BEAR RIVER BLACK CANYON MONITORING REPORT

2005 STUDY RESULTS

Prepared for PacifiCorp
&
the Environmental Coordination Committee

January 31, 2006

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ENVIRONMENTAL

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ACRONYMS AND ABBREVIATIONS

AFDW	Ash-Free Dry Weight
AI	Autotrophic Index
ANOVA	Analysis of Variance
APHA	American Public Health Association
BF	Bankfull
BMI	Benthic macroinvertebrate
BWD ratio	Bankfull width / bankfull water depth
CFS	Cubic Feet per Second
CL	Confidence Level
cm^2	square centimeters
CPUE	Catch per Unit Effort
ECC	Environmental Coordination Committee
FERC	Federal Energy Regulatory Commission
g	Grams
ID DEQ	Idaho Department of Environmental Quality
m^2	square meters
mg	Milligrams
R	Reach
RBT	Rainbow Trout
ΔT	Temperature Difference
T	Transect
μG	Micrograms
WP	Wetted Perimeter
Wr	Relative Weight
WY	Water Year

EXECUTIVE SUMMARY

In December 2003 PacifiCorp received a new operating license for the Bear River Hydroelectric Project (FERC No. 20) located in southeast Idaho. The new license includes a condition requiring PacifiCorp to implement and study a variable flow regime at the Grace Hydropower Facility in the 6.2 mile reach known as the Black Canyon between Grace Dam and the Grace powerhouse. PacifiCorp, in collaboration with the Environmental Coordination Committee (ECC), developed the Bear River Black Canyon Monitoring Study to examine the effect of variable flow regime on the river channel shape, substrate and aquatic biota. Specifically the Black Canyon Monitoring Plan includes investigation of: 1) Macroinvertebrates—population trends, diversity and community indices; 2) Organic Matter Ash-Free Dry Weight (AFDW); 3) Periphyton—chlorophyll concentration and biomass; 4) Fisheries—population trends, community composition, fish condition; 5) Filamentous Algae—density; and 6) Channel Morphology—shape and substrate composition.

The monitoring effort comprises four study reaches. Reach 1, partially regulated by Bear Lake, serves as the reference reach. Reaches 2, 3 and 4, subject to the variable flow regime below Grace Dam, serve as the experimental reaches. The monitoring study spans six-years of data collection. The first three-years serve as a baseline period collecting data in all reaches prior to implementation of the variable flow regime. The second three-year term, years four through six, serve as the experimental phase when reaches 2, 3 and 4 are subjected to flows ranging from 800 to 1500 cfs, approximately 700 to 1400 cfs greater than the minimum instream flow of 65 cfs below Grace Dam. Field sampling occurs once annually in October. Field sampling was initiated in October 2005 and will conclude October 2010. This narrative reports on the first year of monitoring only. As such analysis is limited to comparisons of the similarities and differences of the four study reaches particularly the reference reach relative to the three reaches located downstream of Grace Dam.

The 2005 monitoring effort identified biological and physical habitat differences between the study reaches. Quantitative habitat comparisons took place in reaches 2 and 3 only. Reach 2 is distinctly wider and shallower than reach 3. Qualitative observations of habitat in reaches 1 and 4 indicate differences in gradient, substrate type and channel processes.

Periphyton AFDW exhibited a high degree of sample variability within reaches particularly at reaches 2 and 4. This wide sample variance eliminated significant differences between the partially regulated reference reach and the fully regulated experimental reaches although paired reach comparisons do display statistically significant differences. Periphyton chlorophyll concentrations were significantly different between reaches for pigments a, b and c. Filamentous algae density was greatest in reaches 1 and 4.

The fish community composition varied between sites. Reach 4 had the greatest diversity (5 species) while reach 3 had the highest density (119/100 meters). Reach 2 had the lowest diversity (2 species) and abundance (34/100 meters). Reach 4 was the only reach with rainbow trout present.

Additional data sources indicate that discharge and stream temperature are different between study reaches. Water storage in Bear Lake decreases the magnitude of peak flow events during spring snowmelt and extends the duration of the snowmelt hydrograph into August and early September to fulfill downstream water rights. Reaches 2, 3 and 4 in the Black Canyon of the Bear are fully regulated by upstream irrigation and power generation diversions. Instream flows below Grace Dam are relatively stable year round.

Reach 1 exhibited the highest maximum temperatures (25.9 ºC) of all three reaches with temperature records. Reach 4 exhibited the coolest water temperatures with daily averages below 20 ºC throughout the summer months and occasional maximum recordings greater than 20 ºC. Daily averages in reaches 1 and 2 were greater than 20 ºC for the entire summer season and at times daily minimums remained above 20 ºC for consecutive 24 hour periods.

Identification and enumeration of benthic macroinvertebrates and laboratory analysis of organic matter ash-free dry weight will be completed April 28, 2006. These data sets will be analyzed and presented to PacifiCorp and the ECC as a supplemental report.

1. INTRODUCTION

The effects of flow regulation on stream ecology and fish populations have been and will continue to be widely studied throughout the world (Petts 1984; Naiman and Bilby 1998). Many studies have been and will be conducted in conjunction with the relicensing of hydroelectric projects. These studies are designed in part to evaluate operational effects on downstream water quality and quantity, aquatic biota and habitats, channel structure and stability and on recreational activities such as rafting and fishing.

In December 2003 PacifiCorp received a new operating license for the Bear River Hydroelectric Project (FERC No. 20) located in southeast Idaho. The new license includes a condition requiring PacifiCorp to implement and study a variable flow regime at the Grace Hydropower Facility in the 6.2 mile reach known as the Black Canyon between Grace Dam and the Grace powerhouse. PacifiCorp, in collaboration with the Environmental Coordination Committee (ECC), developed a monitoring plan for the Black Canyon of the Bear River to characterize the aquatic biota and habitat responding to the new minimum instream flow regime and compare those results with the aquatic biota and habitat resulting from the variable flow regime associated with recreational whitewater boating flows.

This study plan focuses specifically on the effect of the variable flow regimes on aquatic biota and habitat in the Black Canyon of the Bear River in southeast Idaho. The study is designed to evaluate and quantify changes in the abundance, composition and distribution of aquatic biota and habitat longitudinally across sites and through time as well as compare post-disturbance conditions to a reference reach.

In years 2005-2007 monitoring studies will be conducted to characterize the aquatic biota and habitat present under the new minimum instream flow conditions in the FERC license. In years 2008-2010 the FERC license requires PacifiCorp to provide periodic whitewater boating flows below Grace Dam. The objective in the 2008-2010 study phase is to characterize the aquatic biota and associated habitat exposed to variable flow regimes resulting from whitewater releases. Data from the 2005-2007 study phase will be compared to results from the 2008-2010 study phase to determine the effects of whitewater releases from Grace Dam on fisheries, macroinvertebrates, periphyton and aquatic habitat at three study reaches located in the 6.2 mile bypass reach.

Specifically the Black Canyon Monitoring Plan includes investigation of: 1) Macroinvertebrates—population trends, diversity and community indices; 2) Organic Matter Ash-Free Dry Weight (AFDW); 3) Periphyton—chlorophyll concentration and biomass; 4) Fisheries—population trends, community composition, fish condition; 5) Filamentous Algae—density; and 6) Channel Morphology—shape and substrate composition.

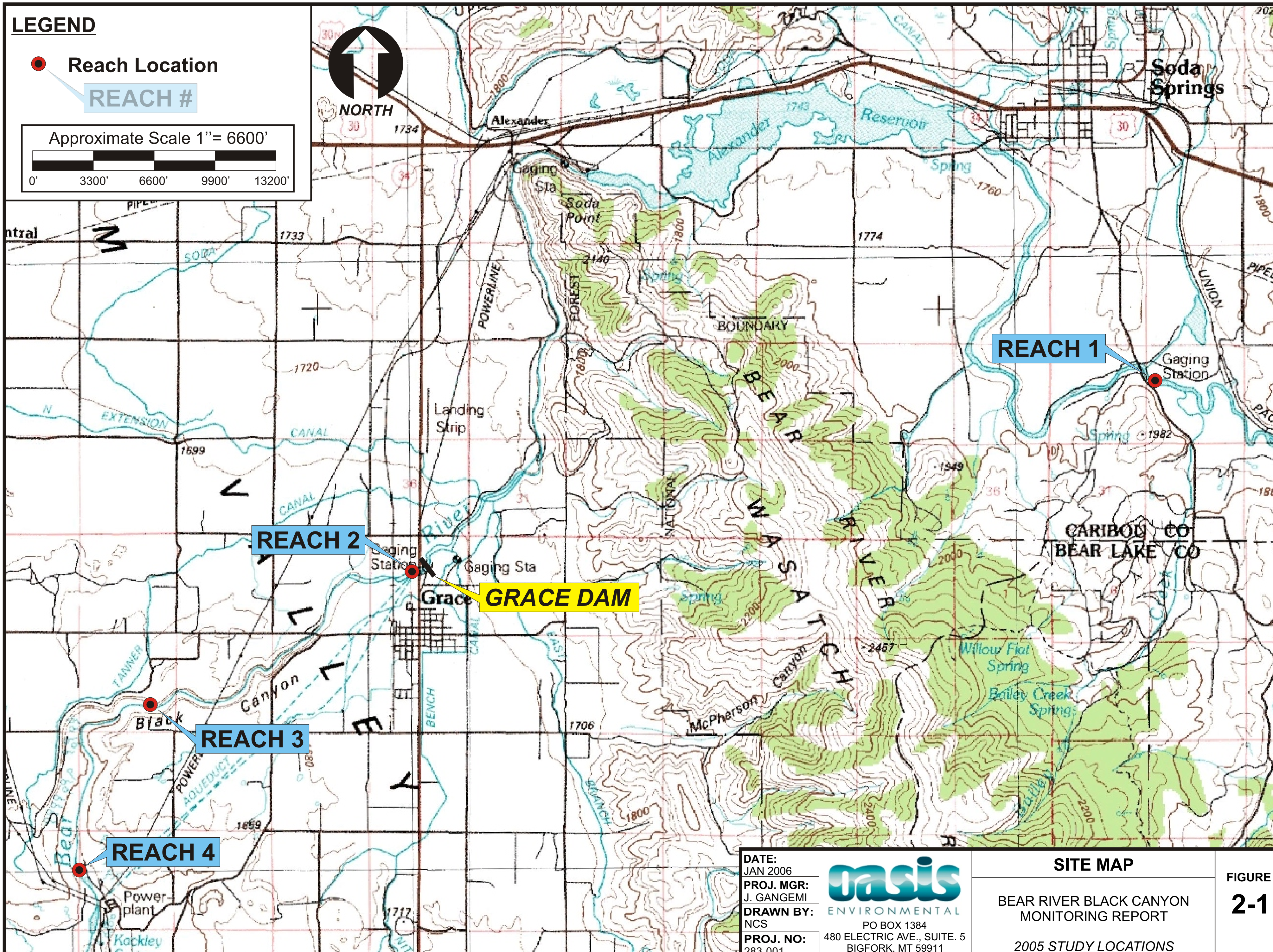
The Black Canyon Monitoring Plan includes a reference reach located upstream of Soda Reservoir and three experimental reaches within the Black Canyon. The reference reach is not subjected to the flow fluctuations associated with the whitewater releases but is partially regulated by Bear Lake. Field sampling will occur once annually in October. Field sampling was initiated in October 2005 and will conclude October 2010.

2. STUDY AREA

The Bear River originates in Summit County, Utah in the northern Uinta Mountains on the Wasatch National Forest. From an aerial perspective the Bear River is a giant three state loop originating in Utah, traversing north into Wyoming then curving west into southeast Idaho before bending in a southerly direction back into Utah and emptying into the Great Salt Lake. This circuitous route is dictated by the north-south orientation of mountain chains and corresponding valleys. In the higher elevation zones snow is the dominant form of precipitation. Accordingly, the majority of the annual hydrograph occurs during spring snowmelt.

Since European settlement in the 1850's numerous water diversion dams and storage reservoirs have been constructed on the Bear River for irrigating agricultural lands. The most notable storage was the diversion of water into the formerly closed basin Bear Lake via Stewart Dam and associated canal system. This canal system greatly increased the storage capacity in the Bear River basin and consequently altered the annual hydrograph significantly below this diversion point. In the 1900's additional dams and diversions were constructed for hydropower generation and irrigation.

This study encompasses four study reaches (Figure 2-1). Reach 1 located upstream of Alexander Reservoir serves as the reference reach for this study. Reaches 2, 3, and 4, located downstream of Grace Dam, serve as the experimental reaches. This 6.2 mile section of the Bear River below Grace Dam is known as the Black Canyon named after the basalt walls of the incised canyon. Approximately 0.5 miles downstream of Grace Dam the Bear River cuts through a basalt bedrock layer into the Black Canyon. The river gradient in the Black Canyon is considerably steeper relative to upstream and downstream reaches. In the Black Canyon the character of the Bear River alternates between steep cascades, plunge pools, riffles and runs. Channel shape and structure is dominated by bedrock ledges and large boulders. In contrast, reach 1 upstream of Alexander Reservoir has a flatter gradient and more closely resembles an alluvial channel with alternating erosion and deposition zones.



DATE: JAN 2006		SITE MAP	FIGURE
PROJ. MGR: J. GANGEMI	oasis ENVIRONMENTAL	BEAR RIVER BLACK CANYON MONITORING REPORT	2-1
DRAWN BY: NCS	PO BOX 1384		
PROJ. NO: 283-001	480 ELECTRIC AVE., SUITE. 5 BIGFORK, MT 59911	*2005 STUDY LOCATIONS*	

2.1 REACH 1: UPSTREAM OF SODA RESERVOIR

Reach 1 is located approximately 1 mile upstream of Soda Reservoir. Five transects were sampled in a 0.25 mile reach directly upstream of Bailey Road. This section of the Bear River is located in a broad alluvial valley. The reach is a Rosgen C type channel. The predominant habitat type is alternating riffles and runs with clearly demarcated scour and deposition zones exhibited by the gravel/cobble point bars above the wetted perimeter. Bankfull zones are clearly delineated by grasses and woody vegetation. The substrate is highly embedded with fine silt and sand. In higher velocity riffle areas substrate is less embedded. In lower velocity runs a thick mat of periphytic algae blankets cobbles and gravels further trapping fine sediments.

Reach 1 serves as the reference reach for comparison with reaches 2, 3 and 4 subjected to the flow fluctuations required in the new FERC license for the Grace hydropower project. Instream flows in reach 1 are partially regulated by a combination of upstream dams and reservoirs. The peaks in the spring snowmelt hydrograph are buffered by upstream reservoir storage. Instream flows remain above normal through August and early September to meet downstream irrigation needs.

2.2 REACH 2: DOWNSTREAM OF GRACE DAM

Reach 2 is located directly downstream of Grace Dam just west of the Highway 34 bridge and the power canal viaduct. Instream flows are relatively stable year-round regulated by releases from Grace Dam. Discharge ranged from 93 to 103 cfs during the October sampling effort. Transects A through E span approximately 800 meters from upstream to downstream. Transects A through C are indicative of the scour and deposition found in alternating pool and riffle stream habitat types with the exception that the pool areas are largely filled in with sand and silt. This is a Rosgen Type C channel. Transects D and E are distinctly different than transects A, B and C. The gradient increases slightly and the substrate shifts to larger particle sizes including extensive bedrock shelves in transect D. Transects D and E are located at the nick point where the Bear River begins cutting through the basalt shelf into the Black Canyon.

2.3 REACH 3: BLACK CANYON

Reach 3 is located in the incised canyon of the Bear River known as the Black Canyon. Instream flows are relatively stable year-round regulated by releases from Grace Dam. Discharge ranged from 93 to 103 cfs during the October sampling effort. Mladenka and Van Every (2004) established five transects in an ascending order from downstream to upstream, starting with transect 6 and ending with transect 10. For the six-year Black Canyon monitoring study the transects in reach 3 have been re-labeled to A, B, C, D and E in descending order from upstream to downstream for consistency with naming conventions in reaches 1, 2 and 4.

Reach 3 is approximately 400 meters long. The reach begins 100 meters upstream of a sweeping left hand turn and continues through the turn, ending approximately 25 meters below it. This section of river channel is constrained and defined by the basalt bedrock of the Black Canyon. The outside of the bend (right bank) is defined by the edge of a talus slope stretching down from the top of the canyon walls, 180 ft in elevation above the stream. Much of reach 3 is run type habitat with the exception of Transect A which is riffle habitat. Transect E is located at the start of a 300 meter long pool. Scour around boulders on the right bank has formed “pocket water” adjacent to the boulders. Deposition of gravel and sand material forms point bars on the river left bank heavily vegetated with perennials and in some cases woody shrubs. Reach 3 resembles a Rosgen Type C channel.

2.4 REACH 4: BEAR RIVER ABOVE GRACE POWER PLANT

Reach 4 is located at the downstream end of the Black Canyon approximately 6.2 miles downstream of Grace Dam. This reach is just upstream of the Grace power plant. Discharge ranged from 120 to 130 cfs during the October sampling period. Discharge in reach 4 is approximately 30 cfs greater than reaches 2 and 3 due to inflows from spring sources just upstream of reach 4. This reach resembles a Rosgen Type B channel. The channel consists of high velocity laminar flow over basalt bedrock ledges with corresponding plunge pools. Basalt bedrock ledges are the dominant substrate type. Large mats of filamentous algae cling to a significant percentage of the bedrock substrate.

3. METHODS

Field and laboratory methods used for the six-year Black Canyon monitoring study are described for each discipline. Hydrology data for reach 1 and reach 2 was obtained from PacifiCorp. Temperature data for reaches 1, 2 and 4 was obtained from the Idaho Department of Environmental Quality (ID DEQ).

3.1 CHANNEL SURVEY

Channel shape and substrate type were surveyed in October at two of the four study areas. The two reaches surveyed were reach 2 and reach 3, located below the Grace Dam and in the middle of Black Canyon respectively. In each reach five transects were surveyed, the locations of which were chosen by staff from the Idaho Department of Environmental Quality (Mladenka and Van Every 2004). Each transect was marked with 18" rebar stakes located on both banks, perpendicular to stream flow. The stakes located on the river right bank were labeled with stamped metal tags describing the transect number and location.

