EFFECTS OF THE VARIABLE FLOW REGIME ON THE ECOLOGY OF THE BLACK CANYON OF THE BEAR RIVER, IDAHO

Prepared for PacifiCorp
&
the Environmental Coordination Committee

June 10, 2009

Prepared by:

oasis ENVIRONMENTAL

191 Jewel Basin Court, Suite 1A
Bigfork, MT 59911

(This page intentionally blank)

TABLE OF CONTENTS

TABLES

FIGURES

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
MSE	Mean square error
NZMS	New Zealand mud snail
R	Reach
RBT	Rainbow Trout
ΔT	Temperature Difference
T	Transect
μG	Micrograms
WP	Wetted Perimeter
Wr	Relative Weight
WY	Water Year

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 Phase I monitoring studies were 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 Phase II study is to characterize the aquatic biota and associated habitat exposed to variable flow regimes resulting from whitewater releases. Data from the 2005-2007 Phase I study (baseline conditions) will be compared to results from the 2008-2010 Phase II study (variable flow conditions) 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 in October 2010.

(This page intentionally blank)

2. STUDY AREA

The Bear River originates in Summit County, Utah in the northern Uinta Mountains in 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 an 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 Soda 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 Soda Reservoir has a flatter gradient and more closely resembles an alluvial channel with alternating erosion and deposition zones.

2.1 REACH 1: UPSTREAM OF SODA RESERVOIR

Reach 1 was 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 was located in a broad alluvial valley. The reach was a Rosgen C type channel. The predominant habitat type was alternating riffles and runs with clearly demarcated scour and deposition zones exhibited by the gravel/cobble point bars above the wetted perimeter. Bankfull zones were clearly delineated by grasses and woody vegetation. The substrate was highly embedded with fine silt and sand. In higher velocity riffle areas substrate was less embedded. In lower velocity runs a thick mat of periphytic algae blanketed cobbles and gravels further trapping fine sediments.

Reach 1 served as the reference reach for comparison with reaches 2, 3 and 4 which were scheduled for periodic spring flow fluctuations required in the new FERC license for the Grace hydropower project. Instream flows in reach 1 were partially regulated by a combination of upstream dams and reservoirs. The peaks in the spring snowmelt hydrograph were buffered by upstream reservoir storage. Instream flows remained above normal through August and early September to meet downstream irrigation needs. Discharge averaged 118 cfs during the October sampling effort in 2007.

2.2 REACH 2: DOWNSTREAM OF GRACE DAM

Reach 2 was located directly downstream of Grace Dam just west of the Highway 34 bridge and the power canal viaduct. Instream flows were relatively stable year-round regulated by releases from Grace Dam. Discharge averaged 82 cfs during the 2007 October sampling effort. Transects A through E spanned approximately 800 meters from upstream to downstream. Transects A through C were 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 reach was a Rosgen Type C channel. Transects D and E were distinctly different than transects A, B and C. The gradient increased slightly and the substrate shifted to larger particle sizes including extensive bedrock shelves in transect D. Transects D and E were located at the nick point where the Bear River begins cutting through the basalt shelf into the Black Canyon.

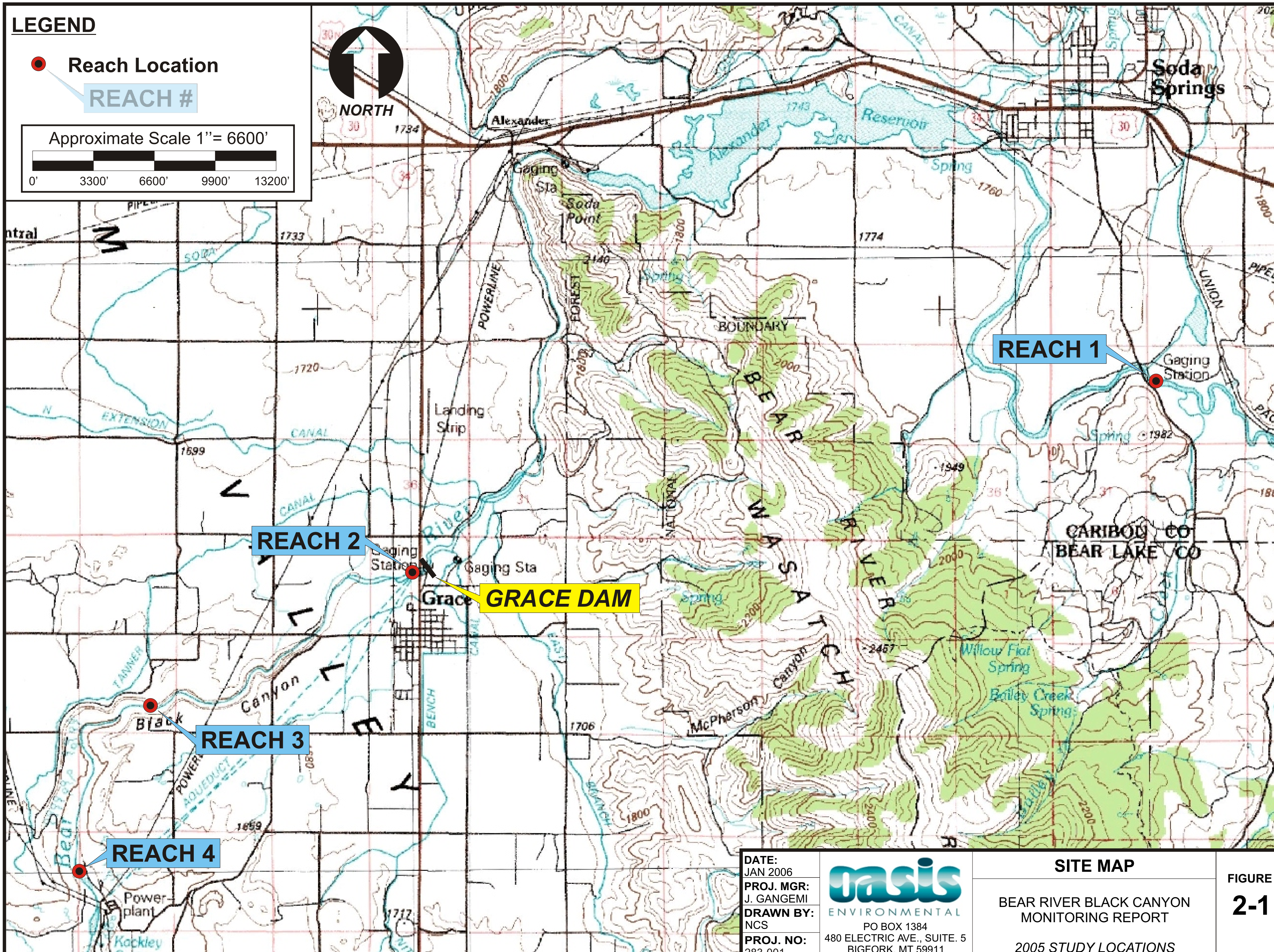
2.3 REACH 3: BLACK CANYON

Reach 3 was located in the incised canyon of the Bear River known as the Black Canyon. Instream flows were relatively stable year-round regulated by releases from Grace Dam. Discharge averaged from 82 cfs during the 2007 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 were 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 was approximately 400 meters long. The reach began 100 meters upstream of a sweeping left hand turn and continued through the turn, ending approximately 25 meters below it. This section of river channel was constrained and defined by the basalt bedrock of the Black Canyon. The outside of the bend (right bank) was 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 was run type habitat with the exception of Transect A which was riffle habitat. Transect E was located at the start of a 300 meter long pool. Scour around boulders on the right bank formed “pocket water” adjacent to the boulders. Deposition of gravel and sand material formed point bars on the river left bank heavily vegetated with perennials and in some cases woody shrubs. Reach 3 resembled a Rosgen Type C channel.

2.4 REACH 4: BEAR RIVER ABOVE GRACE POWER PLANT

Reach 4 was located at the downstream end of the Black Canyon, approximately 6.2 miles downstream of Grace Dam. This reach was just upstream of the Grace power plant. Discharge averaged 112 cfs during the 2007 October sampling period. Discharge in reach 4 was approximately 30 cfs greater than reaches 2 and 3 due to inflows from spring sources just upstream of reach 4. This reach resembled a Rosgen Type B channel. The channel consisted of high velocity laminar flow over basalt bedrock ledges with corresponding plunge pools. Basalt bedrock ledges were the dominant substrate type. Large mats of filamentous algae clung to a significant percentage of the bedrock substrate.



DATE:
JAN 2006

PROJ. MGR:
J. GANGEMI

DRAWN BY:
NCS

PROJ. NO:
283-001

oasis ENVIRONMENTAL
PO BOX 1384
480 ELECTRIC AVE., SUITE. 5
BIGFORK, MT 59911

SITE MAP

BEAR RIVER BLACK CANYON MONITORING REPORT

2005 STUDY LOCATIONS

FIGURE
2-1

(This page intentionally blank)

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. Five transects were surveyed in each reach. The locations of the transects were pre-selected 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.

In 2005, surveys were conducted with a CST/Berger precision autolevel and metric stadia rod. The 2006, 2007 and 2008 surveys were conducted with a Leica Total Station and rod mounted prism. Surveyed elevations for each cross section included right and left bank pins, bankfull, 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.

Bankfull features were difficult to identify in reaches 2 and 3 due to the effects of flow regulation, grazing in reach 2 and vegetation encroachment in reach 3. Deposition zones and scour common in stream systems with fluctuating flow regimes were not evident in reaches 2 and 3. The field crew conducting channel surveys in 2005, 2006, 2007 and 2008 consisted of the same individuals each year for consistency identifying bankfull features in these reaches.

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, 20^{th} 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 and macrophyte 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 m^2 was summed and expressed as filamentous algal coverage per m^2.

3.5 FISHERIES

Electrofishing was used to sample three designated study reaches and one upstream reference reach of the Bear River. For the 2008 sampling event, all sampling was conducted from October 7, 2008 to October 9, 2008 under similar stream flow conditions. In October 2007 and 2008, a Halltech model HT-2000 electrofishing unit was used to sample 100-meter long sections of each reach. For the October 2005 and 2006 sampling events, a Smith-root model 12-B backpack electrofishing unit was used. 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. In 2005, eight BMI samples were combined into a single composite sample for each transect. In total, forty BMI subsamples were collected for each study reach. Individual subsamples were randomly located laterally along each transect encompassing a variety of microhabitats.

In 2006, 2007 and 2008 BMI samples were divided into two jars per transect to test the variance in single surber samples verses composite samples. The first surber sample was collected in the thalweg of the transect and preserved in a separate reference jar referred to as the single surber (SS) sample. The remaining seven surber samples were collected laterally along the same transect in a random fashion and combined in the field to become a composite. These seven surber samples were referred to as the composite sample (CS).

Samples were collected using a 400 cm^2 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 90 percent isopropyl alcohol in the field then decanted in the laboratory and preserved in 95 percent ethanol for long-term storage.

Identification and enumeration was performed by EcoAnalysts in Moscow, Idaho. In 2005, 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.

In 2006, 2007 and 2008 the laboratory sorting procedure was modified to account for differences in the size of the samples and allow comparisons of the within-site variability between SS samples and CS samples. The SS sample (1/8 of the transect) was sub-sampled to 200 organisms. In the event that the sample contained fewer than 200 organisms, the entire sample was sorted. The CS (7/8 of the transect) was sub-sampled to 500 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 expressed as AFDW. The data was standardized to represent the amount of organic material per square meter in grams.

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 within a sample year. Statistical comparisons between the four sample years within an individual study reach were undertaken with the single factor ANOVA ($\alpha = 0.1$) and the non-parametric Kruskal-Wallis H-Test. Baseline conditions for sample years 2005 through 2007 were compared to variable flow conditions within individual study reaches using the single factor ANOVA ($\alpha = 0.1$) and the non-parametric Kruskal-Wallis H-Test.

(This page intentionally blank)

4. RESULTS

The October 2005, 2006, 2007 and 2008 monitoring results are organized into the seven resource parameters. Histograms were used to present descriptive statistics (averages and confidence levels, alpha = 0.1) organized by respective reaches and sample years as well as comparisons between baseline conditions (2005-2007 sample years) with variable flow conditions (2008 sample year). Statistical analysis using the parametric single factor ANOVA ($\alpha = 0.1$) and the non-parametric Kruskal-Wallis H-Test were used to compare results within an individual site over the four sample years and between baseline and variable flow conditions. Non-parametric tests were used in cases where sample variance was significant (Bartlett-Test for homogeneity of variances) thereby violating use of the single factor ANOVA.

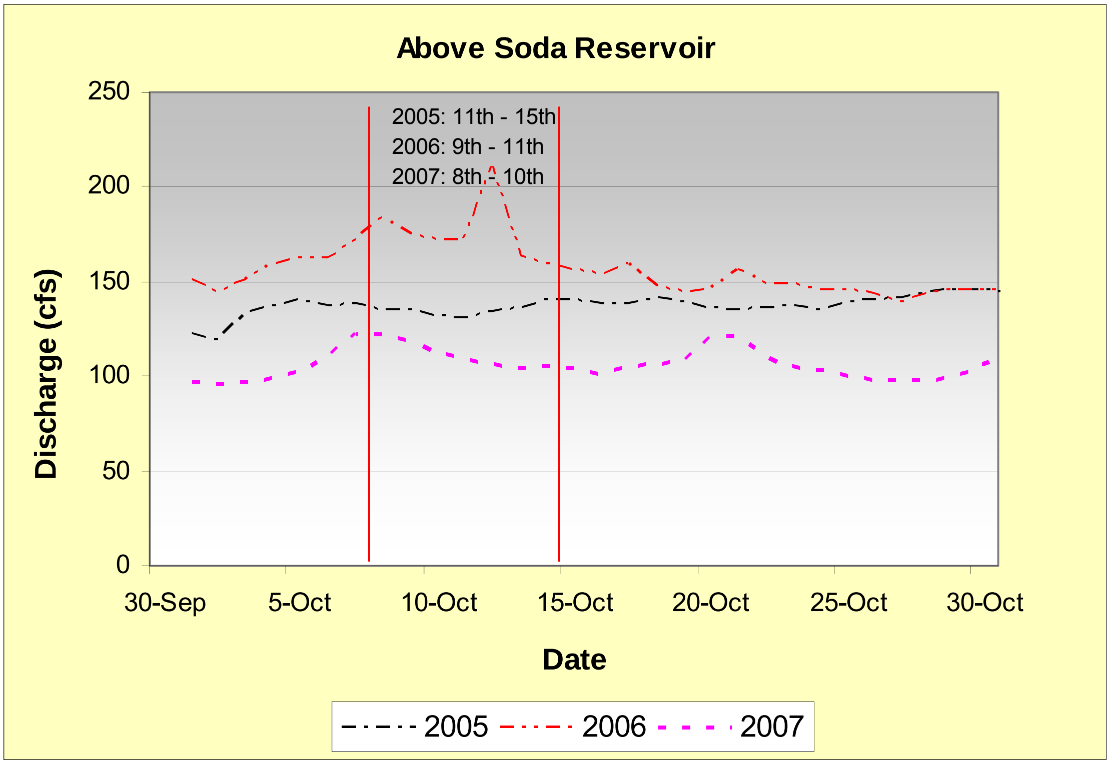
4.1 HYDROLOGY

The 2008 sampling effort occurred from October 6 – 8 under MIF conditions regulated by PacifiCorp's Grace Dam similar to the previous three-years sampling efforts. Discharge in reach 2 was partially regulated by flows from the Lifton Pump Station at Bear Lake. October and annual discharge data for sample years 2005 through 2007 were reported in previous annual reports (Figure 4.1-1). Discharge data for the 2008 water year was not available for reach 1 or the three study reaches in the Black Canyon downstream of Grace Dam at the time this report was released. Based on field observations, discharge during the 2008 sampling effort was similar to volumes observed in previous years.

The annual discharge for each respective water year in reach 1 varied slightly in timing, magnitude and duration of peak flows (Figure 4.1-2). The peak discharge in the 2006-2007 water year was 1610 cfs on July 8th, 2007. This peak was considerably greater than 2005 and 2006 peak discharge. The peak discharge in water year 2004-2005 was 1336 cfs on July 25th and in water year 2005-2006 the peak was 1157 cfs on April 13th. In all three water years flow regulation from Bear Lake upstream shaped the hydrograph. Discharge during the summer irrigation delivery period (generally July 1 to September 1) resulted in prolonged high flows later in the summer season. In 2005, daily average discharge was greater than 1000 cfs from July 1 to August 1. In 2006, daily average discharge remained less than 1000 cfs from July 1 through September 1. In 2007, daily average discharge in reach 1 exceeded 1000 cfs from June 19th through August 4th with additional peak discharges greater than 1000 cfs between August 1 and September 1 2007. The annual discharge data for the 2008 water year should be compared to the previous three years.

In reach 2 the average annual discharge for the 2006-2007 water year was 93 cfs compared to 102 cfs in 2004-2005 and 83 cfs in the 2005-2006 water year. Releases above the minimum instream flow (MIF) occurred during each of the three baseline study years. Only one of these releases was substantially greater than the MIF, a spring pulse flow of 863 cfs on April 17, 2005. No other releases of this magnitude occurred during the three-year baseline monitoring period. Discharge data for reach 2 below Grace Dam was not available for the 2008 water year at the time this report was completed. Four discharge events greater than the MIF occurred in the 2008 water year as part of the variable flow regime (Table 4.1-1). At the time of this report, the discharge volumes of these events were not known.

Figure 4.1-1: Discharge, October sampling period, 2005, 2006 and 2007



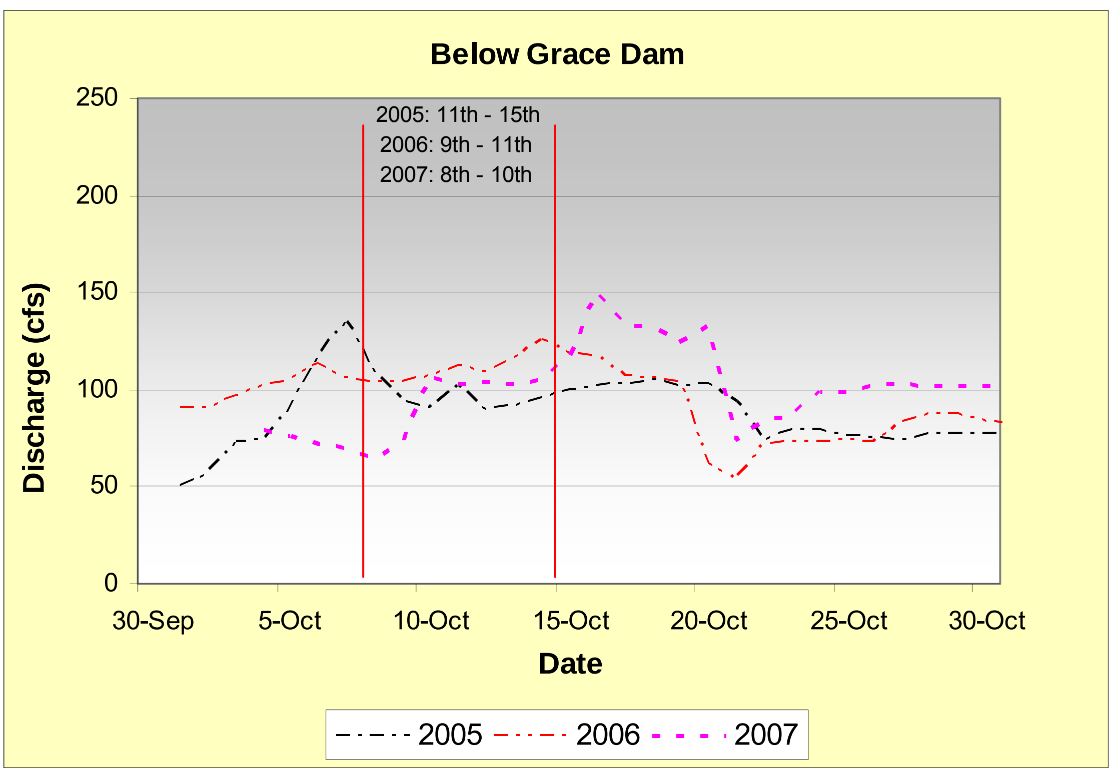
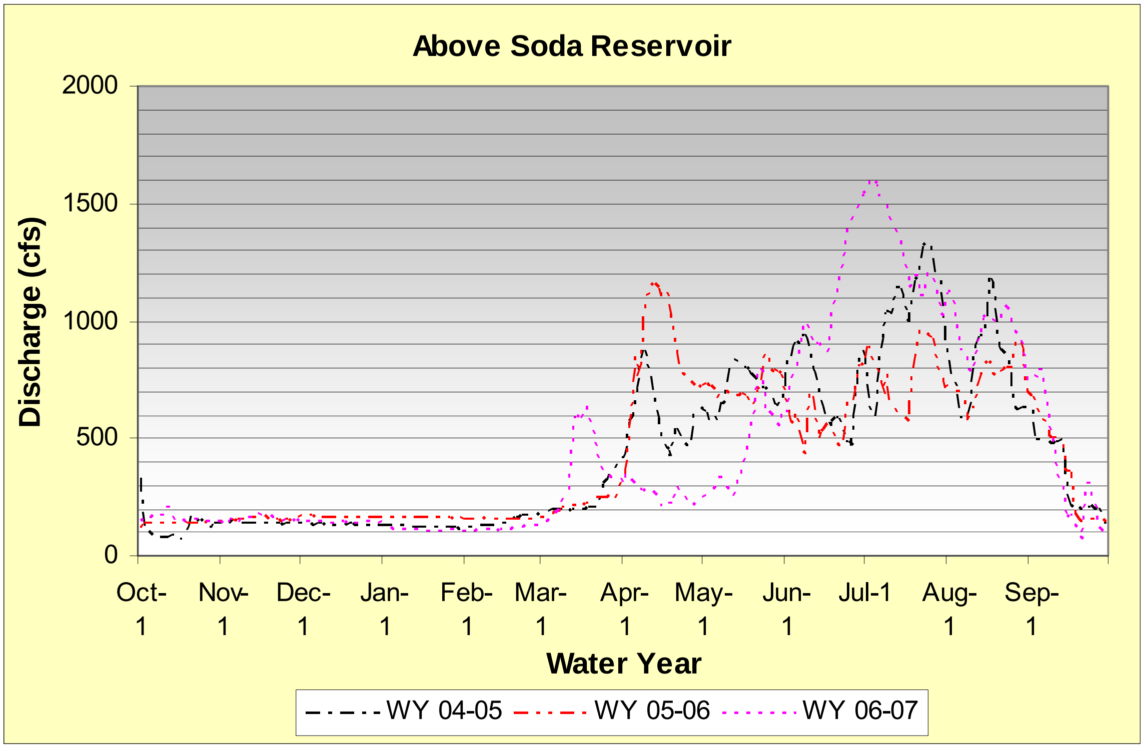
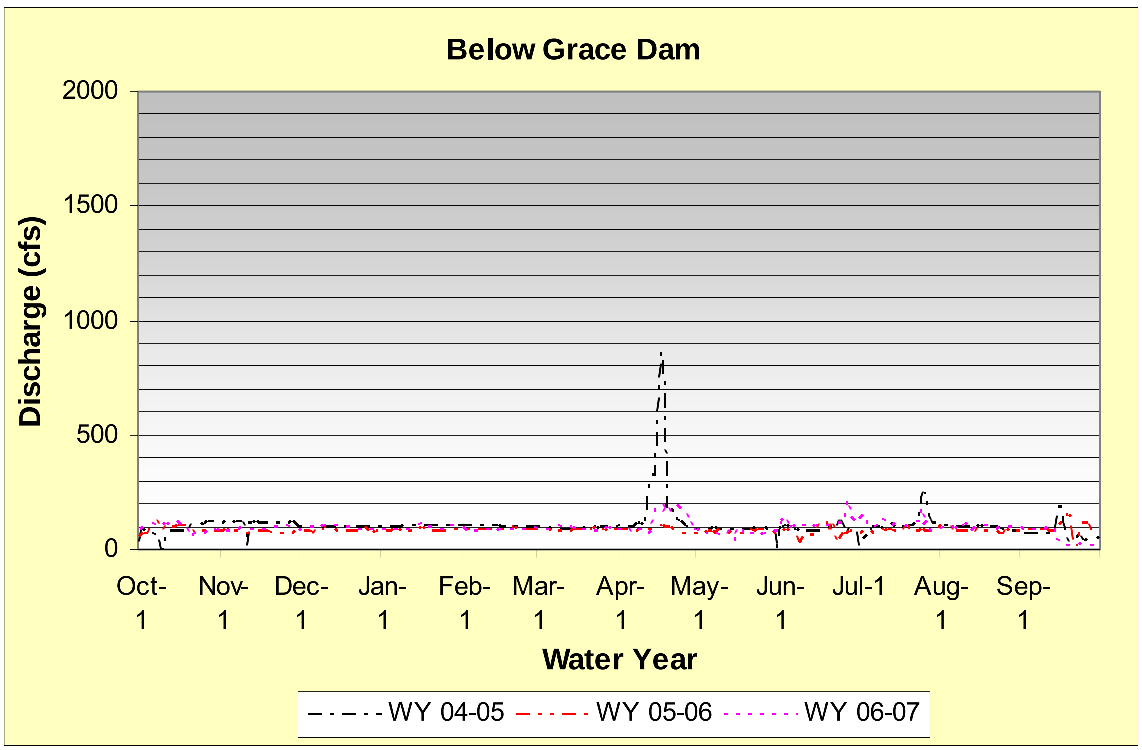


Figure 4.1-2: Baseline discharge (2005-2007) for reaches 1 and 2 on the Bear River





Reach 3 did not have a staff gage and corresponding rating curve for measuring discharge. It was assumed that discharge in reach 3 was roughly equivalent to that measured in reach 2. Reach 4 also lacked a staff gage. Previous studies estimated that discharge in reach 4 was 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.

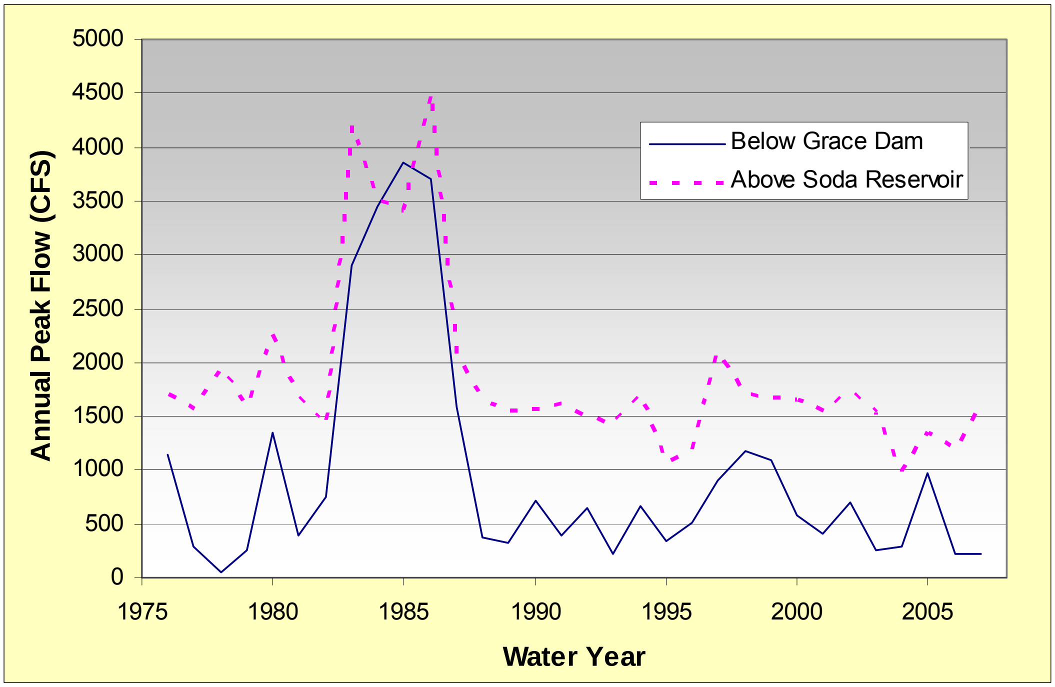
The annual instantaneous peak discharge during the three-year baseline monitoring period for reaches 1 and 2 was lower than annual peaks recorded between 1976 and 2006 (Figure 4.1-3). For the period 1976 to 2007 the average annual peak flow in reach 1 was 1884 cfs. During the three-year baseline monitoring period annual instantaneous peak discharges were 1350 cfs, 1200 cfs and 1610 cfs in 2005, 2006 and 2007 respectively. Discharge data for reach 1 above Soda Reservoir was not available for the 2008 water year at the time this report was completed but the peaks associated with the variable flow events should be compared to historic peaks observed from 1976 to 2006.

In reach 2 the annual peak discharge for the period 1976 to 2006 was 961 cfs compared to an annual instantaneous peak discharge of 965 cfs, 222 cfs, and 218 cfs in 2005, 2006 and 2007 respectively. The peak below Grace dam in 2005 was the result of spring run-off in the Bear River watershed. In 2006 and 2007 spring run-off did not result in spill from Grace Dam. In 2006, pulse flows over Grace dam less than 500 cfs instantaneously occurred in September to assist with channel restoration efforts associated with Cove Dam decommissioning.

Table 4.1-1: Variable flow events in the reach below Grace Dam in 2008.

