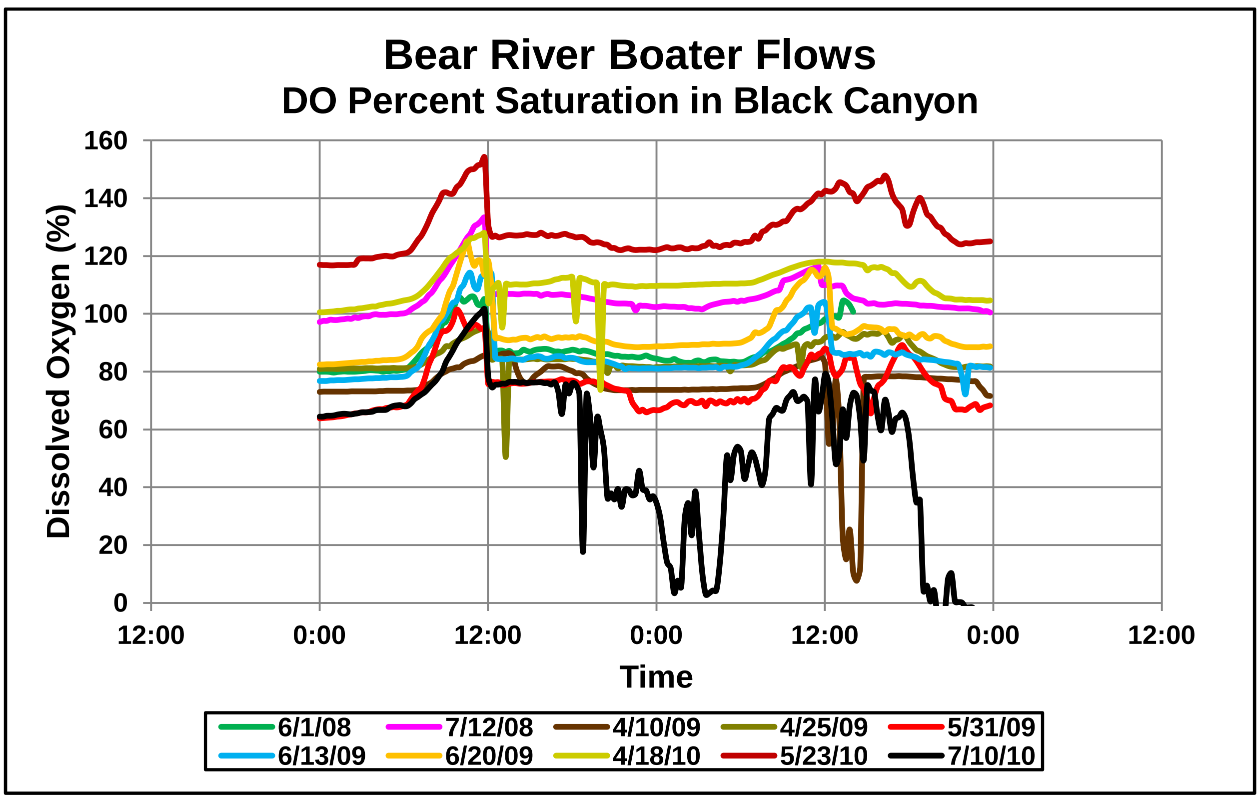

Figure 13. Dissolved oxygen saturation during whitewater releases in Black Canyon.