Surveys were conducted with a CST/Berger precision autolevel and metric stadia rod. Surveyed elevations for each cross section included right and left bank pins, bank full, wetted perimeter and channel elevations. The latter elevations were taken at major elevation changes or in one meter increments, whichever occurred first. Substrate type was recorded with each elevation point

Surveys of both reaches started with shooting benchmark elevations established in 2004 by Idaho DEQ. These elevations were re-set to 100 meters for calculation purposes. Both surveys were closed out by shooting back to the benchmarks. Closure errors were calculated using the equation: Allowable Error = $.007*(\text{total distance}/100)^{1/2}$ (Harrelson et al 1994.)

3.2 SUBSTRATE SURVEY

Wolman pebble counts were conducted on reaches 2 and 3. The pebble count for reach 2 started at a randomly selected point in transect TD (ID DEQ T4). The pebble count for reach 3 started at a randomly selected point in transect TD (ID DEQ T7). Standard procedures for conducting Wolman pebble counts were followed (Wolman 1954). Particles were classified into six categories: Fines (0-0.062 mm), Sand (0.062-2.0 mm), Gravel (2.0-64 mm), Cobble (64-256 mm), Boulder (256-4096 mm), and Bed Rock. Pebble counts were conducted in an upstream direction due to the high amount of fine sediment mobilized in the water column.

3.3 PERIPHYTON

Periphyton was sampled in all four study reaches using natural substrate material. Cobble substrate was randomly selected in each transect of the four study reaches. After removal from the stream, a 4 cm by 4 cm surface area was immediately scraped with a razor blade and the dislodged material rinsed with deionized water into a Nalgene filtering apparatus containing a 47 mm Gelman A/E glass-fibre filter. Two samples were scraped and filtered from each rock substrate for paired analysis of AFDW and chlorophyll concentrations. Filtered material was stored on dry ice in dark containers to prevent pigment degradation. Periphyton samples were analyzed for the concentration of chlorophyll a, b and c according to the methods described in the Standard Methods for Examination of Water & Wastewater (American Public Heath Association, 20th ed., 1999). Periphyton samples were homogenized and extracted with 90 percent acetone. Chlorophyll concentration was determined using a spectrophotometer correcting for degraded materials within the sample.

3.4 FILAMENTOUS ALGAE

Filamentous algae coverage was quantified along five transects in each of the four study reaches. Researchers deployed a 50 cm by 50 cm pvc square sampler further divided into quarter sections by an intersecting grid at 25 cm. The algal coverage for each quarter cell in the grid was recorded as a percentage per cell. The cumulative percent coverage per 0.25 m2 was summed and expressed as filamentous algal coverage per m2.

3.5 FISHERIES

Electrofishing was used to sample three designated study reaches and one upstream reference reach of the Bear River. All sampling was conducted from October 13, 2005 to October 15, 2005 under similar stream flow conditions. A Smith-root model 12-B backpack electrofishing unit was used to sample 100 meter long sections of each reach. In each section, a three person crew conducted two consecutive upstream electrofishing passes, collecting all fish possible with dip nets. All captured fish were anesthetized, identified by species, weighed in grams, and total length was measured in millimeters. All rainbow trout captured were checked for freeze-brands and the location and orientation of the freeze-brand was recorded.

For each reach, relative species composition was determined by taking the total number of fish caught of each species, dividing by the total catch of all species, and multiplying by 100 (% of catch). In addition, relative biomass by species was determined for each reach by taking the total weight of each species, dividing by the total weight of all species, and multiplying by 100 (% of biomass). Catch per unit effort (CPUE) was calculated by dividing the total number of fish collected in two passes by the total electrofishing effort in minutes.

Relative weight (Wr) was used to assess the condition of rainbow trout and common carp according to the methods described by Anderson and Neumann (1996). The condition (relative weight) of the other species collected was not determined because the relative weight equations have not been developed for those species or they were not within the applicable length for the equations.

3.6 BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates were sampled in October at all four study reaches. In each reach five transects were sampled. Eight BMI samples were combined into a single composite sample for each transect. In total there were 40 BMI subsamples for each study reach. Individual subsamples were randomly located longitudinally along each transect encompassing a variety of microhabitats.

Samples were collected using a 400 cm2 surber sampler with 500 µm mesh. The substrate was disturbed to a depth of 10 cm. Individual substrate was scrubbed clean of attached material and organisms. The effort used per collection of each individual sample was consistent throughout all the study reaches. Samples were preserved in 95 percent ethanol.

Identification and enumeration was performed by EcoAnalysts in Moscow, Idaho. Macroinvertebrates were processed according to Idaho DEQ standards. These standards include the identification of 500 organisms to the genus/species-level (or the lowest possible level) for all groups of organisms.

3.7 ORGANIC MATTER ASH-FREE-DRY-WEIGHT

Organic Matter present in BMI samples was quantified using American Public Health Association (APHA) Standard Methods (1999) for Ash-Free Dry Weight (AFDW). A subsample of each composite BMI sample was homogenized, filtered, weighed after drying at 100 ºC and re-weighed again after being placed in the muffle furnace at 500 ºC to measure the amount of organic material in terms of AFDW. The data was standardized to represent the amount of organic material per m^2 in grams and includes dry mass, inorganic mass, and AFDW.

3.8 STATISTICAL ANALYSIS

Statistical analysis was carried out using a single factor ANOVA (alpha = 0.1) to compare differences among the four study reaches. Statistical comparisons between individual experimental reaches (reaches 2, 3 and 4) and the reference reach (reach 1) were undertaken with the Student's t-test (alpha = 0.1).

4. RESULTS

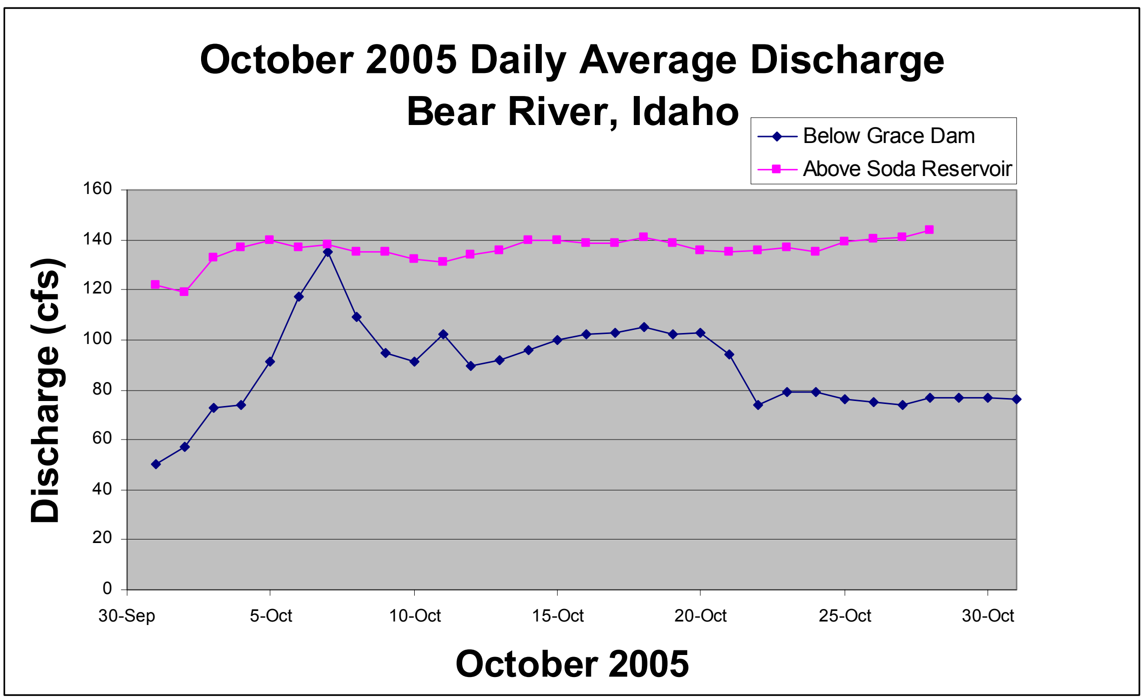
The results are organized into the seven resource parameters monitored in this study effort. Histograms are used to present descriptive statistics (averages and confidence levels, alpha = 0.1). Statistical analysis was carried out using a single factor ANOVA (alpha = 0.1) to compare differences among the four study reaches. Statistical comparisons between individual experimental reaches (reaches 2, 3 and 4) and the reference reach (reach 1) were undertaken with the Student's t-test (alpha = 0.1).

Although outside the scope of study in this monitoring effort temperature and discharge are incorporated in the results section to supplement data analysis. Discharge data measured at the USGS gage located upstream of Soda Reservoir and the USGS gage located in the bypass channel below Grace dam are included for comparison of hydrologic differences between the reference site and study reaches 2, 3, and 4 located below the dam. Hourly temperature data for reaches 1, 2 and 4 was obtained from the ID DEQ.

4.1 HYDROLOGY

During the October sampling period, October 11-15th, 2005, discharge was 136 cfs in reach 1 above Soda Reservoir compared to 96 cfs in reach 2 below Grace Dam (Figure 4.1-1). Reach 3 does not have a staff gage and corresponding rating curve for measuring discharge. It is assumed that discharge in reach 3 is roughly equivalent to that measured in reach 2. Previous studies have estimated that discharge in reach 4 is approximately 30 to 60 cfs greater than reach 2 flows (Connelly Baldwin, personal communication). The additional discharge is from groundwater inflows located at the bottom end of the Black Canyon. For this study we assumed flows in reach 4 were 30 cfs greater than discharge measured in reach 2.

Figure 4.1-1: Discharge, October 11-15, 2005 Sampling Period



Discharge in the reference reach is routinely higher than flows measured below Grace Dam. In the 2004-2005 water year inflows to Soda Reservoir fluctuated between 500 cfs and 1300 cfs from April 1 through September 1 2005 (Figure 4.1-2). The extended hydrograph in July and August is due to the release of storage from Bear Lake to satisfy downstream water rights. In contrast discharge below Grace Dam was relatively stable at 100 cfs for much of the 2004-2005 water year with the exception of a single peak flow of 863 cfs on April 17th, 2005. Reach 2 discharge was typically 500 to 1200 cfs less than flows in reach 1 from April through August. Analysis of the annual peak flows from 1976 through 2005 further illustrates the hydrologic differences between these reaches (Figure 4.1-3). Exceptions occur in the early to mid 1980's when above normal water years maximized the storage capacity in Bear Lake causing spring and summer inflows to equal outflows. In normal and below normal water years diversion of water for power generation and upstream irrigation diversions account for the hydrologic differences between reach 1 and reach 2.

Figure 4.1-2: Discharge, 2004-2005 water year

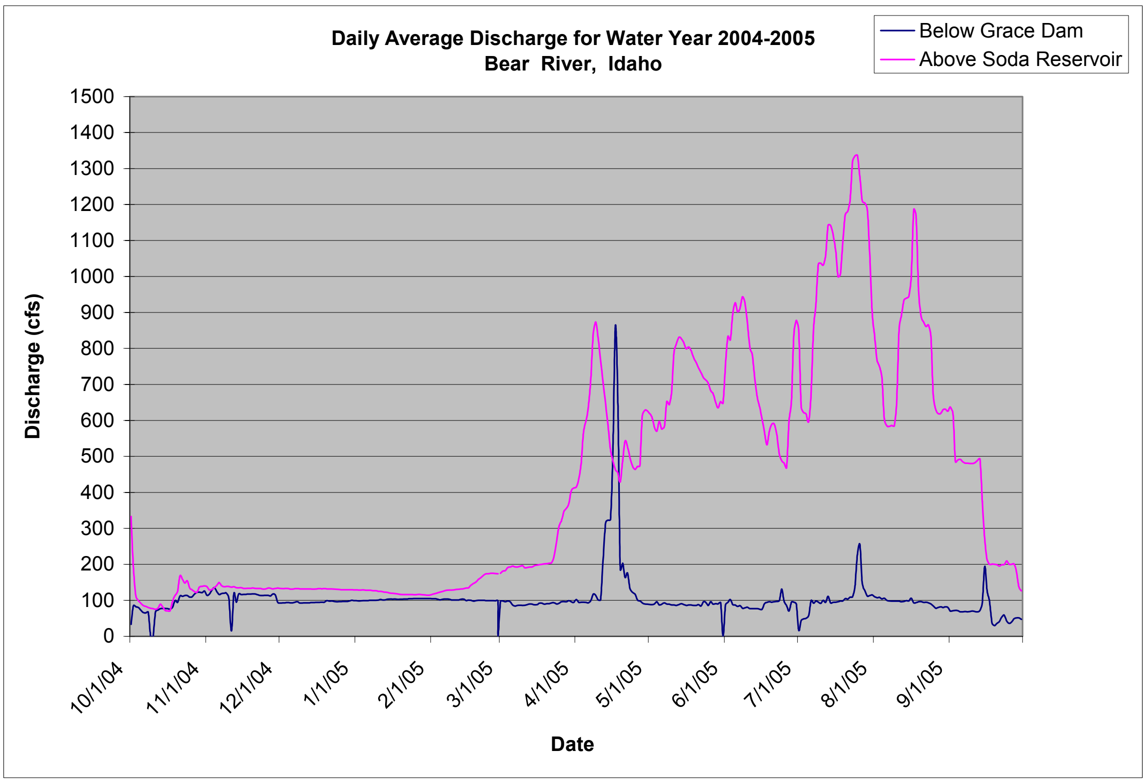
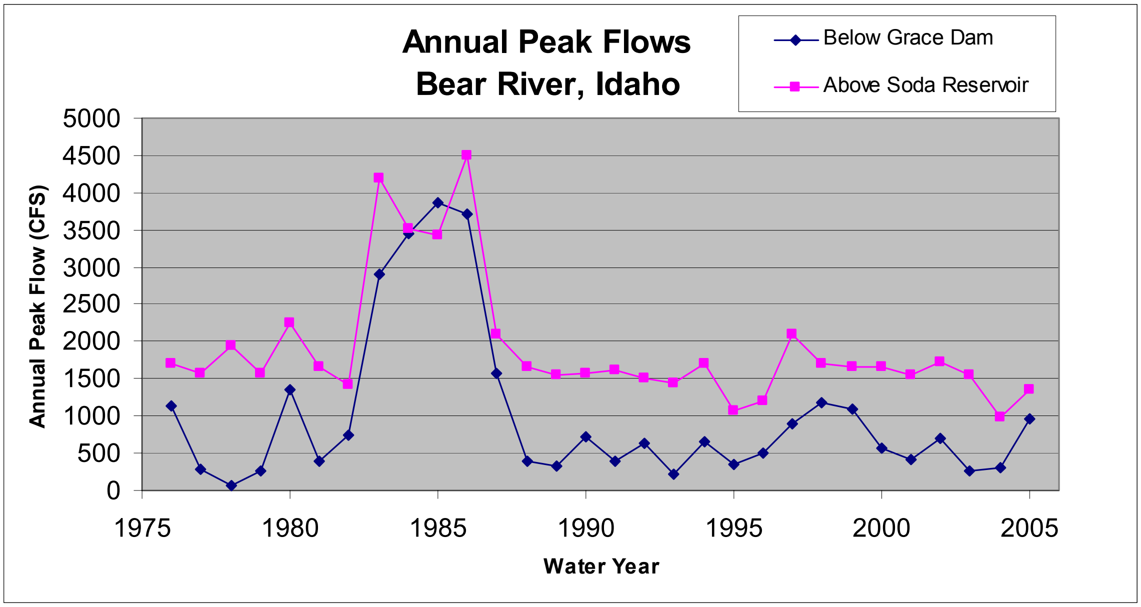


Figure 4.1-3: Annual peak discharge (1976-2005)



4.2 CHANNEL SHAPE AND SUBSTRATE

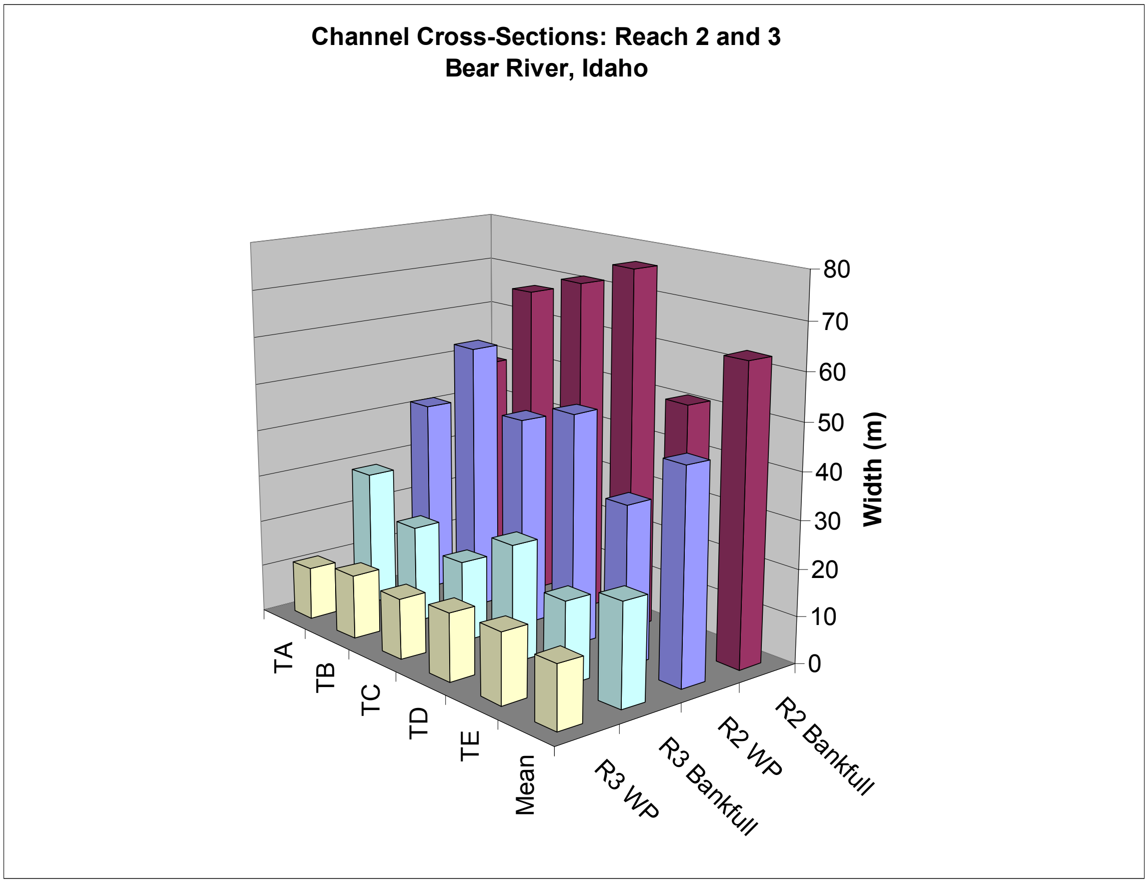
Reach 2 transects were surveyed between 0745 and 1130 hours on October 12, 2005. Discharge was 89 cfs. Reach 3 transects (DEQ 2004 T6-T10) were surveyed between 0845 and 1330 hours on October 15, 2005. The flow recorded for the Bear River below the Grace Dam during the reach 3 survey was 101 cfs. Discharge measured below Grace Dam is assumed to be representative of instream flows in reach 3. The 2005 channel survey data for Reach 2 and 3 is displayed in Table 4.2-1. Channel cross-section profiles for each respective transect in reaches 2 and 3 are included in the appendix (Figures A-1 and A-2). Channel cross-sections were not surveyed for reaches 1 and 4.