Date	Description	Discharge	Downramp Rate
4/14/2009	Scheduled Varial Mapping Event		.25 FT / HR
4/20/2009	Scheduled First Stranding Test		.25 FT / HR
6/1/2009	Scheduled Second Stranding Test		.25 FT / HR
7/12/2009	In Flow Dependent Event		.25 FT / HR
7/13/2009	Scheduled Third Stranding Test		.25 FT / HR

Figure 4.1-3: Annual peak discharge (1976-2007), Bear River, ID



4.2 CHANNEL SHAPE AND SUBSTRATE

Reach 2 transects were surveyed on October 6, 2008 between 0830 and 1430 hours. Discharge was similar to previous sampling years. Reach 3 transects were surveyed on October 8, 2008 between 0800 and 1130 hours. The flow appeared to be similar to previous sampling years in reach 3. The flows recorded for the Bear River during the previous sampling events in reach 2 were 89 cfs in 2005, 104 cfs in 2006 and 65 cfs in 2007. In reach 3 instream flows were 101 cfs in 2005, 107 cfs in 2006 and 107 cfs in 2007.

In 2008, reach 2 had a mean bankfull width of 62.51 meters (Table 4.2-1). The mean bankfull widths for reach 2 in 2005, 2006 and 2007 were 63.04, 62.71 and 62.88 meters respectively. In 2008, the bankfull widths were narrowest at transect TE, 49.58 meters, and widest at transect TD, 77.75 meters. Compared to the mean bankfull width during the baseline study period (2005 – 2007), bankfull widths in 2008 were greater in transect TA and TD; 1.35 and 1.33 meters respectively. In contrast, mean bankfull widths in transect TB, TC and TE were greater during the baseline period compared to the bankfull width measured under variable flow conditions in 2008; 3.62, 0.59 and 0.30 meters respectively.

The mean water depths associated with the bankfull elevation in 2008 were between 0.25 meters at transect TD and 0.46 meters at transect TA. In 2008, the mean water depth based on bankfull elevations was 0.38 meters compared to 0.34, 0.40, and 0.43 meters in 2005, 2006 and 2007 respectively. Mean bankfull water depths for transects TB, TC, TD and TE in 2008 were similar to the mean bankfull depths in the three baseline study years. Transect TA in 2008 was 0.13 meters shallower than the mean for the three baseline study years. Beaver activity in transect TA has altered the left channel and bank substantially during the four-year study period. Channel cross section profiles for the respective transects exhibit similar shape for the four sample years (Figure 4.2-1).

Table 4.2-1: Channel survey data for reaches 2 and 3; October 2005, 2006, 2007 and 2008.

Reach	Transect	Bankfull Width (m)				Average Bankfull Depth (m)				Bankfull Width/Depth Ratio			
		2005	2006	2007	2008	2005	2006	2007	2008	2005	2006	2007	2008
2	TA	48.85	48.85	49.34	50.36	0.57	0.58	0.64	0.46	86.46	84.06	77.38	109.14
2	TB	67.22	67.22	69.19	64.26	0.48	0.45	0.48	0.42	140.97	150.74	145.12	154.80
2	TC	71.30	71.50	70.79	70.61	0.31	0.27	0.29	0.31	226.42	267.65	247.44	225.33
2	TD	76.57	76.57	76.13	77.75	0.16	0.25	0.30	0.25	483.48	312.19	252.06	309.02
2	TE	51.28	49.42	48.95	49.58	0.19	0.44	0.43	0.44	269.73	111.77	113.46	113.76
Reach 2 Mean		**63.04**	**62.71**	**62.88**	**62.51**	**0.34**	**0.40**	**0.43**	**0.38**	**241.41**	**185.28**	**167.09**	**182.41**
3	TA	28.80	28.80	28.80	27.88	0.73	1.21	1.33	0.74	39.34	23.81	21.66	37.57
3	TB	20.70	20.70	20.70	20.47	0.63	0.65	0.67	0.57	33.09	31.95	30.86	35.91
3	TC	17.10	17.10	17.10	17.09	0.62	0.65	0.63	0.62	27.37	26.45	27.21	27.57
3	TD	24.80	24.80	24.80	18.20	0.86	0.41	0.41	0.41	28.77	60.12	59.81	44.34
3	TE	17.50	17.50	17.50	17.33	1.03	1.00	1.00	0.76	17.03	17.44	17.47	22.78
Reach 3 Mean		**21.78**	**21.78**	**21.78**	**20.19**	**0.77**	**0.78**	**0.81**	**0.62**	**29.12**	**31.95**	**31.40**	**33.64**

In 2008, reach 3 had a mean bankfull width of 20.19 meters. The bankfull widths ranged from 17.09 meters at TC to 27.88 meters at TA. The mean bankfull widths for reach 3 in 2005, 2006 and 2007 were 21.78 meters respectively. Mean bankfull widths in transect TA and TD were greater during the baseline period compared to the bankfull width measured under variable flow conditions in 2008; 0.92 and 6.60 meters respectively. In 2008, the field crew established a new left bank pin due to deposition along the left bank area. The new pin was shortened the channel width considerably. Bankfull widths in Transects TB, TC and TE for 2008 were similar to the mean bankfull widths measured in the baseline period. Channel cross section profiles for the respective transects exhibit similar shape for the four sample years (Figure 4.2-2).

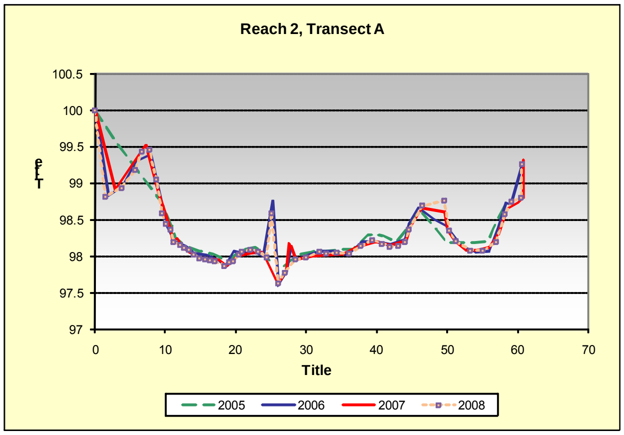
The mean water depths associated with the elevation of the bankfull indicators were between 0.41 meters at TD and 0.76 meters at TE. The mean water depth was 0.62 meters in 2008 compared to 0.77, 0.78 and 0.81 in 2005, 2006 and 2007 respectively. Compared to the bankfull mean water depths in the baseline study period, the 2008 water depths were shallower for the most part. The difference in mean water depths between the baseline period and 2008 was -0.35, -0.08, -0.15 and -0.25 for transects TA TB, TD and TE respectively. Bankfull water depths in transect TC were similar between study periods.

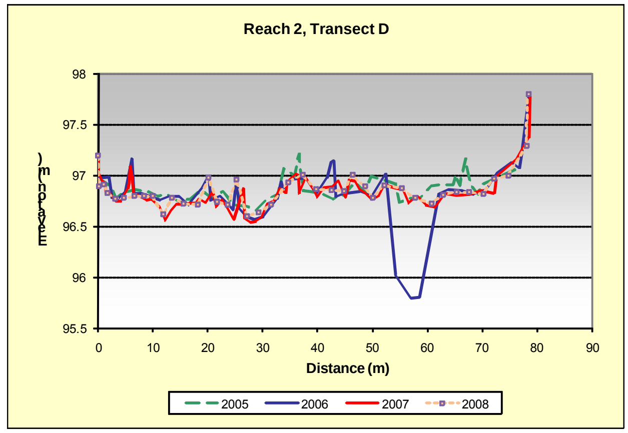
Rosgen (1994, 1996) uses the bankfull width to water depth ratio (BWD ratio) to characterize streams in his Level II stream classification system. The BWD ratio for reach 2 in 2008 ranged from 109.14 at TA to 309.02 at TD. The mean BWD ratio for reach 2 in 2008 was 182.41. Rosgen's stream classification system ranks these BWD indices "very high". The BWD ratio for reach 2 was 241.41in 2005, 185.28 in 2006 and 167.09 in 2007. These BWD indices are also classified by Rosgen as "very high."

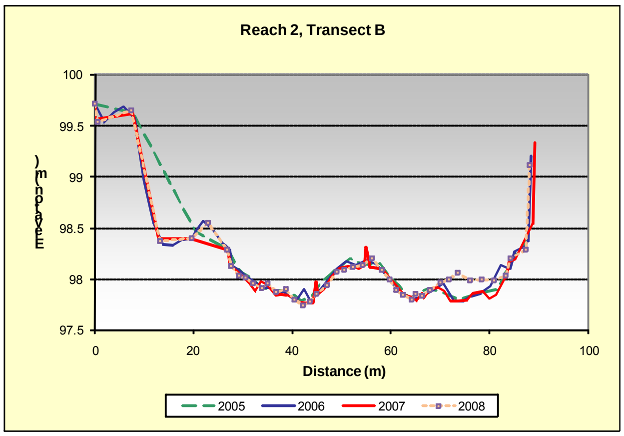
The BWD ratio for reach 3 ranged from 22.78 at TE to 44.34 at TD, and the mean was 33.64. Rosgen ranks these BWD ratios in the "moderate to high" range. The mean BWD ratio for reach 3 was 29.12 in 2005, 31.95 in 2006 and 31.40 in 2007. The Rosgen BWD indices for these three years are also "moderate to high."

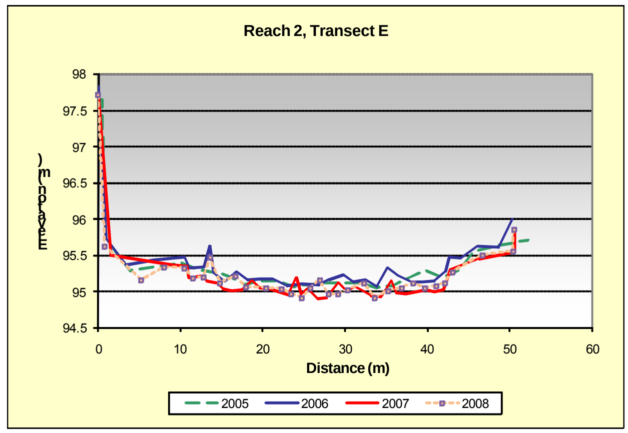
Substrate composition in reach 2 shifted dramatically between the baseline period and the variable flow conditions in 2008 (Figure 4.2-1). In 2008, Wolman pebble counts indicated that fines composed only 3% of the substrate composition compared to a mean of 40% during the baseline period. In fact, in the baseline period, fines comprised more than double the amount of any other class size in reach 2. Sand also composed a substantially lower percentage in 2008 compared to the baseline period; 4% compared to 14%. Gravel, cobble, boulder and bedrock were greater in 2008 compared to the baseline period; 18%, 26%, 13% and 36% respectively.

Figure 4.2-1: Reach 2 channel cross sections over the four-year study period.









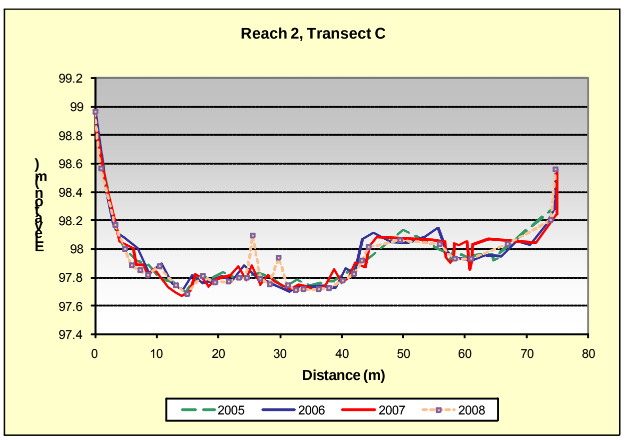
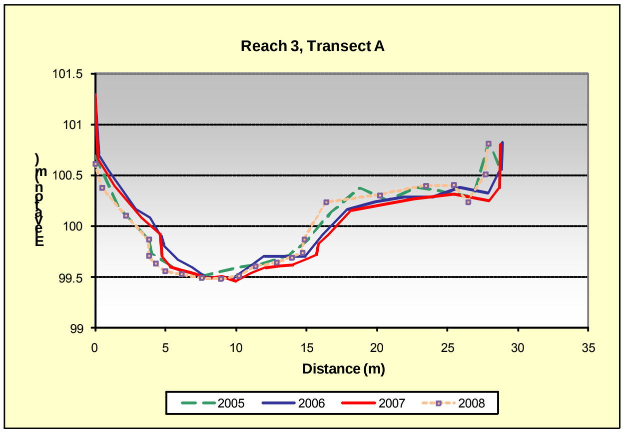
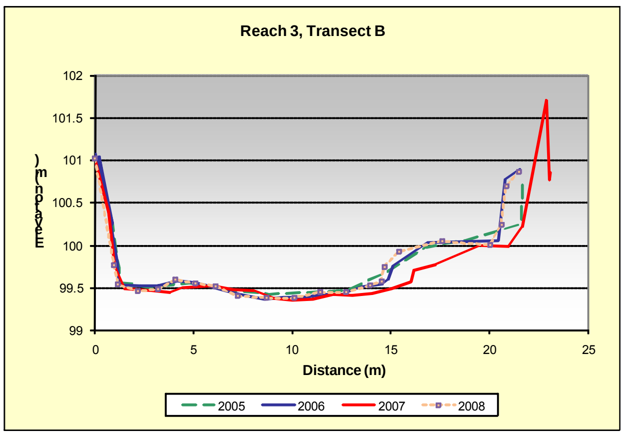
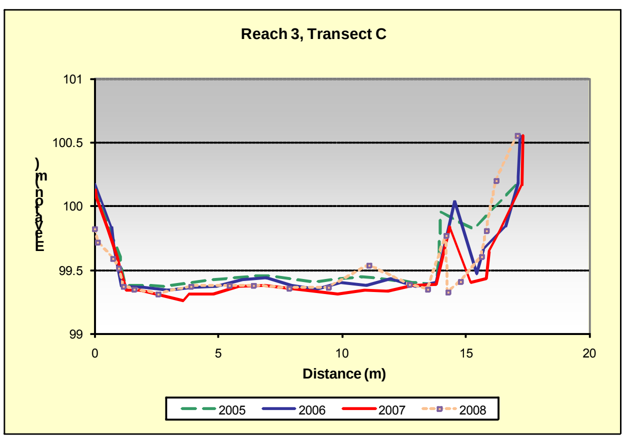
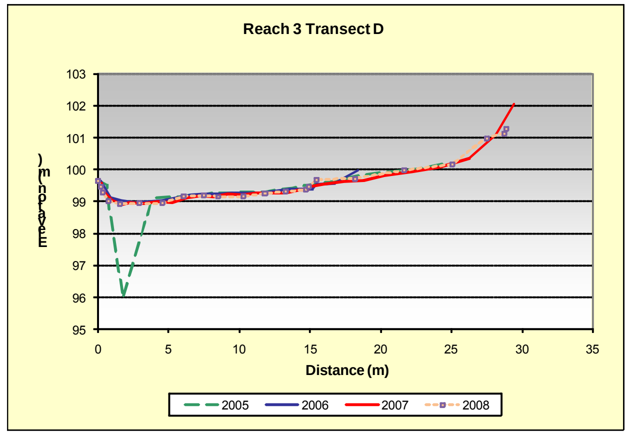


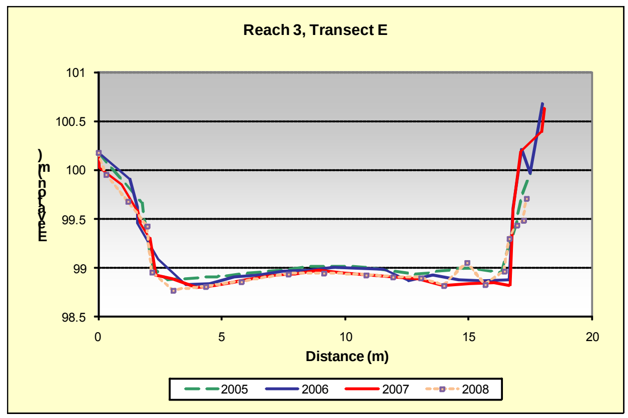
Figure 4.2-2: Reach 3 channel cross sections over the four-year study period.





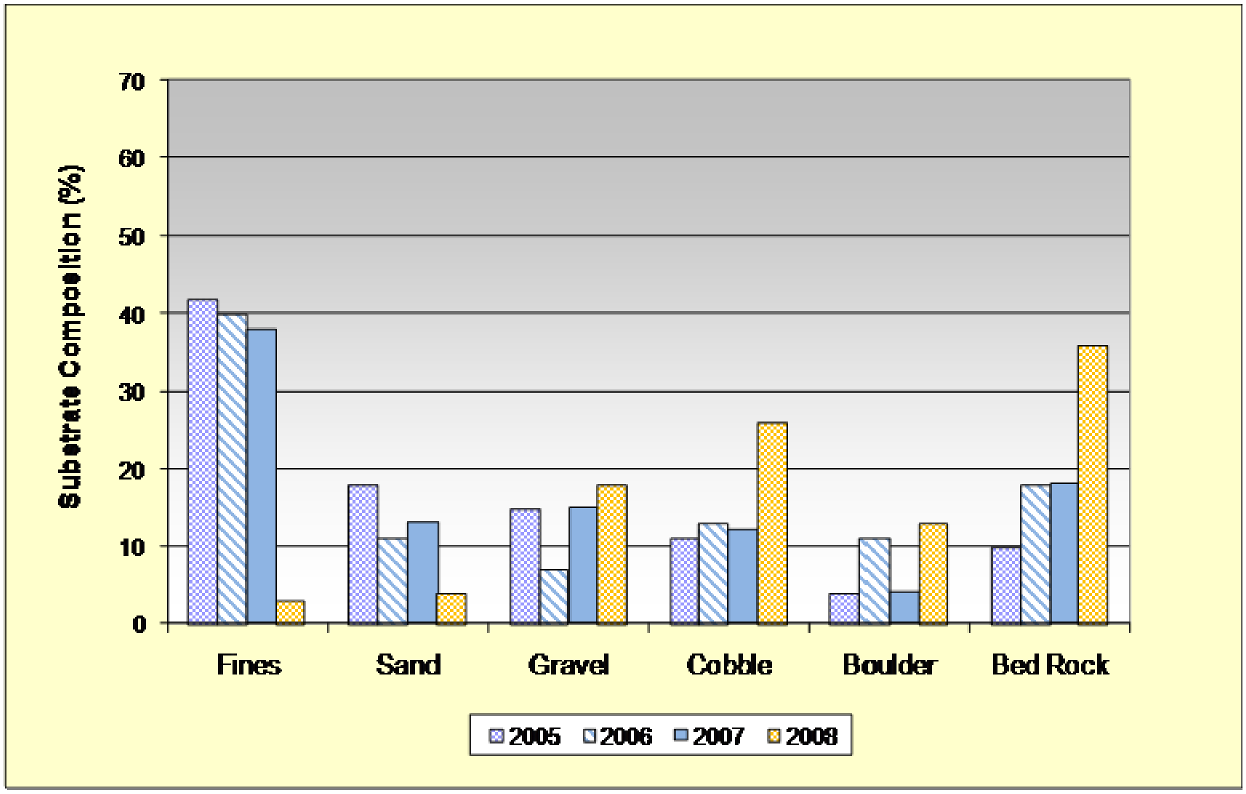






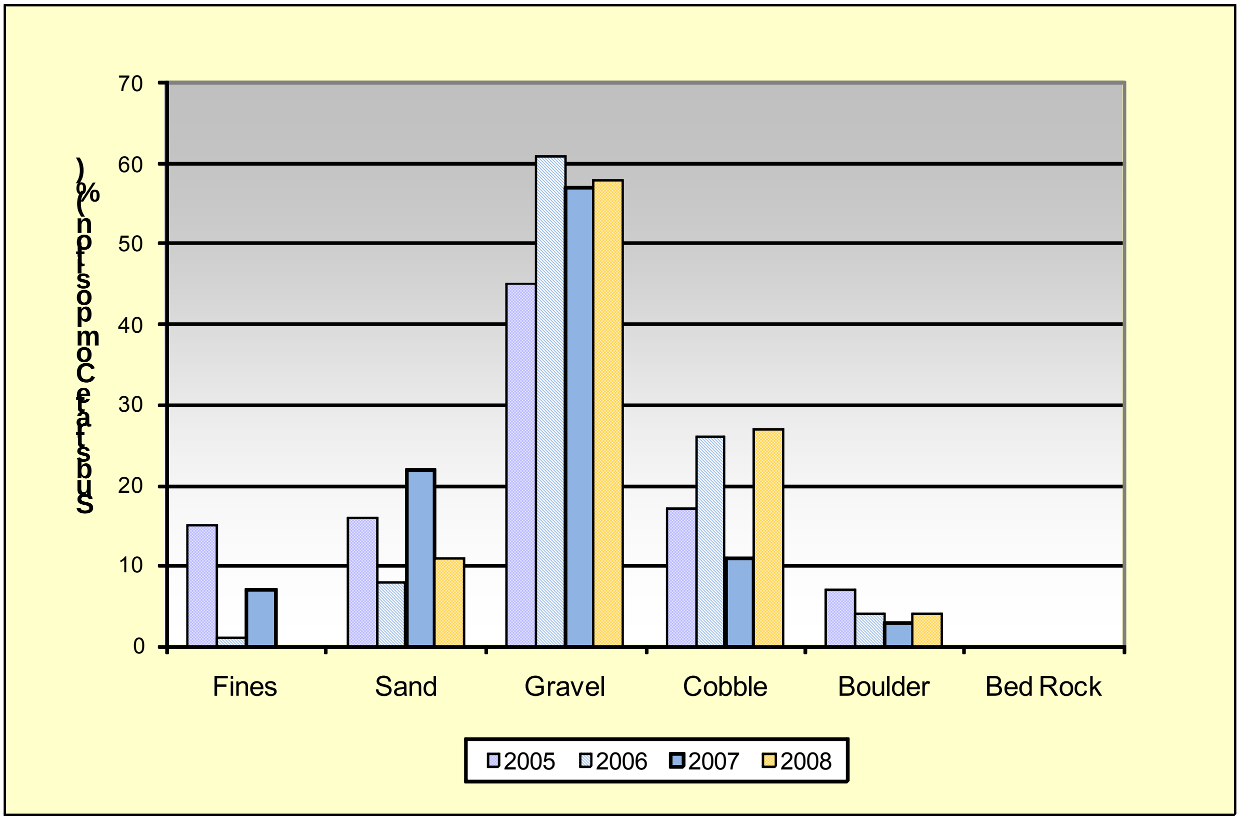
In 2008, field staff noted the visible increase in gravel and cobble in the substrate in reach 3. There was a complete absence of fines in the Wolman pebble counts compared to 7.7% in the three-year baseline period. Sand decreased to 11% in 2008 compared to a mean of 15.3% during the baseline period. Gravel was 58% of the substrate in 2008 compared to 54.3% in the baseline. Cobble increased to 27% of the substrate in 2008 compared to 18% in the baseline period.

Figure 4.2-3: Substrate composition over four-year study period in reach 2.



oasis ENVIRONMENTAL

Figure 4.2-4: Substrate composition over four-year study period in reach 3.



4.3 PERIPHYTON— ASH-FREE DRY WEIGHT AND CHLOROPHYLL

Periphyton AFDW in 2008 was substantially lower in reference reach 1 than treatment reaches 2, 3 and 4 located below Grace Dam (Figure 4.3-1). Periphyton AFDW was highest in Reach 2 for the 2008 sampling event. The AFDW average for reach 1 was 24.3 g/m^2 compared to 119.2 g/m^2, 77.2 g/m^2 and 70.2 g/m^2 for reaches 2, 3, and 4 respectively.

AFDW comparisons within individual study reaches indicate significant differences between sample years in reaches 2 and 3 (0.09 and 0.04 respectively, ANOVA). In reach 1, periphyton AFDW was significantly lower in 2005 and 2008 compared to sample years 2006 and 2007 ($p=0.002$, H-test). The high sample variance in 2007 precluded the parametric single factor ANOVA. In reach 3, periphyton AFDW was significantly greater in 2006 compared to 2005 and 2007 ($p=0.04$, H-test). Periphyton AFDW in reaches 4 was similar over the four sample.

Periphyton AFDW comparisons between the three-year baseline sampling period and the first year of the variable flow regime found significant differences in reaches 1 and 2. Periphyton AFDW was significantly greater in the baseline period in reach 1 compared to the variable flow period ($p=0.03$, H-test). In contrast, periphyton AFDW increased in 2008 at each of the treatment reaches exposed to the variable flow regime but was significant in reach 2 only ($p=0.04$, H-test).

Periphyton chlorophyll a in 2008 was substantially lower in reference reach 1 than treatment reaches 2, 3 and 4 located below Grace Dam (Figure 4.3-3). The chlorophyll a average for reach 1 was 23.4 mg/m^2 compared to 203.6 mg/m^2, 111.6 mg/m^2 and 249.8 mg/m^2 for reaches

2, 3, and 4 respectively. These results were similar to patterns observed in 2005 and 2007 for the respective reaches.

Periphyton chlorophyll a comparisons within individual reaches indicate significant differences between the three-year baseline sampling period and the first year of the variable flow regime in reaches 1, 2 and 3. In reach 1, mean chlorophyll a was significantly higher during the three-year baseline period compared to 2008; 83.7 versus 23.4 mg/m^2 (p=0.10, ANOVA). In reach 3, mean chlorophyll a was also significantly higher during the three-year baseline period compared to 2008; 179.7 versus 111.6 mg/ m^2 (p=0.07, ANOVA). In contrast, periphyton mean chlorophyll a in reach 2 was significantly lower in the baseline period compared to the variable flow regime conditions; 160.1 versus 203.6 mg/m^2 (p=0.09, H-test). In reach 4, mean periphyton chlorophyll a concentrations were similar between the baseline and the variable flow periods (236.4 and 249.8 mg/m^2 respectively).

In 2008, the Autotrophic Index (AI) varied between the four study sites(Figure 4.3-5). Reach 3 had the highest AI, 1101.0, followed by reach 1, 965.9, reach 2, 611.3 and, lastly, reach 4, 303.2. Periphyton AI comparisons across the four sample years within a single study reach indicate significant differences in study reaches 1, 2 and 3 (p=0..1, p=0.04 and p=0.01 respectively, H-test). In reach 1, periphyton AI values were substantially lower compared to the elevated levels observed in 2007. In reach 3, 2008 AI values were noticeably higher than previous years. In reach 4, periphyton AI was not significantly different between sample years.

Periphyton AI comparisons within individual reaches were similar between the three-year baseline sampling period and the first year of the variable flow regime in reaches 1, 2 and 4. In reach 3, mean AI values were significantly lower during the three-year baseline period compared to 2008; 350.9 versus 1101.0 (p=0.03, H-test).

Figure 4.3-1: Periphyton mean AFDW, October 2005, 2006, 2007 and 2008.

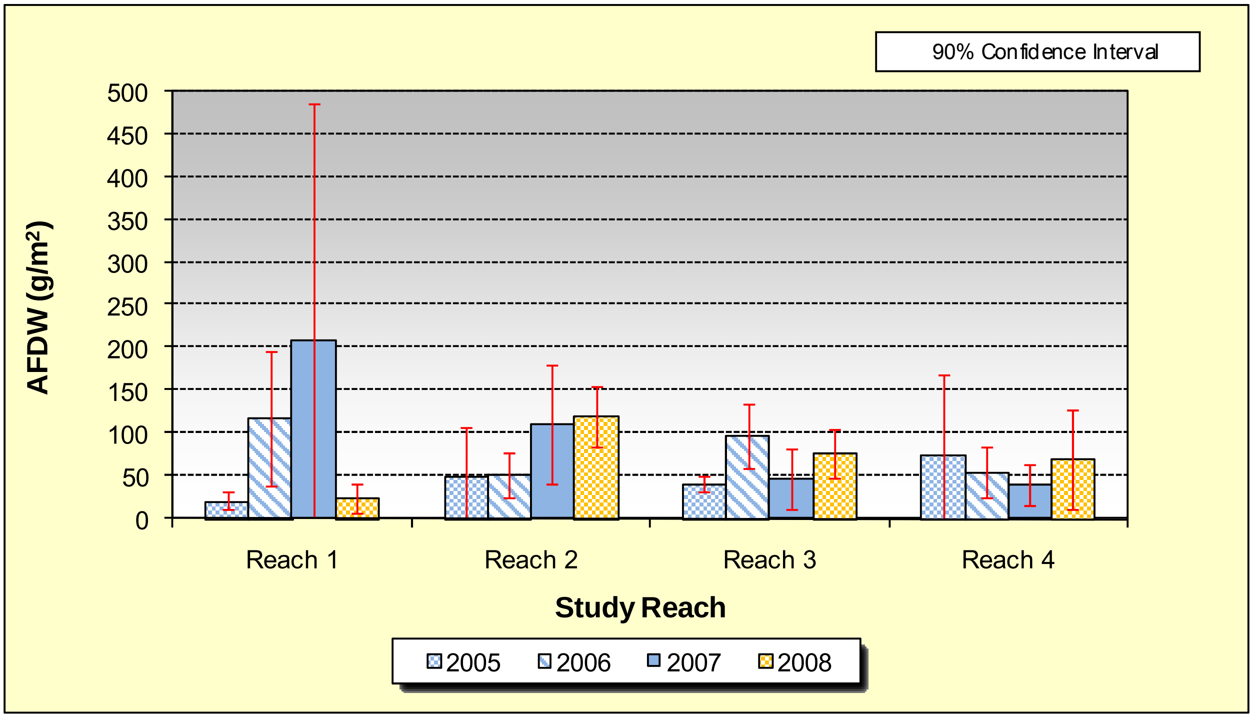


Figure 4.3-2: Periphyton mean AFDW, baseline period versus variable flow.