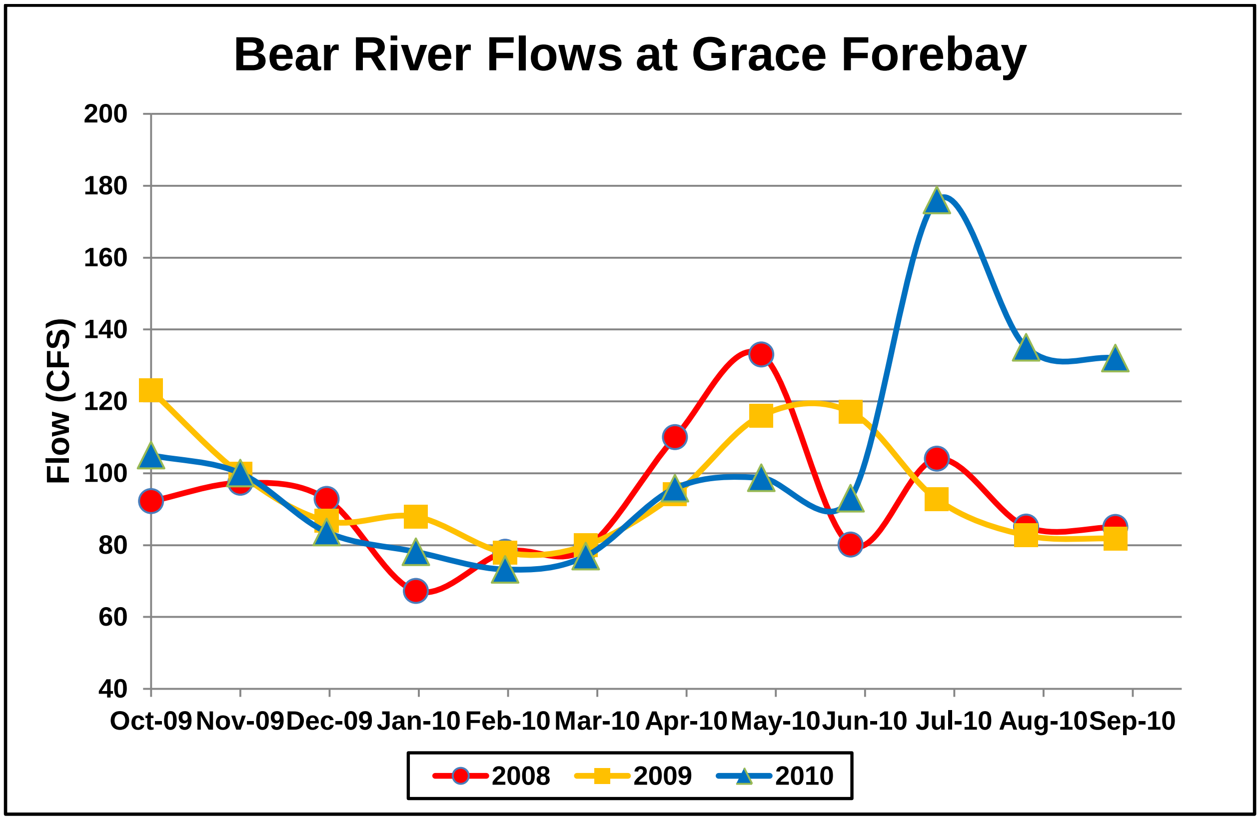

Figure 14. Average monthly flows recorded at the Grace Forebay.

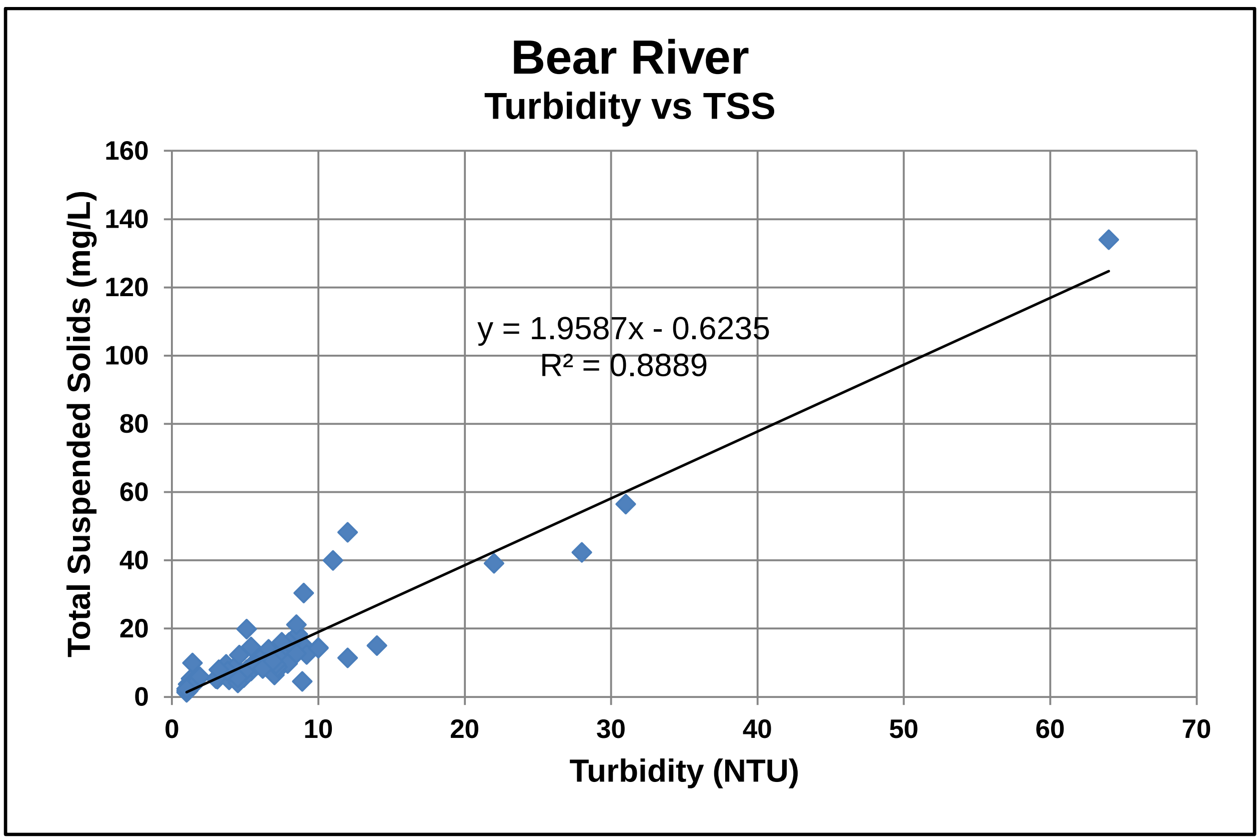

Figure 15. Turbidity vs. TSS relationship in the Bear River study area.