Bankfull features were difficult to identify due to the effects of flow regulation in the Black Canyon combined with grazing in reach 2. Bankfull features such as areas of deposition and banks void of vegetation from water scour were not evident in either study reach.

Reach 2 and reach 3 exhibit distinctly different channel widths (Figure 4.2-1). Reach 2 wetted perimeter widths were three times wider than reach 3 (Student's t-test p = 0.001). The mean wetted perimeter width for reach 2 was 45.1 meters compared to 13.4 meters in reach 3. Reach 2 wetted perimeter widths ranged from 11.1 meters in transect TA to 15.0 meters in transect TE. In contrast, reach 2 wetted perimeter widths were three times greater than reach 3; the narrowest wetted perimeter of 33.7 meters in transect TE to 57.0 meters in transect TB.

Mean bankfull width was also three times greater in reach 2; 63.0 meters in reach 2 compared to 21.8 meters in reach 3 (Student's t-test p = 0.003). In reach 2 bankfull width ranged from 48.9 meters at transect TA to 76.6 meters at transect TD. Bankfull widths in reach 3 ranged from 17.1 meters in reach TC to 28.8 meters in transect TA.

Figure 4.2-1: Wetted perimeter and bankfull widths for reaches 2 and 3

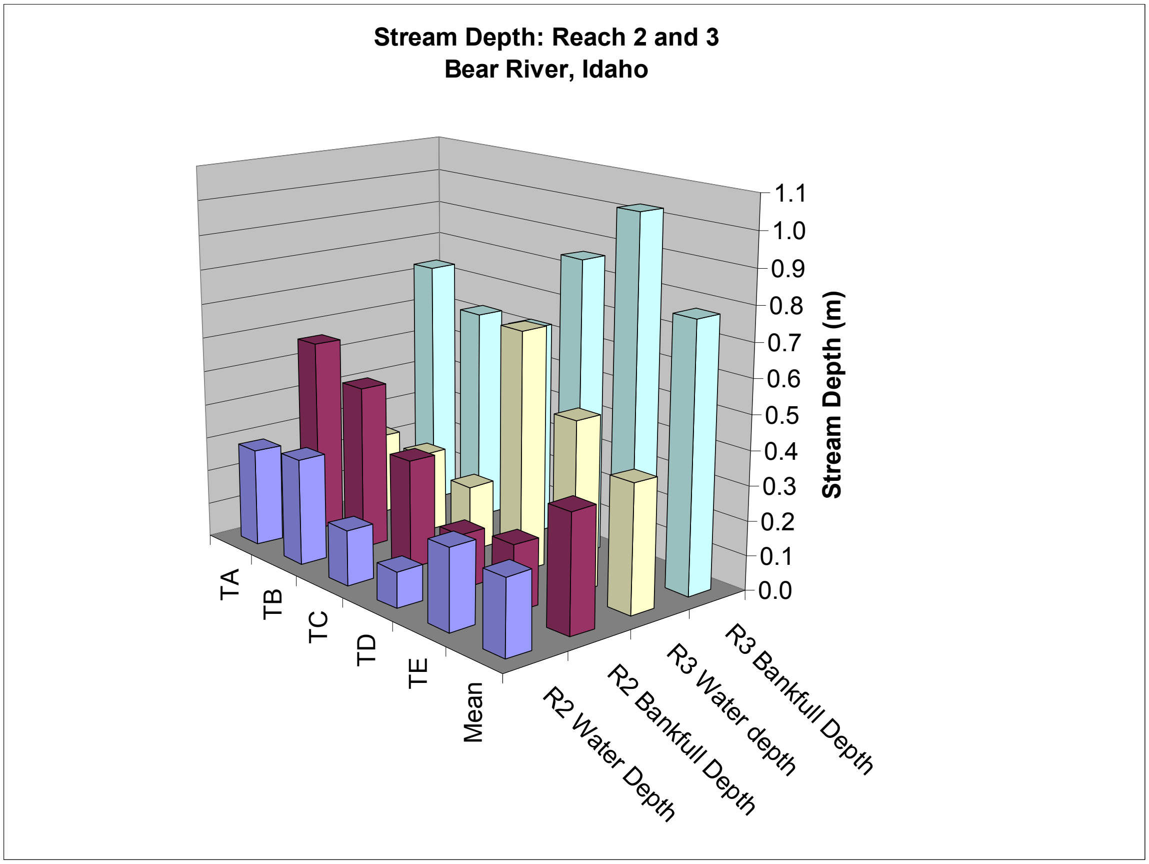


Because of the narrower channel width in reach 3 water depths were nearly two times deeper compared to reach 2 water depths (Figure 4.2-2) but these differences were not statistically significant. Mean water depths under baseflow conditions were 0.22 meters in reach 2 compared to 0.37 meters in reach 3. In reach 2 transect TD had the lowest mean water depth, 0.11 meters. Transect TB in reach 2 had the highest mean water depth, 0.31 meters. In reach 3 transects TA and TB had the lowest mean water depth, 0.24 meters. Transect TD in reach 3 had the highest mean water depth, 0.69 meters.

Water depths under bankfull discharge were calculated using surveyed elevations. Mean bankfull water depths in reach 3 were significantly greater than reach 2 (Student's t-test $p = 0.04$). In fact mean bankfull water depth in reach 3 was more than two times greater than reach 2; 0.77 meters compared to 0.34 meters. In reach 2 mean bankfull water depth ranged from 0.16 meters in transect TD to 0.57 meters in transect TA. Not surprisingly transect TD in reach 2, the widest of all the transects surveyed at 76.6 meters, also contained the shallowest water depths. In reach 3 mean bankfull water depth ranged from 0.62 meters in transect TC to 1.03 meters in transect TE. Transect TE in reach 3 is located at the start of a deep pool approximately 300 meters in length.

Rosgen (1994) uses the bankfull width to water depth ratio (BWD ratio) to characterize streams in his Level II stream classification system. The BWD ratio in reach 2 was significantly different than reach 3 (Student's t-test $p = 0.04$). In fact the BWD ratio in reach 2 was twenty times greater than reach 3. In reach 2 the BWD ratio ranged from 86.5 in transect TA to 483.5 in transect TD. Rosgen's stream classification system ranks these BWD indices very high. In reach 3 the BWD indices ranged from 17.0 in Transect TE to 39.3 in transect TA. These BWD ratios are considered to be in the moderate to high range for the Rosgen Level II stream classification.

Figure 4.2-2: Wetted perimeter and bankfull stream depths for reaches 2 and 3



The substrate composition recorded across survey transects differed between reaches 2 and 3 (Figure 4.2-3). These differences are further supported by Wolman pebble counts in the respective reaches (Figure 4.2-4). In reach 2 transects TA, TB and TC contained a high percentage of fines. The small percent of substrate classified as gravel and cobble in these transects was typically highly embedded with fine sediment. The substrate composition in transects TA, TB and TC is indicative of a depositional zone. In contrast transects TD and TE in reach 2 are indicative of an erosional zone. The substrate composition was dominated by cobble and boulder sized particles in transects TD and TE. Approximately 15 percent of the substrate in transect TD was basalt bedrock. Wolman pebble counts indicate that fine sediment makes up 42 percent of reach 2 followed by sand at 18 percent. Spawning gravels were present in isolated pockets in Reach 2 but no single pocket exceeded 1 m^2.

In reach 3 gravel was the dominant particle size for all five transects. In transects TA, TB and TC gravel made up over 80 percent of the substrate. Cobble made up approximately 10-20 percent of the substrate in those same reaches. Much of the gravel and cobble was about 50 percent embedded with fine sediments. In addition to the gravel and cobble substrate transects TD and TE also contained fines and boulder substrate respectively. Wolman pebble counts in reach 3 found gravel sized particles to be 45 percent of the substrate followed by cobble (17 percent), sand (16 percent) and fines (15 percent). Reach 3 contained 51.3 m^2 of spawning gravels. The high level of embeddedness of these gravels makes the spawning suitability of these gravels suspect.

Figure 4.2-3: Substrate composition for reaches 2 and 3

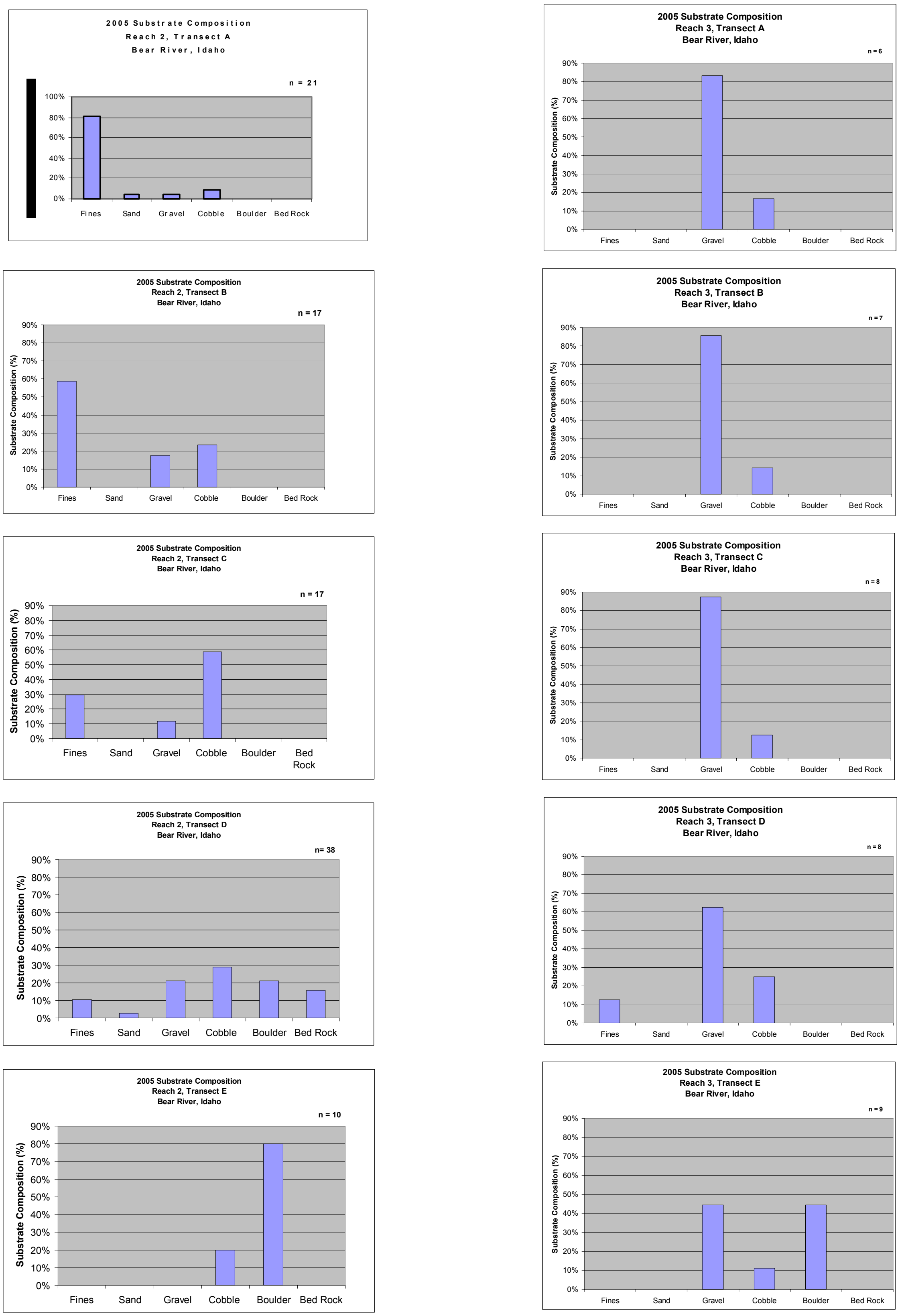


Figure 4.2-4: Wolman pebble counts in reaches 2 and 3, October 2005

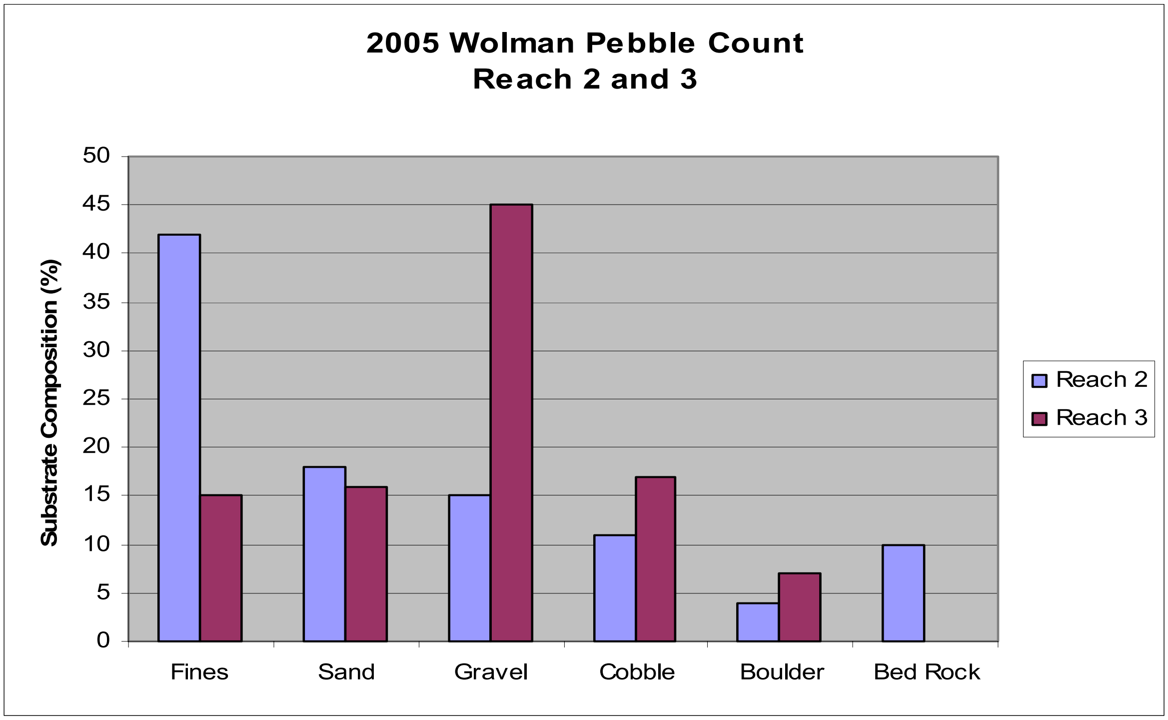


Table 4.2-1: Channel survey data for reaches 2 and 3, October 2005

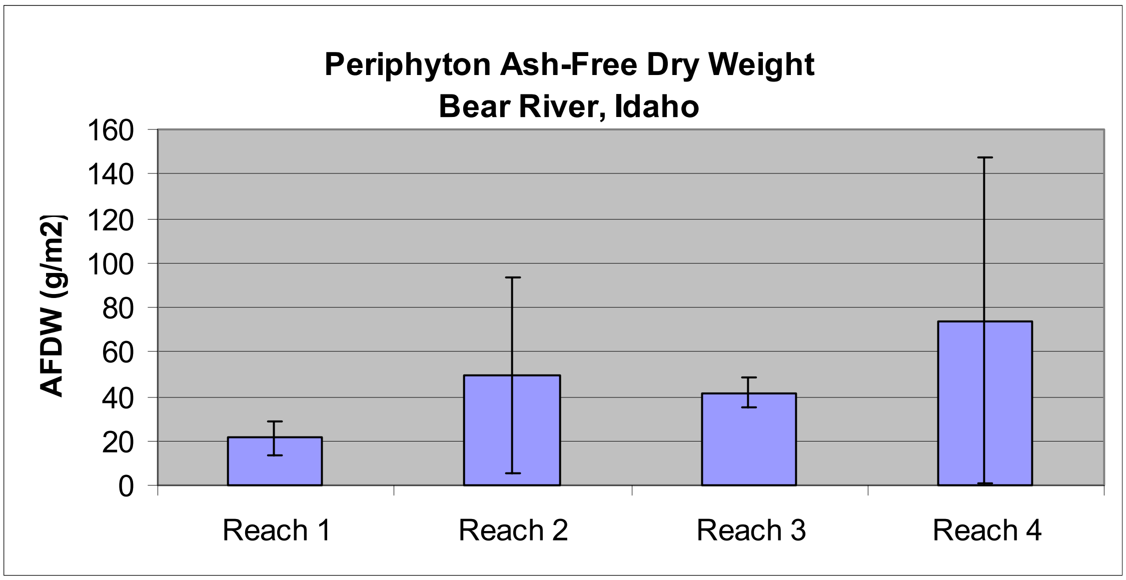
Transect Identification			Wetted Perimeter		Bankfull			Substrate
Reach	2005 Transect	ID DEQ Transect	WP Width (m)	Mean Water Depth (m)	Bankfull Width (m)	Mean Bankfull Depth (m)	Bankfull Width/Depth Ratio	Spawning Gravels (m^2)
2	TA	T1	41.55	0.28	48.85	0.57	86.46	0
2	TB	T2	57.00	0.31	67.22	0.48	140.97	0
2	TC	T3	44.54	0.16	71.30	0.31	226.42	0
2	TD	T4	48.86	0.11	76.57	0.16	483.48	0
2	TE	T5	33.69	0.24	51.28	0.19	269.73	0
Reach 2 Mean			**45.13******	**0.22**	**63.04*****	**0.34****	**241.41**	**0**
3	TA	T10	11.1	0.24	28.8	0.73	39.34	10.5
3	TB	T9	13.6	0.24	20.7	0.63	33.09	12.2
3	TC	T8	12.9	0.19	17.1	0.62	27.37	10.8
3	TD	T7	14.3	0.69	24.8	0.86	28.77	9.2
3	TE	T6	15	0.49	17.5	1.03	17.03	8.6
Reach 3 Mean			**13.38******	**0.37**	**21.78*****	**0.77****	**29.12**	**10.26**