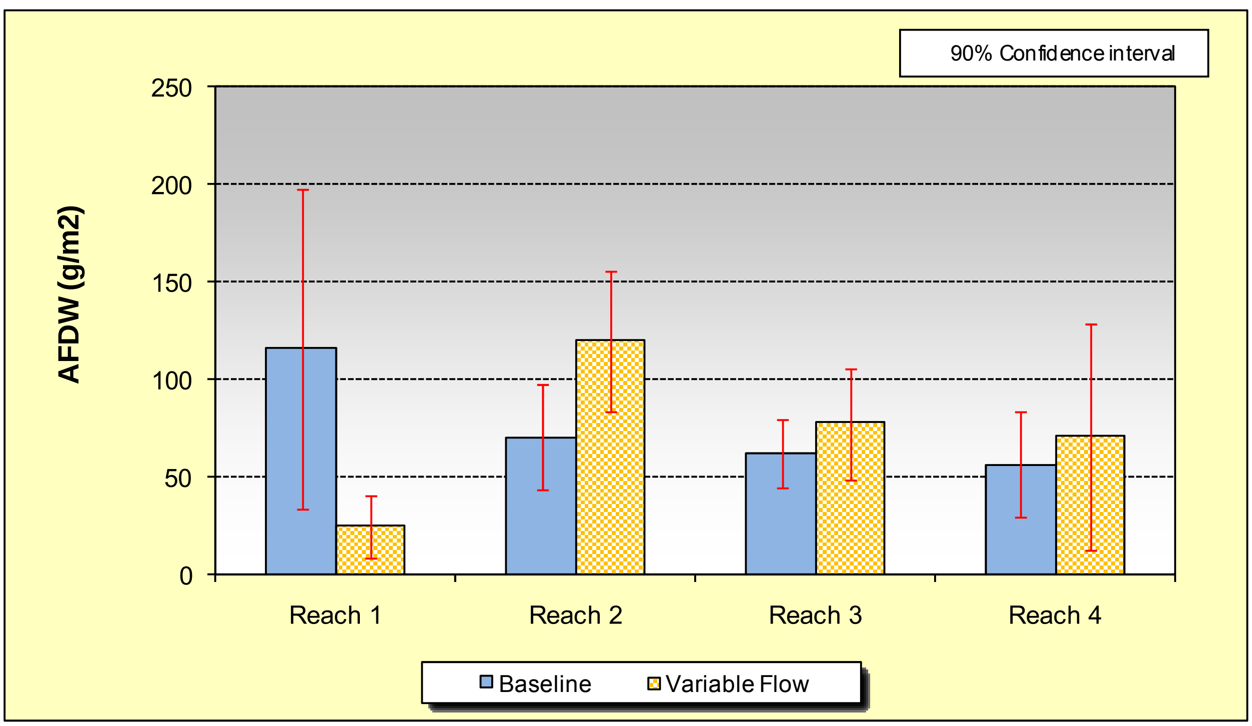


Figure 4.3-3: Periphyton mean chlorophyll a concentration, October 2005 through 2008.

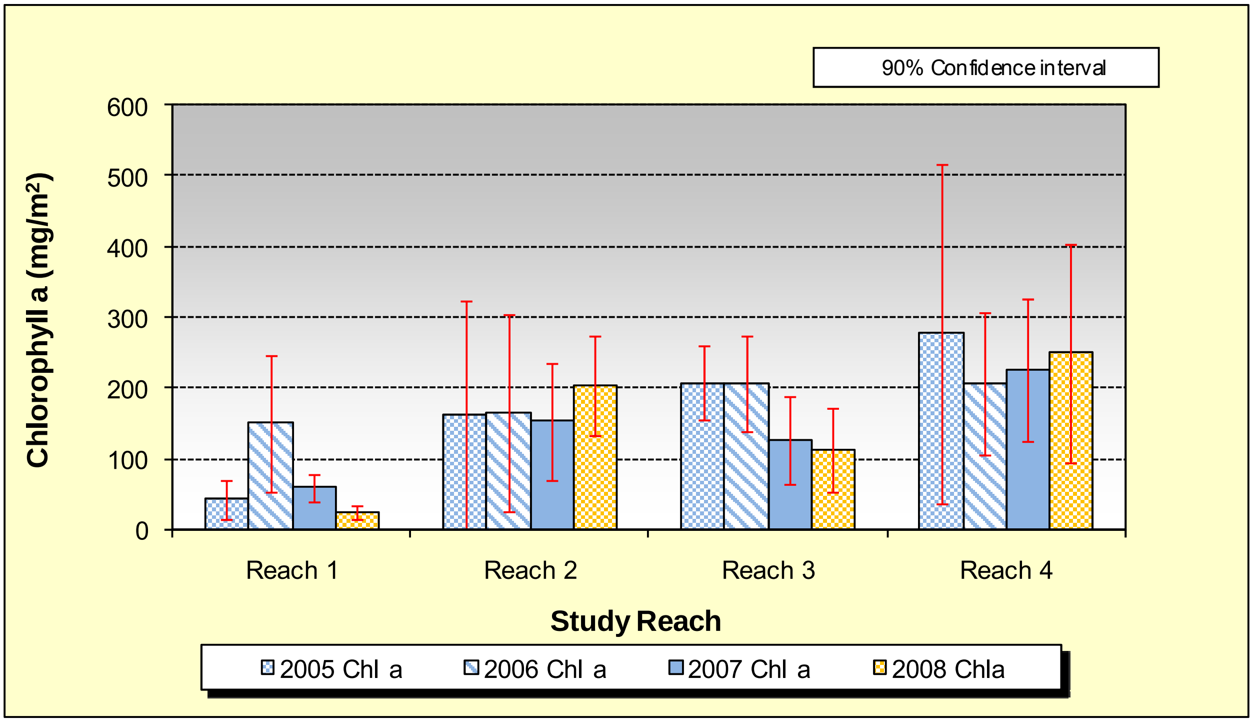
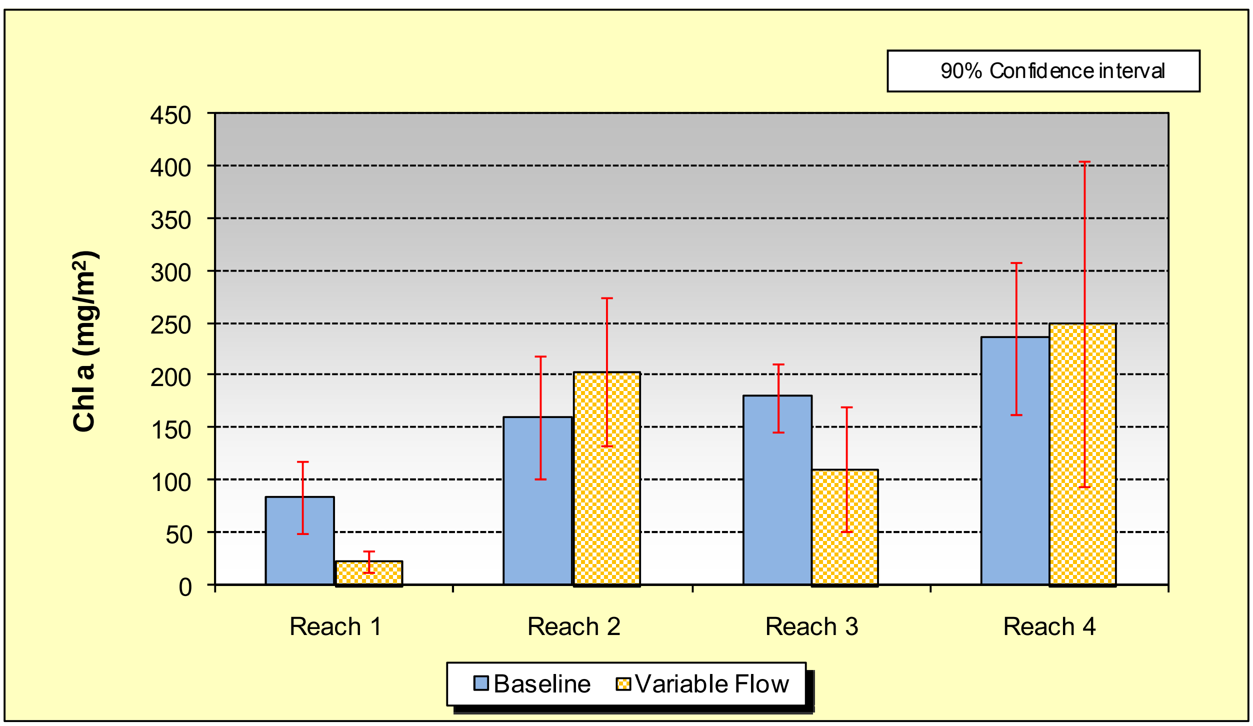


Figure 4.3-4: Periphyton mean chlorophyll a, baseline period versus variable flow.

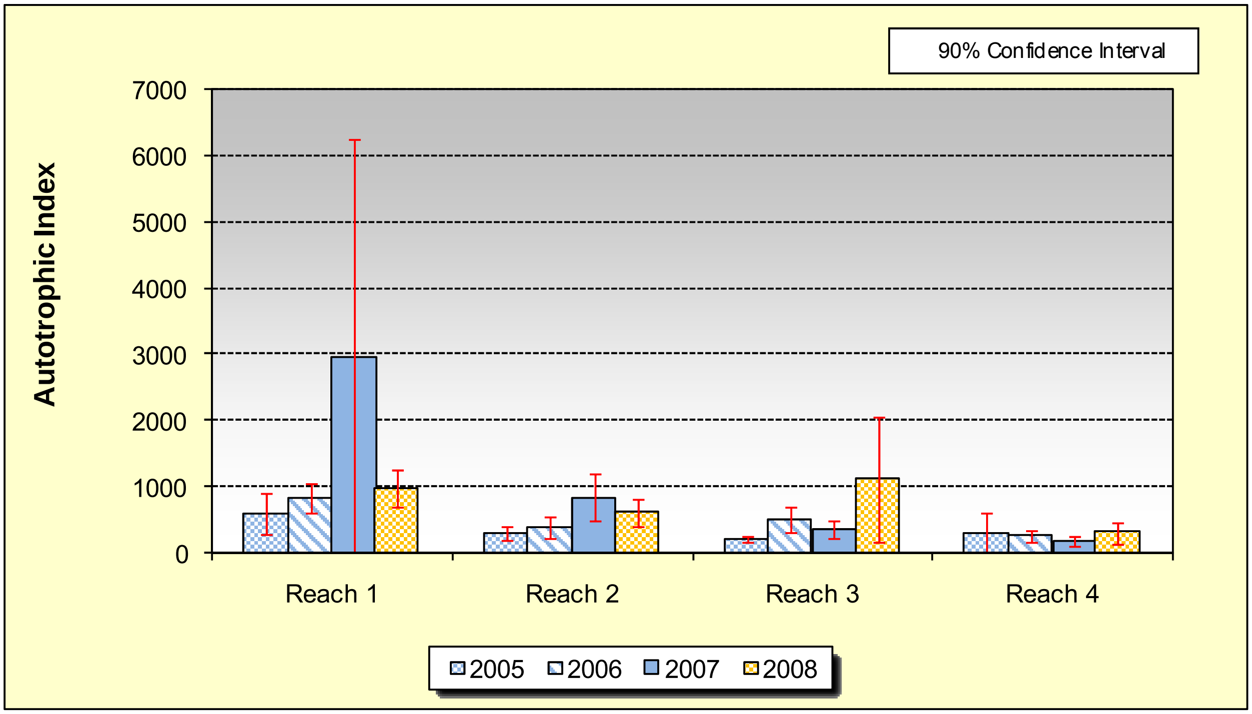


4.4 FILAMENTOUS ALGAE

In 2008, filamentous algae cover (Figure 4.4-1) was highest in reach 4 (97%) followed by reach 2 (90%), reach 3 (53%) and, lastly, reach 1(36%). Filamentous algae coverage was significantly different between years within reaches 1, 2 and 3 (p=0.07, p=0.008 and p=0.009 respectively, H-test). In reach 4, filamentous algae coverage was similar over the four sample years.

Filamentous algae comparisons within individual reaches indicate significant differences between the three-year baseline sampling period and the first year of the variable flow regime in reaches 1, 2 and 3 (Figure 4.4-2). In reach 1, mean filamentous algae cover was significantly higher during the three-year baseline period compared to 2008; 77% versus 36% m^2 (p=0.01, ANOVA). In reaches 2 and 3, mean filamentous algae cover was significantly lower during the three-year baseline period compared to 2008; 40% versus 90% in reach 2 and 8% versus 53% in reach 3 (p=0.002 and p=0.001 respectively, ANOVA). In reach 4, filamentous algae cover was similar under the baseline and variable flow conditions.

Figure 4.3-5: Periphyton mean autotrophic index, October 2005, 2006, 2007 and 2008.



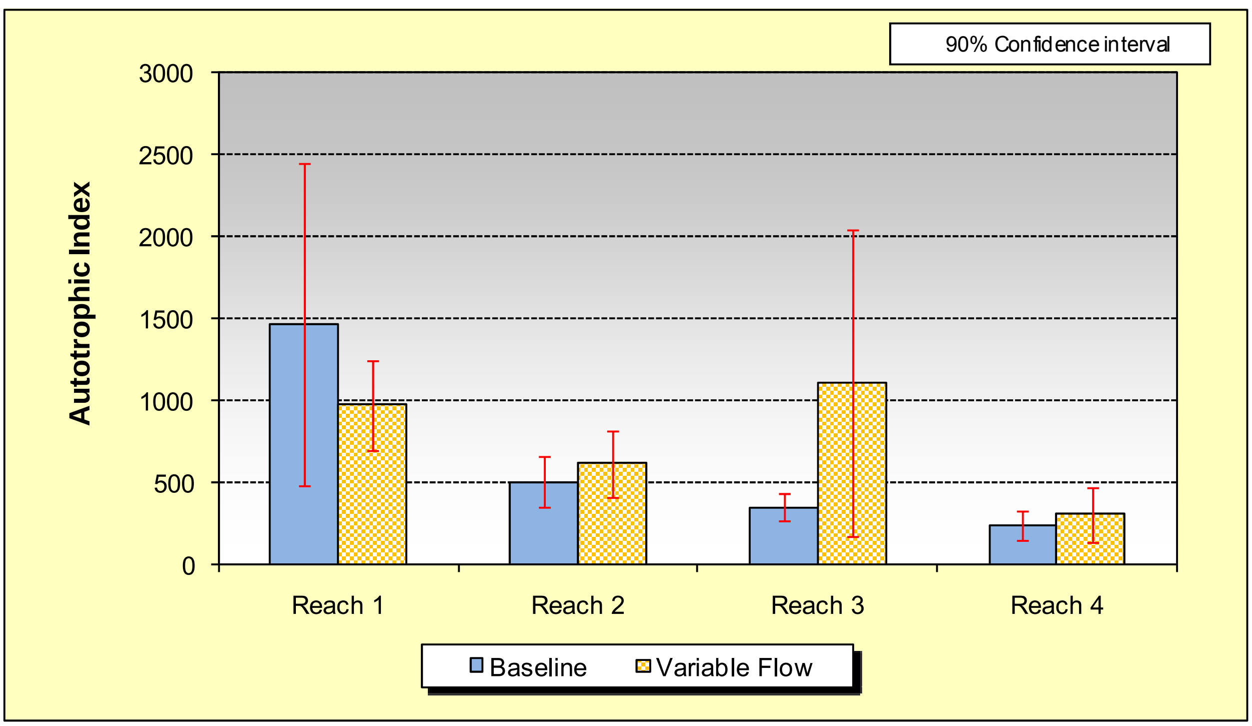


Figure 4.4-1: Filamentous algae cover, October 2005, 2006, 2007 and 2008.

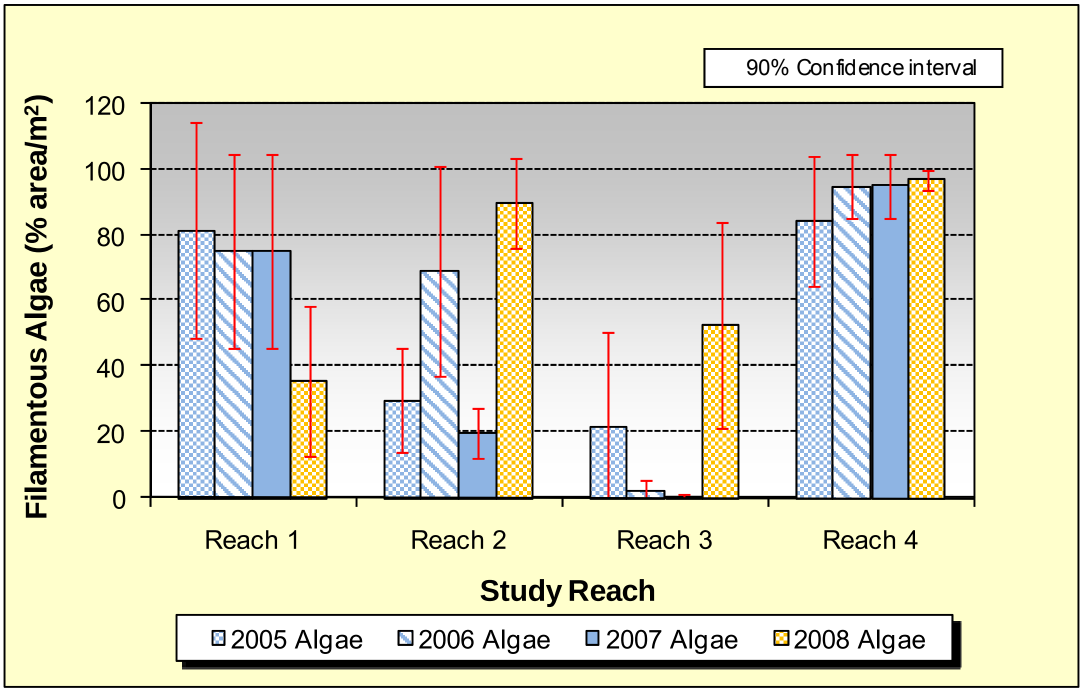
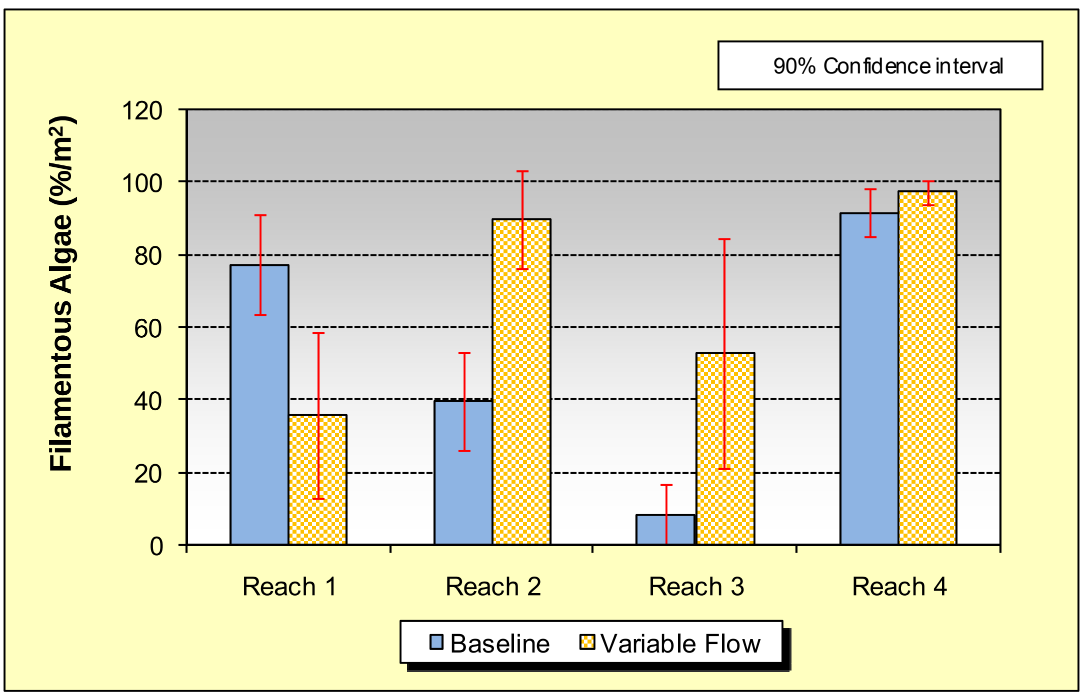


Figure 4.4-2: Filamentous algae cover, baseline period versus variable flow.



4.5 FISHERIES

Fisheries data was 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. Eight species total were collected in this sampling effort but not all species were present in each study reach. The analysis was divided into results for each respective study reach.

4.5.1 Reach 1—Above Soda Reservoir

Five species were collected in reach 1 for a total catch of 16 fish and biomass of 0.92 kg (Table 4.5-1). Longnose dace were the most abundant (9 fish; 69% of the catch) followed by mottled sculpin (3; 19%), small mouth bass (2; 15%), rainbow trout (1; 6%), and cutthroat trout (1; 6%) (Figure 4.5-1). Cutthroat trout comprised a majority of the biomass at 63% (568 g), followed by rainbow trout (28%; 250 g), longnose dace (5%; 40 g), mottled sculpin (4%; 38 g) and small mouth bass (1%; 6 g) (Figure 4.5-2).

Catch per unit effort (CPUE) was highest for longnose dace at 0.49 fish/minute, followed by mottled sculpin (0.16 fish/minute), common carp (0.11 fish/minute), rainbow trout (0.05 fish/minute) and cutthroat trout (0.05 fish/minute) (Figure 4.5-3).

The relative weight of the 1 cutthroat trout collected in reach 1 was 103. The relative weight of the 1 rainbow trout collected was 110. The rainbow trout was marked with a freeze-brand located on the left side in front of the dorsal fin and had the orientation of an upside down T. This particular location of the freeze-brand indicated that the fish was released in 2008 and the orientation indicated that it was released above Soda Reservoir.

Table 4.5-1: Fish density and biomass per 100 meters in reach 1, October 2008

Species	N	Weight (g)	CPUE (fish / minute)
Longnose Dace (*Rhinichthys cataractae*)	9 (56%)	40 (5%)	0.49
Small Mouth Bass (*Micropterus dolomieu*)	2 (13%)	6 (1%)	0.11
Mottled Sculpin (*Cottus bairdi*)	3 (19%)	38 (4%)	0.16
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*)	1 (6%)	250 (28%)	0.05
Cutthroat Trout (*Oncorhynchus clarki*)	1 (6%)	568 (63%)	0.05
Total	16	902	0.86

Figure 4.5-1: Fish species composition, October 2008

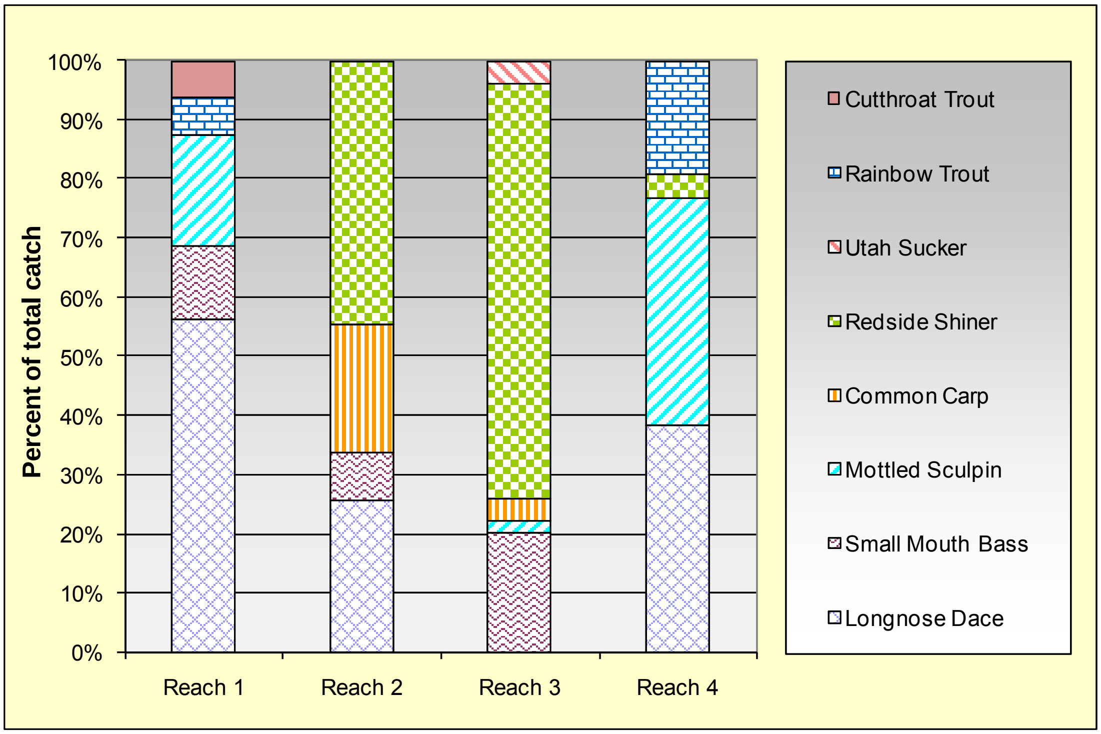


Figure 4.5-2: Fish species biomass, October 2008

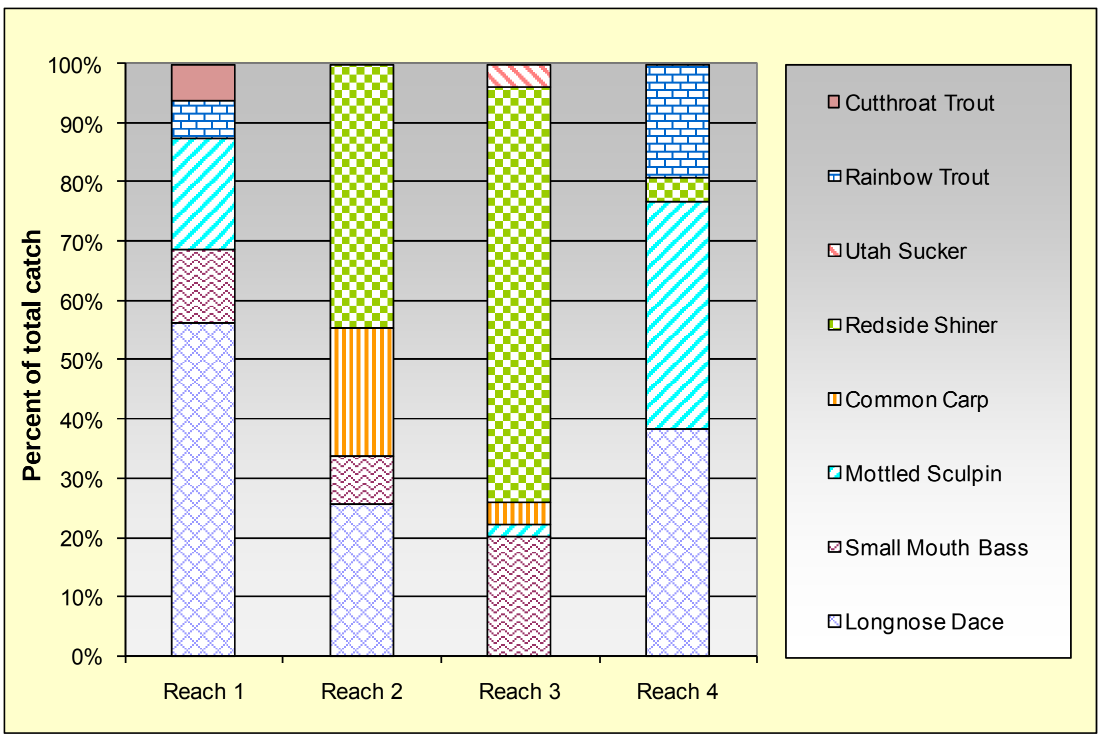
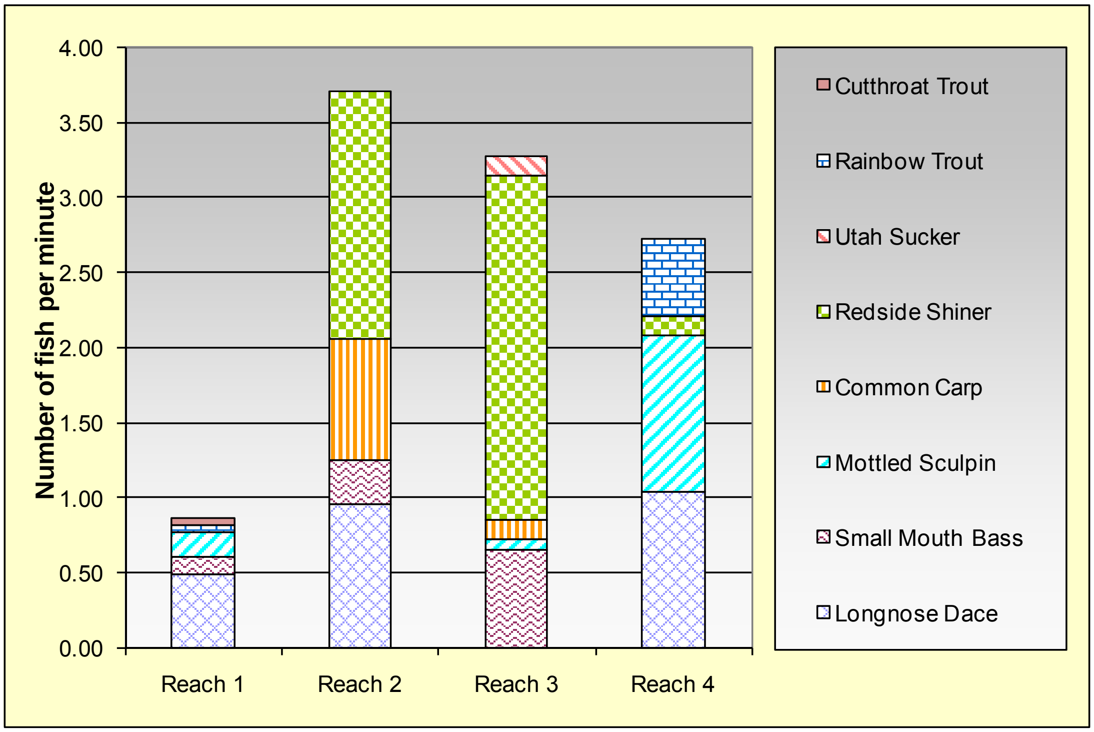


Figure 4.5-3: Catch per unit effort for reaches 1, 2, 3 and 4, October 2008



4.5.2 Reach 2— Below Grace Dam

Four species were collected in reach 2 for a total catch of 74 fish and biomass of 0.46 kg (Table 4.5-2). Redside shiner were the most abundant as they accounted for 33 of the 74 fish collected (45% of the catch) followed by longnose dace (19; 26%), common carp (16; 22%), and small mouth bass (6; 8%) (Figure 4.5-1). Longnose dace comprised a majority of the biomass at 33% (150g) followed by common carp (30%, 138 g), redside shiner (23%; 108 g), and small mouth bass (14%; 64 g) (Figure 4.5-2).

Table 4.5-2: Fish density and biomass per 100 meters in reach 2, October 2008

Species	N	Weight (g)	CPUE (fish / minute)
Longnose Dace (*Rhinichthys cataractae*)	19 (26%)	150 (33%)	0.95
Small Mouth Bass (*Micropterus dolomieu*)	6 (8%)	64 (14%)	0.30
Mottled Sculpin (*Cottus bairdi*)	0	0	0
Common Carp (*Cyprinus carpio*)	16 (22%)	138 (30%)	0.80
Redside Shiner (*Richardsonius balteatus*)	33 (45%)	108 (23%)	1.65
Utah Sucker (*Catostomus ardens*)	0	0	0
Rainbow Trout (*Oncorhynchus mykiss*)	0	0	0
Cutthroat Trout (*Oncorhynchus clarki*)	0	0	0
Total	74	460	3.70

Catch per unit effort was greatest for redside shiner at 1.65 fish / minute followed by longnose dace (0.95 fish/minute), common carp (0.80 fish/minute), and small mouth bass (0.30 fish/minute) (Figure 4.5-3).

4.5.3 Reach 3— Black Canyon

Five species were collected in reach 3 for a total catch of 50 fish and a biomass of 3.57 kg (Table 4.5-3). Redside shiner dominated in abundance (35 fish; 70% of catch) followed by small mouth bass (10; 20%), common carp (2; 4%), Utah sucker (2; 4%) and mottled sculpin (1; 2%) (Figure 4.5-1). The two Utah suckers collected accounted for 93% of the biomass (3330 g), followed by redisde shiner (4%; 146 g), small mouth bass (2%, 64 g), common carp (1%; 20 g) and mottled sculpin (<1%; 14 g) (Figure 4.5-2).

Table 4.5-3: Fish density and biomass per 100 meters in reach 3, October 2008

Species	N	Weight (g)	CPUE (fish / minute)
Longnose Dace (*Rhinichthys cataractae*)	0	0	0
Small Mouth Bass (*Micropterus dolomieu*)	10 (20%)	64 (2%)	0.65
Mottled Sculpin (*Cottus bairdi*)	1 (2%)	14 (<1%)	0.07
Common Carp (*Cyprinus carpio*)	2 (4%)	20 (1%)	0.13
Redside Shiner (*Richardsonius balteatus*)	35 (70%)	146 (4%)	2.29
Utah Sucker (*Catostomus ardens*)	2 (4%)	3330 (93%)	0.13
Rainbow Trout (*Oncorhynchus mykiss*)	0	0	0
Cutthroat Trout (*Oncorhynchus clarki*)	0	0	0
Total	50	3574	3.27

Catch per unit effort was greatest for redside shiner at 2.29 fish/minute, followed by small mouth bass (0.65 fish/minute), common carp (0.13 fish / minute), Utah sucker (0.13 fish/minute), and mottled sculpin (0.07 fish/minute) (Figure 4.5-3).

4.5.4 Reach 4—Above Grace Power Plant

Four species were collected in reach 4 for a total catch of 47 fish with a biomass of 2.49 kg (Table 4.5-4). Longnose dace and mottled sculpin were the most abundant (18 fish; 38% of the catch for each) followed by rainbow trout (9; 19%), and redside shiner (2; 4%) (Figure 4.5-1). Rainbow trout accounted for a large majority of the biomass at 88% (2198g). The remaining 12% of the biomass was comprised of longnose dace (7%; 164 g), mottled sculpin (4%; 106g), and redside shiner (1%; 26 g) (Figure 4.5-2).

Table 4.5-4: Fish density and biomass per 100 meters in reach 4, October 2008

Species	N	Weight (g)	CPUE (fish / minute)
Longnose Dace (*Rhinichthys cataractae*)	18 (38%)	164 (7%)	1.04
Small Mouth Bass (*Micropterus dolomieu*)	0	0	0
Mottled Sculpin (*Cottus bairdi*)	18 (38%)	106 (4%)	1.04
Common Carp (*Cyprinus carpio*)	0	0	0
Redside Shiner (*Richardsonius balteatus*)	2 (4%)	26 (1%)	0.12
Utah Sucker (*Catostomus ardens*)	0	0	0
Rainbow Trout (*Oncorhynchus mykiss*)	9 (19%)	2198 (88%)	0.52
Cutthroat Trout (*Oncorhynchus clarki*)	0	0	0
Total	47	2494	2.72

Catch per unit effort was greatest for longnose dace (1.04 fish/minute) and mottled sculpin (1.04 fish/minute), followed by rainbow trout (0.52 fish/minute), and redside shiner (0.12 fish/minute) (Figure 4.5-3).

A total of 9 rainbow trout were collected in reach 4. Five of the 9 fish were marked with a freeze-brand and 4 fish had no mark. The freeze-brands were all located on the left side in front of the dorsal fin and had the orientation of an upright T. This particular location of the freeze-brands indicated that the fish were released in 2008 and the orientation indicated that they were released at the foot bridge below the Grace power plant.

The 9 rainbow trout collected in reach 4 ranged in length from 213 mm to 352 mm and had a mean length of 272 mm (Table 4.5-5). They ranged in weight from 104 g to 502 g with a mean weight of 244 g. The length-frequency distribution of the 9 rainbow trout collected in reach 4 is shown in figure 4.5-4.

Table 4.5-5: Rainbow Trout lengths and weights in reach 4, October 2008

Number	Freeze brand	Length (mm)	Weight (g)	Relative Weight
1	None	307	342	109
2	Footbridge 2008	260	214	112
3	Footbridge 2008	263	186	94
4	Footbridge 2008	213	104	100
5	None	352	502	105
6	Footbridge 2008	242	162	106
7	None	269	226	107
8	Footbridge 2008	271	208	96
9	None	274	254	114
	Average	272	244	105

Figure 4.5-4: Length frequency distribution for RBT in reach 4, October 2008

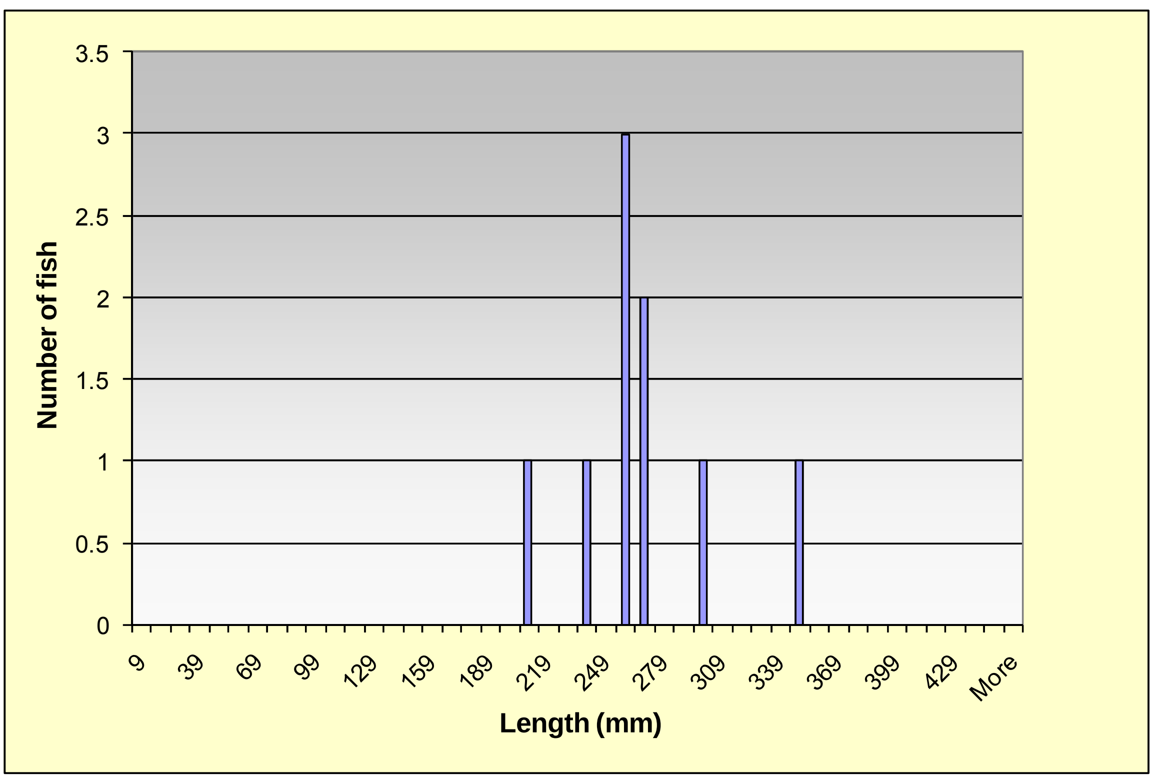
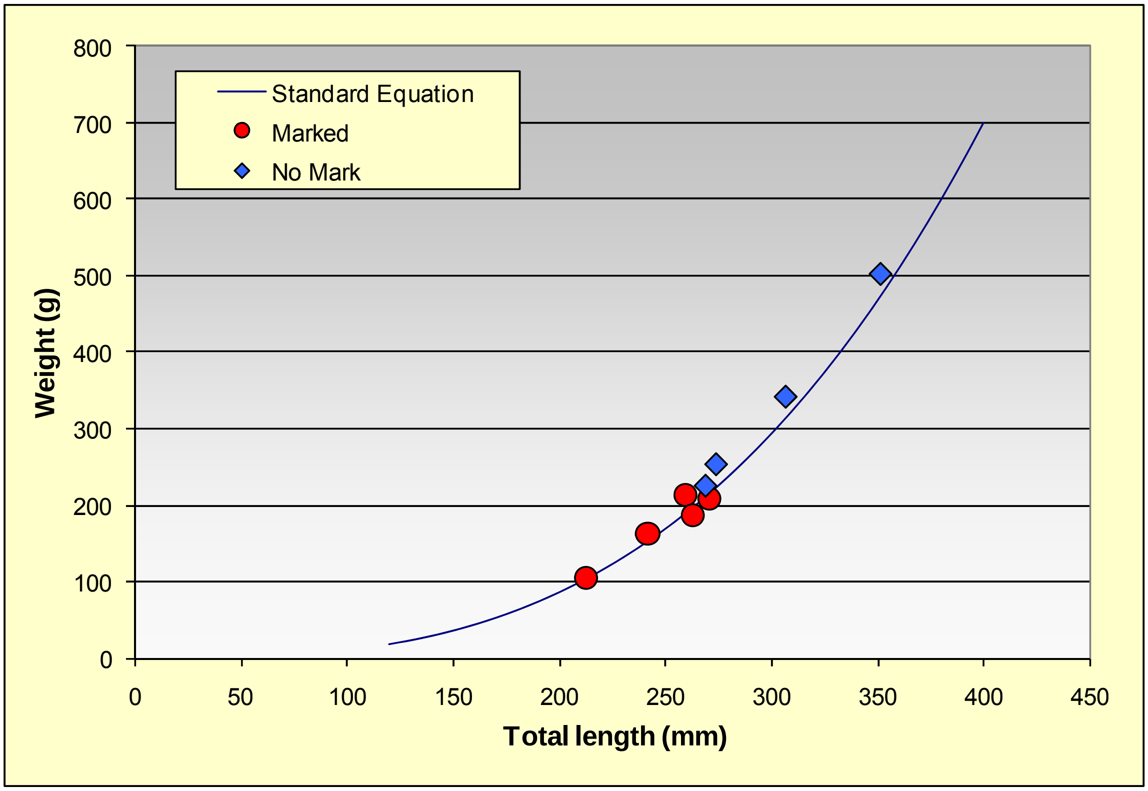


Figure 4.5-5. Length-weight relationship for rainbow trout in reach 4, October 2008



The relative weights of 7 of the 9 rainbow trout collected in reach 4 fell on or above the standard weight-length curve (Wr = 100) while 2 of the 9 rainbows had relative weights that fell below the curve (Figure 4.5-5). The mean relative weight (Wr) for all 9 rainbows was 105 and ranged from 94 to 114 (Table 4.5-5). The 5 freeze-branded fish had a mean relative weight of 102 and ranged from 94 to 112. For the 4 unmarked fish, the mean relative weight was 109 and ranged from 105 to 114.

4.5.5 Within Reach Comparisons—2005, 2006, and 2007

In reach 1, species richness was greatest in 2006 and 2008. Five species were collected in reach 1 in 2006 and 2008 compared to four species in 2005 and 2007 (Table 4.5-6). Longnose dace and mottled sculpin were collected in all 4 years, and common carp were collected in 3 of the 4 years. One juvenile Utah sucker was collected in 2006 and one redside shiner was collected in 2007. One rainbow trout and one cutthroat trout were collected in reach 1 in 2008.

Table 4.5-6: Fish density and biomass for reach 1, October 2005, 2006, 2007 and 2008

	Species	2005			2006			2007		
		N	Weight (g)	CPUE	N	Weight (g)	CPUE	N	Weight (g)	CPUE
Before Whitewater Flows	Longnose Dace	55 (65%)	362 (5%)	3.29	14 (36%)	78 (29%)	0.83	35 (59%)	186 (48%)	1.97
	Small Mouth Bass	1 (1%)	30 (<1%)	0.06	9 (23%)	40 (15%)	0.53	0	0	0
	Mottled Sculpin	26 (31%)	260 (4%)	1.56	12 (31%)	94 (35%)	0.71	20 (34%)	172 (44%)	1.13
	Common Carp	2 (2%)	6654 (91%)	0.12	3 (8%)	48 (18%)	0.18	3 (5%)	28 (7%)	0.17
	Redside Shiner	0	0	0	0	0	0	1 (2%)	4 (2%)	0.06
	Utah Sucker	0	0	0	1 (3%)	10 (4%)	0.06	0	0	0
	Rainbow Trout	0	0	0	0	0	0.00	0	0	0
	Cutthroat Trout	0	0	0	0	0	0	0	0	0
	Total	84	7306	5.03	39	270	2.31	59	390	3.33
	Species	2008			2009			2010		
		N	Weight (g)	CPUE	N	Weight (g)	CPUE	N	Weight (g)	CPUE
After Whitewater Flows	Longnose Dace	9 (56%)	40 (5%)	0.49	N/A	N/A	N/A	N/A	N/A	N/A
	Small Mouth Bass	2 (13%)	6 (1%)	0.11	N/A	N/A	N/A	N/A	N/A	N/A
	Mottled Sculpin	3 (19%)	38 (4%)	0.16	N/A	N/A	N/A	N/A	N/A	N/A
	Common Carp	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
	Redside Shiner	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
	Utah Sucker	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
	Rainbow Trout	1 (6%)	250 (28%)	0.05	N/A	N/A	N/A	N/A	N/A	N/A
	Cutthroat Trout	1 (6%)	568 (63%)	0.05	N/A	N/A	N/A	N/A	N/A	N/A
	Total	16	902	0.86	N/A	N/A	N/A	N/A	N/A	N/A

In reach 2, species richness was much greater in 2006, 2007, and 2008 than in 2005 (Table 4.5-7). Four species were collected in 2006, 2007, and 2008 while only 2 species were collected in 2005. Longnose dace and small mouth bass were present all years, redside shiner were collected in 3 of 4 years (2006, 2007, and 2008), Utah sucker were collected in 2006 and 2007, and common carp were collected only in 2008.

Table 4.5-7: Fish density and biomass for reach 2, October 2005, 2006, 2007 and 2008

	Species	2005			2006			2007		
		N	Weight (g)	CPUE	N	Weight (g)	CPUE	N	Weight (g)	CPUE
Before Whitewater Flows	Longnose Dace	33 (97%)	257 (97%)	1.52	29 (88%)	206 (84%)	1.28	32 (82%)	338 (66%)	1.55
	Small Mouth Bass	1 (3%)	8 (3%)	0.05	1 (3%)	8 (3%)	0.04	1 (3%)	8 (2%)	0.05
	Mottled Sculpin	0	0	0	0	0	0	0	0	0
	Common Carp	0	0	0	0	0	0	0	0	0
	Redside Shiner	0	0	0	2 (6%)	20 (8%)	0.09	5 (13%)	30 (6%)	0.24
	Utah Sucker	0	0	0	1 (3%)	12 (5%)	0.04	1 (3%)	140 (27%)	0.05
	Rainbow Trout	0	0	0	0	0	0.00	0	0	0.00
	Cutthroat Trout	0	0	0	0	0	0	0	0	0
	Total	34	265	1.57	33	246	1.45	39	516	1.89
	Species	2008			2009			2010		
		N	Weight (g)	CPUE	N	Weight (g)	CPUE	N	Weight (g)	CPUE
After Whitewater Flows	Longnose Dace	19 (26%)	150 (33%)	0.95	N/A	N/A	N/A	N/A	N/A	N/A
	Small Mouth Bass	6 (8%)	64 (14%)	0.3	N/A	N/A	N/A	N/A	N/A	N/A
	Mottled Sculpin	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
	Common Carp	16 (22%)	138 (30%)	0.8	N/A	N/A	N/A	N/A	N/A	N/A
	Redside Shiner	33 (45%)	108 (23%)	1.65	N/A	N/A	N/A	N/A	N/A	N/A
	Utah Sucker	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
	Rainbow Trout	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
	Cutthroat Trout	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
	Total	74	460	3.7	N/A	N/A	N/A	N/A	N/A	N/A

In reach 3, species richness was greater in 2007 and 2008 than in 2005 and 2006 (Table 4.5-8). Five species were collected in 2007 and 2008 while four species were collected in 2005 and 2006. Redside shiner and Utah sucker were collected all 4 years, while Longnose dace and small mouth bass were collected in 3 of 4 years. One large adult common carp was collected in 2007 while 2 juvenile carp were collected in 2008. One mottled sculpin was collected in reach 3 in 2008, and one rainbow trout was collected in 2006.

Table 4.5-8: Fish density and biomass for reach 3, October 2005, 2006, 2007 and 2008

	Species	2005			2006			2007		
		N	Weight (g)	CPUE	N	Weight (g)	CPUE	N	Weight (g)	CPUE
Before Whitewater Flows	Longnose Dace	5 (4%)	22 (5%)	0.43	3 (3%)	12 (2%)	0.23	5 (7%)	24 (<1%)	0.30
	Small Mouth Bass	1 (1%)	4 (<1%)	0.09	0	0	0	3 (4%)	30 (<1%)	0.18
	Mottled Sculpin	0	0	0	0	0	0	0	0	0
	Common Carp	0	0	0	0	0	0	1 (1%)	4960 (54%)	0.06
	Redside Shiner	101 (85%	392 (83%)	8.71	73 (82%)	240 (31%)	5.48	52 (75%)	198 (2%)	3.13
	Utah Sucker	12 (10%)	56 (12%)	1.03	12 (13%)	234 (30%)	0.09	8 (12%)	3920 (43%)	0.48
	Rainbow Trout	0	0	0	1 (1%)	294 (38%)	0.08	0	0	0
	Cutthroat Trout	0	0	0	0	0	0	0	0	0
	Total	119	474	10.26	89	780	5.88	69	9132	4.15

	Species	2008			2009			2010		
		N	Weight (g)	CPUE	N	Weight (g)	CPUE	N	Weight (g)	CPUE
After Whitewater Flows	Longnose Dace	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
	Small Mouth Bass	10 (20%)	64 (2%)	0.65	N/A	N/A	N/A	N/A	N/A	N/A
	Mottled Sculpin	1 (2%)	14 (<1%)	0.07	N/A	N/A	N/A	N/A	N/A	N/A
	Common Carp	2 (4%)	20 (1%)	0.13	N/A	N/A	N/A	N/A	N/A	N/A
	Redside Shiner	35 (70%)	146 (4%)	2.29	N/A	N/A	N/A	N/A	N/A	N/A
	Utah Sucker	2 (4%)	3330 (93%)	0.13	N/A	N/A	N/A	N/A	N/A	N/A
	Rainbow Trout	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
	Cutthroat Trout	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
	Total	50	3574	3.27	N/A	N/A	N/A	N/A	N/A	N/A

Reach 4 had 5 fish species collected in 2005 and 2006 but only four in 2007 and 2008 (Table 4.5-9). Longnose dace, mottled sculpin, redside shiner, and rainbow trout were all collected in all 4 years of the study, while Utah suckers were collected in small numbers in 2005 and 2006 only.

In reach 1, longnose dace accounted for the largest proportion of the relative species composition in all 4 years (65%, 36%, 59%, and 56% of catch) (Figure 4.5-6). Mottled sculpin were the next most abundant in all years at 31%, 31%, 34% and 19% of the catch. In all years, other species comprised less than 10% of the catch except in 2006 and 2008, when small mouth bass accounted for 23% and 13%, respectively.

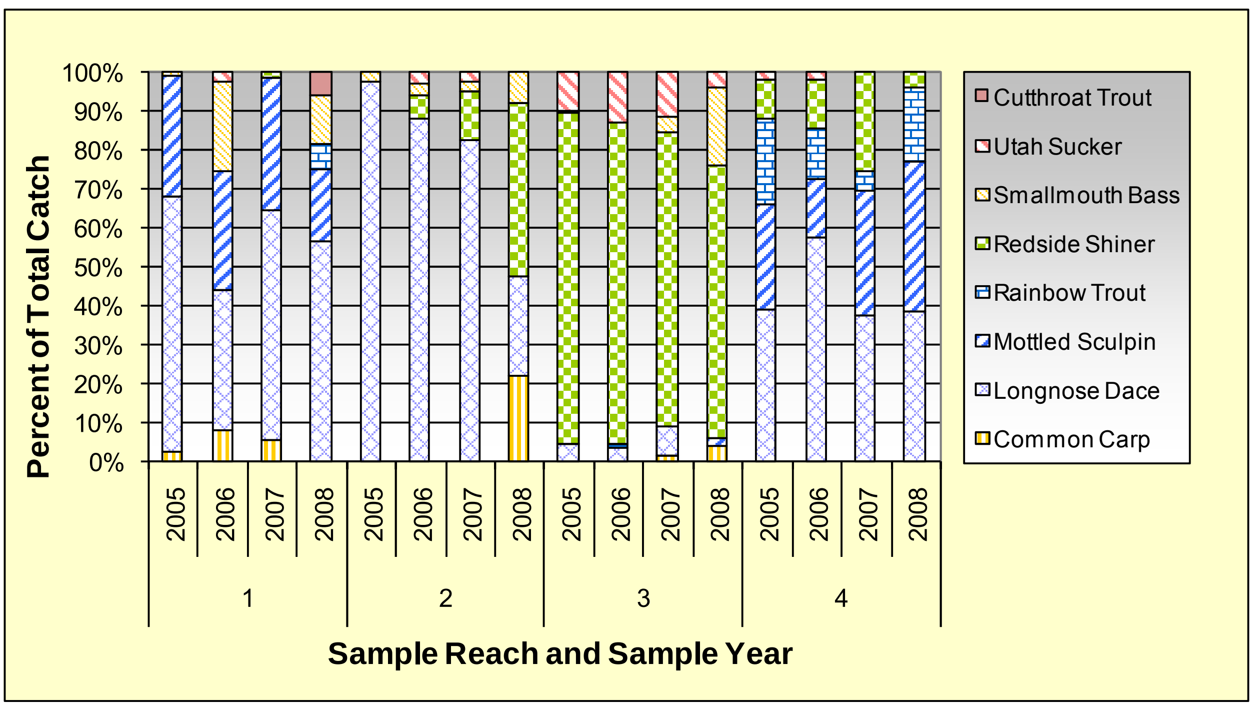
In reach 2, longnose dace were by far the most abundant in 2005, 2006 and 2007 (97%, 88%, 82%), however redside shiner were the most abundant in 2008 at 45% while longnose dace accounted for just 26% (Figure 4.5-6). Redside shiner accounted for relatively small proportions of the catch in 2006 (6%) and 2007 (13%) and were not collected in 2005. Common carp accounted for 22% of the catch in 2008 but were not collected in reach 2 in any other years. Small mouth bass comprised 3% to 8% of the catch over the 4 sample years. Utah sucker accounted for only a small proportion of the catch (3%) in 2006 and 2007, and were not collected in this reach in 2005 or 2008.

In reach 3, redside shiner were the most abundant species in all sample years (85%, 82%, 75% and 70%) (Figure 4.5-6). In 2005, 2006, and 2007 Utah sucker were the next most abundant at 10%, 13%, and 12% respectively, while it was small mouth bass accounting for 20% of the catch in 2008. Longnose dace, common carp, mottled sculpin, and rainbow trout also accounted for small proportions of the catch in reach 3 during this study.

Table 4.5-9: Fish density and biomass for reach 4, October 2005, 2006, 2007 and 2008

	Species	2005			2006			2007		
		N	Weight (g)	CPUE	N	Weight (g)	CPUE	N	Weight (g)	CPUE
Before Whitewater Flows	Longnose Dace	39 (39%)	263 (4%)	2.59	27 (57%)	134 (7%)	1.10	35 (37%)	225 (10%)	1.77
	Small Mouth Bass	0	0	0	0	0	0	0	0	0
	Mottled Sculpin	27 (27%)	180 (3%)	1.80	7 (15%)	66 (3%)	0.29	30 (32%)	252 (12%)	1.52
	Common Carp	0	0	0	0	0	0	0	0	0
	Redside Shiner	10 (10%)	92 (1%)	0.67	6 (13%)	58 (3%)	0.25	24 (26%)	238 (11%)	1.21
	Utah Sucker	2 (2%)	58 (1%)	0.13	1 (2%)	52 (3%)	0.04	0	0	0
	Rainbow Trout	22 (22%)	6308 (91%)	1.46	6 (13%)	1600 (84%)	0.25	5 (5%)	1460 (67%)	0.25
	Cutthroat Trout	0	0	0	0	0	0	0	0	0
	Total	100	6901	6.65	47	1910	1.93	94	2175	4.75
	Species	2008			2009			2010		
		N	Weight (g)	CPUE	N	Weight (g)	CPUE	N	Weight (g)	CPUE
After Whitewater Flows	Longnose Dace	18 (38%)	164 (7%)	1.04	N/A	N/A	N/A	N/A	N/A	N/A
	Small Mouth Bass	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
	Mottled Sculpin	18 (38%)	106 (4%)	1.04	N/A	N/A	N/A	N/A	N/A	N/A
	Common Carp	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
	Redside Shiner	2 (4%)	26 (1%)	0.12	N/A	N/A	N/A	N/A	N/A	N/A
	Utah Sucker	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
	Rainbow Trout	9 (19%)	2198 (88%)	0.52	N/A	N/A	N/A	N/A	N/A	N/A
	Cutthroat Trout	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A
	Total	47	2494	2.72	N/A	N/A	N/A	N/A	N/A	N/A

Figure 4.5-6: Species composition for reaches 1, 2, 3, and 4, 2005, 2006, 2007 and 2008



In reach 4, longnose dace accounted for the majority of the relative species composition in all four years of this study at 39%, 57%, 37% and 38% of the catch (Figure 4.5-6). Mottled sculpin were the next most abundant in all 4 years (27%, 15%, 32%, and 38%). Rainbow trout accounted for 22% of the catch in 2005, 13% in 2006, 5% in 2007, and 19% in 2008. Redside shiner comprised a small to moderate amount of the catch all 3 years at 10% in 2005, 13% in 2006, 26% in 2007, and 6% in 2008.