* p = 0.1, ** p = 0.05, *** p = 0.01, **** p = 0.001

4.3 PERIPHYTON—CHLOROPHYLL AND ASH-FREE DRY WEIGHT

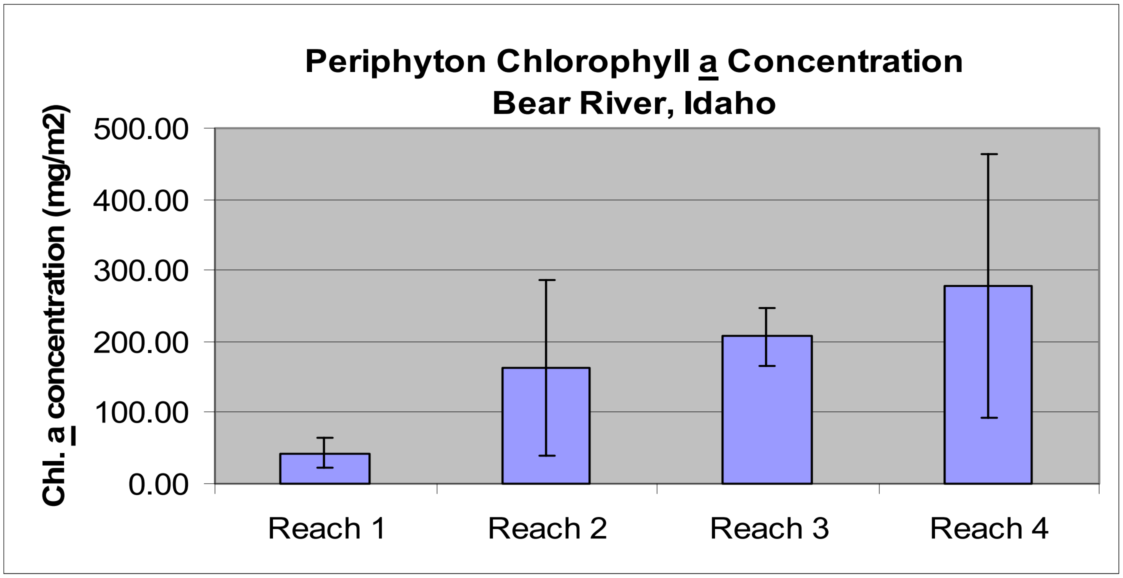
Periphyton AFDW was substantially greater in study reaches 2, 3 and 4 located in the bypass reach than the reference reach located upstream of Soda Reservoir (Figure 4.3-1). This difference between the reference reach and the experimental reaches was not statistically significant (single factor ANOVA alpha 0.1) due to the high variance at reaches 2 and 4 despite the fact that the AFDW average for the three experimental reaches was two or more times greater than the reference reach. The AFDW average for reach 1 was 21.1 g/m^2 compared to 49.4 g/m^2, 41.6 g/m^2 and 74.0 g/m^2 for the reaches 2, 3, and 4 respectively. Reach 1 and reach 3 had the least AFDW sample variance. Direct statistical comparisons (Student's t-test) between reach 1 and reach 3 indicates a significant difference (p = 0.05) in AFDW averages between these reaches.

Figure 4.3-1: Periphyton mean AFDW, October 2005 (CL alpha = 0.1)



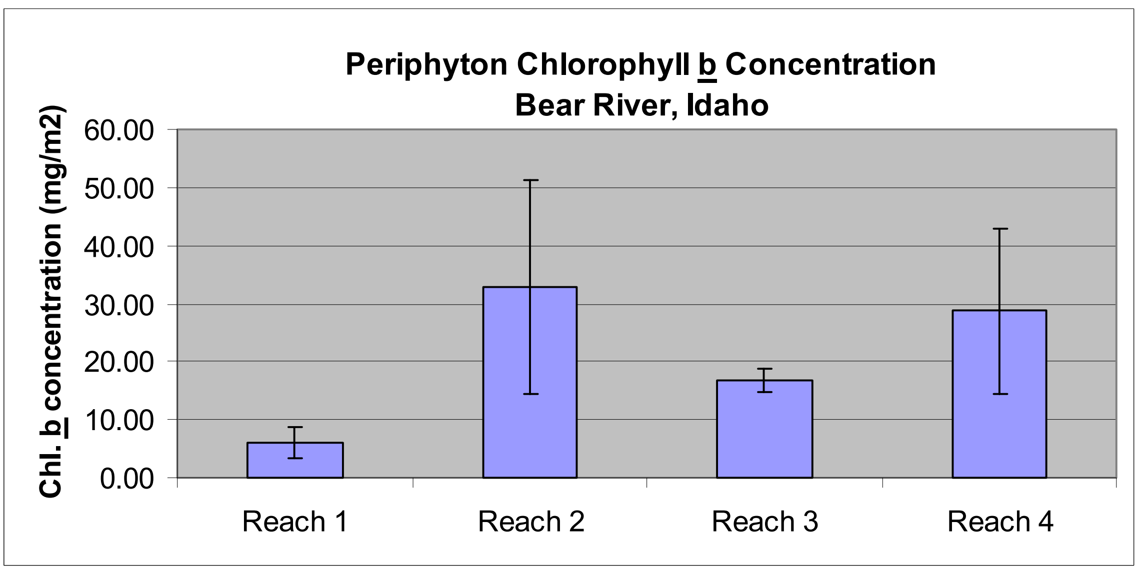
Chlorophyll a concentrations increased progressively from upstream to downstream with the lowest readings in the reference reach and highest in reach 4 (Figure 4.3-2). Chlorophyll a average values were 42.7 mg/m^2, 162.5 mg/m^2, 207.4 mg/m^{2}and 277.3 mg/m^2 respectively for reaches 1 through 4. Despite this dramatic increase in chlorophyll a concentrations between the reference and experimental reaches the results were not significantly different statistically (single factor ANOVA p = 0.15) due to the large sample variance at reaches 2 and 4. Paired statistical comparisons (Student's t-test) between reaches 1 and 3 as well as reaches 1 and 4 exhibit a statistically significant difference (p = 0.0002 and p = 0.1 respectively).

Figure 4.3-2: Periphyton mean chlorophyll a concentration, October 2005 (CL alpha = 0.1)



Like chlorophyll a the chlorophyll b concentrations were higher in the experimental study reaches below Grace Dam than in the reference reach upstream of Soda Reservoir (Figure 4.3-3). Reach 1 had the lowest average chlorophyll b concentrations, 6.0 mg/m^2. In contrast, reaches 2, 3 and 4 average chlorophyll b concentrations were 32.8 mg/m^2, 16.7 mg/m^2, and 28.7 mg/m^2 respectively. This is a 2.5 to 5 fold increase in chlorophyll b concentrations in the experimental reaches. These differences are statistically significant (single factor ANOVA $p = 0.07$). Paired statistical comparisons (Student's t-test) between reaches 1 and reaches 2, 3 and 4 respectively also exhibit a statistically significant difference ($p = 0.07$; $p = 0.0001$; and $p = 0.07$). Reaches 2 and 4 had the highest degree of sample variability.

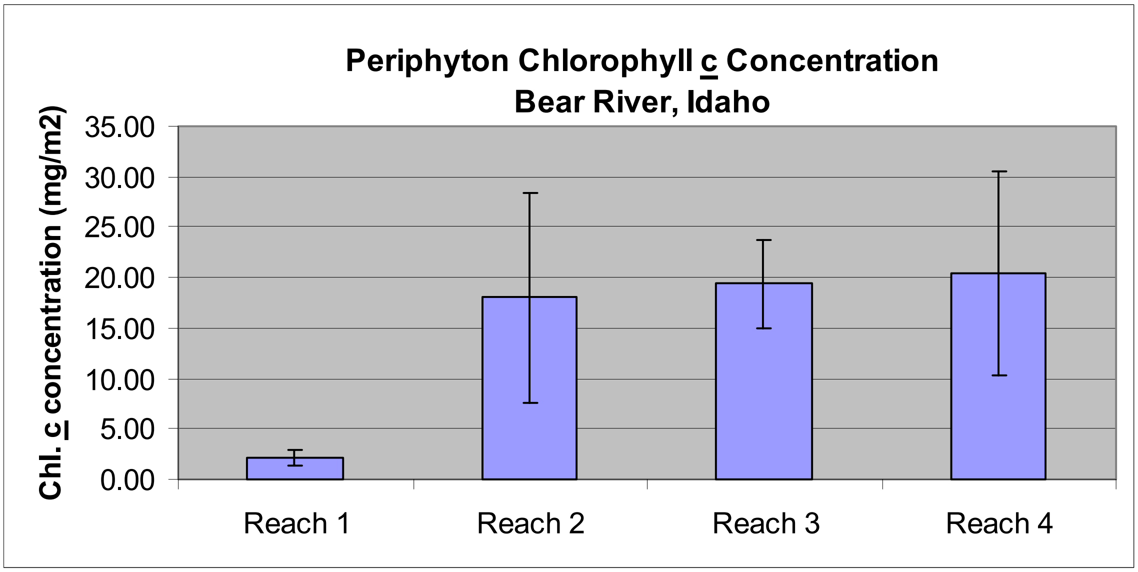
Figure 4.3-3: Periphyton mean chlorophyll b concentration, October 2005 (CL alpha = 0.1)



Chlorophyll c concentrations were also substantially greater in the three experimental reaches relative to the reference reach (Figure 4.3-4). Reach 1 chlorophyll c concentration was 2.1 mg/m^2 compared to 18.1 mg/m^2, 19.4 mg/m^2 and 20.5 mg/m^2 respectively in reaches 2, 3 and 4.

This nine fold increase in chlorophyll c concentration between reference and experimental reaches is statistically significant (single factor ANOVA p = 0.04). Paired statistical comparisons (Student's t-test) between reaches 1 and reaches 2, 3 and 4 respectively also exhibit a statistically significant difference (p = 0.07; p = 0.002; and p = 0.04). Reaches 2 and 4 had the highest degree of sample variability.

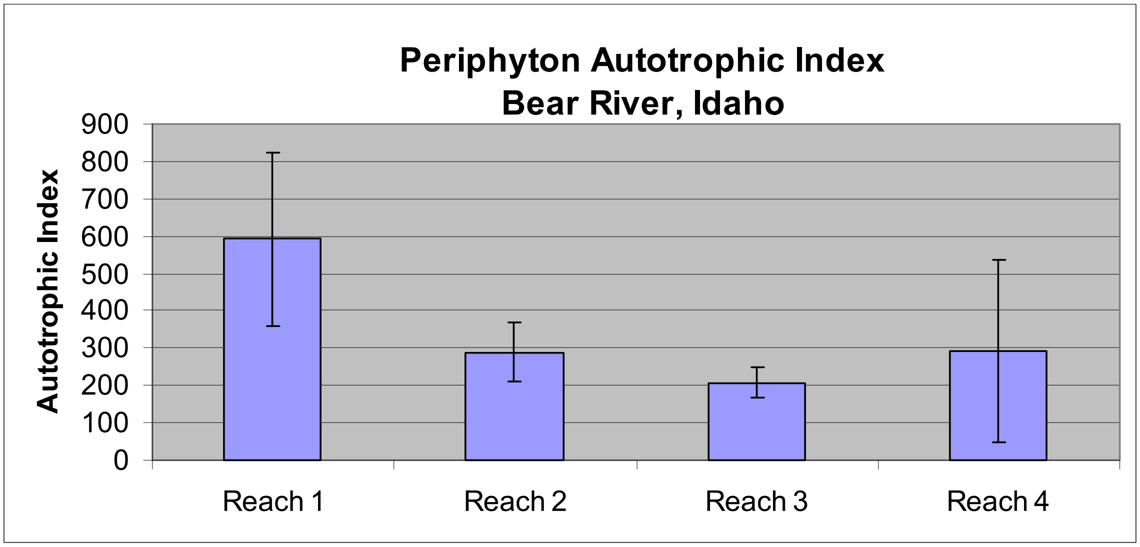
Figure 4.3-4: Periphyton mean chlorophyll c concentration, October 2005 (CL alpha = 0.1)



The autotrophic index (AI), the ratio AFDW/chlorophyll a, provides information on the relative viability of the periphyton community. If large amounts of nonliving organic material are present, the numerator becomes inflated, and the ratio exceeds the normal range of 50-200 (APHA 1999). All four study reaches exceed the normal range; reach 1-591.4; reach 2-287.7; reach 3-207.5; and reach 4-292.6 (Figure 4.3-5). These inflated numerators indicate that the periphyton matrix contains a large amount of non-algal organic material. This organic material likely includes bacteria, BMI and detritus trapped in the algal filaments.

There is a statistically significant difference in AI values between reaches (single factor ANOVA p = 0.09). Paired statistical comparisons (Student's t-test) between reach 1 and reach 3 reveals a significant difference (p = 0.05). Similar paired statistical comparisons between reach 1 and reaches 2 and 4 were not significant (p = 0.17 and p = 0.19 respectively).

Figure 4.3-5: Periphyton mean autotrophic index, October 2005 (CL alpha = 0.1)



4.4 FILAMENTOUS ALGAE

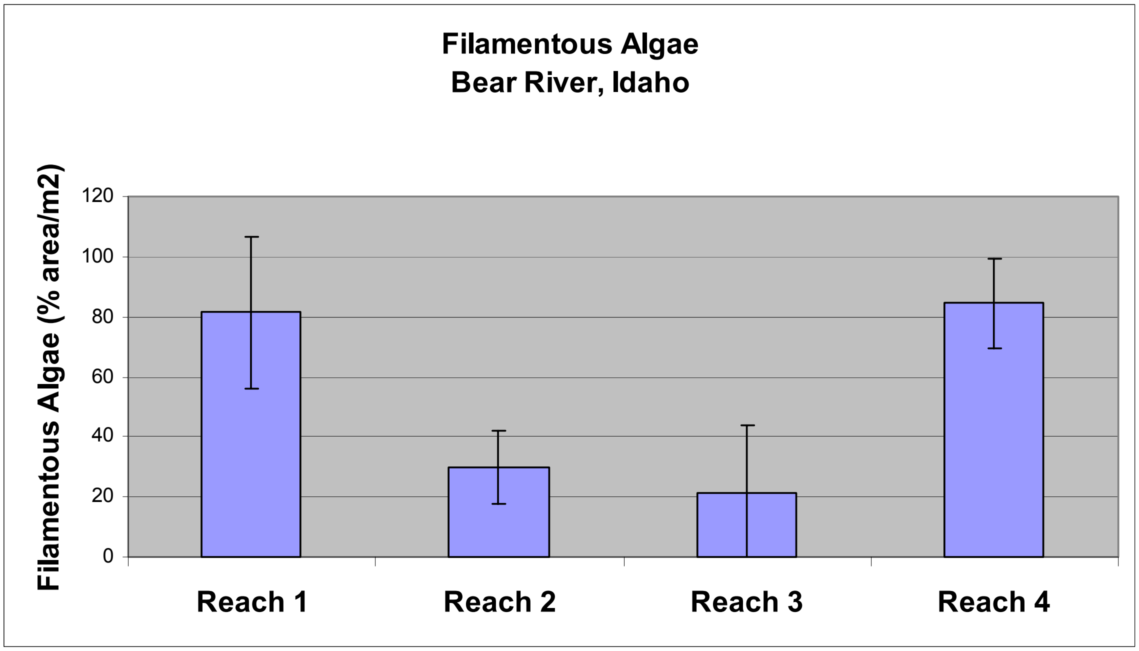
Filamentous algae coverage was significantly different between the four study reaches (single factor ANOVA p = 0.002). Paired statistical comparisons (Student's t-test) between reach 1 and each experimental reach reveal a significant difference between the reach 1 - reach 2 comparison (p = 0.05) and the reach 1 - reach 3 comparison (p = 0.02) but no statistical significance between the reach1 - reach 4 comparison (p = 0.9).

Reaches 1 and 4 had on average considerably higher percent algal coverage compared to reaches 2 and 3 (Figure 4.4-1). Filamentous algae blanketed much of the cobble substrate in reach 1 with the exception of transect A where higher current velocities likely moved substrate during higher discharge events. Long stalks of filamentous algae covered much of the bedrock substrate in reach 4 except where higher velocities scoured the surface clean. Transects B, C, D and E in reach 1 were covered with a thick mat consisting of periphytic algae and fine sediment. The algal filaments in reach 1 were much shorter and a dull brown color relative to the long, bright green filaments found in reach 4.

In reach 2, transects TA, TB and TC had similar algal coverage. Transect D had the lowest percent cover of filamentous algae while transect E had the highest algal coverage. Transect D is the transition point between the lower gradient depositional channel and the bedrock controlled steeper gradients of the Black Canyon. The high algal coverage transect TE with its steeper gradient suggests other factors beyond current velocity influence filamentous algae presence.

In reach 3 filamentous algae cover was highest in transect E where the reach transitions into pool habitat. Otherwise algal coverage in reach 3 was relatively low particularly in transects A and B compared to transects in reaches 1, 2 and 4.