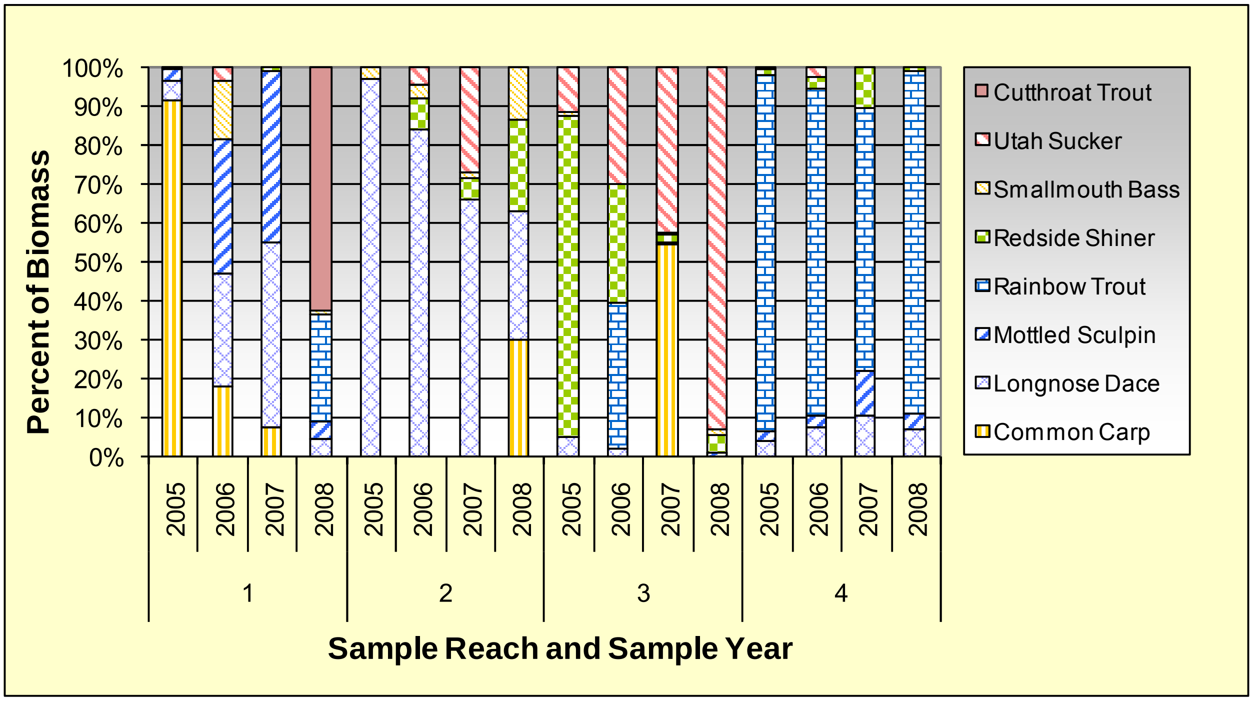
In reach 1, the total biomass was 7.31 kg in 2005, but was only 0.27 in 2006, 0.39 in 2007, and 0.90 in 2008 (Table 4.5-6). The large difference in total biomass was largely the result of collecting two large adult common carp in 2005 while only small juvenile carp were collected in 2006 and 2007 and no carp were collected in 2008. Accordingly, common carp accounted for 91% of the biomass in 2005 at 6.65 kg while in 2006 and 2007 they accounted for only 18% and 7%, respectively (Figure 4.5-7). Despite only 2 trout being collected, Cutthroat trout accounted for a majority of the biomass at 63% (0.57 kg) in 2008 followed by rainbow trout at 28% (0.25kg). In 2006, mottled sculpin accounted for the largest proportion of the biomass at 35% with just 0.09 kg followed by longnose dace at 29% (0.08 kg). In 2007 longnose dace accounted for the highest proportion of the biomass at 48% (0.19 kg) followed closely by mottled sculpin at 44% (0.17kg).

Total biomass in reach 2 was very similar in 2005 and 2006 at 0.27 and 0.25 kg, respectively, and in 2007 and 2008 biomass was greater at 0.52 kg and 0.48 kg (Table 4.5-7). The increase in biomass in 2007 was due mainly to the capture of one 0.14 kg Utah sucker (27% of biomass) however in 2008 the increased biomass resulted from collecting larger numbers of juvenile carp and redside shiners. Longnose dace comprised a majority of the biomass in all 4 years (97% in 2005; 84 % in 2006, 66% in 2007, and 33% in 2008). In the first 3 years, the remaining biomass was typically comprised of small proportions of small mouth bass and redside shiner (Figure 4.5-7) but in 2008 common carp accounted for 30%.

In reach 3, total biomass was much greater in 2007 (9.13 kg) and 2008 (3.57 kg) than in 2006 (0.78 kg) or 2005 (0.47 kg) (Table 4.5-8). For 2007, a majority of the total biomass can be attributed to the collection of one large adult common carp (4.96 kg, 54% of total biomass) while several large adult Utah suckers were collected in 2008 accounting for 93% (3.33 kg) of the total biomass. No carp were collected in reach 3 in 2005 or 2006 and only 2 juvenile carp were collected in 2008. In each of the first four years of this study, a different species has accounted for the highest proportion of the biomass in reach 3. Redside shiner comprised a majority of the biomass in 2005 (83%, 0.39 kg) while rainbow trout made up a majority of the biomass in 2006 at 0.29 kg (38%). Common carp accounted for the highest proportion of the biomass in 2007 at 54% (4.96 kg) and Utah sucker made up the majority of the biomass in 2008 at 93% (Figure 4.5-7).

Total biomass in reach 4 was considerably greater in 2005 (6.90 kg) than in 2006 (1.91 kg), 2007 (2.18 kg), or 2008 (2.49 kg) (Table 4.5-9). This decrease in total biomass was consistent with a decrease in the number of rainbow trout collected in 2006 (6), 2007 (5), and 2008 (9) verses the 22 collected in 2005. Rainbow trout accounted for a large majority of the biomass during all four years of this study at 91% in 2005, 84% in 2006, 67% in 2007, and 91% in 2008 (Figure 4.5-7). The remainder of the biomass in reach 4 was typically comprised of small proportions of longnose dace, mottled sculpin, redside shiner, and Utah sucker.

Figure 4.5-7: Biomass for reaches 1, 2, 3, and 4, 2005, 2006, 2007 and 2008



In reach 1, total catch and CPUE varied considerably between the four study years. Total catch was highest in 2005 at 84 fish, followed by 59 fish in 2007, 39 fish in 2006, and just 19 fish in 2008 (Table 4.5-6). Likewise, catch per unit effort (CPUE) was also highest in 2005 at 5.03 fish/minute, lesser at 3.33 fish/minute in 2007, and 2.31 fish/minute in 2006, and was lowest in 2008 at just 0.86 fish/minute.

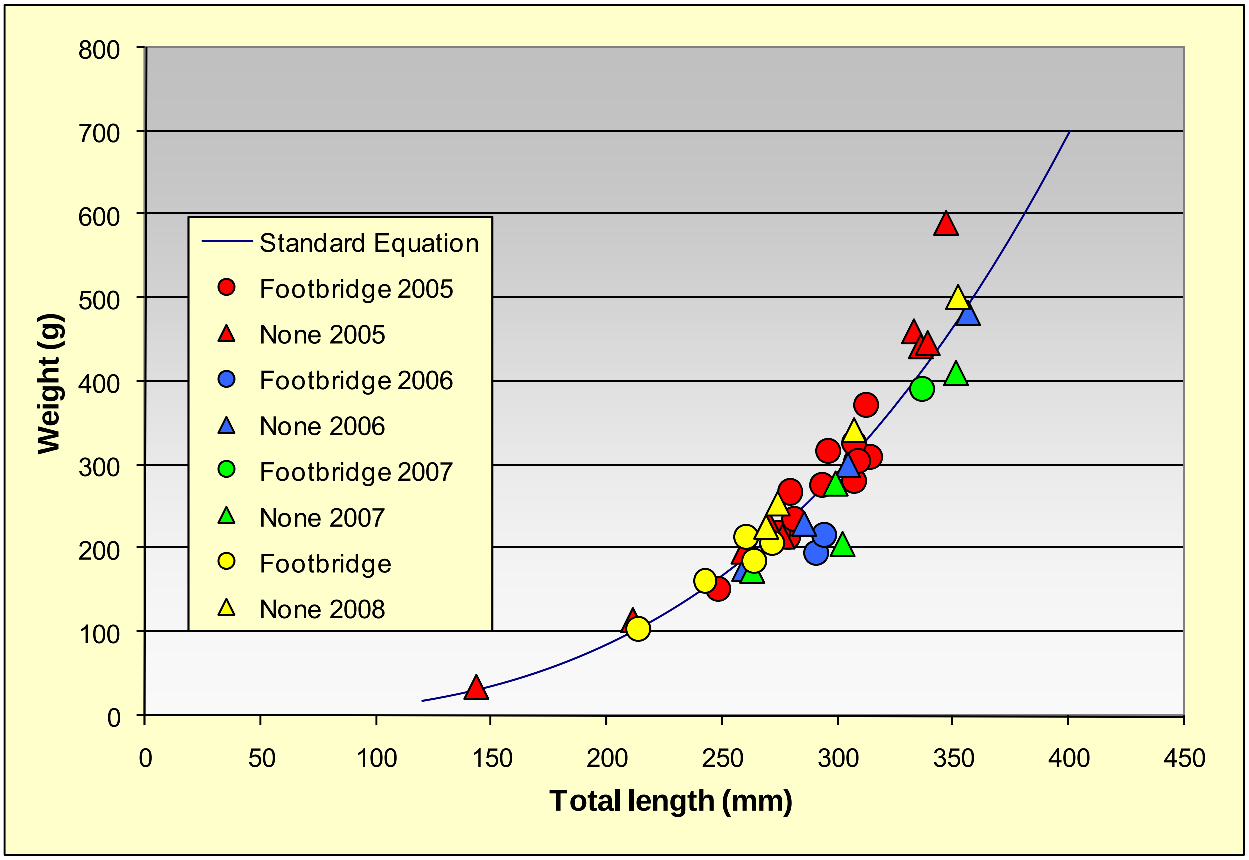
Total catch in reach 2 was similar between 2005, 2006, and 2007 with 34, 33, and 39 fish, respectively, however it increased considerably in 2008 to 74 fish (Table 4.5-7). Correspondingly, CPUE was also similar during the first 3 years with a rate of 1.57 fish/minute in 2005, 1.45 fish/minute in 2006, and 1.89 fish/minute in 2007, and then increased to 3.70 fish/minute in 2008.

Total catch in reach 3 decreased each year of the study. In 2005, total catch was highest at 119 fish, decreased to 89 fish in 2006, to 69 in 2007, and decreased to just 50 fish in 2008 (Table 4.5-8). Following the same trend as total catch, CPUE was highest in 2005 at 10.26 fish/minute, then decreased to 5.88 fish/minute in 2006, 4.15 fish/minute in 2007, and 3.27 fish/minute in 2008.

In reach 4, total catch was much higher in 2005 (100 fish) and 2007 (94 fish) than in both 2006 and 2008 when only 47 fish were collected (Table 4.5-9). Similarly, CPUE was also considerably greater in 2005 (6.65 fish/minute) and 2007 (4.75 fish/minute) than in 2006 (1.93 fish/minute) and 2008 (2.72 fish/minute).

Overall, the condition (relative weight) of rainbow trout in reach 4 was highest in 2008 with a mean of 105 (Figure 4.5-8). Mean relative weight of all rainbow trout collected was 104 in 2005, 89 in 2006, and in 2007 the mean was 87. The mean relative weight of freeze-branded hatchery released fish was highest in 2008 at 102 compared to 95 in 2007, 76 in 2006, and 100 in 2005. The mean relative weight of rainbow trout without freeze-brands was 109 in 2008 and 2005, 95 in 2006, and 85 in 2007.

Figure 4.5-8: Length-weight relationship for rainbow, reach 4, 2005, 2006, 2007 and 2008



4.6 TEMPERATURE

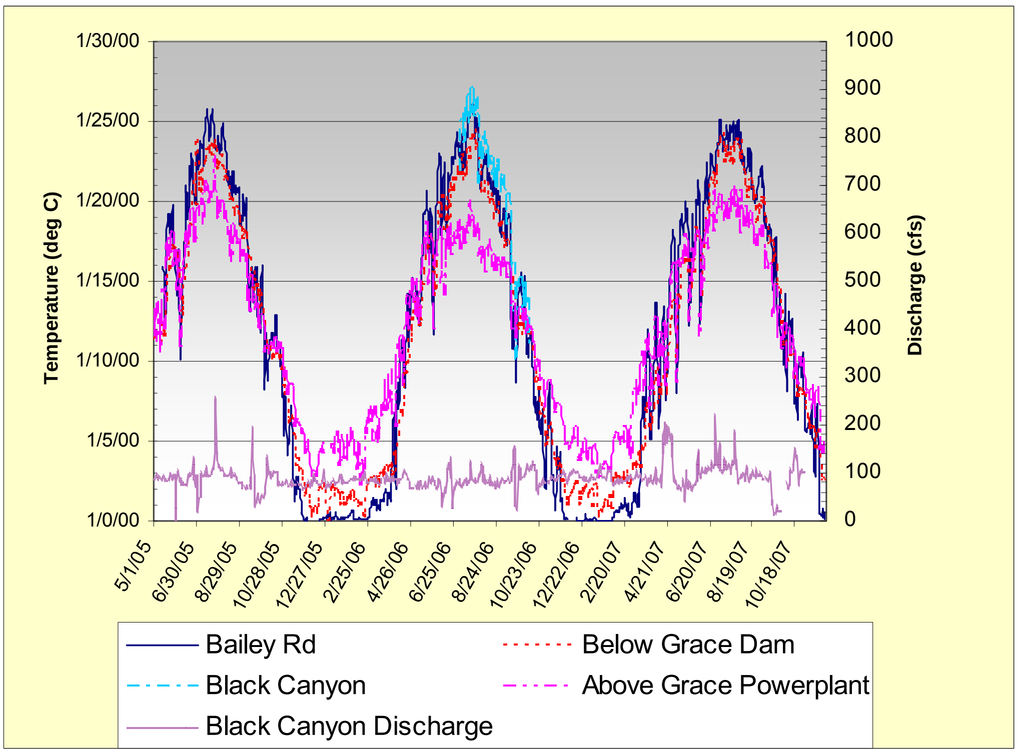
Water temperature can be a critical factor limiting the distribution and abundance of aquatic species particularly coldwater fishes. Releases from Grace Dam have the potential to cause thermal loading to surface waters in reaches 2, 3 and 4. Over the three-year monitoring period discharge has remained relatively stable in the regulated reach below Grace Dam reflecting the MIF requirement in the FERC license. On several occasions, spills from Grace Dam have occurred to pass water downstream to meet irrigation demands. In 2005, the maximum summer flow below Grace Dam was 255 cfs on July 26, 2005. In 2006, several small discharge spikes occurred in the summer time frame; 128 cfs on June 21; 122 cfs on July 22, 115 cfs on August 4 and 152 cfs on September 18. In 2007, the maximum flow below Grace Dam was 218 cfs on June 27th. During that release maximum temperatures in reach 4 reached 20.8 ºC, equivalent to the highest temperature recorded in reach 4 in 2007.

The absence of substantial changes in discharge in the summer season during the three-year baseline monitoring period made it difficult to detect if there was an interaction between changes in discharge at Grace Dam and stream temperatures in reaches 2, 3 and 4 (Figure 4.6-1). In 2006, daily maximum stream temperatures in reach 4 increased approximately 1 ºC from the previous day on June 21 and July 19 corresponding to discharge increases from Grace

Dam. In 2007, daily maximum stream temperature on June 27 was approximately 2 ºC higher than the day prior or after the release.

The variable flows released from Grace Dam in 2008 provide an opportunity to track potential changes in stream temperatures induced by releases from Grace Dam in reaches 2, 3 and 4. Surface water releases from Grace Dam have the potential to increase stream temperatures above the Idaho water quality standards established for the Bear River. Idaho DEQ staff deploy and retrieve hobo temps in study reaches 1, 2, 3 and 4 annually. The temperature data should be analyzed to determine the magnitude of the temperature changes, if any, associated with releases from Grace Dam. The temperature changes are likely to vary seasonally.

Figure 4.6-1: Maximum water temperatures in reaches 1, 2, 3 and 4, 2005 through 2007



Constraints on the project budget have prevented analysis and reporting of the temperature data for the 2008 report. Previous analysis and reporting of temperature data has been outside the original scope of work. OASIS has provided this analysis to the ECC to provide a thorough assessment of habitat and water quality conditions in the reference and treatment reaches. Further analysis of this data is recommended to assess compliance with water quality standards and evaluate potential for thermal impacts to salmonids.

4.7 BENTHIC MACROINVERTEBRATES

BMI density in 2008 exhibited patterns between study reaches similar to the three previous study years (Figure 4.7-1). Reach 4 contained the highest BMI density (44,008 organisms/m^2) of all four study reaches (Table 4.7-1). Interestingly, the 2008 BMI density in the reach 4 was less than half the mean measured in reach 4 over the previous three sample years. BMI density in study reaches 1, 2 and 3 was 15,696, 25,750 and 8,750 organisms/m^2 respectively. As in the previous three years, reach 3 contained the lowest BMI density for the 2008 sampling effort although substantially greater compared to the 2007 sampling.

Comparisons across all four sample years within a single study reach indicate BMI densities were similar over time at each reach (single factor ANOVA and Kruskal-Wallis H-test). BMI density comparisons between the three-year baseline sampling period and the first year of the variable flow regime found no significant differences within study reaches 1, 2 or 3 (Figure 4.7-2). In reach 4, BMI density under baseline conditions was significantly higher than variable flow conditions (p=0.05, H-test). The mean BMI density for the three-year baseline period was 90,356 organisms/m^2 compared to 44,008 organisms/m^2 in the first year of the variable flow conditions.

Table 4.7-1: Average BMI density in October at four reaches; 2005, 2006 and 2007

Study Reach	BMI								EPT							
	2005		2006		2007		2008		2005		2006		2007		2008	
	Density	No. taxa	Density	No. taxa	Density	No. taxa	Density	No. taxa	Density	No. taxa	Density	No. taxa	Density	No. taxa	Density	No. taxa
Reach 1	25,144	39	21,190	39	14,367	28	15,696	30	14,836	14	13,415	16	10,544	13	9,665	14
Reach 2	16,402	37	31,929	39	16,151	25	25,750	35	595	5	1,244	5	124	3	1,164	5
Reach 3	5,390	45	8,621	39	3,645	35	8,750	38	826	11	2,125	10	727	9	3,531	10
Reach 4	86,048	25	104,430	34	80,589	20	44,008	35	412	2	2,310	5	238	2	2,171	5

Reach 1 contained the highest EPT density (9,665 organisms/m^2) of all four study reaches in 2008 (Figure 4.7-3). EPT density in study reaches 2, 3 and 4 was 1,164, 3,531 and 2,171 organisms/m^2 respectively. In reach 1, EPT comprised 62 percent of the overall BMI density compared to 5 percent, 40 percent and 5 percent in reaches 2, 3 and 4 respectively.

Comparisons across all four sample years within a single study reach indicate EPT densities were similar over time in reaches 1 and 3 but differed in reaches 2 and 4 (p=0.05 and p=0.005 respectively, H-test). EPT density comparisons between the three-year baseline sampling period and the first year of the variable flow regime found no significant differences in reach 1 but significant increases in EPT density in study reaches 2, 3 and 4 under the variable flow conditions (Figure 4.7-4). In reaches 2 and 4, EPT density was significantly higher during the first year of variable flow compared to the three-year baseline period (p=0.05 respectively, H-test). In reach 3, EPT density was significantly greater during the first year of variable flow than the three-year baseline period (p=0.07, ANOVA). EPT density during the first year of variable flow in reach 3 was double the mean for the baseline period (3,531 compared to 1,226 organisms/m2). EPT density in reach 3 under the variable flow conditions comprised 40% of the BMI community compared to 20% during the three-year baseline period.

Figure 4.7-1: BMI Density, 2005, 2006, 2007 and 2008.

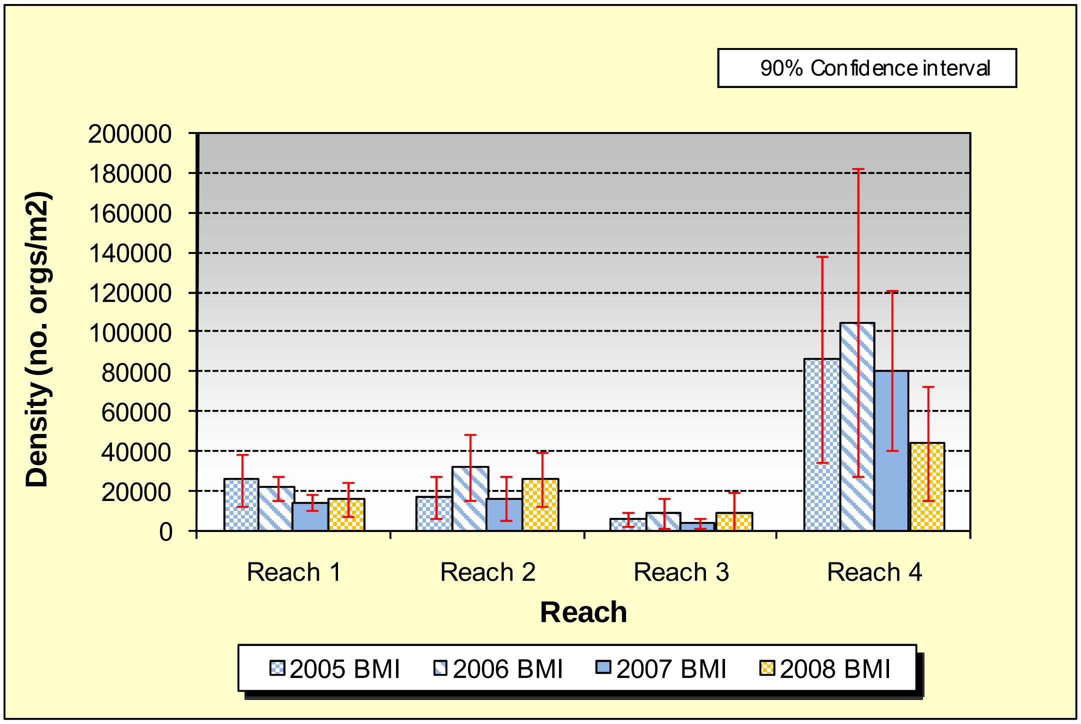


Figure 4.7-2: BMI Density, baseline period versus variable flow.

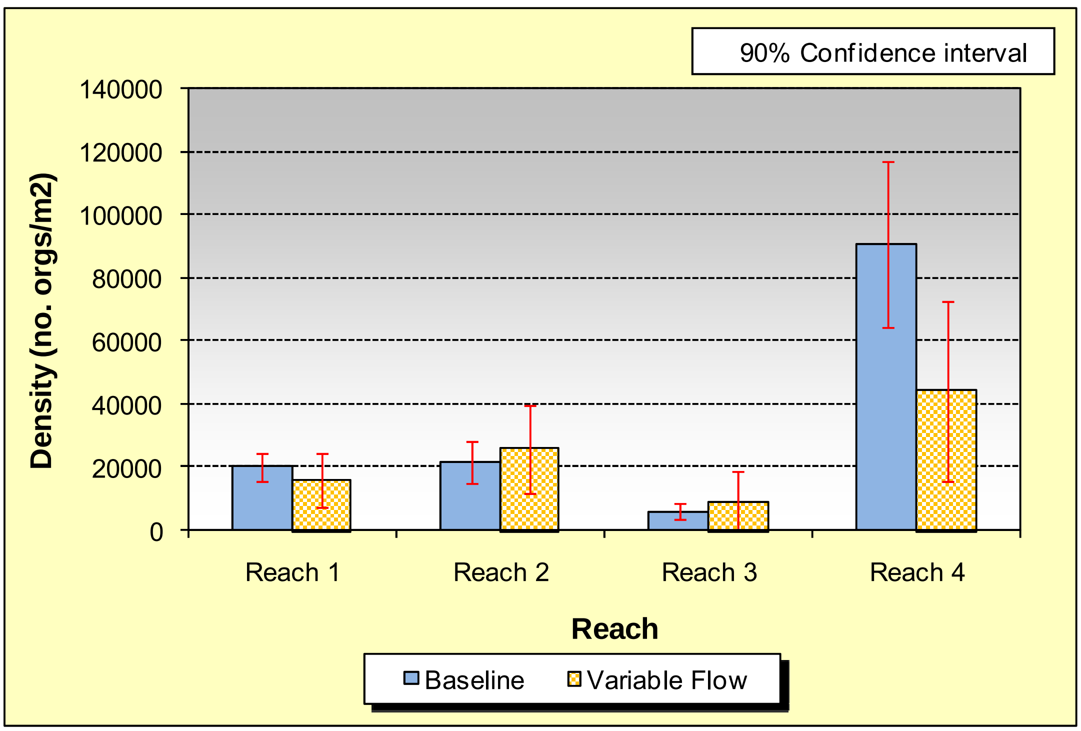


Figure 4.7-3: EPT density, 2005, 2006, 2007 and 2008.

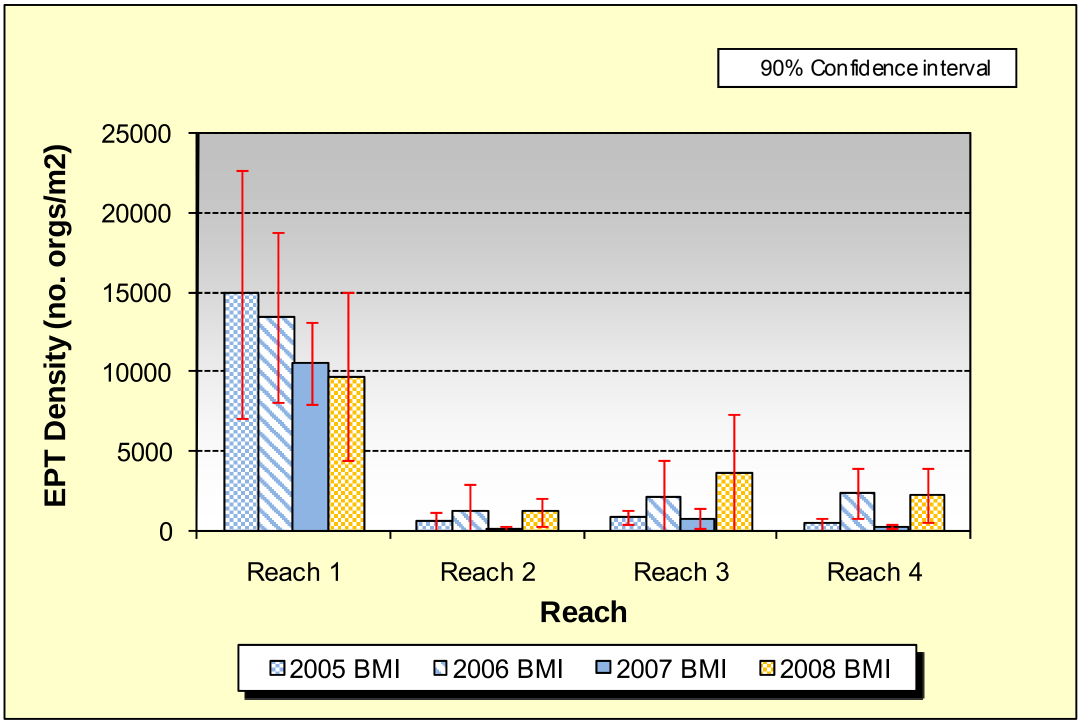
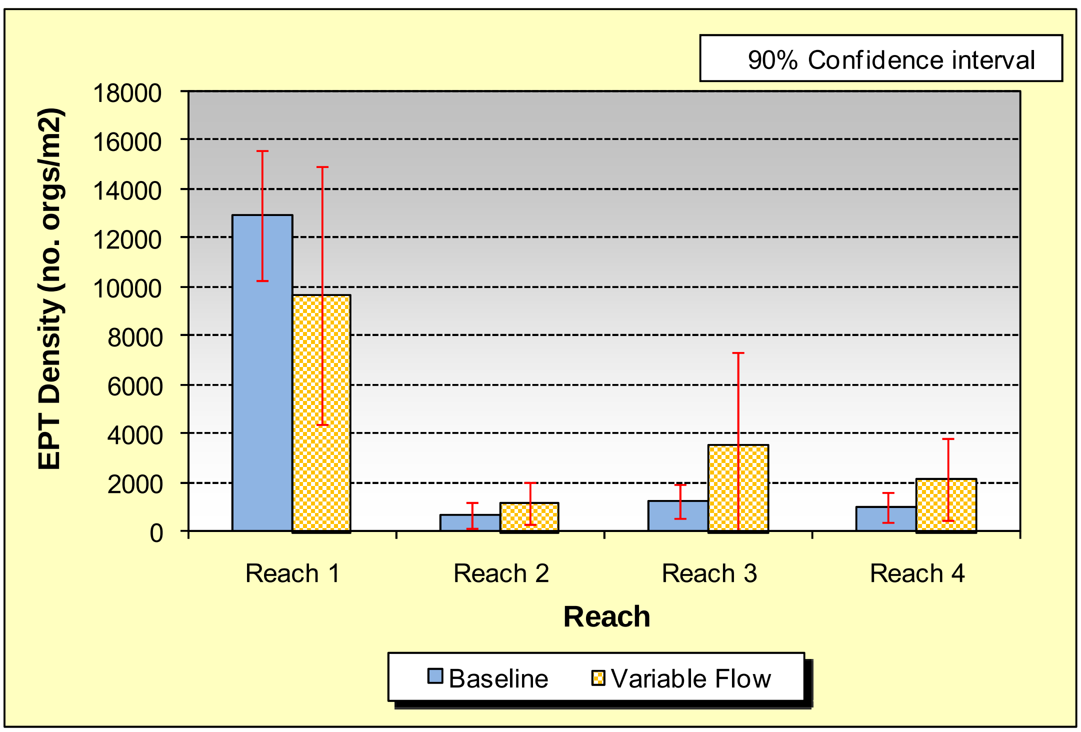


Figure 4.7-4: EPT Density, baseline period versus variable flow.