Figure 4.4-1: Filamentous algae density, October 2005 (CL alpha = 0.1)



4.5 FISHERIES

Fisheries data were analyzed to determine species abundance, biomass and relative weight. Relative weight is a measure of fish condition. Catch per unit effort (CPUE) was calculated for each reach for comparison purposes within and between sample study years. Seven species total were collected in this sampling effort but not all species were present in each study reach. The analysis is divided into results for each respective study reach.

4.5.1 Reach 1—Above Alexander Reservoir

Four species were collected in reach 1 for a total catch of 84 fish and biomass of 7.31 kg (Table 4.5-1). Longnose dace were the most abundant (55 fish; 65% of the catch) followed by mottled sculpin (26; 31%), common carp (2; 2%), and small mouth bass (1; 1%) (Figure 4.5-1). Common carp comprised the majority of the biomass at 91% (6654 g), followed by longnose dace (5%; 362 g), mottled sculpin (4%; 260 g), and small mouth bass (<1%; 30 g) (Figure 4.5-2).

Table 4.5-1: Fish density and biomass per 100 meters in reach 1, October 2005

Species	N	Weight (g)	CPUE (fish / minute)
Longnose Dace (*Rhinichthys cataractae*)	55 (65%)	362 (5%)	3.29
Small Mouth Bass (*Micropterus dolomieu*)	1 (1%)	30 (<1%)	0.06
Mottled Sculpin (*Cottus bairdi*)	26 (31%)	260 (4%)	1.56
Common Carp (*Cyprinus carpio*)	2 (2%)	6654 (91%)	0.12
Redside Shiner (*Richardsonius balteatus*)	0	0	0
Utah Sucker (*Catostomus ardens*)	0	0	0
Rainbow Trout (*Oncorhynchus mykiss*)	0	0	0
Total	**84**	**7306**	**5.03**

CPUE was highest for longnose dace at 3.29 fish / minute, followed by mottled sculpin (1.56 fish / minute), common carp (0.12 fish / minute), and small mouth bass (0.06 fish / minute) (Figure 4.5-3).

The relative weights of the 2 common carp collected in reach 1 indicated that they were in above average condition, as each of the fish had a relative weight of 117.

Figure 4.5-1: Fish species composition, October 2005

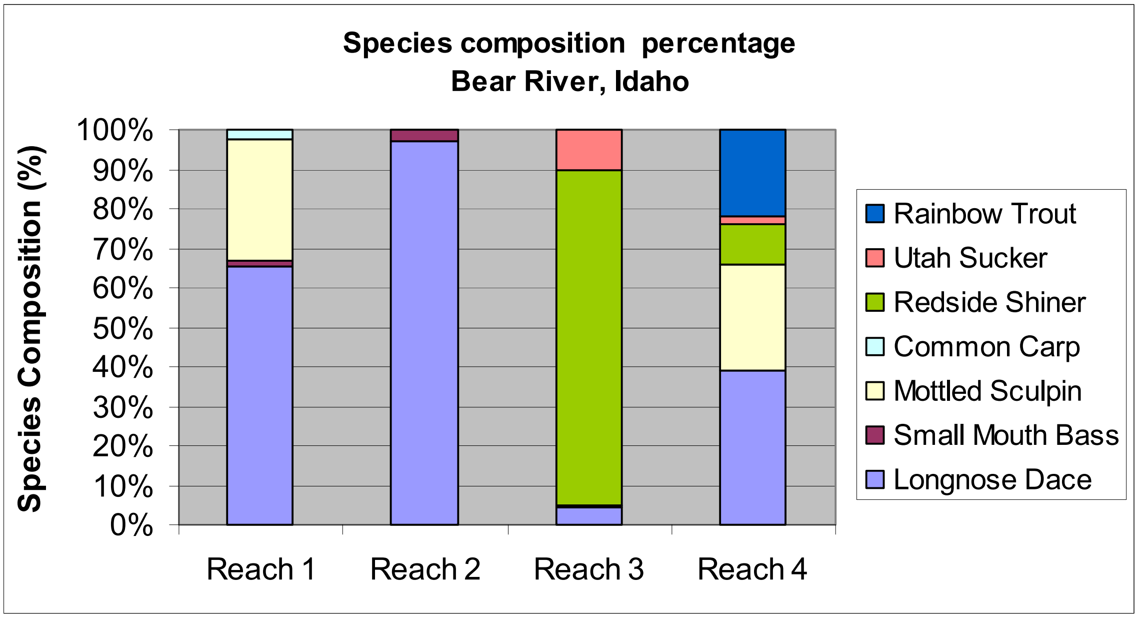


Figure 4.5-2: Fish species biomass, October 2005

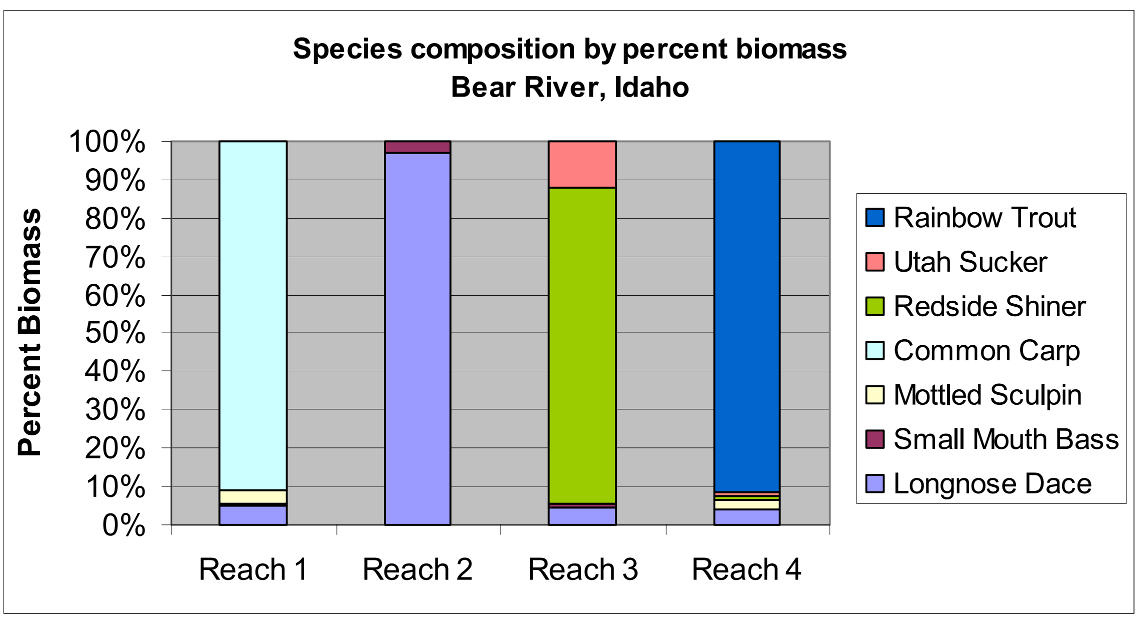
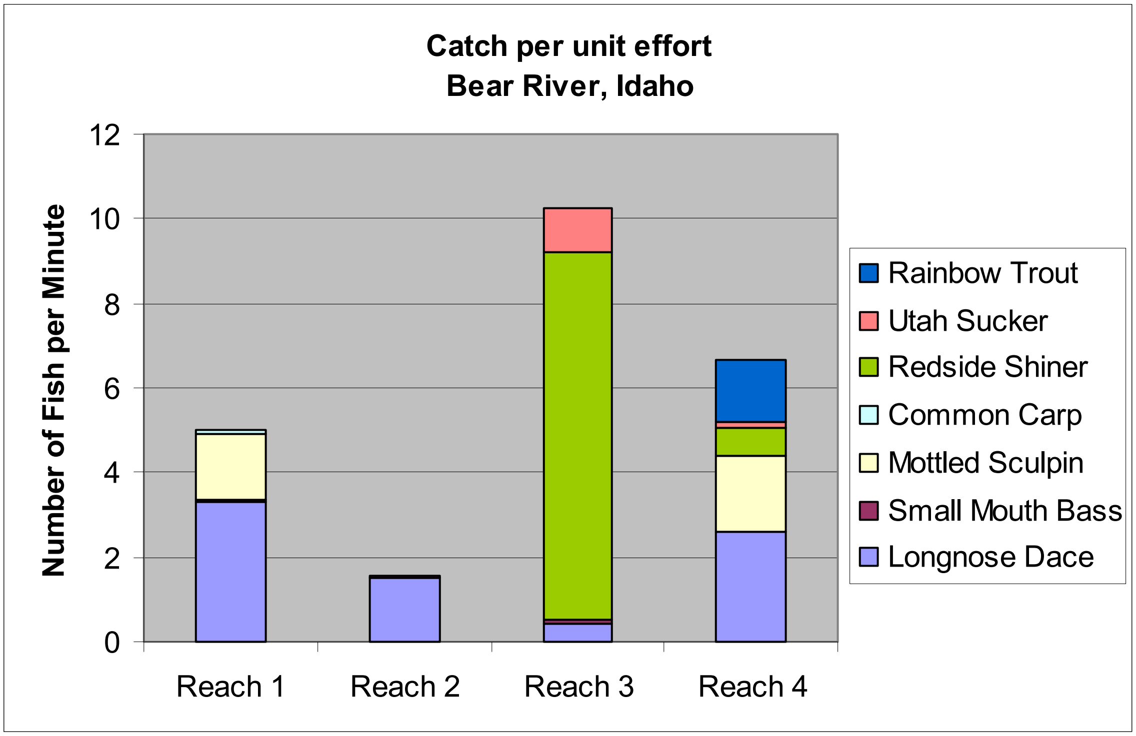


Figure 4.5-3: Catch per unit effort for reaches 1, 2, 3 and 4, October 2005



4.5.2 Reach 2— Below Grace Dam

Only two species were collected in reach 2 for a total catch of 34 fish and biomass of 0.27 kg (Table 4.5-2). Longnose dace were the most abundant as they accounted for 33 of the 34 fish collected (97% of the catch) and the only other fish collected was a juvenile small mouth bass (1; 3%) (Figure 4.5-1). Accordingly, longnose dace comprised a large majority of the biomass at 97% (257g) and the one small mouth bass accounted for the remaining 3% (8 g) (Figure 4.5-2).

Catch per unit effort was greatest for longnose dace at 1.52 fish / minute, and CPUE for small mouth bass was 0.06 fish / minute (Figure 4.5-3).

Table 4.5-2: Fish density and biomass per 100 meters in reach 2, October 2005

Species	N	Weight (g)	CPUE (fish / minute)
Longnose Dace (*Rhinichthys cataractae*)	33 (97%)	257 (97%)	1.52
Small Mouth Bass (*Micropterus dolomieu*)	1 (3%)	8 (3%)	0.05
Mottled Sculpin (*Cottus bairdi*)	0	0	0
Common Carp (*Cyprinus carpio*)	0	0	0
Redside Shiner (*Richardsonius balteatus*)	0	0	0
Utah Sucker (*Catostomus ardens*)	0	0	0
Rainbow Trout (*Oncorhynchus mykiss*)	0	0	0
Total	34	265	1.57

4.5.3 Reach 3— Black Canyon

Four species were collected in reach 3 for a total catch of 119 fish and a biomass of 0.47 kg (Table 4.5-3). Redside shiner dominated in abundance (101 fish; 85% of catch) followed by Utah sucker (12; 10%), longnose dace (5; 4%), and small mouth bass (1; 1%) (Figure 4.5-1). Redside shiner accounted for 83% of the biomass (392 g), followed by Utah sucker (12%, 56 g), longnose dace (5%; 22 g), and small mouth bass (<1%; 4 g) (Figure 4.5-2).

Catch per unit effort was greatest for redside shiner at 8.71 fish / minute, followed by Utah sucker (1.03 fish / minute), longnose dace (0.43 fish / minute), and small mouth bass (0.09 fish / minute) (Figure 4.5-3).

Table 4.5-3: Fish density and biomass per 100 meters in reach 3, October 2005

Species	N	Weight (g)	CPUE (fish / minute)
Longnose Dace (*Rhinichthys cataractae*)	5 (4%)	22 (5%)	0.43
Small Mouth Bass (*Micropterus dolomieu*)	1 (1%)	4 (<1%)	0.09
Mottled Sculpin (*Cottus bairdi*)	0	0	0
Common Carp (*Cyprinus carpio*)	0	0	0
Redside Shiner (*Richardsonius balteatus*)	101 (85%)	392 (83%)	8.71
Utah Sucker (*Catostomus ardens*)	12 (10%)	56 (12%)	1.03
Rainbow Trout (*Oncorhynchus mykiss*)	0	0	0
Total	119	474	10.26

4.5.4 Reach 4—Above Grace Power Plant

The 5 species collected in reach 4 was the most of all the study reaches, and this was the only reach where rainbow trout were captured. The total catch was 100 fish with a biomass of 6.90 kg (Table 4.5-4). Longnose dace were the most abundant (39 fish; 39% of the catch) followed by mottled sculpin (27; 27%), rainbow trout (22; 22%), redside shiner (10; 10%), and Utah sucker (2; 2%) (Figure 4.5-1). Rainbow trout accounted for the majority of the biomass at 91% (6308g). The remaining 9% of the biomass was comprised of longnose dace (4%; 263 g), mottled sculpin (3%; 180 g), redside shiner (1%; 92g), and Utah sucker (1%; 58g) (Figure 4.5-2).

Table 4.5-4: Fish density and biomass per 100 meters in reach 4, October 2005

Species	N	Weight (g)	CPUE (fish / minute)
Longnose Dace (*Rhinichthys cataractae*)	39 (39%)	263 (4%)	2.59
Small Mouth Bass (*Micropterus dolomieu*)	0	0	0.00
Mottled Sculpin (*Cottus bairdi*)	27 (27%)	180 (3%)	1.80
Common Carp (*Cyprinus carpio*)	0	0	0.00
Redside Shiner (*Richardsonius balteatus*)	10 (10%)	92 (1%)	0.67
Utah Sucker (*Catostomus ardens*)	2 (2%)	58 (1%)	0.13
Rainbow Trout (*Oncorhynchus mykiss*)	22 (22%)	6308 (91%)	1.46
Total	100	6901	6.65

Catch per unit effort was greatest for longnose dace at 2.59 fish / minute followed by mottled sculpin (1.80 fish / minute), rainbow trout (1.46 fish / minute), redside shiner (0.67 fish / minute), and Utah sucker (0.13 fish / minute) (Figure 4.5-3).

A total of 22 rainbow trout were collected in reach 4. Thirteen of the 22 fish were marked with freeze-brands and 9 fish had no mark. All 13 freeze-brands were on the right side below the dorsal fin and they all had the same orientation (upright T), indicating that all marked fish were from the same cohort. This particular location of the freeze-brands indicated that these fish were released in 2005 and the orientation indicated that they were released at the foot bridge below the Grace power plant.

The 22 rainbow trout collected in reach 4 ranged in length from 143 mm to 347 mm and had a mean length of 287 mm (Table 4.5-4). They ranged in weight from 34 g to 590 g with a mean weight of 287 g. The length-frequency distribution of the 22 rainbow trout from reach 4 is shown in Figure 4.5-4.

Figure 4.5-4: Length frequency distribution for rainbow trout in reach4, October 2005

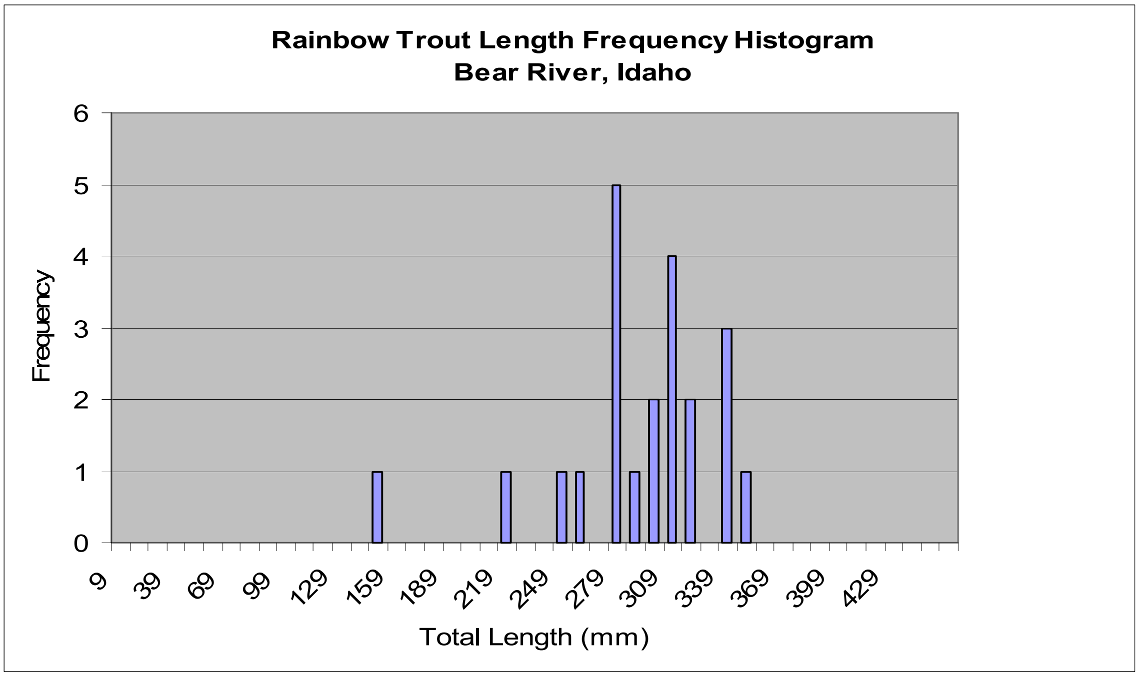
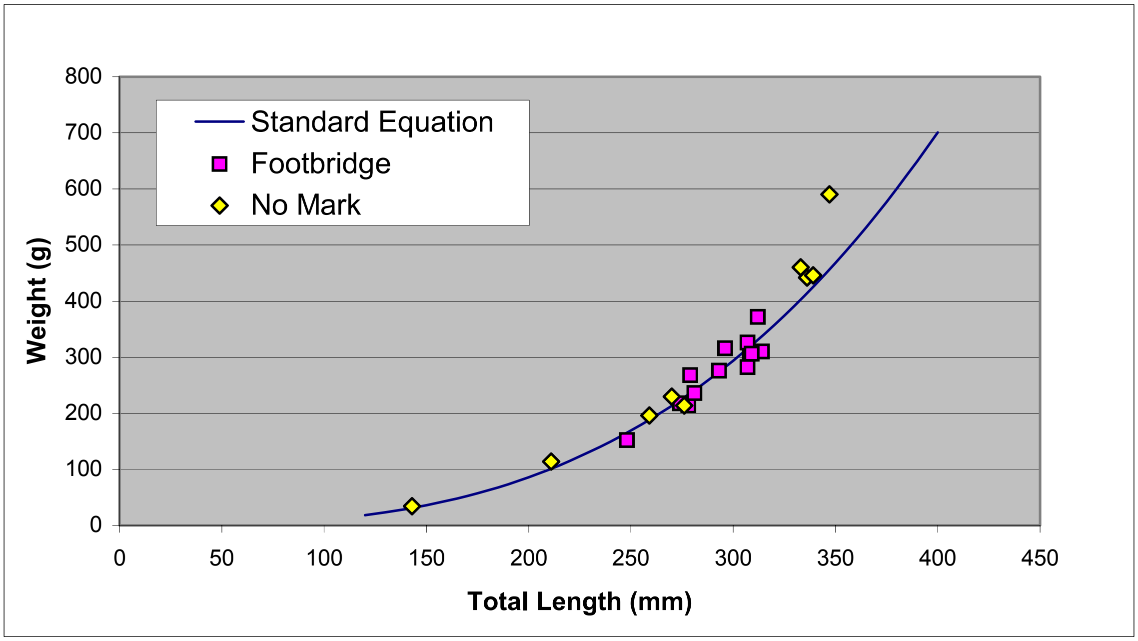