BMI taxa richness ranged from a low of 30 taxa in reach 1 to a high of 38 taxa in reach 3 (Figure 4.7-5). Reaches 2 and 4 each had 35 taxa. In 2008, BMI taxa richness increased at all four sample sites respectively relative to the 2007 values which were the lowest of all four sample years. Comparisons across all four sample years within a single study reach indicate taxa richness was significantly different between years in reaches 1, 2 and 4 but similar in reach 3 (p=0.0004, p=0.09 and p=0.0004 respectively, ANOVA).

BMI taxa richness comparisons between the three-year baseline sampling period and the first year of the variable flow regime found significant differences in reaches 1 and 4 but no differences in reaches 2 and 3 (Figure 4.7-6). In reach 1, the reference reach not exposed to the variable flow treatment, BMI taxa richness was significantly lower during the 2008 variable flow period (p=0.10, ANOVA). In contrast, BMI taxa richness in reach 4 was significantly higher under the variable flow conditions in 2008 (p=0.02, ANOVA). In reach 2, 35 BMI taxa were present under variable flow conditions compared to 34 during baseline conditions. In reach 3, 38 BMI taxa were present under the variable flow conditions compared to 40 during the baseline period.

EPT taxa richness ranged from a high of 14 taxa in reach 1 to a low of 5 taxa in reaches 2 and 4 respectively (Figure 4.7-7). Reach 3 had 10 EPT taxa. In 2008, EPT taxa richness was greater at all four sample sites relative to the 2007 values which were the lowest of all four sample years. In reach 4, EPT taxa richness was significantly different between the four sample years (p=0.00008, ANOVA). EPT taxa richness within individual reaches 1, 2 and 3 for the four year study period showed no significant differences between sample years.

EPT taxa richness comparisons between the three-year baseline sampling period and the first year of the variable flow regime found significant differences in reach 4 but no differences in reaches 1, 2 and 3 (Figure 4.7-8). In reach 2, 5 EPT taxa were present under variable flow conditions compared to 4 during baseline conditions. In reach 3, 10 EPT taxa were present under the baseline and variable flow conditions respectively. Reach 4 contained 3 EPT taxa during the baseline period compared to 5 EPT taxa during the 2008 variable flow. This small increase in EPT taxa in reach 4 was significant (p=0.02, H-test).

In reach 4, the EPT taxa community in 2008 contained 6 taxa (average 5.4 for five transects). The Ephemeroptera taxa present consisted of *Baetis tricaudatus, Fallceon quilleri and Tricorythedes sp.*. Each of these taxa were observed during one or more of the previous baseline sampling years but not continuously. *Baetis tricaudatus was* present in all three baseline sampling years. *Tricorythedes sp*. was present in 2005 and 2007. *Fallceon quilleri,* was present in 2006 only. The Ephemeroptera taxa, *Ephemerella sp*., present only in 2006 was not present in 2008 under the variable flow regime.

Trichoptera taxa in 2008 consisted of *Hydroptila sp.*, *Nectopsyche sp.* and *Neotrichia sp.*. Each of these taxa was observed previously during one or more of the baseline sampling events. *Hydroptila sp.* was observed in 2006. Hydroptilidae, the family level of identification, was observed in 2005. *Nectopsyche sp.* was present in 2005 and 2007. *Neotrichia sp.*. was observed in 2006 only. The Trichoptera taxa, *Chimarra sp.* and *Glossosomatidae*, observed in 2006 in reach 4 were not observed in any other sampling year. The Trichoptera taxa, *Amiocentrus aspilus*, previously found in reach 4 in 2005 was not observed in 2006, 2007 or 2008. Plecoptera taxa were not present in reach 4 in 2005, 2006, 2007 or 2008.

Figure 4.7-5: BMI taxa richness, 2005, 2006, 2007 and 2008

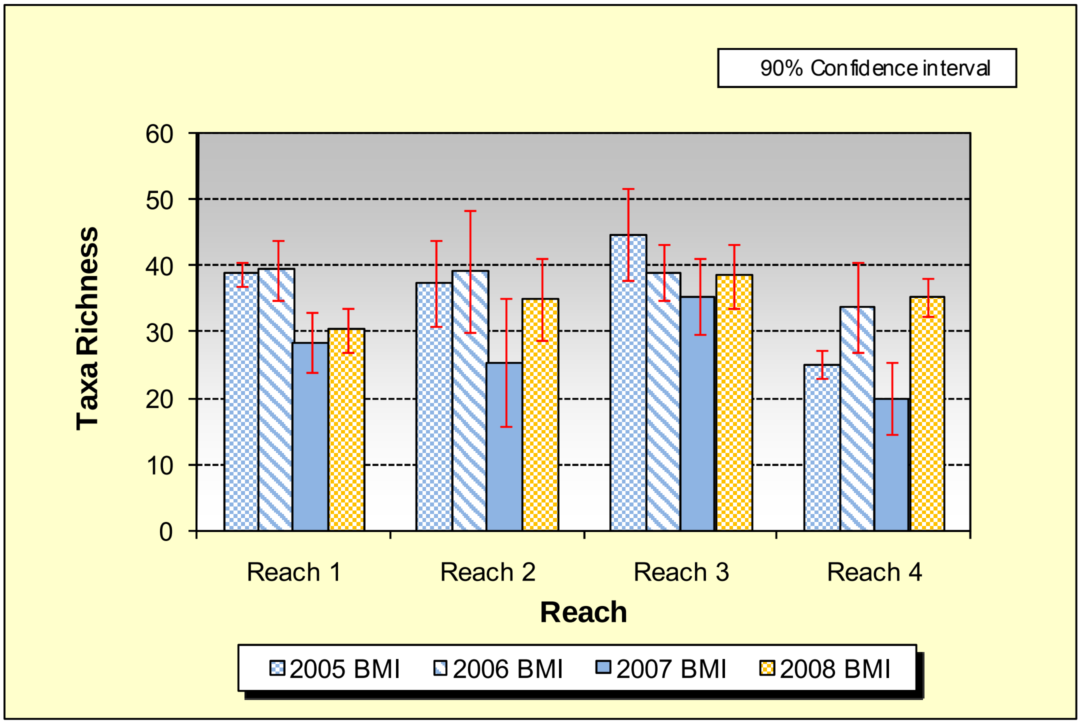


Figure 4.7-6: BMI taxa richness, baseline period versus variable flow.

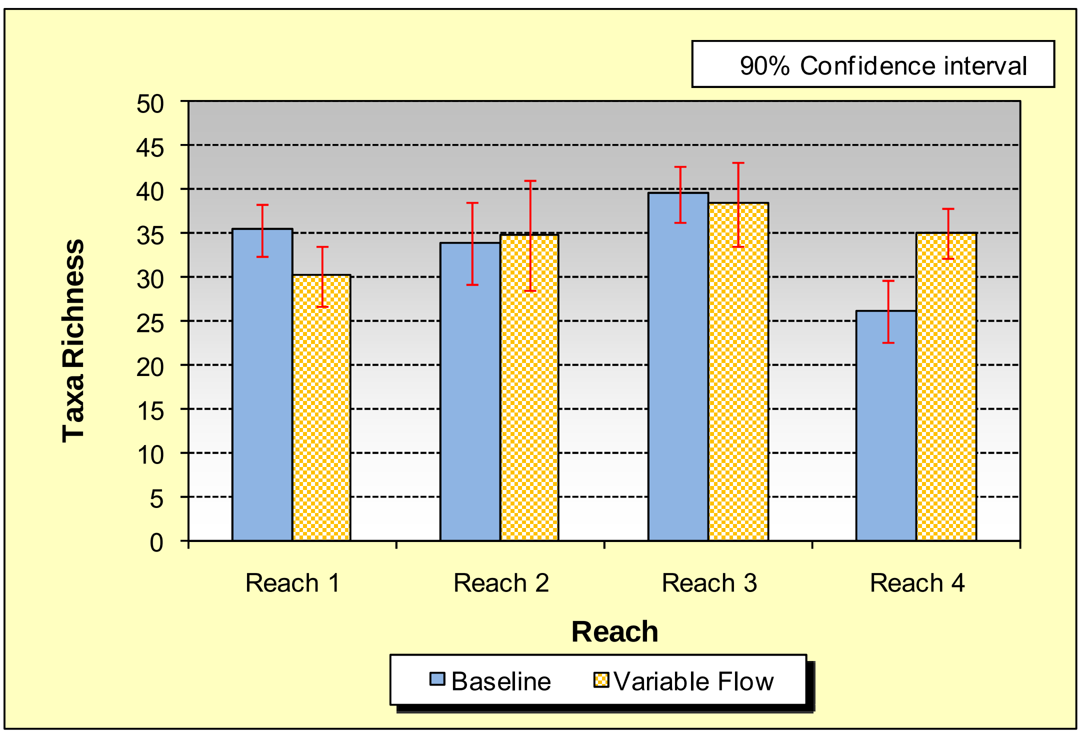


Figure 4.7-7: EPT taxa richness, 2005, 2006, 2007 and 2008

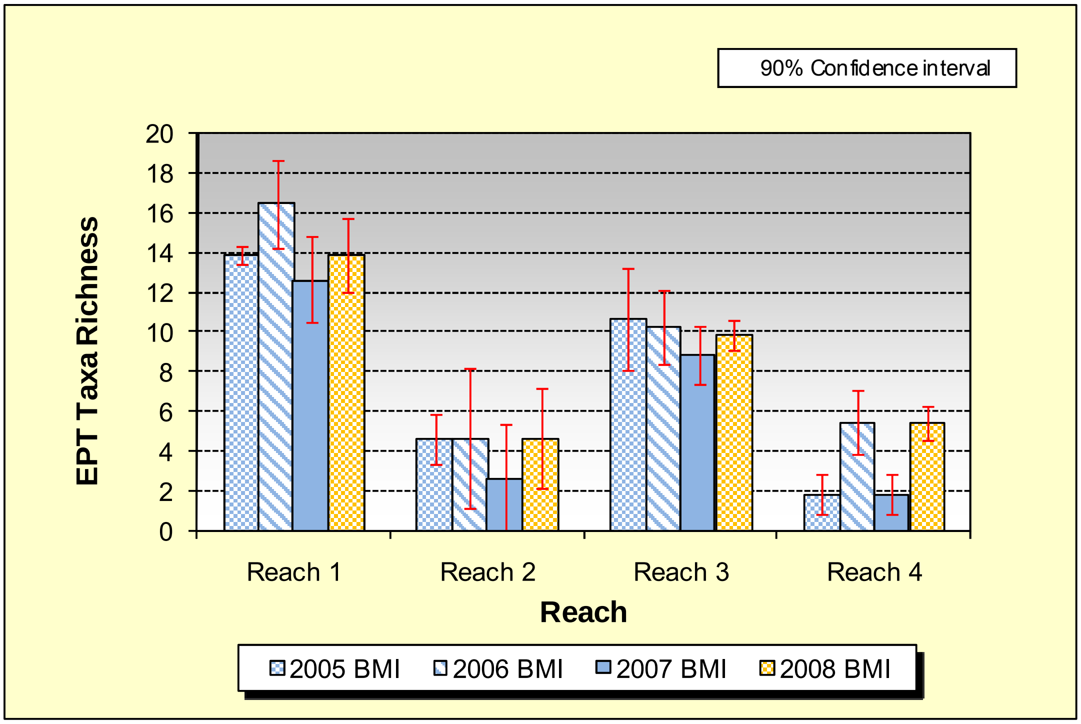
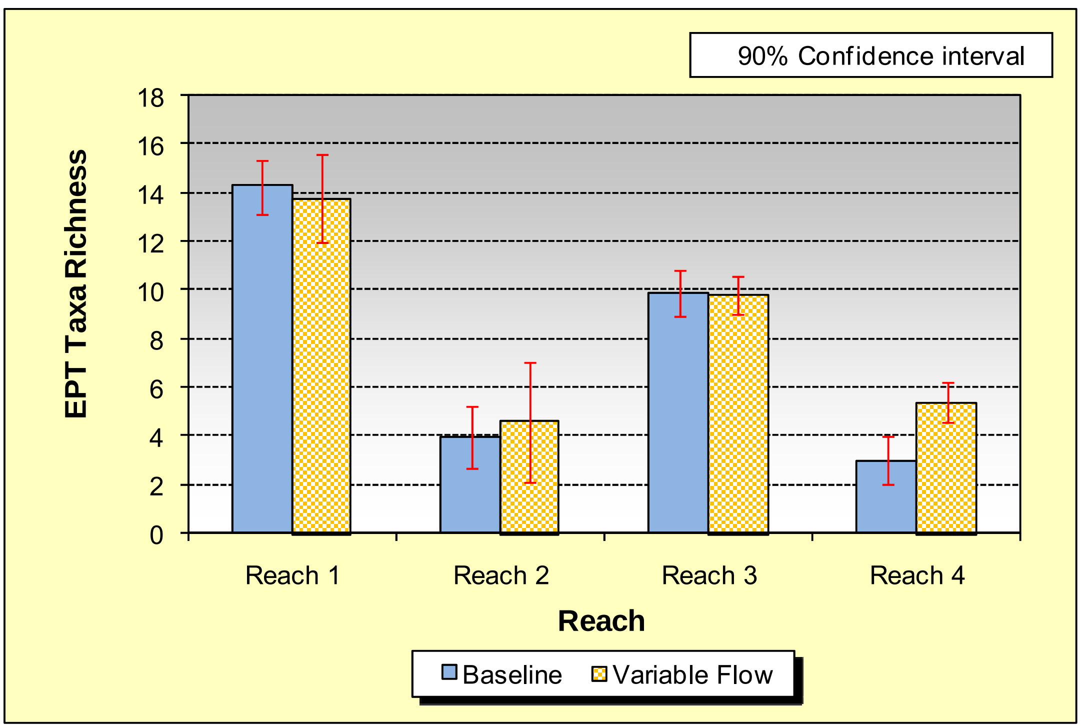


Figure 4.7-8: EPT taxa richness, baseline period versus variable flow.



Dominant taxa measures reveal the proportion of the dominant taxa relative to the larger BMI community. In 2008, the top three dominant taxa in reach 1 comprised 40.8% of the BMI density; dominant taxa 1—18.0%, dominant taxa 2—12.2% and dominant taxa 3—10.6% (Table 4.7-2). In reach 2, the top three dominant taxa comprised 54.2% of the BMI density; dominant taxa 1—28.6%, dominant taxa 2—16.3% and dominant taxa 3—9.3%. In reach 3, the top three dominant taxa comprised 56.9% of the BMI density; dominant taxa 1—32.2%, dominant taxa 2—16.5% and dominant taxa 3—8.2%. In reach 4, the top three dominant taxa comprised 59.2% of the BMI density; dominant taxa 1—36.9%, dominant taxa 2—14.1% and dominant taxa 3—8.23%.

Table 4.7-2: Top three dominant taxa percentages, 2005, 2006, 2007 and 2008

Study Reach	Dominant Taxa 1 (%)				Dominant Taxa 2 (%)				Dominant Taxa 3 (%)				Totals (%)			
	2005	2006	2007	2008	2005	2006	2007	2008	2005	2006	2007	2008	2005	2006	2007	2008
R1	20.2	17.3	19.3	18.0	12.5	12.6	15.1	12.2	8.9	10.6	12.3	10.6	41.6	40.5	46.7	40.8
R2	31.6	25.2	38.4	28.6	12.4	12.3	16.4	16.3	9.9	9.5	11.4	9.3	53.9	47.0	66.2	54.2
R3	21.7	13.4	23.0	32.2	9.8	10.4	14.0	16.5	8.4	9.7	9.4	8.2	40.0	33.5	46.4	56.9
R4	79.6	70.3	82.6	36.9	5.3	5.3	3.6	14.1	3.1	3.9	2.4	8.2	88.0	79.4	88.6	59.2

The percentage of dominant taxa in reaches 1 and 2 was similar across the four-year study period (Figure 4.7-9). In reaches 3 and 4, the percentage of dominant taxa was significantly different between years (reach3—p=0.02, H-test; reach 4—p=0.00001, ANOVA). The second dominant taxa was significantly different over the four-year study period in reaches 3 and 4 (p=0.004 and p=0.008 respectively, H-test) but similar between years in reaches 1 and 2 (Figure 4.7-10). The third dominant taxa (Figure 4.7-11) was significantly different between years in reaches 1 and 4 (p=0.07 and p=0.009 respectively, H-test).

The dominant taxa in reach 1 across all four study years consisted of Ephemeroptera, Trichoptera and Diptera taxa with a rotating list of individual taxon dominating the different transects in any given year. In 2005 three different dominant taxa were present in reach 1; *Simulium sp.* (TA), *Hydropsyche sp.* (TB) and *Ephemerella inermis/infrequens* (TC, TD and TE). The dominant taxa in 2006 was similar to that in 2005; *Simulium sp.* (TA and TD), *Hydropsyche sp.* (TB) and *Ephemerella infrequens* (TC and TE). In 2007, the dominant taxa included two new Trichoptera taxa in addition to *Hydropsyche sp.* and a chronomid; *Protoptila sp.* (TA), *Hydropsyche sp.* (TB), *Cricotopus trifascia gr.* (TC and TD) and *Culoptila sp.* (TE). In 2008, the dominant taxa included in reach 1 included (TA, TB and TE), *Simulium sp.* (TC and TD) and *Baetis tricaudatus*. This marks the first time *Baetis tricaudatus* was the dominant taxa in reach 1 although the taxa has been present as the second dominant taxa in 2005. *Baetis tricaudatus* is a multivoltine taxa with a fast life cycle.

The dominant taxa in reach 2 across all four study years consisted of a crustacean (*Ostracoda*), water mites and dipterans. In 2005, the dominant taxa in reach 2 was *Ostracoda* in transects TA, TB, TC and TE. Transect TD was dominated by the water mite *Hygrobates sp.* The dominant taxa in 2006 and 2007 in reach 2 was identical for four of the five transects, TB through TE; *Simulium sp.*(TB), *Ostracoda* (TC) and *Hygrobates sp*. (TD and TE). Transect TA contained *Microtendipes pedellus gr.* in 2006 and *Turbellaria* in 2007. In 2008, the dipteran *Dicrotendipes sp.* was present in transects TA, TB and TC. This taxa was observed in reach 2 in 2005 as the third dominant taxa in transect TA but has been present as a dominant taxa since that initial sample year. Tansect TD and TE contained the water mite *Hygrobates sp.* in 2008.

Figure 4.7-9: Dominant taxon percentage; 2005, 2006, 2007 and 2008

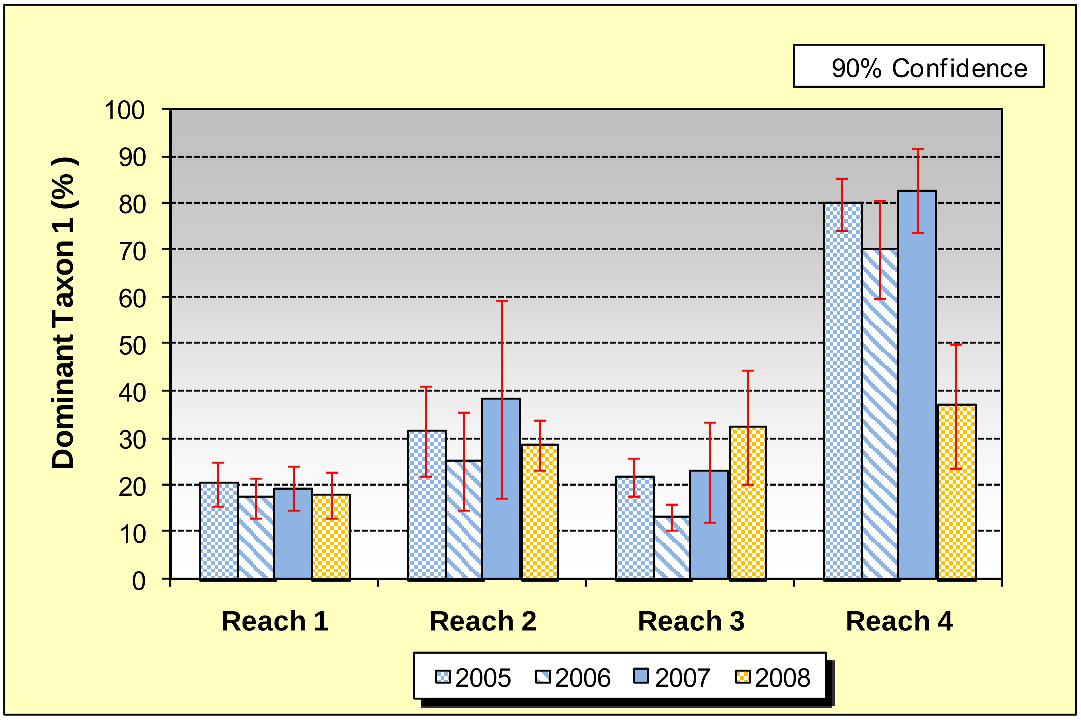


Figure 4.7-10: Second dominant taxon percentage; 2005, 2006, 2007 and 2008

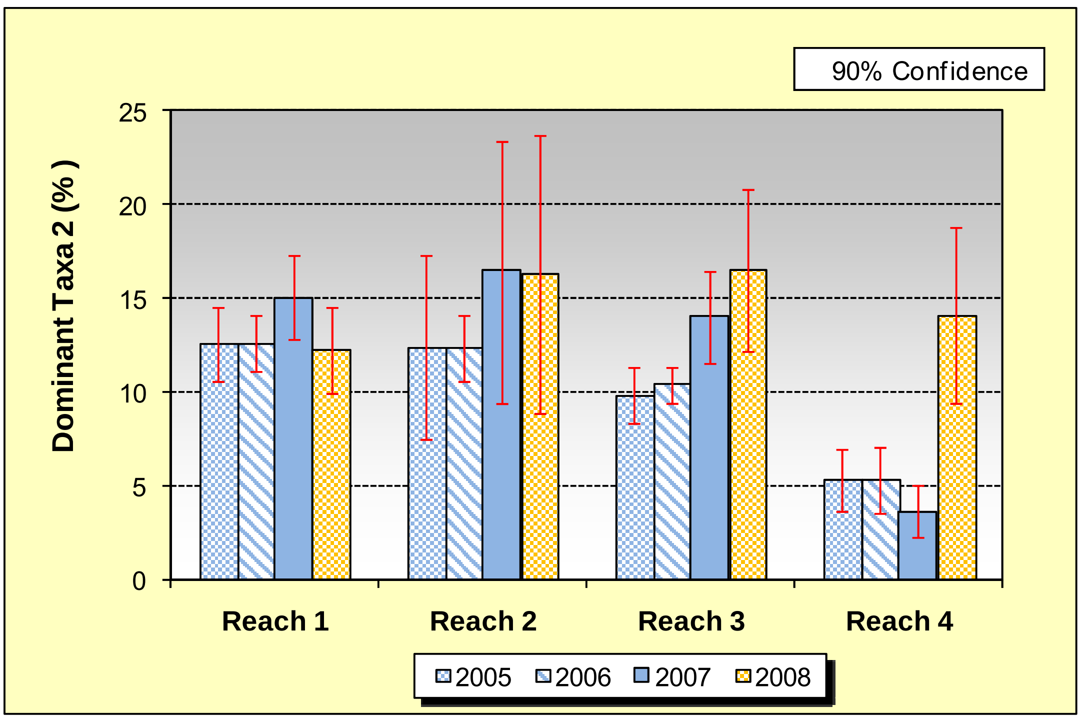
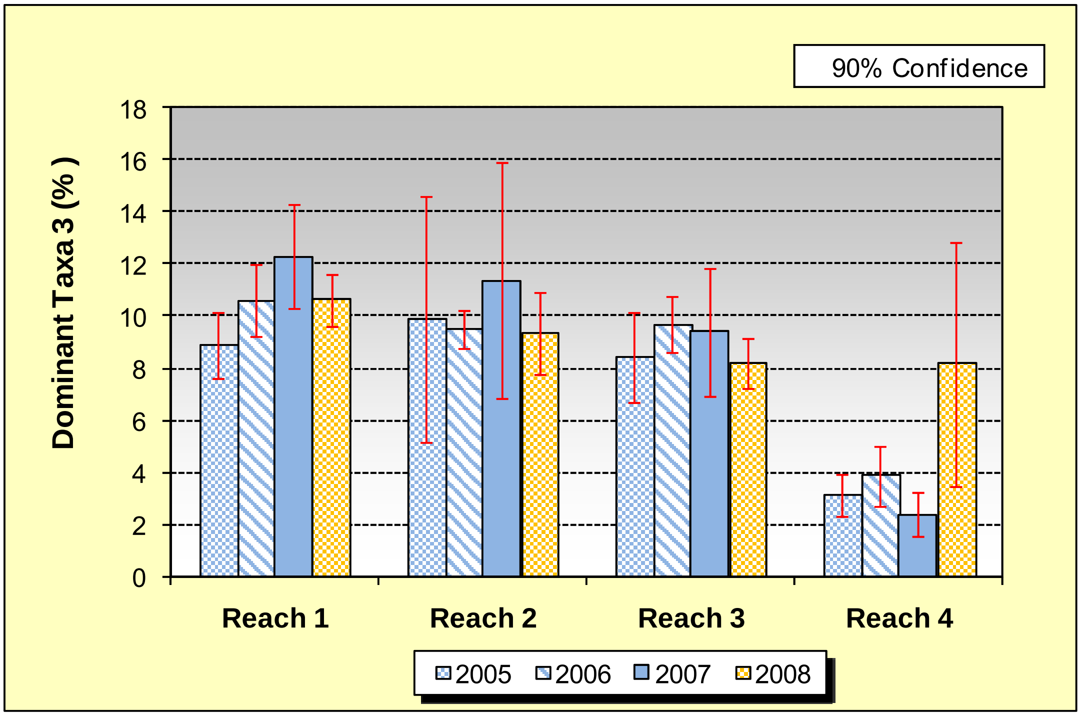


Figure 4.7-11: Third dominant taxon percentage; 2005, 2006, 2007 and 2008



The dominant taxa in reach 3 consisted largely of dipterans, water mites and an aquatic Lepidoptera (*Petrophila sp.*) over the four study years. In 2005, the water mite *Hygrobates sp.* was the dominant taxa at four of the five transects and *Orthocladius sp.*, a chironomid, was the dominant taxa at the fifth transect. In 2006, five different taxa dominated each transect; *Pseudochironomus sp.* (TA), *Hygrobates sp.* (TB), *Petrophila sp.* (TC), *Turbellaria* (TD) and *Prostoma sp.* (TE). In 2007, *Orthocladius sp.* was the dominant taxa in two transects (TA and TC), *Hygrobates sp.* (TB), *Petrophila sp.* (TD) and *Ostracoda* (TE). In 2008, the Ephemeroptera taxa, *Fallceon quilleri*, was the dominant taxa in transects TA dn TC. This marks the first time and Ephemeroptera taxa was the dominant taxa in reach 3 for the four study years. The water mite, *Hygrobates sp.,* was the dominant taxa in transects TB and TC. In transect TE, *Microtendipes pedellus gr.,* a dipteran, was the dominant taxa.

In Reach 4, the BMI community has been overwhelmingly dominated by a single taxa in 2005, 2006 and 2007 (79.6%, 70.3% and 82.6% respectively. In 2008, the dominant taxa comprised only 36.9% of the BMI community, a significant decline compared to the previous three sampling years (p=0.00001, ANOVA). Despite the decline in the dominant taxa, reach 4 continues to be dominated in 2008 by the invasive Gastropoda, *Potamopyrgus antipodarum*. In 2005, transects TA through TE in reach 4 were dominated by *Potamopyrgus antipodarum*. In 2006, transects TA through TE in reach 4 were dominated by *Hydrobiidae*, the family level for the taxa *Potamopyrgus antipodarum.* This more conservative identification by taxonomists in 2006 was most likely *Potamopyrgus antipodarum.* In 2007, transects TA through TE in reach 4 were again dominated by *Potamopyrgus antipodarum*. In 2008, transects TA through TC and TE in reach 4 were dominated by *Potamopyrgus antipodarum*. Transect TD was dominated by the Dipteran, *Rheotanytarsus sp.*

Table 4.7-3 and 4.7-4 list the density per square meter and relative abundance for all taxonomic orders present at each respective study reach. In reach 1, The BMI community composition in 2008 more closely resembled the community observed in 2005 and 2006. In 2005, the BMI community composition consisted of Ephemeroptera (38%), Diptera (35%), Trichoptera (20%)

and Annelida (4%). The remaining orders were less than 1% of the community composition. In 2006, the BMI community composition consisted of Diptera (35%), Trichoptera (32%) and Ephemeroptera (31%). In 2007, reach 1 community composition consisted of Trichoptera (55%), Ephemeroptera (19%), Chironomidae (19%) and Diptera (5%). In 2008, reach 1 community composition consisted of Ephemeroptera (31%), Trichoptera (31%), Chironomidae (19%) and Diptera (18%).