Table 4.5-5: Rainbow Trout length, weight, and relative weight in reach 4, October 2005

Number	Freeze brand	Length (mm)	Weight (g)	Relative Weight
1	Foot bridge '05	278	214	92
2	Foot bridge '05	248	152	92
3	Foot bridge '05	314	310	92
4	Foot bridge '05	293	276	101
5	Foot bridge '05	279	268	114
6	Foot bridge '05	307	282	90
7	Foot bridge '05	274	218	98
8	Foot bridge '05	312	372	113
9	Foot bridge '05	308	306	96
10	Foot bridge '05	307	326	104
11	Foot bridge '05	296	316	112
12	Foot bridge '05	309	306	95
13	Foot bridge '05	281	236	98
14	None	259	196	104
15	None	276	214	94
16	None	333	460	114
17	None	143	34	109
18	None	211	114	113
19	None	336	442	107
20	None	339	446	105
21	None	270	230	108
22	None	347	590	129
	Average	287	287	104

Overall, rainbow trout condition (relative weight) was good. In Figure 4.5-5, the solid line represents the standard equation for rainbow trout (Wr = 100). The yellow diamonds represent 9 fish lacking freeze-brands. The pink squares represent 13 fish marked with freeze-brands indicating they were released at the footbridge adjacent to the Grace power plant in 2005. The relative weights were clustered closely and symmetrically around the standard equation line (Wr = 100) (Figure 4.5-5). The mean relative weight (Wr) for all 22 rainbows was 104 and ranged from 90 to 129. For the 13 freeze-branded fish, the mean relative weight was 100 and ranged from 90 to 114. For the 9 un-marked fish, the mean relative weight was 109 and ranged from 94 to 129.

Figure 4.5-5. Rainbow Trout length-relative weight relationship, Reach 4, October 2005



4.6 TEMPERATURE

Water temperature can be a critical factor limiting the distribution and abundance of aquatic species particularly coldwater fishes. For this reason analysis of water temperatures at respective study sites was included in this report. Idaho DEQ staff deployed hobo temps in study reaches 1, 2 and 4 for much of the 2005 calendar year. Record intervals were set at 1 hour. Water temperature was not measured at study reach 3.

Daily average, minimum and maximum temperatures were calculated from the hourly data for each study reach respectively (Figures 4.6-1, 4.6-2, and 4.6-3). Water temperatures in each respective study reach displays varying degrees of response to meteorological conditions. Daily maximum water temperature for each study reach was plotted for comparison purposes (Figure 4.6-4). The difference in maximum temperature, ΔT, between reach 2 verses reaches 1 and 4 respectively was plotted to analyze longitudinal water temperature differences (Figure 4.6-5).

Reach 1 consistently exhibited the highest daily maximum water temperatures of the three reaches monitored with the exception of June 27 and July 1, 2005 when reach 2 temperatures were greater. From June 30, 2005 through August 29, 2005 daily maximum water temperatures in reach 1 were above 20 ºC. The maximum water temperature for all study reaches (25.8 ºC) was recorded in reach 1 on July 22, 2005. Diel temperature fluctuations (maximum minus minimum daily temperature) during the summer months (June 21 through September 21, 2005) in reach 1 averaged 4.0 ºC.

Reach 2 water temperatures were consistently cooler than temperatures in Reach 1 (average of 1.1 ºC cooler June 21 through September 21, 2005). The maximum difference between sites occurred on June 15, 2005 when Reach 2 maximum temperature was 15.9 ºC and reach 1 was 21 ºC, a difference of 5.1 ºC. The maximum water temperature recorded in Reach 2 was 23.9 ºC on July 1, 2005. Diel temperature fluctuations during the summer months in reach 2 averaged 1.4 ºC indicating a substantially narrower range in daily temperature fluctuations relative to reach 1. In other words the daily minimum water temperatures in reach 1 tend to be lower than reach 2. Discharge spikes below Grace Dam on July 26 (255 cfs) and September 16, 2005 (194 cfs) did not appear to alter daily maximum stream temperatures (Figure 4.6-4)

Reach 4 exhibited the coolest water temperatures of the three reaches monitored. Reach 4 averaged 2 ºC cooler each day than reach 2 below Grace Dam for the summer season. Daily average temperatures never exceeded 20 ºC for the year. The maximum water temperature in reach 4 was 22.9 ºC recorded on July 25, 2005. Diel temperature fluctuations during the summer months in reach 4 averaged 4.0 ºC.

Figure 4.6-1: Water temperature in reach 1, 2005

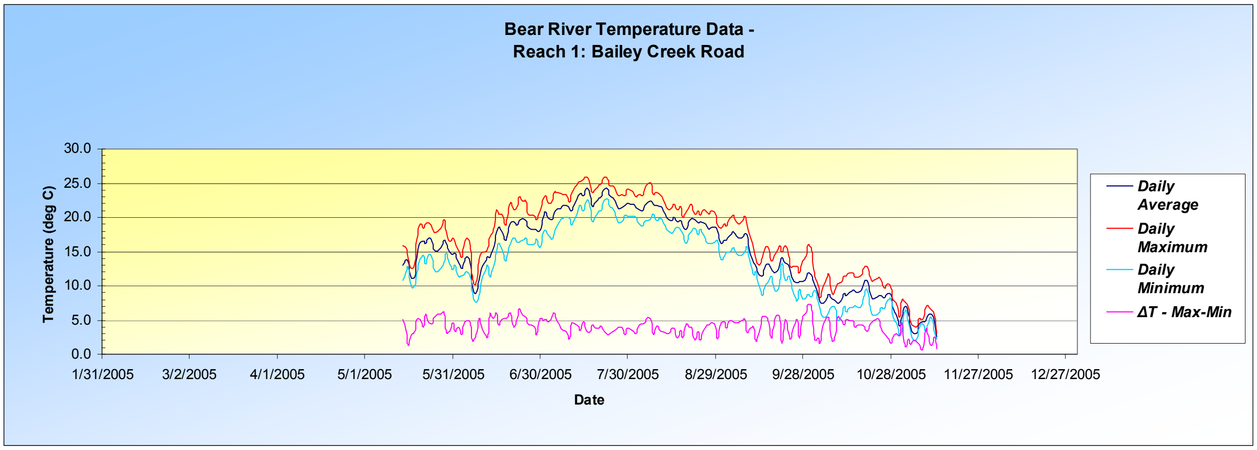


Figure 4.6-2: Water temperature in reach 2, 2005

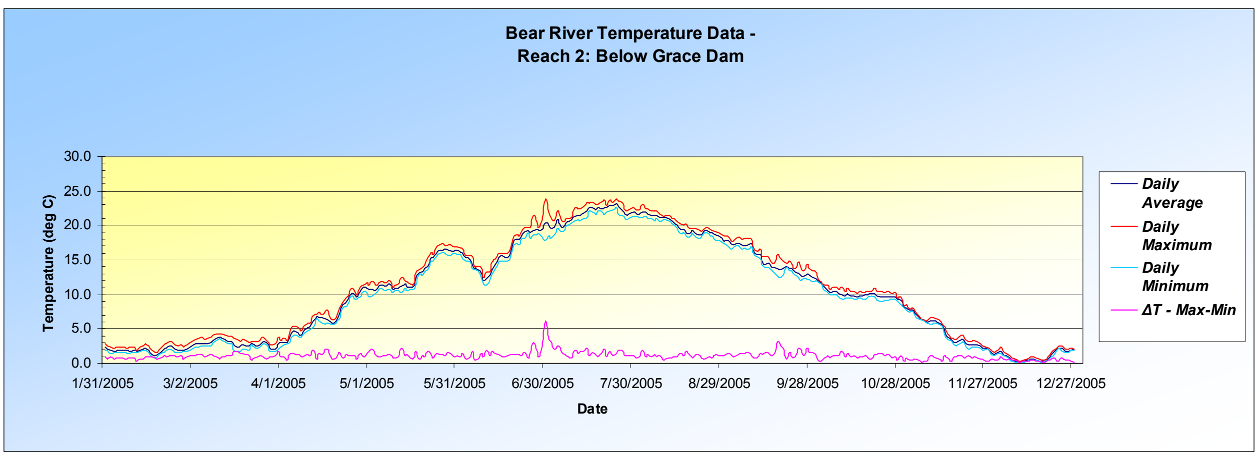


Figure 4.6-3: Water temperature in reach 4, 2005

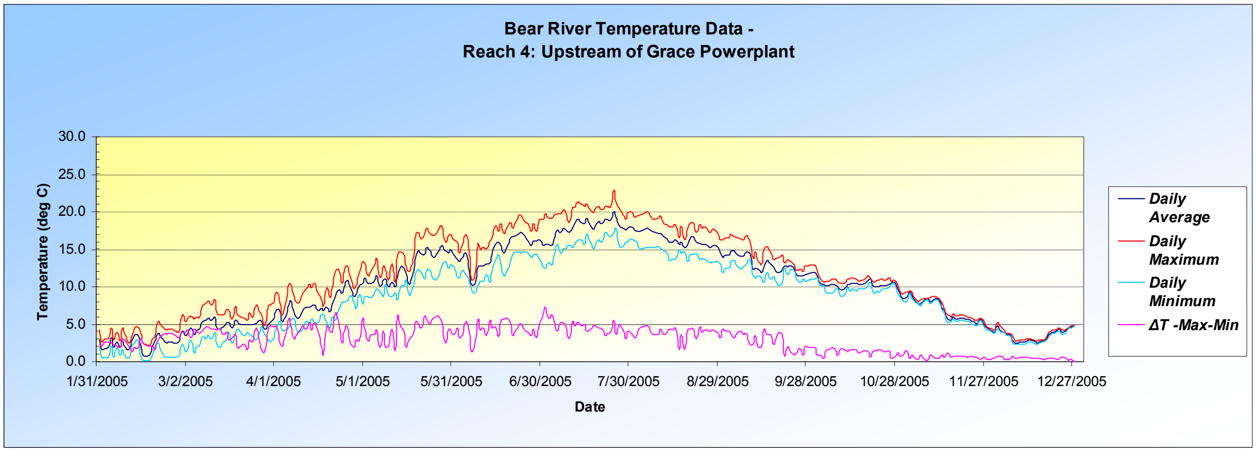


Figure 4.6-4: Maximum water temperatures in reaches 1, 2 and 4, 2005

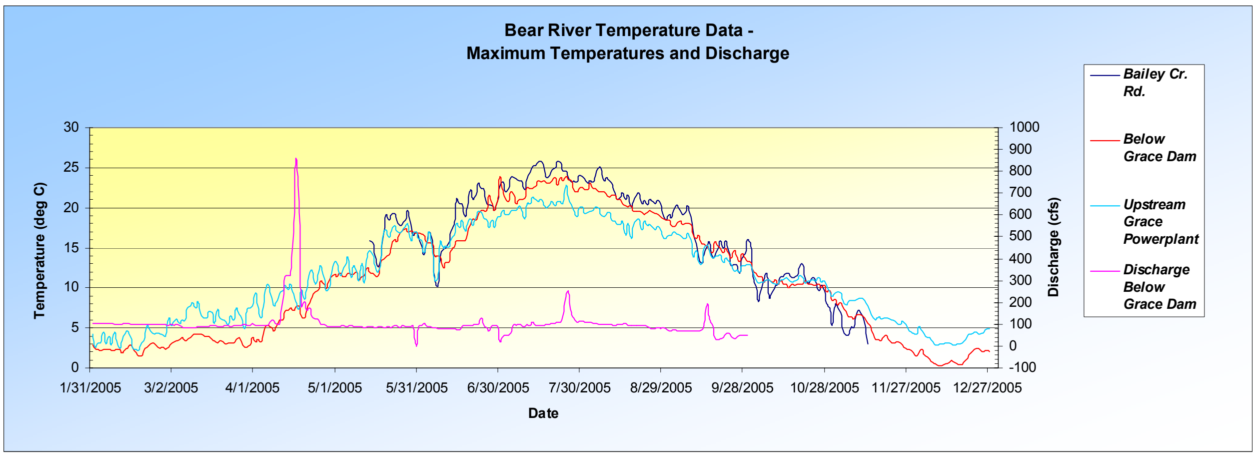
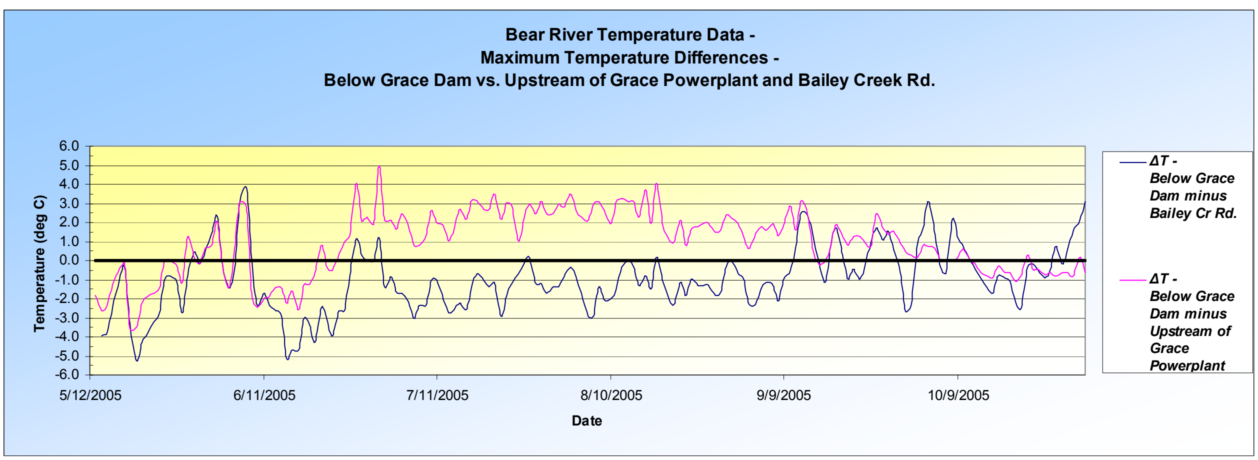


Figure 4.6-5: Daily maximum water temperature differences, ΔT, between reaches, 2005



4.7 BENTHIC MACROINVERTEBRATES

BMI were sampled along five transects in each of the four study reaches in October 2005. Eight subsamples, taken along each transect, were combined into a single composite sample for the transect. For each study reach there were forty subsamples combined into five composite samples. EcoAnalysts expects to complete BMI identification and enumeration by April 28, 2006. OASIS will distribute a supplemental report to PacifiCorp and the ECC within four weeks receipt of the BMI data.

4.8 ORGANIC MATTER ASH-FREE-DRY-WEIGHT

Organic Matter present in each composite BMI sample was subsampled, homogenized, filtered, weighed after drying at 100 ºC and re-weighed again after being placed in the muffle furnace at 500 ºC. This laboratory procedure measures dry mass, inorganic mass, and the ability to calculate the amount of organic material expressed as AFDW. The number is then standardized to AFDW per m^2 in grams. EcoAnalysts expects to complete the organic matter AFDW laboratory procedures by April 28, 2006. OASIS will distribute a supplemental report to PacifiCorp and the ECC within four weeks receipt of the organic matter data.

5. DISCUSSION

The new license for the Bear River Hydroelectric Project (FERC No. 20) includes a condition requiring PacifiCorp to implement and study a variable flow regime at the Grace Hydropower Facility in the 6.2 mile reach known as the Black Canyon between Grace Dam and the Grace powerhouse. PacifiCorp, in collaboration with the Environmental Coordination Committee (ECC), developed the Bear River Black Canyon Monitoring Study to examine the effect of the variable flow regime on the river channel shape, substrate and aquatic biota. Specifically the Black Canyon Monitoring Plan includes investigation of: 1) Macroinvertebrates—population trends, diversity and community indices; 2) Organic Matter Ash-Free Dry Weight (AFDW); 3) Periphyton—chlorophyll concentration and biomass; 4) Fisheries—population trends, community composition, fish condition; 5) Filamentous Algae—density; and 6) Channel Morphology—shape and substrate composition.