In reach 2, the BMI community composition remained similar for the most part over the four-year sampling period with the exception of Acarina which doubled in percentage after 2005. In 2005, BMI community composition was dominated by Chironomidae (39%) followed by Crustacea (26%), Acarina (12%), and other organisms (12%). In 2006, BMI community composition was again dominated by Chironomidae (36%), Acarina (20%), other organisms (13%) and Crustacea (11%). In 2007, BMI community composition was dominated by Acarina (27%), Crustacea (26%), Chironomidae (22%) and other organisms (14%). In 2008, Chironomidae occupied a much larger percentage of the BMI community (54%) followed by Acarina (21%), other organisms (7%), Crustacea (5%) and Diptgera (5%). The order Trichoptera made up 4% of the BMI community composition in 2005 and 2006 respectively, 1% in 2007 and 3%in 2008.. The order Ephemeroptera was less than 1 percent of the BMI community all four years. The order Plecoptera was not present in reach 2 in any of the sample years.

BMI community composition in reach 3 contained more Ephemeroptera in 2008 under the variable flow regime compared to the previous three-years. In 2005, BMI community composition consisted of Acarina (26%), Chironomidae (24%), Trichoptera (11%), Coleoptera (11%), Diptera (7%), Lepidoptera (5%) and Ephemeroptera (4%). In 2006, BMI community composition consisted of Chironomidae (28%), Trichoptera (21%), Acarina (17%), Colepotera (13%), Lepidoptera (9%), Diptera (4%) and Ephemeroptera (3%). In 2007, BMI community composition consisted of Chironomidae (27%), Acarina (21%), Trichoptera (17%), Colepotera (11%), Lepidoptera (9%), Crustacea (6%), Diptera (4%) and Ephemeroptera (3%). In 2008, Ephemeroptera comprised 30% of the community composition, a substantial increase compared to the three baseline sampling events. The remainder of the BMI community composition in reach 3 in 2008 consisted of Acarina (33%), Trichoptera (11%), Chironomidae (8%), Colepotera (4%), Crustacea (4%), Diptera (3%) and Lepidoptera (1%). Lepidoptera declined in 2008 relative to the baseline period.. Plecoptera were not present in reach 3 in 2007 and 2008 but comprised less than 1% in 2005 and 2006.

Reach 4 was dominated by the order Gastropoda in all four sample years although in a much smaller percentage in 2008; 2005 (85%), 2006 (77%), 2007 (89%) and 2008 (38%). Chironomidae was the second most dominant taxa in the three sample years; 2005 (8%), 2006 (11%), 2007 (5%) and 2008 (36%). Acarina increased to 10% in 2008, an increase compared to the previous three-years. Ephemeroptera comprised 4% of the BMI community, a substantial increase compared to previous years. Reach 4 was the only site where gastropods were dominated the BMI community composition. Gastropods made up less than 1% of the community composition in reaches 1, 2 and 3 in all three sample years.

Table 4.7-3: BMI relative abundance by taxonomic order, reaches 1 and 2

Taxonomic Order	Reach 1								Reach 2							
	2005		2006		2007		2008		2005		2006		2007		2008	
	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Ephemeroptera	9508	38%	6,544	31%	2,680	19%	4,805	31%	11	0%	116	0%	26	0%	281	1%
Plecoptera	354	1%	81	0%	38	0%	50	0%	0	0%	0	0%	0	0%	0	0%
Trichoptera	4961	20%	6,798	32%	7,825	54%	4,803	31%	584	4%	1,128	4%	98	1%	882	3%
Odonata	3	0%	6	0%	0	0%	0	0%	95	1%	83	0%	77	0%	243	1%
Coleoptera	52	0%	73	0%	112	1%	65	0%	58	0%	73	0%	40	0%	49	0%
Chironomidae	6939	28%	4,438	21%	2,713	19%	2,976	19%	6425	39%	11,444	36%	3,518	22%	13,795	54%
Diptera	1770	7%	2,838	13%	761	5%	2,765	18%	671	4%	2,171	7%	401	2%	1,293	5%
Lepidoptera	266	1%	83	0%	179	1%	136	1%	9	0%	24	0%	0	0%	4	0%
Gastropoda	5	0%	0	0%	0	0%	0	0%	1	0%	17	0%	0	0%	0	0%
Bivalvia	145	1%	90	0%	15	0%	10	0%	108	1%	1,096	3%	105	1%	9	0%
Annelida	1042	4%	158	1%	4	0%	45	0%	300	2%	1,683	5%	1,095	7%	589	2%
Acarina	47	0%	72	0%	14	0%	9	0%	2029	12%	6,502	20%	4,326	27%	5,356	21%
Crustacea	31	0%	14	0%	17	0%	15	0%	4221	26%	3,383	11%	4,167	26%	1,412	5%
Other Organisms	0	0%	8	0%	7	0%	5	0%	1889	12%	4,207	13%	2,302	14%	1,818	7%
Total Organisms/m2	25,123		21,202		14,366		15,685		16,400		31,927		16,156		25,730	

Table 4.7-4: BMI relative abundance by taxonomic order, reaches 3 and 4

Taxonomic Order	Reach 3								Reach 4							
	2005		2006		2007		2008		2005		2006		2007		2008	
	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Ephemeroptera	216	4%	295	3%	123	3%	2,585	30%	211	0%	1,188	1%	157	0%	1,751	4%
Plecoptera	3	0%	2	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Trichoptera	607	11%	1,827	21%	604	17%	947	11%	199	0%	1,116	1%	81	0%	422	1%
Odonata	31	1%	2	0%	4	0%	27	0%	19	0%	59	0%	0	0%	0	0%
Coleoptera	588	11%	1,086	13%	384	11%	307	4%	478	1%	1,040	1%	52	0%	234	1%
Chironomidae	1,309	24%	2,453	28%	976	27%	674	8%	6,829	8%	11,744	11%	4,042	5%	15,856	36%
Diptera	374	7%	324	4%	161	4%	287	3%	1,027	1%	3,484	3%	1,013	1%	3,242	7%
Lepidoptera	267	5%	767	9%	325	9%	79	1%	0	0%	0	0%	0	0%	0	0%
Gastropoda	12	0%	0	0%	1	0%	0	0%	72,841	85%	79,890	77%	71,841	89%	16,784	38%
Bivalvia	0	0%	2	0%	18	0%	14	0%	221	0%	341	0%	305	0%	32	0%
Annelida	122	2%	41	0%	9	0%	36	0%	491	1%	227	0%	63	0%	138	0%
Acarina	1,427	26%	1,431	17%	748	21%	2,926	33%	2,664	3%	1,554	1%	1,274	2%	4,213	10%
Crustacea	136	3%	36	0%	230	6%	321	4%	225	0%	497	0%	416	1%	630	1%
Other Organisms	298	6%	351	4%	62	2%	552	6%	994	1%	2,991	3%	1,220	2%	765	2%
Total Organisms/m2	5,391		8,618		3,644		8,754		86,201		104,131		80,465		44,068	

In reach 1, functional feeding group composition was relatively similar during the three-year baseline sampling period with the exception of 2007 when scrapers increased from 8% and 7% respectively in 2005 and 2006 to 34% in 2007 (Table 4.7-5). In 2008, scrapers declined relative to 2007 back to a community percentage similar to 2006 and 2007. The 2008 shredder percentage was similar to 2006 and 2007. Gatherers increased in 2008 to 40% of the BMI community.

In reach 2, functional feeding group composition was relatively similar across all four sample years for gatherers, predators, and shredders. Filterers increased in 2008 (15%) to levels formerly observed in 2006 (18%) compared to 6% and 5% in 2005 and 2006 respectively. Scrapers were 1% or less of the community in all four sample years. Predators occupied 31%, 35%, 39% and 31% respectively in 2005, 2006, 2007 and 2008. The predator feeding group occupied similar percentages in reaches 2 and 3 but was less than 10% in reaches 1 and 4.

In reach 3, gatherers were the dominant functional group in 2008 (41%). Gatherers comprised similar percentages of the community composition in the previous three-years; 30%, 35% and 38% in 2005, 2006 and 2007 respectively. Predators were the second dominant functional group in reach 3 in 2008 (35%). In 2005, 2006 and 2007 predators comprised 44%, 27% and 26% respectively. Filterers comprised 12% of the community in 2008 compared to 6%, 15% and 14% in 2005, 2006 and 2007 respectively. Scrapers were the only group to decline in 2008 (4%) compared to 15% in 2005 and 20% in 2006 and 2007.

In reach 4 scrapers comprised the largest percentage of the functional feeding group composition in all four sample years, 83%, 73%, 84% and 42% respectively. 2008 marks a sharp decline in scraper numbers in the BMI community. In contrast, gatherers, filterers and predators increased substantially. Gatherers comprised 8%, 13%, 6% in 2005, 2006 and 2007 respectively compared a 21% in 2008. Filterers comprised 1% in 2005, 5% in 2006, 2% in 2007 and 17% in 2008. Predators were the next most common group with 6% in years 2005 and 2006, 4% in 2007 and an increase to 14% in 2008.

Table 4.7-5: Functional feeding group composition reaches 1, 2, 3 and 4.

Functional Feeding Group	Reach 1				Reach 2				Reach 3				Reach 4			
	2005	2006	2007	2008	2005	2006	2007	2008	2005	2006	2007	2008	2005	2006	2007	2008
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Filterers	31	43	32	37	6	18	5	15	6	15	14	12	1	5	2	17
Gatherers	34	36	20	40	54	35	45	42	30	35	38	41	8	13	6	21
Predators	8	3	3	2	31	35	39	31	44	27	26	35	6	6	4	14
Scrapers	8	7	34	11	1	1	0	0	15	20	20	4	83	73	84	42
Shredders	19	11	11	9	7	10	11	11	2	2	2	4	1	2	2	3
Piercer-Herbivores	0	0	0	1	1	0	0	0	1	0	1	4	0	1	0	1
Unclassified	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	2

4.8 ORGANIC MATTER ASH-FREE DRY WEIGHT

Organic matter AFDW was highest in reach 4 in 2008, 44.8 g/m^2, compared to 13.9, 23.5, and 17.6 g/m^2 in reaches 1, 2 and 3 respectively (Figure 4.8-1). Comparisons across all four sample years within a single study reach indicate organic matter AFDW was significantly different between years in all four reaches (p=0.000001 and p=0.08 for reaches 1 and 2, ANOVA and p=0.03 and p=0.02 for reaches 3 and 4, Kruskal-Wallis H-Test).

Organic matter AFDW comparisons between the three-year baseline sampling period and the first year of the variable flow regime found significant differences in reaches 1 and 4 but no differences in reaches 2 and 3 (Figure 4.8-2). In reaches 1 and 4, organic matter AFDW was significantly lower during the 2008 variable flow period compared to the initial three-year baseline period (p=0.008 and p=0.09 respectively, Kruskal-Wallis H-Test).

Figure 4.8-1: Organic matter ash-free dry weight, 2005, 2006, 2007 and 2008

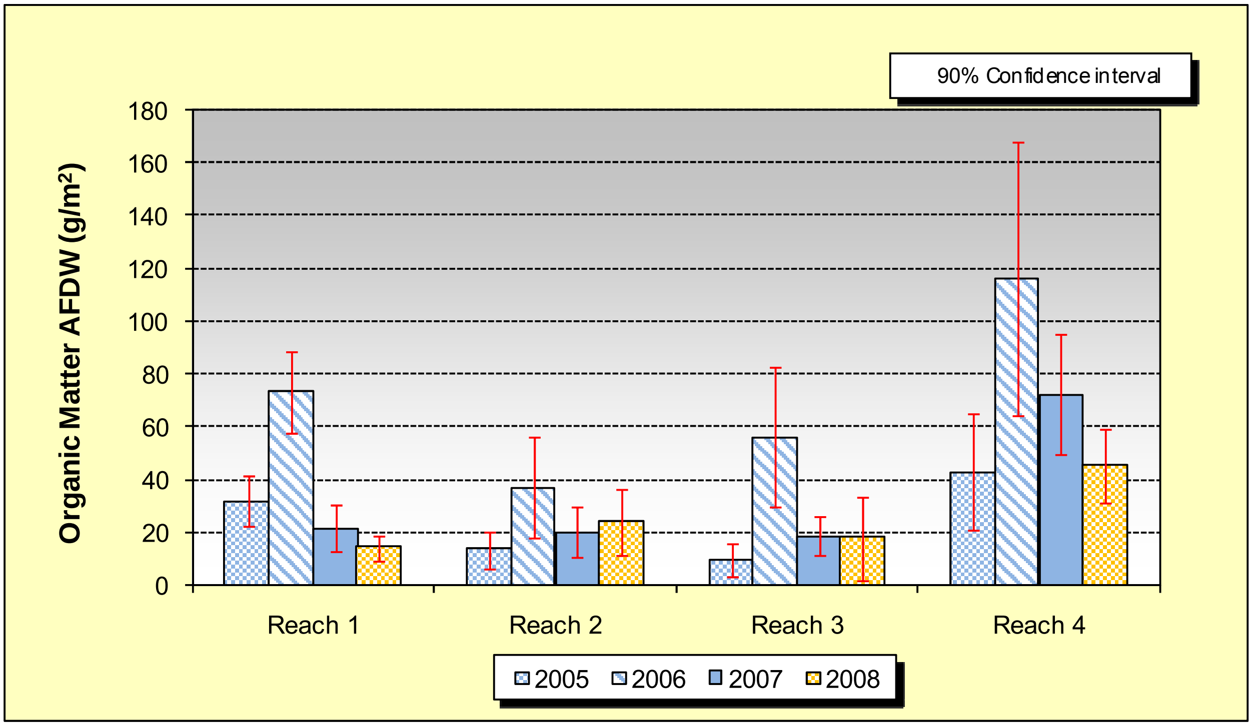
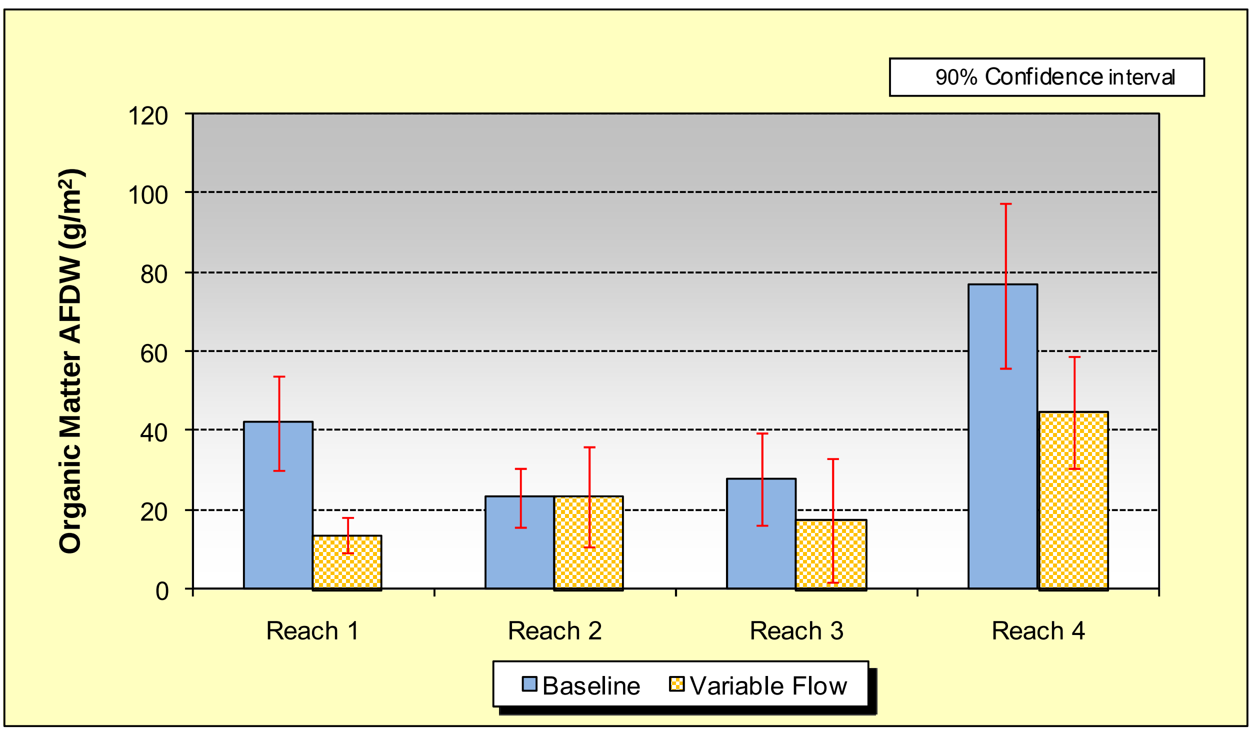


Figure 4.8-2: Organic matter ash-free dry weight, baseline period versus variable flow.



5. DISCUSSION

5.1 CHANNEL SHAPE AND SUBSTRATE

October discharge volumes in reaches 2 and 3 downstream from Grace Dam varied between the four sampling years. Because of these differences in discharge between sample years, survey metrics dependent on discharge vary between years. Consequently, between year comparisons are based on bankfull metrics only.

The mean bankfull width for all five transects in reach 2 in 2008 was 62.51 meters. This represents a decrease of 0.37 meters compared to the baseline mean bankfull width of 62.88 meters for the three sample years, 2005, 2006 and 2007. This decrease of 0.37 meters between the baseline average and the variable period represents a 0.5% change in the mean bankfull width for reach 2. The mean bankfull depth for the baseline period was 0.39 meters compared to 0.38 in 2008 under the variable flow regime. The majority of the river banks in reach 2 were severely impacted by cattle grazing, making typical bankfull indicators such as changes in vegetation and changes in slope very difficult to accurately locate in a single year let alone use the same bankfull elevation between years. The channel in reach 2 has not changed shape during the four-years of monitoring as evidenced in the consistency in the annual channel cross sections for reach 2. The small change in mean bankfull width is well within the margin of error for measuring bankfull width in the field particularly given the lack of bankfull indicators in this reach.

In reach 2, the substrate composition was similar for the three-year baseline sampling period with fines being the dominant substrate, approximately 40 percent of the overall substrate composition. After introduction of the variable flows in 2008, the percentage of fines and sand were greatly reduced while the percentage of cobble and bedrock increased. During the baseline period, the percentage of fines was twice as high as the subdominant substrate, bedrock. Under the variable flow conditions, bedrock was the dominant substrate in reach 2. The flows released for whitewater in the spring and summer of 2008 likely mobilized the abundant fines observed in the 2005, 2006 and 2007 Wolman pebble counts. During the whitewater flows, turbidity values were high (Mark Stenberg, personal communication).

Bankfull widths in reach 3 remained constant during the three-year baseline period but decreased by 1.59 meters in 2008. During the baseline period, channel cross section markers (rebar pins) were difficult to locate on the left bank in transects C and D due to the dense vegetation growth obscuring the pins. In 2008, field staff observed increased depositional zones of sand and fine gravel along the left bank in reach 3. The left bank is the inside of the meander bend. This deposition obscured the left bank pin for transect D in 2008 requiring placement of a new pin. Transect A also had substantial vegetation growth in 2008 and deposition of sand and small gravel on the left bar but the pin was located.

The mean bankfull depth for the combined transects in reach 3 was 0.62 meters in 2008 compared to a mean of 0.79 meters during the three-year baseline period. Substantial decreases in mean bankfull depth occurred in transects TA and TE in 2008 but the overall channel shape for each transect remained consistent between years. In transect TA, the decrease was likely due to a change in the bankfull indicator on the left bank reducing the the overall bankfull elevation marked by field staff. In transect TE, the decrease in mean banfull depth was likely due to deposition of sand in the transect causing a decrease in depth. Transect TE marks the start of a long pool in the Black canyon greater than 200 meters in length. Sand during the variable flow events likely deposited sand in the top of this pool at the velocity transition from riffle to pool.

In 2008, field staff noted what appeared to be an increase in gravels and cobbles in reach 3 compared to previous years. However, Wolman pebble count data indicate very little has changed overall in the substrate composition between years although fine particle sizes were not present in 2008. The decrease in fines within the reach may have lead field staff to observe an ocular increase in gravels and cobbles.

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.

Periphyton AFDW and chlorophyll concentrations typically change rapidly in streams due to disturbance events such as discharge fluctuations (Steinman and McIntire 1990) or rapid growth responses to changing environmental conditions such as turbidity (Sheath et al. 1986). Consequently, identifying environmental factors responsible for differences in the periphyton community between sample years based on a single annual sampling event of periphyton AFDW and chlorophyll can be problematic. The fall sampling event associated with the Black Canyon Monitoring Study provides a snapshot of the periphyton community in the respective reaches in the same time frame. Because of the single sampling event researchers were not able to identify the factors contributing to differences in the periphyton community between reaches or explain causes in inter-annual variation when it occurs. Understanding the environmental factors influencing the periphyton community in a given reach is best achieved through systematic sampling where periphyton is sampled on a weekly or biweekly basis. This latter study approach enables researchers to track periphyton growth rates while simultaneously monitoring biotic and abiotic factors (Biggs 1990; Biggs 1996; Biggs and Kilroy 2000). Nonetheless, the present study design allows managers to document the periphyton community annually and identify statistically significant differences where they exist.

Years 4, 5 and 6 of the the Black Canyon Monitoring effort mark the experimental phase of the study design when whitewater flows will be released into the Black Canyon below Grace Dam serving as the treatment to study reaches 2, 3 and 4. Discharge, in particular, has been determined to be an important environmental factor influencing site specific algal growth (Biggs and Kilroy 2000). In reaches 2, 3 and 4 discharge remained virtually the same for all three reaches during the annual October sampling events with the exception that reach 4 had 30 to 60 cfs more discharge than reaches 2 and 3. In 2008, four variable flow events ranging in magnitude from 800 to 1200 cfs were released into the Black Canyon of the Bear River between April and July. The October periphyton sampling documents potential changes in the periphyton community resulting, in part, from variable flow releases from Grace Dam.

The periphyton community did not exhibit a consistent response in the three treatment reaches in the first year of variable flow releases. Periphyton AFDW was significantly higher in reach 2 under the variable flow conditions compared to the baseline mean. In reaches 3 and 4, periphyton AFDW under variable flow conditions was similar to the baseline period. In contrast, periphyton AFDW was significantly lower in reach 1 under variable flows than during the baseline period. Periphyton chlorophyll a, like AFDW, failed to exhibit a consistent pattern in the treatment reaches. In reach 2, chlorophyll a was significanlty higher during the variable flow phase whereas reach 3 was significantly lower. Chlorophyll a in reach 1 was significantly lower in the variable flow phase compared to the baseline period. The lack of a consistent response in the periphyton chlorophyll a and AFDW in the treatment reaches suggests that environmental factors in addition to discharge influence periphyton AFDW at the individual study reaches.

The autotrophic index (AI), the ratio AFDW/Chlorophyll a, provides information on the relative viability of the periphyton community. If large amounts of non-photosynthesizing organic material are present, the numerator becomes inflated, and the ratio exceeds the normal range of 50-200 (APHA 1999). In all four October sampling events, the four study reaches exceed the normal AI range. The 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. In 2008, The AI value in reach 3 was significantly greater than the previous three-years under baseline conditions indicating there was even more non-photosynthesizing organic matter than previous years. The elevated AI values in reach 3 may be the result of increased biological productivity associated with mobilization of fine sediments and silt containing elevated nutrient levels. AI values in reaches 1, 2 and 4 were similar between the baseline period and the first year of variable flows.

5.3 FILAMENTOUS ALGAE

Filamentous algae coverage was significantly higher in reaches 2 and 3 under the variable flow regime conditions compared to the baseline conditions. Reach 4 remained similar between the baseline and variable flow conditions. In contrast, filamentous algae coverage decreased in reach 1 during the variable flow regime period compared to the baseline period. Initially, it was anticipated the variable flows would reduce filamentous algae coverage through increased flows scouring the substrate. Reach 3 was assumed to be the most vulnerable to scour due to the smaller substrate size lending to increased movement at lower flow thresholds relative to some transects in reach 2 with bedrock and boulders (TC, TD and TE) and all the transects in reach 4 consisting primarily of bedrock ledges. The fact that algal coverage did not respond in the fashion expected might be due to several factors; 1) variable flows were insufficient in volume to mobilize and scour substrate or 2) mobilization of nutrients during the variable flow release may in fact stimulate algal growth. The study plan is not capable of differentiating the responses because sampling is limited to a single annual event in the fall season. The annual sample fails to detect short term responses following treatment. During the variable flow period, chlorophyll a concentration was higher in reach 2 but lower in reach 3 compared to the baseline period. Increases in chlorophyll a concentration typically signifies newer algal growth containing higher quality food for macroinvertebrate grazers. The inconsistency between reaches 2 and 3 makes it difficult to draw definitive conclusions on the effects of variable flows on filamentous algae in the respective study reaches.

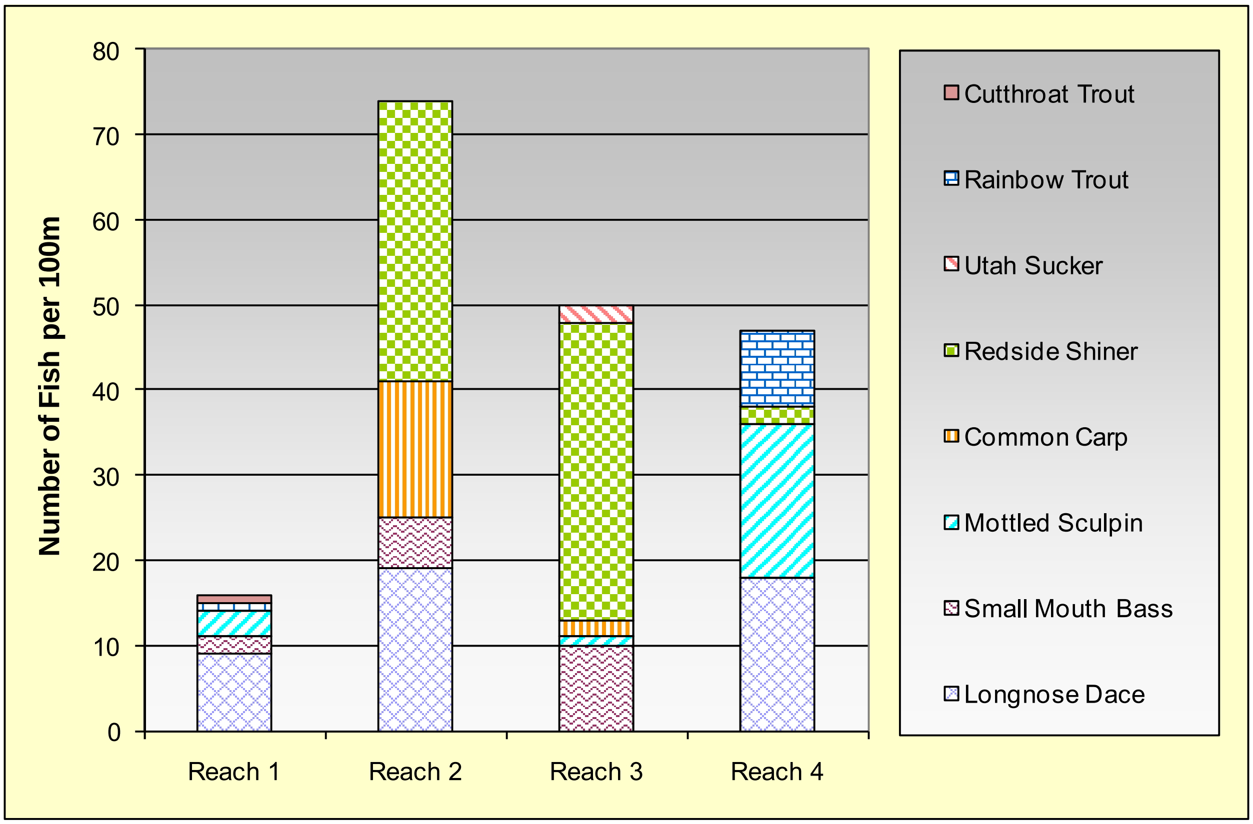
5.4 FISHERIES

In 2008, reaches 1 and 3 contained the highest fish species richness of the four study reaches with 5 species collected, while reaches 2 and 4 each had 4 species collected. No single species was collected in all 4 reaches in 2008.

Multi-year comparisons within each study reach indicate that species richness increased in 3 of the 4 reaches between 2005 and 2006. Between sample years 2006 and 2007 species richness increased in only 2 reaches (from 4 species to 5) and decreased in the other 2 reaches (from 5 species to 4). In 2008, species richness increased in reach 1 from 4 to 5 species while richness remained constant in the other 3 reaches. In nearly all cases, when an additional species was detected in a sample, they were only collected in small numbers (1 or 2 fish per 100 meters), and therefore had low relative abundances. The opposite was also true; when a species went undetected in a sample, they had only been collected in small numbers during past sampling years. Thus, while it is possible that these apparent changes in species richness were a result of a species not being present in a reach during the sampling period, it is also possible that some species were present in small numbers but were not detected during sampling.