The monitoring effort comprises four study reaches. Reach 1, partially regulated by Bear Lake, serves as the reference reach. Reaches 2, 3 and 4, subject to the variable flow regime below Grace Dam, serve as the experimental reaches. The monitoring study spans six-years of data collection. The first three-years serve as a baseline period collecting data in all reaches prior to implementation of the variable flow regime. The second three-year term, years four through six, serve as the experimental phase when reaches 2, 3 and 4 are subjected to flows ranging from 800 to 1500 cfs, approximately 700 to 1400 cfs greater than the minimum instream flow of 65 cfs below Grace Dam. Field sampling occurs once annually in October. Field sampling was initiated in October 2005 and will conclude October 2010. This discussion reports on the first year of monitoring only. As such analysis is limited to comparisons of the similarities and differences of the four study reaches with particular emphasis on the reference reach relative to the three reaches located downstream of Grace Dam.

5.1 CHANNEL SHAPE AND SUBSTRATE

The 2005 monitoring effort identified channel shape and substrate differences between reaches 2 and 3. Reach 2 is distinctly wider and shallower than reach 3. Bankfull widths and depths also indicate that reach 3 is more confined and consequently has greater bankfull depths than reach 2. Furthermore, reach 3 substrate is generally coarser than that in reach 2 with the exception of transects TD and TE in reach 2. Qualitative observations of habitat in reaches 1 and 4 also indicate differences in gradient, substrate type and channel processes. The substrate in all four study reaches is highly embedded with fine sediment.

Reach 2, from a stream characteristic perspective, contains two distinctly different channel morphologies. Transects A-C (ID DEQ 2004 transects T1-T3) are located in the upper section of the reach just downstream of the power canal below the dam. This section of the reach is similar to a Rosgen Type C stream with pool- riffle morphology in these upper three transects. Transects A-C are predominantly depositional zones as opposed to erosional zones. In contrast, transects D and E (ID DEQ 2004 T4 and T5) are located at the bedrock nick point forming the start of the Black Canyon. Bedrock shelves are common in transects D and E. The channel in this section of reach 2 is similar to a Rosgen Type B stream with morphology changing from pool-riffle (transects A, B and C) to plane-bed. Water depths are more uniform across the width of the channel compared to reaches A, B and C. The substrate in transect TD is primarily basalt bedrock. Transect E features the narrowest wetted perimeter width, as the stream becomes constrained by the basalt canyon walls. In contrast, the transects in reach 3 displayed similar stream morphologies.

In June, 2004 Mladenka and Van Every conducted a study on the channel morphology and substrate composition of the 6.2 mile bypass reach below Grace Dam on the Bear River. The

2004 study established the five transects respectively for reaches 2 and 3 in the Black Canyon of the Bear. Channel cross-sections were surveyed for these transects in 2004 prior to implementation of the 65 cfs minimum instream flow (MIF). Annual surveys of these transects and substrate composition monitoring in years 2005-2007 will serve as base line data for comparison with surveys in years 2008-2010.

The 2004 channel survey (Mladenka and Van Every 2004) was conducted at significantly lower flows (less than 9 cfs) compared to instream flows ranging from 89-101 cfs during the October 2005 field study. This increase in discharge resulted in greater wetted perimeter widths and stream depths creating more wetted surface area for algae, BMI and fish. The 2004 data did not delineate wetted perimeter and bankfull locations for the respective transects, thereby preventing calculations of the percent increase in available aquatic habitat under the new minimum instream flow regime. In subsequent years mean depth, wetted perimeter (WP), and bankfull (BF) widths will be analyzed over time to assess changes in channel shape and available habitat.

During the period between the 2004 and 2005 study there was a single discharge event significantly greater than the MIF (Figure 4.1-2). This discharge event occurred April 16-18, 2005. During this peak discharge event the maximum stream flow was 863 CFS. In the absence of specific studies it is uncertain if a flow of this magnitude is capable of mobilizing the bedload in reaches 2 and 3. The fact that there were no dramatic changes between the 2004 and 2005 transect surveys suggests the event did not mobilize bedload material. Subsequent channel surveys coupled with hydrologic analysis will potentially shed light on the discharges that mobilize sediments and gravels in study reaches 2 and 3.

Flow regulation is known to influence channel bed composition and channel morphology. In an unregulated stream system, spring snowmelt frequently produces flows capable of mobilizing bedload and winnowing silt and sand from coarse substrates (Osmundson, 2002). Bankfull metrics are useful for classifying stream reaches and comparison with reference sites (Rosgen 1994, 1996). Bankfull discharge is defined as the effective discharge (Leopold 1994) that transports the largest cumulative sediment load (Wolman and Miller, 1960) and is the channel forming flow.

Bankfull features were difficult to identify in reaches 2 and 3 were difficult to distinguish due in part to regulation from Grace Dam as well as grazing in reach 2. Bankfull features serve as a useful metric for comparisons between reaches as well as with regional streams of similar size. Rosgen (1994) uses the bankfull width to water depth ratio (BWD ratio) to characterize streams in his Level II stream classification system. The BWD ratio in reach 2 ranks very high in Rosgen’s stream classification system. In reach 3 the BWD indices are considered to be in the moderate to high range. These higher BWD indices may be a result of 80 years of flow regulation below Grace Dam.

5.2 PERIPHYTON

Periphyton, sometimes referred to as benthic algae, is the algal growth found on substrates in aquatic environments. In addition to algae this benthic layer on rock substrates typically hosts a wide assemblage of micro and macroscopic organisms as well as detritus and fine sediments. Accordingly, AFDW values represent the weight of the algal material contained in the periphyton community as well as bacteria, benthic macroinvertebrates and detritus trapped in the longer algal filaments. Chlorophyll analysis on the other hand measures the ability of pigments to absorb light and as such serves as a measure of algal community productivity. The autotrophic index (AI), the ratio AFDW/chlorophyll a, provides information on the relative viability of the periphyton community.

Periphyton AFDW exhibited a high degree of sample variability within reaches particularly at reaches 2 and 4. This wide sample variance eliminated significant differences between the partially regulated reference reach and the fully regulated experimental reaches although paired reach comparisons do display statistically significant differences. Reach 4, as expected based on visual observations of the ubiquitous filamentous algae mats in the reach, had the highest periphyton AFDW but also contained the greatest sample variance. Reach 1 had the lowest periphyton AFDW of the four study reaches. The low periphyton AFDW in reach 1 may be a result of higher discharge in the spring and summer mobilizing substrate thereby scouring algal growth from previous seasons. In contrast, discharge in reach 2, 3 and 4 rarely mobilizes substrate thereby allowing algal filaments to accumulate for longer periods.

Periphyton chlorophyll concentrations, on the other hand, were significantly different between reaches for pigments a, b and c. Chlorophyll pigments a, b and c were consistently higher in reaches 2, 3 and 4 than reach 1. Higher chlorophyll concentrations, particularly for pigment a, indicates more primary production and for primary consumers such as macroinvertebrate grazers higher nutritional food value (Cummins and Klug 1979).

The inflated autotrophic index (AI) for all four study reaches indicates that the periphyton matrix contains a large amount of non-algal organic material. This organic material likely includes bacteria, BMI and detritus trapped in the algal filaments. For macroinvertebrate grazers the additional non-algal material, particularly bacteria, may be an equally important high quality food source (Merritt and Cummins 1984). Careful examination of the BMI community at respective sites may reveal additional insights into the periphyton data.

Periphyton AFDW and chlorophyll concentrations can change rapidly in streams due to disturbance events (Steinman and McIntire 1990) or rapid growth responses to changing environmental conditions (Sheath et al. 1986). Consequently drawing conclusions about stream conditions based on isolated sampling events of periphyton AFDW and chlorophyll concentrations can be misleading. Understanding the relationship between periphyton AFDW and chlorophyll concentrations and the stream ecosystems is best achieved through systematic sampling where periphyton is sampled on a weekly or biweekly basis.

5.3 FILAMENTOUS ALGAE

Filamentous algae is fairly ubiquitous within the four study reaches. The differences observed in filamentous algae cover within and between the reaches may be the result of a combination of micro and macrohabitat factors. At the microhabitat scale current velocity and substrate size greatly influences the presence of filamentous algae. Increased current velocities have the ability to scour algae from substrate as well as mobilize the substrate itself. Within a given study reach the lower gradient transects tended to have higher concentrations of filamentous algae relative to higher gradient transects with the exception of transect TE in reach 2.

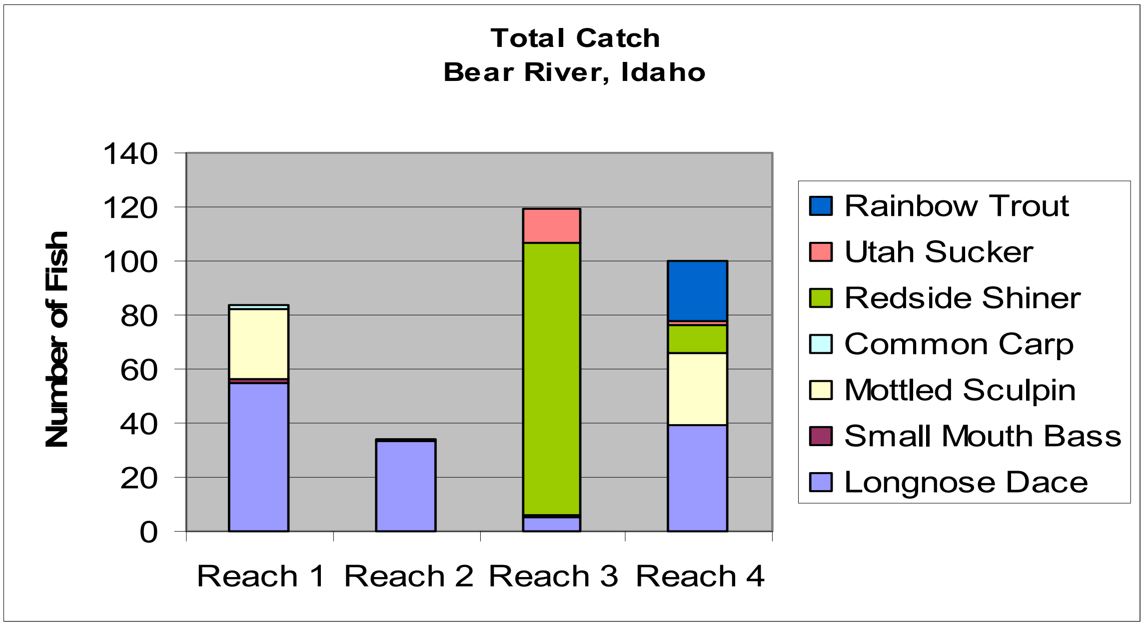
Between reach differences in percent algal coverage cannot be attributed to gradient alone. For example, reach 4 contains the highest percent algal coverage of all four study reaches yet this reach also has the highest stream gradient of the four reaches. Clearly other environmental factors are resulting in the high percentage of filamentous algae in reach 4. Groundwater upwellings in reach 4 might be contributing higher concentrations of dissolved organic carbon or other nutrients stimulating filamentous algae growth. Upwellings and associated nutrient inputs may also be the reason for higher filamentous algae coverage in reach 1 as well as transect TE in reach 2.

5.4 FISHERIES

Reach 4 contained the highest fish species richness of the four study reaches. Reach 4 was the only reach where rainbow trout were collected. Reaches 1 and 3 both had 4 species collected, and reach 2 showed the least diversity with only 2 species. Longnose dace was the only species that was collected in all 4 reaches.

Reach 3 had the highest density of fish per 100 meters (119) (Figure 5.4-1). The majority of these were redside shiners. No trout were recorded in reach 3. Fish density in reach 4 was 100 per 100 meters. Reach 1 contained 84 fish per 100 meters. Reach 2 had the lowest fish density, 34 per 100 meters. All but one of these 34 were longnose dace.

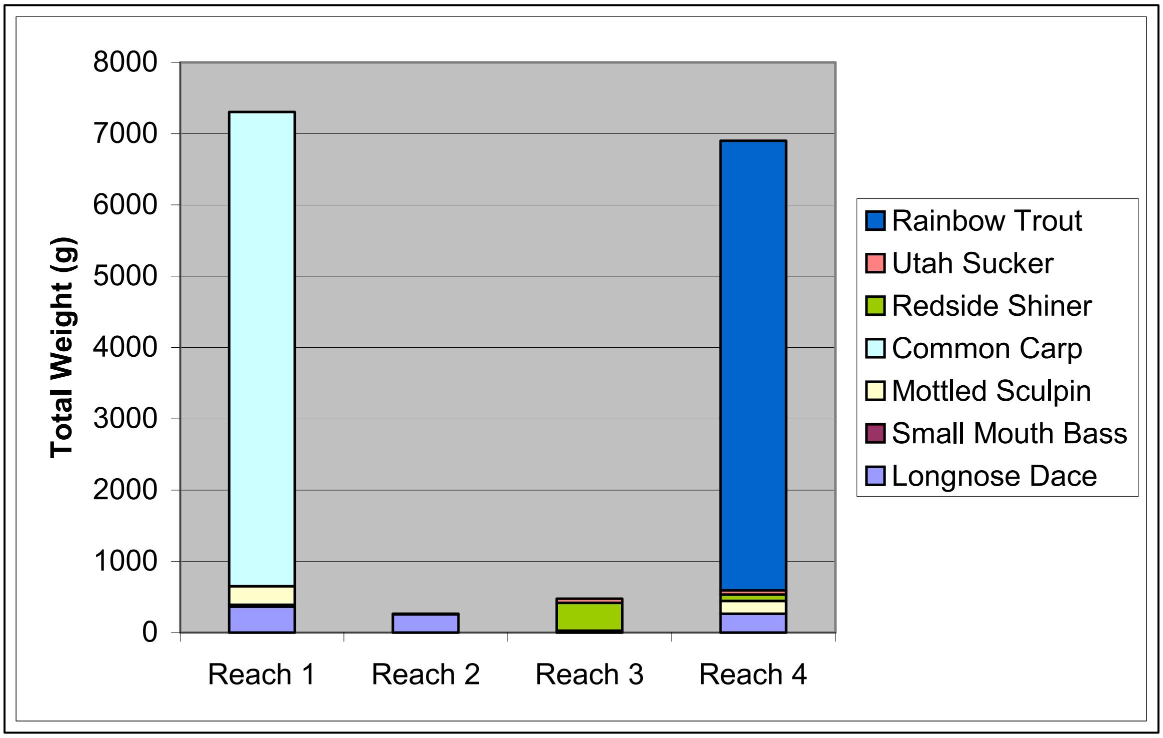
Figure 5.4-1: Fish density per 100 meters for reaches 1, 2, 3 and 4, October 2005



The highest overall catch rate was 10.26 fish / minute in reach 3, followed by 6.65 fish / minute in reach 4, 5.03 fish / minute in reach 1, and the lowest catch rate was 1.57 fish / minute in reach 2 (Figure 4.5-3). Longnose dace had the highest catch rate in 3 of the 4 reaches (reaches 1, 2, and 4), and redside shiner had the highest catch rate in reach 3. Accordingly, the relative species composition was dominated by longnose dace in 3 of the 4 reaches (reaches 1, 2, and 4) whereas redside shiner represented the largest percentage of the sample in reach 3 (Figure 4.5-1).

The highest total biomass was in reach 1 (7.31 kg), and was followed closely by reach 4 (6.90 kg) (Figure 5.4-2). Reach 3 and reach 2 had far less total biomass at 0.47 kg and 0.27 kg, respectively. While common carp represented only 2 of the 84 fish collected in reach 1, they accounted for over 91% of the biomass (Figure 4.5-2). In reach 2, longnose dace were the most abundant and they accounted for a large majority (97%) of the biomass. Similarly, in reach 3, redside shiner accounted for 83% of the biomass and they were also the most abundant. In reach 4, rainbow trout accounted for over 91% of the biomass, but they only accounted for 22% of the catch in terms of abundance.

Figure 5.4-2: Fish biomass (g) per 100 meters for reaches 1, 2, 3 and 4, October 2005



Within reach comparisons between the number of species, relative species composition, catch per unit effort (CPUE), biomass, and condition (relative weight) will be made once sufficient data is obtained in subsequent sampling years. In addition, the abundance, length, and weight of freeze-branded rainbow trout will be used in subsequent years to monitor persistence of individual cohorts, recruitment variability, and growth rates among cohorts for comparisons between years and treatments.

It should be noted that Idaho Fish and Game released 250 freeze-branded rainbow trout below the foot bridge near the Grace power plant on October 14, 2005. This release was approximately 1 hour prior to and 75 meters downstream of the fish sampling for reach 4. As a result, some of the fish collected that day may have just been released from the hatchery truck. Accordingly, the condition (relative weight) of some of the freeze-branded fish collected that day may reflect the hatchery conditions more than the habitat conditions in the Bear River. However, this detail should not negatively impact or bias the results of this study as long as it is taken into consideration during data analysis and when interpreting the results.

5.5 TEMPERATURE

Comparisons of hourly water temperature data for reaches 1, 2 and 4 reveals a difference between reaches. These differences are particularly notable during the summer months. Reach 1 exhibited the highest maximum temperatures (25.9 ºC) of all three reaches. Reach 4 exhibited the coolest water temperatures with daily averages below 20 ºC throughout the summer months and occasional maximum recordings greater than 20 ºC. Daily averages in reaches 1 and 2 were greater than 20 ºC for the entire summer season and at times daily minimums remained above 20 ºC for consecutive 24 hour periods.

5.6 HYDROLOGY

Reach 1 differs from reaches 2, 3 and 4 hydrologically. Water storage in Bear Lake decreases the magnitude of peak flow events during spring snowmelt and extends the duration of the snowmelt hydrograph into August and early September to fulfill downstream water rights. Reaches 2, 3 and 4 in the Black Canyon of the Bear are fully regulated by upstream irrigation and power generation diversions. Instream flows below Grace Dam are relatively stable year round. Spring inflows just upstream of reach 4 contribute an additional 30-60 cfs on top of the existing base flow.

5.7 BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates data will be analyzed upon completion of laboratory identification and enumeration.

5.8 ORGANIC MATTER AFDW

Organic matter AFDW will be analyzed upon completion of benthic macroinvertebrate identification and enumeration.

6. CONCLUSIONS

The new license for the Bear River Hydroelectric Project (FERC No. 20) includes a condition requiring PacifiCorp to implement and study a variable flow regime at the Grace Hydropower Facility in the 6.2 mile reach known as the Black Canyon between Grace Dam and the Grace powerhouse. PacifiCorp, in collaboration with the Environmental Coordination Committee (ECC), developed the Bear River Black Canyon Monitoring Study to examine the effect of the variable flow regime on the river channel shape, substrate and aquatic biota. Specifically the Black Canyon Monitoring Plan includes investigation of: 1) Macroinvertebrates—population trends, diversity and community indices; 2) Organic Matter Ash-Free Dry Weight (AFDW); 3) Periphyton—chlorophyll concentration and biomass; 4) Fisheries—population trends, community composition, fish condition; 5) Filamentous Algae—density; and 6) Channel Morphology—shape and substrate composition.

The monitoring effort comprises four study reaches. Reach 1, partially regulated by Bear Lake, serves as the reference reach. Reaches 2, 3 and 4, subject to the variable flow regime below Grace Dam, serve as the experimental reaches. The monitoring study spans six-years of data collection. The first three-years serve as a baseline period collecting data in all reaches prior to implementation of the variable flow regime. The second three-year term, years four through six, serve as the experimental phase when reaches 2, 3 and 4 are subjected to flows ranging from 800 to 1500 cfs, approximately 700 to 1400 cfs greater than the minimum instream flow of 65 cfs below Grace Dam. Field sampling occurs once annually in October. Field sampling was initiated in October 2005 and will conclude October 2010. This study reports on the first year of monitoring only. As such analysis is limited to comparisons of the similarities and differences of the four study reaches particularly the reference reach relative to the three reaches located downstream of Grace Dam.

The 2005 monitoring effort identified biological and physical habitat differences between the study reaches but no distinct pattern differences distinguish the upstream reference reach from the three experimental reaches below Grace Dam. Quantitative habitat comparisons between reaches 2 and 3 indicate that reach 2 is distinctly wider and shallower than reach 3. Qualitative observations of habitat in reaches 1 and 4 indicate differences in gradient, substrate type and channel processes. Within site comparisons over time are needed to isolate the effects of flow on physical habitat.

Periphyton AFDW exhibited a high degree of sample variability within reaches particularly at reaches 2 and 4. This wide sample variance eliminated significant differences between the partially regulated reference reach and the fully regulated experimental reaches although paired reach comparisons do display statistically significant differences. Periphyton chlorophyll concentrations were significantly different between reaches for pigments a, b and c. In addition, filamentous algae density was greatest in reaches 1 and 4. Because periphyton AFDW and chlorophyll concentrations can respond rapidly to changing environmental conditions drawing conclusions from this single sampling event is limited. Examination of trends from consecutive sample years may shed additional insights on differences in the periphyton community between the reference and experimental reaches.

The fish community composition varied between sites. Reach 4 had the greatest diversity (5 species) while reach 3 had the highest density (119/100 meters). Reach 2 had the lowest diversity (2 species) and abundance (34/100 meters). Reach 4 was the only reach with rainbow trout present. It should be noted that rainbow trout are stocked at two week intervals in reach 4 May through October.

Additional data sources indicate that discharge and stream temperature are different between study reaches. Water storage in Bear Lake decreases the magnitude of peak flow events during spring snowmelt and extends the duration of the snowmelt hydrograph into August and early September to fulfill downstream water rights. Reaches 2, 3 and 4 in the Black Canyon of the Bear are fully regulated by upstream irrigation and power generation diversions. Instream flows below Grace Dam are relatively stable year round. Hydrologic data will continue to be incorporated into the analysis for subsequent sampling years.

Reach 1 exhibited the highest maximum temperatures (25.9 ºC) of all three reaches with temperature records. Reach 4 exhibited the coolest water temperatures with daily averages below 20 ºC throughout the summer months and occasional maximum recordings greater than 20 ºC. Daily averages in reaches 1 and 2 were greater than 20 ºC for the entire summer season and at times daily minimums remained above 20 ºC for consecutive 24 hour periods. It is hoped that temperature data will continue to be recorded for reaches 1, 2 and 4 and possibly even reach 3. Temperature data is particularly helpful for understanding the presence and absence of particular fish species.

Identification and enumeration of benthic macroinvertebrates and laboratory analysis of organic matter ash-free dry weight will be completed April 28, 2006. These data sets will be analyzed and presented to PacifiCorp and the ECC as a supplemental report.

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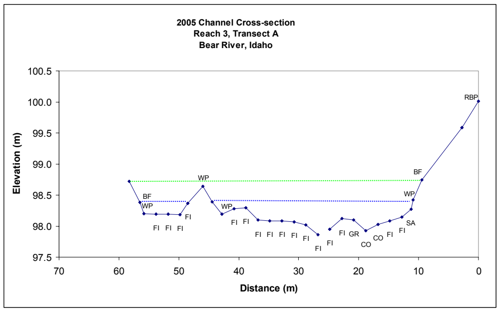
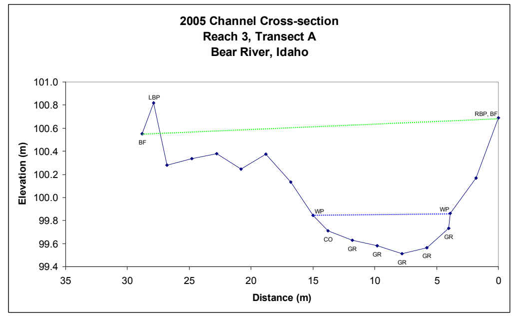
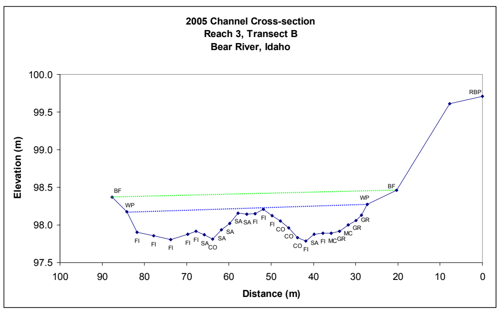
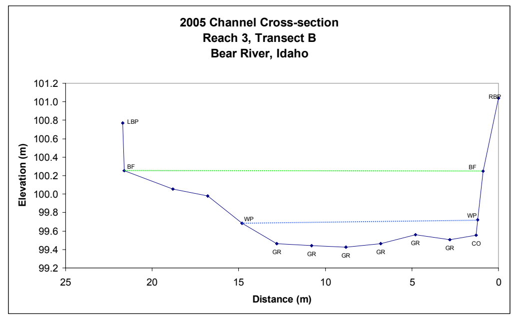
Appendix A
Additional Figures and Photographs

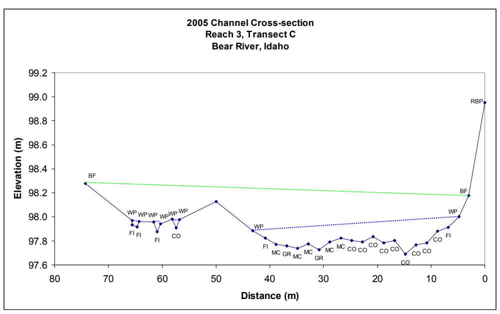
Figure A-1: Channel cross-sections for transects A, B, C, D and E located in reaches 2 and 3 in the Black Canyon of the Bear River

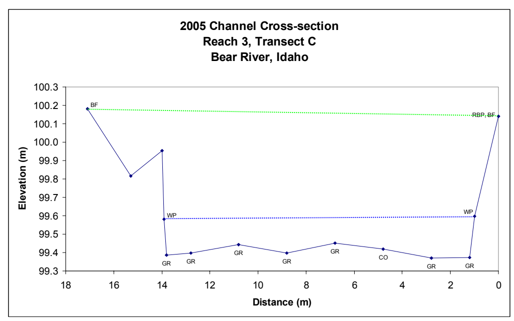


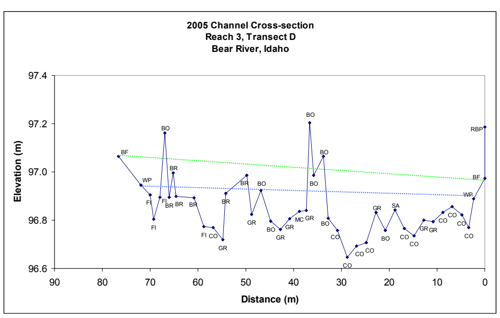


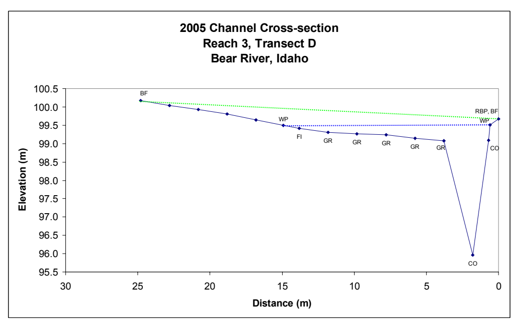


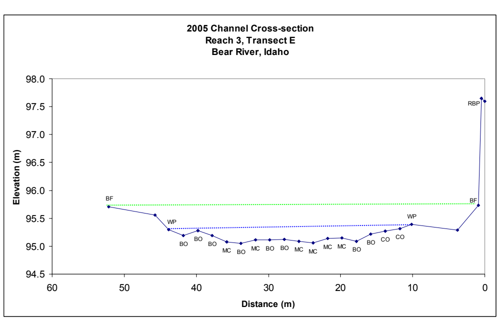


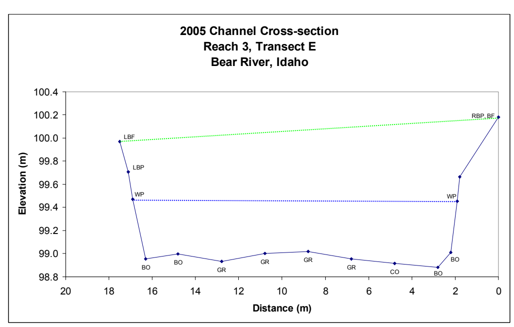












PHOTOGRAPHS

REACH 1

Upstream view of reach 1.

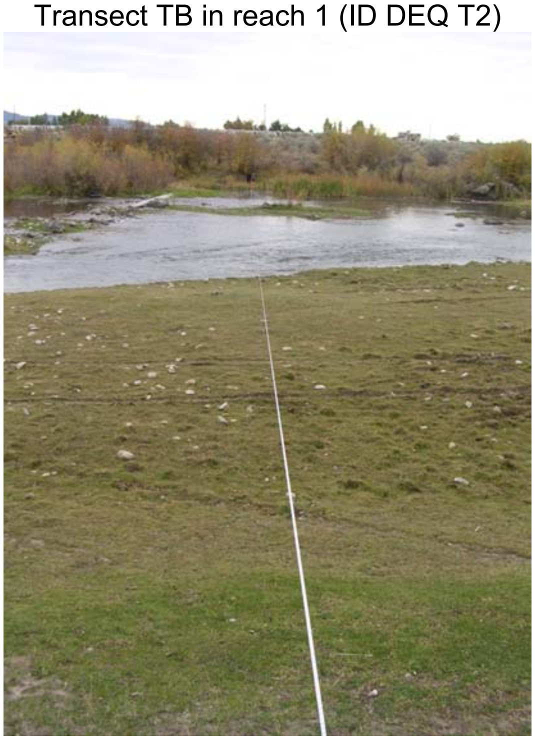
Downstream view of reach 1.

REACH 2

Upstream view of reach 2 from transect TE.

Transect TA in reach 1 (ID DEQ T1)

Transect TB in reach 1 (ID DEQ T2)



Transect TC in reach 1 (ID DEQ T3)

Transect TD in reach 1 (ID DEQ T4)

Transect TE in reach 1 (ID DEQ T5)

REACH 3

View of reach 3 from canyon rim with transects TA TB and TC visible.

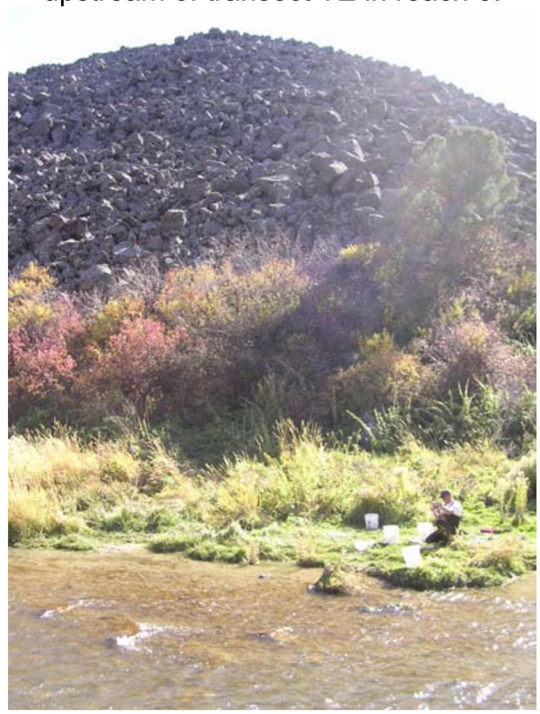
View of reach 3 from canyon rim with transects TD and TE visible.

Upstream view of reach 3 from Transect TC (ID DEQ T8).

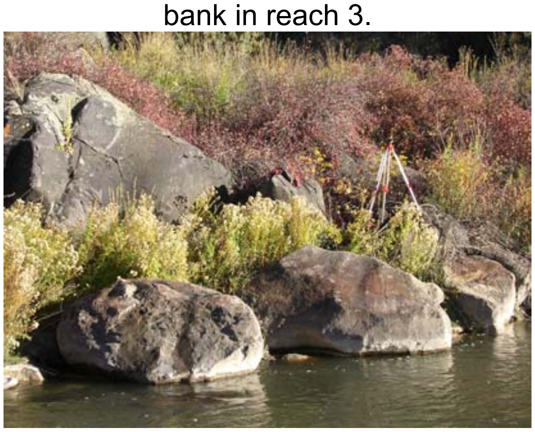
Downstream view of pool below reach 3 from Transect TE (ID DEQ T6).

Upstream view from transect TC (ID DEQ T8) in reach 3.

Vegetated point bar on river left bank just upstream of transect TE in reach 3.



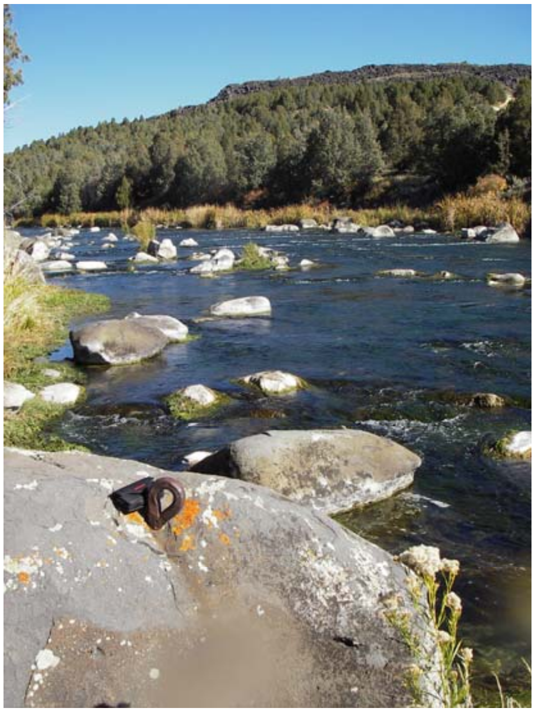
Large boulder substrate typical of river right bank in reach 3.



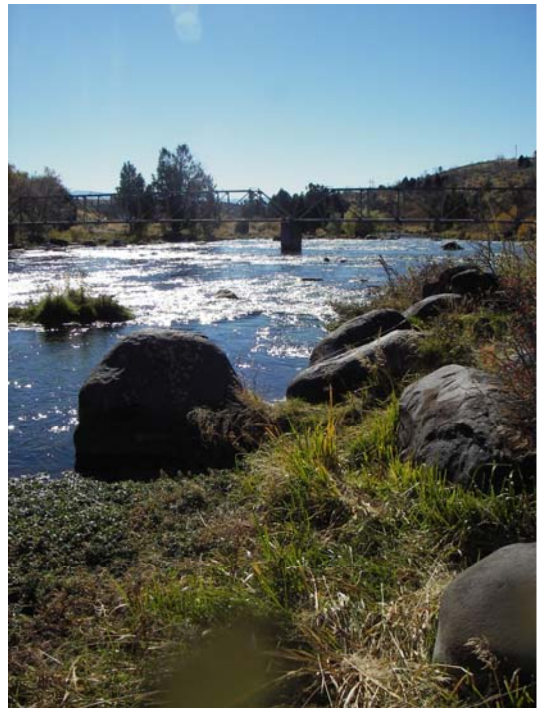
Downstream view of reach 3 from transect TC.

REACH 4

Upstream view from transect TE in Reach 4.

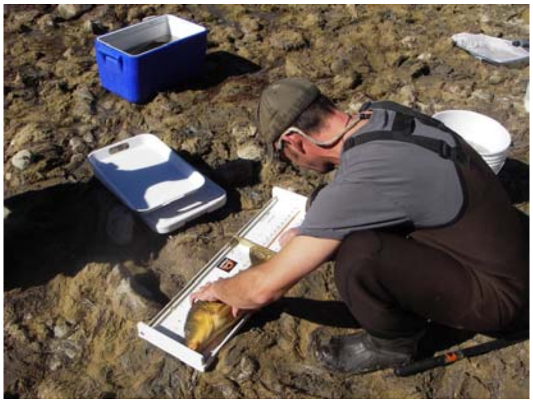


Downstream view from transect TE in Reach 4.



FISHERIES PHOTOS

Length measurement for carp collected in reach 1.



Carp collected in reach 1.

Measuring redside shiners in reach 3.

Electroshocking in reach 3.

Mottled sculpins and longnose dace collected in reach 1.

Handling rainbow trout in reach 4.

Diseased longnose dace collected in reach 4.

PERIPHYTON SAMPLING

Substrate scraped for periphyton analysis.

Scraping and filtering periphyton in reach 2.

BENTHOS SAMPLING

Sampling benthos with surber sampler in reach 2.