In 2008, reach 2 had the highest total catch of fish per 100 meters (74) compared to the other three reaches (Figure 5.4-1). The majority of these were redside shiner (45%), longnose dace (26%), and common carp (22%). Total catch in reach 3 was the next highest at 50 per 100 meters and was dominated by redside shiner (70%). Reach 4 had a total catch of 47 fish per 100 meters, and reach 1 had the lowest total catch at 16 per 100 meters.

Figure 5.4-1: Total catch per 100 meters for reaches 1, 2, 3, and 4, October 2008



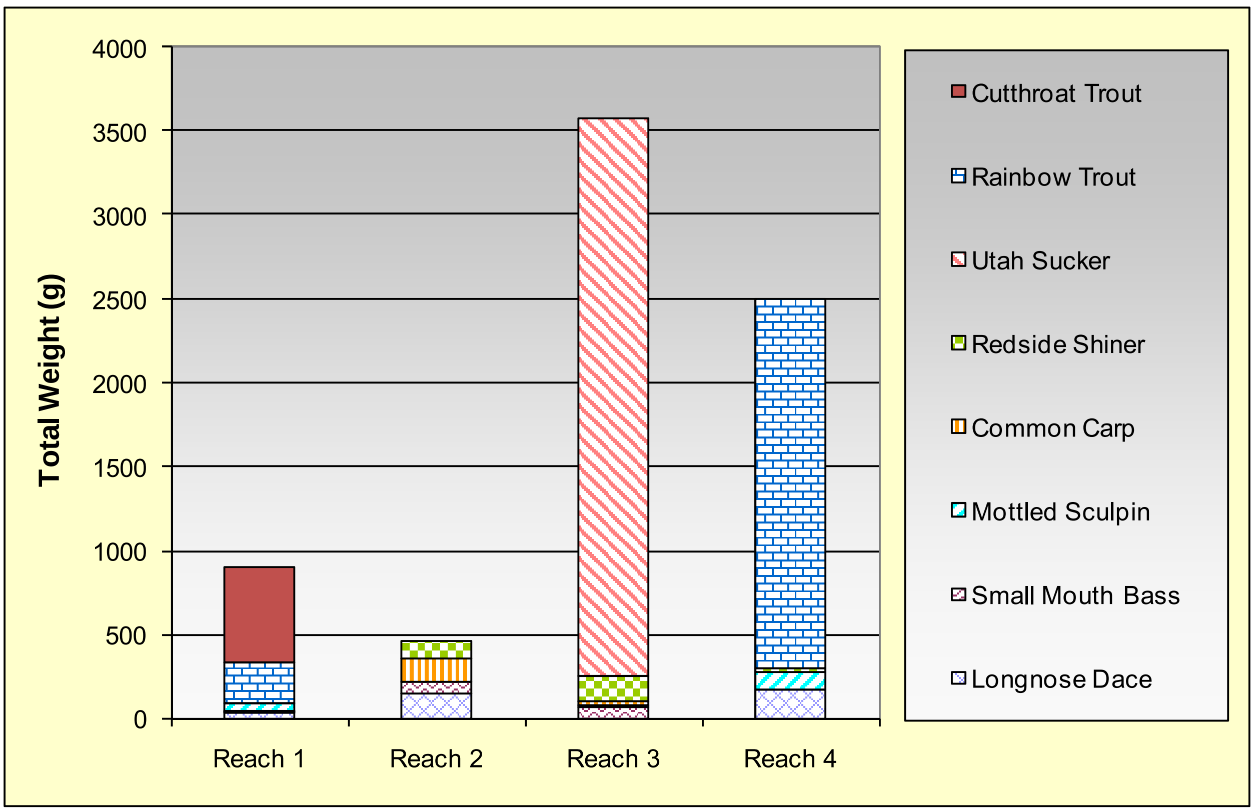
In 2008, the highest overall catch rate was 3.70 fish / minute in reach 2, followed by 3.27 fish/minute in reach 3, 2.72 fish/minute in reach 4, and the lowest catch rate was 0.80 fish/minute in reach 1 (Figure 4.5-3). Redside shiner had the highest catch rate in 2 of the 4 reaches (reaches 2 and 3), while longnose dace had the highest catch rate in reach 1 and 4. Accordingly, the relative species composition was dominated by redside shiner in reaches 2 and 3 whereas longnose dace represented the largest percentage of the sample in reach 1 and 4 (Figure 4.5-2).

Multi-year comparisons within each reach indicate that total catch varied considerably between years in all 4 study reaches. Multi-year comparisons also indicate that catch rates follow similar trends between years as total catch, and thus show a similar degree of variation. The similarities between total catch and catch rates are expected due to the direct correlation of these two metrics. Accordingly, catch rates varied considerably between years in all 4 reaches.

In 2008, the highest total biomass was in reach 3 (3.57 kg), and was followed by reach 4 (2.49 kg) (Figure 5.4-2). Reach 1 and reach 2 had far less total biomass at 0.90 kg and 0.46 kg, respectively. In reach 1, the one cutthroat trout collected accounted for over half of the biomass (63%). In reach 2, redisde shiner were the most abundant (45% of total catch) however longnose dace accounted the largest proportion of the biomass at 33%. In reach 3, redside shiner were by far the most abundant (70% of the catch), however Utah sucker comprised a very large majority of the biomass at 93% despite the fact that only 2 suckers were collected. In reach 4, rainbow trout accounted for 88% of the biomass, but they only accounted for 19% of the catch in terms of abundance.

Multi-year comparisons within each reach show that there is a large amount of variation in total biomass between years in reaches 1, 3, and 4 while reach 2 shows considerably less variation than the other reaches. A large amount of the variation between years in total biomass is likely the result of collecting just a few large bodied adult carp, suckers, or rainbows in some year(s) while none were collected in other years. Data from reach 2 further supports this idea since no large bodied adults were collected in any of the sample years and accordingly, there was little variation between years.

Figure 5.4-2: Fish biomass per 100 meters, reaches 1, 2, 3 and 4, October 2008



5.5 TEMPERATURE

Surface water releases from Grace Reservoir during the variable flow regime period have the potential to increase stream water temperatures in reaches 2, 3 and 4 during the summer season. During the three-year baseline period, daily average stream temperatures sporadically exceeded the 20 ºC salmonid threshold in both reaches 2 and 3, but not in reach 4 between June 21 and September 21. In reach 2, minimum instream flows exceeded the 20 ºC salmonid threshold in all three baseline study years; 37, 37 and 40 days respectively. In reach 3, water temperatures were monitored from July 5 2006 to October 10, 2006. Daily minimum water temperatures exceeded the 20 ºC salmonid threshold on 32 days starting on July 5. Increased discharges from Grace Dam associated with the variable flow releases are not likely to cause large increases in stream temperatures in reaches 2 and 3 since those temperatures are already greatly influenced by meteorological conditions similar to those influencing surface water temperatures in the Grace impoundment. In reach 1, daily minimum water temperatures also exceeded the 20 ºC salmonid threshold over each summer season in the baseline period; 2005 (21 days), 2006 (17 days) and 2007 (34 days).

In reach 4, daily average stream temperatures and daily maximums remained consistently below 20 ºC for the much of the summer season except for three dates annually; July 25, 2005, July 19, 2006 and July 23, 2007. The July 19, 2006 rise in daily maximum temperatures above 20 ºC corresponded to an increase in discharge from Grace Dam of 122 cfs. In 2005, 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. Outside the summer season (June 21 to September 21), daily average water temperatures in reaches 1, 2 and 3 were below the 20 ºC threshold. Deployment of an additional hobo temp in the epilimnion of the Grace impoundment would yield additional data on surface water temperature discharged into the Black Canyon.

Temperature data for the three-year baseline monitoring period at the four study reaches revealed distinct seasonal patterns. Comparisons between reaches 1, 2, 3 and 4 also revealed distinct differences in water temperature. These differences were particularly notable during the summer months. Reach 3 exhibited the highest maximum temperatures (27.1 ºC) of all four reaches over the three-year baseline period. Reach 4 exhibited the coolest water temperatures with daily averages consistently below 20 ºC throughout the summer months and a single day each year when a maximum water temperature exceeded 20 ºC. Daily averages in reaches 1, 2 and 3 exceeded 20 ºC for a substantial number of days each summer season. In all three-years, daily minimums in reaches 1 and 2 exceeded the 20 ºC threshold for a continuous 20 days or more with the maximum 40 days in 2007 in reach 2.

Similar water temperature analysis should be undertaken for the variable flow regime conditions particularly in reaches 2, 3 and 4 to determine the influence of surface water releases on downstream stream temperatures. Stream temperatures in reaches 2 and 3 already exceed the salmonid threshold prior to release of the variable flows. It is unlikely that variable flow releases will further increase stream temperatures in reaches 2 and 3. In reach 4, changes in stream temperature were not analyzed under the variable flow conditions. This temperature data should be analyzed to determine the potential of variable flow releases to increase stream temperatures in reach 4 and the duration of the temperature change. This information will provide important information regarding potential impacts to salmonids.

5.6 HYDROLOGY

Discharge data was included in the previous three annual reports for individual study reaches where available. Discharge data measured at the USGS gage located upstream of Soda

Reservoir and the USGS gage located in the bypass channel below Grace dam were included for comparison of hydrologic differences between the reference site and study reaches 2, 3, and 4 located below the dam as well as instream flow differences during sampling efforts in 2005, 2006, and 2007. Discharge data was not available for the 2008 water year at the time of this report. Consequently, 2008 discharge data is unfortunately not included in this annual report for comparative analysis. Four variable flow events, the treatments in the study design, occurred in the spring and summer of 2008. Discharge data should be analyzed to determine the magnitude, timing and duration of variable flows in reaches 2, 3 and 4 as well as changes in discharge in the reference reach relative to previous sampling events.

Reach 1 differs from reaches 2, 3 and 4 hydrologically. Water storage in Bear Lake partially regulates flows in reach 1 by decreasing the magnitude of peak flow events during spring snowmelt and shifting the snowmelt hydrograph into July, August and early September to fulfill downstream water rights. In 2007, releases from Bear Lake started in June due to the increased air temperatures and below normal run-off relative to the 2005 and 2006 water years. Regulated releases from Bear Lake peaked at 1610 cfs in 2007 compared to 933 cfs in 2006 and 1336 cfs in 2005. These hydrologic differences between sample years were small and not likely to cause changes in the biological community between sample years in reach 1.

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 remain relatively stable year round. Groundwater upwellings and springs just upstream of reach 4 contribute an additional 30-60 cfs on top of the existing base flow. During the three-year baseline monitoring period, no scheduled whitewater releases occurred in the reaches below Grace Dam. In April 2005, a spill flow of 863 cfs occurred from spring run-off. In mid-September of 2006, pulse flows were released from Grace Dam to assist channel restoration efforts in the former Cove impoundment. Daily average flows reported for those releases were 152 cfs on September 18, 2006. Instantaneous peak flow data for these pulse flows were not available but were assumed not to exceed 500 cfs from Grace Dam. In the spring of 2008, scheduled whitewater flows were released from Grace Dam ranging in magnitude from 800 to 1200 cfs on three weekends starting in April and concluding in early July.

5.7 BENTHIC MACROINVERTEBRATES

In 2008, BMI density for respective study reaches was similar to the three previous October baseline sampling events with the exception of reach 4 where BMI density under variable flow conditions declined to less than half the density measured under the three-years of baseline conditions. The precipitous drop in overall BMI density in reach 4 was overshadowed by a doubling in the EPT density in 2008. This significant increase in EPT density marks a shift in the BMI community composition in reach 4 under the variable flow conditions. There was a significant increase in overall BMI taxa richness and EPT taxa richness as well in reach 4 in 2008 compared to previous years under baseline conditions. In the previous three years under baseline conditions, the New Zealand mud snail (*Potamopyrgus antipodarum*) was the dominant taxa in reach 4 comprising anywhere from 70 to 83 percent of the community composition. Under the variable flow conditions in 2008, the New Zealand mud snail (NZMS) continued to dominate the community composition but was only 37 percent of the totally community. The changes in the BMI community composition in reach 4 in the first year of the variable flow releases resulted in increased taxa diversity, an increase in EPT density and a reduction in the dominant invasive taxa. Despite the decrease in overall BMI density, these shifts in the BMI community composition likely reflect positive changes for reach 4. Decreases in the density of the NZMS may have reduced competition for food resources or habitat for EPT taxa.

EPT density was also significantly greater in reaches 2 and 3 under variable flow conditions compared to baseline conditions. Although still a small percentage of the overall BMI community composition, the increased EPT densities in reach 2 signify a change in habitat conditions under the variable flow releases. In reach 3, EPT taxa comprised 41 percent of the BMI community, a substantial increase from previous years under baseline sampling conditions. In fact, the Ephemeroptera, *Fallceon quilleri*, was the dominant taxa in two of the five transects in reach 3. This marked the first time the dominant taxa in reach 3 was an Ephemeroptera taxa.

EPT taxa are typically found in water bodies with cold, well oxygenated water and favor good quality habitat with sufficient interstitial spaces in the substrate. As such, these orders are used as an index for assessing water quality and habitat conditions. The previous lack of EPT taxa in reaches 2, 3 and 4 during the baseline period indicated poor water quality and/or habitat conditions. Water quality, although not part of the study design, was roughly similar between the baseline and variable flow sampling events. The substrate in reaches 2 and 3, on the other hand, did have less silt and sand under the variable flow conditions which would increase the interstitial spaces in gravels and cobble and flow of oxygenated water. The increase in EPT taxa in reaches 2 and 3 was likely the result of this change in the substrate composition. Despite this increase in EPT taxa these reaches continue to exhibit poor habitat quality. For example, reach 2 continued to be dominated by dipterans (chironomids in particular) and Acarina (water mites) in 2008 despite the increase in EPT density. Dipterans are typically indicative of poor water quality and habitat condition.

In contrast to the changes observed in reaches 2, 3 and 4, EPT density in reach 1 was lower under variable flow conditions compared to baseline but not significant. The differences observed in EPT density between the baseline and variable flow conditions might be due to spatial and temporal variability inherent in the BMI community. Results from years 5 and 6 will help determine if these changes in community composition are longer lasting.

As noted in 2006, the presence of NZMS, *Potamopyrgus antipodarum*, in reach 4 raises concerns. NZMS is an invasive species. *Potamopyrgus antipodarum* was the dominant taxa in reach 4 for all four October sampling events; 2005 (81%) 2006 (74%), 2007, (83%) and 2008 (37%). The dramatic decline in community percentage in 2008 under the variable flow releases is promising. The periodic increases in discharge associated with the variable flows may serve as a mechanism for limiting the dominance of NZMS in reach 4. This, in turn, may increase the density of other BMI taxa more readily available as a food source to salmonids. The Department of Ecology at Montana State University-Bozeman maintains a website dedicated to disseminating information on NZMS distribution and ecological research (http://www.esg.montana.edu/aim/mollusca/nzms/). This site may have information in the future about management tools used to control NZMS populations.

Reach 1, in 2008, contained the most balanced BMI functional feeding group composition compared to the three treatment reaches below Grace Dam. Reach 1 was dominated by gatherers (40%), filterers (37%), scrapers (11%) and shredders (9%). Given the October sampling date coupled with leaf fall from the adjacent riparian community these functional groups were expected for this time period (Vannote et al. 1980). The percentage of scrapers in 2008 declined substantially from the elevated levels observed in 2007 resembling percentages observed in 2005 and 2006. Scrapers are typically a small percentage of the community composition in fall sampling events due to the decline of algal food resources. The filter feeders likely take advantage of the high nutrient concentrations resulting from agricultural land-use practices adjacent to and upstream from reach 1.

In Reach 2, the BMI community was dominated by gatherers and predators in all four sample years. The gatherer feeding group in reach 2 consists largely of chironomids. The general lack of riparian vegetation in reach 2 due to grazing practices coupled with the upstream reservoir trapping leaf litter input likely accounts in part for the lack of shredder taxa in this reach. The percentage of filterers increased slightly under the variable flow conditions compared to the previous three years of baseline. Poor habitat quality likely also plays a significant role in the lack of diversity in the functional feeding groups in reach 2.

Reach 3 in the Black Canyon was dominated by predators and gatherers under the variable flow conditions whereas the percentage of scrapers declined substantially compared to the baseline period. The decline in the scraper community corresponds to the decrease in chlorophyll a in reach 3 under the variable flow conditions. Chlorophyll a serves as a measure of higher food quality for grazing taxa. Lower chlorophyll a values signify a decrease in the availability of high quality food. Gatherers were the dominant group in reach 3 in 2008 corresponding to the increase in the autotrophic index in reach 3. Inflated AI values suggest more bacterial content in the periphyton providing a higher quality food resource for gatherers. Shredders continued to comprise only a small percentage of the community in all four sample years.

Similar to observations from the previous three sampling years, reach 4 continued to be dominated by scrapers in 2008 likely capitalizing on the abundant filamentous algae. However, scrapers comprised roughly half the community percentage observed in previous years under baseline conditions. Reach 4 continues to be favorable for scrapers with its open canopy coupled with the stable bedrock substrate, stable flow regime and nutrient inputs from groundwater upwellings making the site conducive to algal growth. Other researchers have found increases in scraper densities corresponding to reaches with open canopies (Hawkins et al. 1982; Noel et al. 1986; Fuller et al. 1986; Behmer and Hawkins 1986). The NZMS is classified as a scraper. The lack of disturbance in the previous three-years under baseline conditions might have further enabled the NZMS scraper specialist to outcompete generalist species. Resh et al (1988) attributed increased BMI species richness to the increased habitat complexity that results in streams with intermediate levels of disturbance. Prior to the variable flows introduced in 2008, reach 4 received little disturbance annually and, as expected, the species diversity was low dominated by the invasive NZMS capitalizing on the abundant filamentous algae. Disturbance was introduced in 2008 under the variable flow releases. The NZMS density in reach 4 declined precipitously. Other functional groups increased substantially such as filter feeders (17%), gatherers (21%) and predators (14%).

Reach 4 supported a substantially higher BMI density than the other three study reaches in all four study years including 2008, despite the substantial decline in BMI density compared to the previous three-years of sampling under baseline conditions. Autochthonous food sources such as filamentous algae are considered to be of higher nutritional value than allochthonous inputs (Anderson and Cummins 1979; Minshall 1978). The quality of the food resources in Reach 4 combined with the low species diversity and lack of disturbance in the baseline years may have attributed to the significantly higher BMI densities. However, the NZMS is a questionable food source for salmonids even in high densities. The significant increase in EPT abundance in 2008 may increase the available food resources for salmonids despite the overall decline in BMI density under variable flows.

5.8 ORGANIC MATTER ASH-FREE DRY WEIGHT

The 2008 organic matter AFDW values were similar to those observed in 2005 and 2007 in all four study reaches. Organic matter AFDW was significantly greater in 2006 compared to 2005, 2007 and 2008 for each sample reach. The fact that the 2006 AFDW values were greater in all reaches suggests external basin-wide factors were responsible for the increase rather than site specific factors.

Reach 4 had the highest organic matter AFDW per square meter for each respective sample year. The relatively stable flow regime coupled with the bedrock ledges allows the mats of macrophytes and filamentous algae to maximize growth with little scour or disturbance from bedload movement on an annual basis. In contrast, substrate in reaches 1, 2 and 3 was smaller and less stable making it more susceptible to movement at lower discharge volumes compared to reach 4. Furthermore, organic matter growth in reach 4 might be greater than the other three reaches due to nutrient inputs associated with the groundwater upwellings. Travertine deposits indicative of calcium carbonate precipitates were observed in reach 4. The nutrient inputs associated with the upwelling likely stimulates macrophyte and filamentous algal growth. Calcium carbonate deposits were not observed in reaches 1, 2 or 3.

In reaches 2 and 3, organic matter AFDW exhibited no differences between the three-year baseline period and the first year of variable flows in the respective study reaches. In contrast, reach 4 organic matter declined under the variable flow conditions compared to the baseline period. In reach 1, the reference reach, organic matter AFDW also declined in the variable flow period. The inconsistency between the three treatment reaches and changes in the reference reach creates uncertainty regarding the environmental factors influencing organic matter AFDW in each study reach.

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 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 will be 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 report compares the study results from the baseline monitoring effort, years 2005 through 2007 with the first year of variable flows in 2008. The year 3 report, the 2005, 2006 and 2007 data, served as a baseline characterization of the four study reaches. The baseline data analysis determined that reaches 1, 2, 3 and 4 were distinctly different from each other. Because of these distinct differences, the comparative analysis in 2008 examines changes over time within respective study reaches rather than comparisons between reaches.

Channel morphological characteristics remained largely unchanged in reaches 2 and 3 under the variable flow conditions in 2008 compared to baseline monitoring in 2005, 2006 and 2007. Variable flows ranging from 800 to 1200 cfs were released on four occasions between April and July 2008 into the Black Canyon of the Bear River inundating study reaches 2, 3 and 4. In reaches 2 and 3, there was a substantial decrease in silt and sand size particles in the substrate composition.

The periphyton community response to the variable flow releases varied between study reaches. In reach 2, chlorophyll a and AFDW were significantly higher under the variable flows compared to baseline conditions. In contrast, chlorophyll a was significantly lower in reach 3 under variable flow conditions but AFDW was similar to the baseline period. In reach 4 the periphyton community exhibited no changes between the baseline period and the variable flow releases.

Chlorophyll a and AFDW were significantly lower in reach 1, the reference reach, under the variable flow conditions. The AI was significantly higher in reach 3 under variable flow conditions compared to the baseline period. The inconsistent responses in periphyton metrics to the variable flow treatment for respective reaches suggests environmental factors other than discharge play a role influencing periphyton biomass. Periphyton biomass exhibits considerable spatial and temporal heterogeneity even within a given study reach (Steinman and McIntire 1990). Furthermore, the annual fall sampling incorporated into the study design may not have the temporal resolution to detect short term changes in the periphyton community in response to the variable flow releases. Alternatively, the reach specific responses in the periphyton community could be a manifestation of the interaction between substrate and discharge unique to each reach. Reach 3 contains the smallest average substrate particle sizes for the four reaches with the exception of transects TA, TB and TC in reach 2. Consequently, reach 3 would be more vulnerable to scour at lower discharges compared to reaches 2 and 4. This scour could cause disturbance in the periphyton community. Chlorophyll a did decline in reach 3 but the AFDW values remained similar between the baseline and variable flow periods.

Filamentous algae coverage was significantly higher in reaches 2 and 3 during the variable flow sampling period but significantly lower in reach 1, the reference reach. Reach 4 did not exhibit any differences in filamentous algal growth between the baseline and variable flow periods. The cause for the increase in reaches 2 and 3 remains uncertain. The variable flow releases were expected to scour some of the filamentous algae causing a decrease in growth between the baseline and variable flow sampling periods. On the other hand, scour associated with the higher discharge during the variable flow period may have mobilized nutrients thereby stimulating algal growth in reaches 2 and 3. Additional sampling in years 5 and 6 will track filamentous growth over time to determine if the differences continue.

In 2008, eight fish species were collected for the combined four reaches. Reach 2 had the highest density of fish in 2008 with 74 fish. In comparison, reach 2 typically had the lowest density of the four study reaches during the baseline period. Redside shiner abundance increased substantially in reach 2 during the variable flow sampling period. Two salmonids, a rainbow trout and cutthroat trout, were collected in reach 1 in 2008. This marked the first collection of salmonids in reach 1. The rainbow trout was a hatchery fished released above Soda Reservoir.

Reach 4 was the only reach where rainbow trout were collected in all four sample years. Rainbow trout were not present in the other study reaches with the exception of a single rainbow trout collected in reach 3 in 2006 and one in reach 1 in 2008. In reach 4, rainbow trout total catch and CPUE was considerably higher in 2005 than in a 2006, 2007, or 2008 (Table 4.5-9). It should be noted that these differences are likely a result of the rainbow trout stocking schedule. In 2005, Idaho Fish and Game released 250 freeze-branded rainbow trout below the foot bridge near the Grace power plant on October 14. 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 nearby hatchery truck. In 2006, the last stocking occurred on September 12, and in 2007 and 2008 the last stocking occurred on August 29th. Accordingly, in 2006, 2007 and 2008 the rainbow trout had more time to disperse throughout the river or be caught by anglers. Either scenario could have contributed to the decreased total catch and decreased CPUE. Low rainbow trout abundance and catch rates observed in 2006, 2007 and 2008 compared to 2005 suggests a strong relationship between catch rates and the rainbow trout stocking schedule.

BMI density showed no substantial differences between the baseline and the variable flow periods in reaches 1, 2 and 3 respectively. Reach 4, on the other hand, exhibited a significant decrease in BMI density under the variable flow conditions. Although NZMS continues to be the dominant taxa in reach 4, the density of the taxa declined dramatically during the variable flow sampling period. During the variable flow period, the EPT density increased significantly in reach 4 as well as in reaches 2 and 3. EPT taxa are more available in general as a salmonid food source than NZMS. The increase in EPT taxa in reaches 2 and 3 was likely the result of changes in the substrate composition. In reach 4, the increase in EPT taxa may be due to less competition with NZMS for habitat or simply reduced interactions with NZMS. Little information is available on the interactions between NZMS and native BMI taxa. The potential ecological effects of this invasive species on other trophic levels in reach 4 remains uncertain. As of the October 2008 sampling, NZMS were not present in reaches 1, 2 or 3. Continued educational signage at the footbridge in reach 4 will help to warn anglers and boaters of the potential to inadvertently transport these aquatic hitchhikers to upstream reaches and adjacent water bodies.

(THIS PAGE INTENTIONALLY BLANK)

7. LITERATURE CITED

Animal Diversity Web (On-line) "Hydrobiidae". Accessed March 29, 2007 at http://animaldiversity.ummz.umich.edu/site/accounts/information/Hydrobiidae.html

Anderson, N.H. and K.W. Cummins. 1979. Influences of diet on life histories of aquatic insects. J. Fish. Res. Board Can. 36: 335-342.

American Public Health Association. 1999. Standard methods for the examination of water and wastewater. Twentieth edition. American Public Health Association, Washington, D.C.

Anderson, R.O., and R.M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447-482 *in* B.R. Murphy and D.W. Willis, editors, Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Baldwin, C. January 2006. personal communication.

Behmer, D.J., and C. P. Hawkins. 1986. Effects of overhead canopy on macroinvertebrate production in a Utah stream. Fresh. Biology 16: 287-300.

Beschta, R.L. and W.S. Platts. 1986. Morphological features of small streams: significance and function. Water Resources Bulletin. 22:369-379.

Bevenger, G.S., R. M. King. 1995. A pebble count procedure for asssessing watershed cumulative effects. USFS Rocky Mountain Research Station General Technical Report RM-319.

Biggs, B.J.F. 1990: Use of relative specific growth rates of periphytic diatoms to assess enrichment of a stream. New Zealand Journal of Marine and Freshwater Research 24: 9–18.

Biggs, B.J.F. 1996: Patterns in benthic algae of streams. In: Stevenson, R J.; Bothwell, M.L.; Lowe, R.L. Algal Ecology: Freshwater Benthic Ecosystems. Academic Press, San Diego.

Biggs, B.J.F. and C. Kilroy. 2000. Stream periphyton monitoring manual. NIWA. Christchurch, New Zealand. 246 p.

Cohen, J. 1988 Statistical Power Analysis for the Behavioral Sciences, second ed, Lawrence Erlbaum assoc. pub. Hillsdale NJ.

Cummins, K.W. and M.J. Klug. 1979. Feeding ecology of stream invertebrates. Annual Review of Ecology and Systematics 10:147-172.

Fuller, R.L., J.L. Roelofs, and T.J. Fry. 1986. The importance of algae to stream invertebrates. J.N. Am. Benthological Soc. 5(4): 290-296.

Harrelson, C.C., C.L Rawlins and , J.P. Potyondy. 1994. Stream channel reference sites: an illustrated guide to field technique. U.S. Department of Agriculture Rocky Mountain Forest and Range Experiment Station Fort Collins, Colorado, General Technical Report 245.

Hawkins, C.P., M.L. Murphy, and N.H. Anderson. 1982. Effects of canopy, substrate, composition, and gradient on the structure of macroinvertebrate communities in Cascade Range streams of Oregon. Ecology 63(6): 1840-1856.

Leopold, L.B., 1994. A View of the River. Harvard University Press. Cambridge.

Merritt, R.W. and K.W. Cummins. 1984. An introduction to the aquatic insects of North America. Kendall/Hunt. pp. 722

Minshall, G.W. 1978. Autotrophy in stream ecosystems. BioScience 28(12): 767-771.

Mladenka, Greg and Lynn Van Every. 2004. Bear River Black Canyon Substrate Survey.

Naiman, R.J. and R.E. Bilby (editors). 1998. River ecology and management lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York, 696 p.

Noel, D.S., C.W. Martin, and C.A. Federer. 1986. Effects of forest clearcutting in New England on stream macroinvertebrates and periphyton. Environmental Management 10(5): 661-670.

Osmundson, D.B., R.J Ryel, V.L. Lamarra and J. Pitlick. 2002. Flow-sediment-biota relations: implications for river regulation effects on native fish abundance. Ecological Society of America, Washington, D.C., Ecological Applications, 12(6), pp. 1719-1739.

Petts, G.E. 1984. Impounded rivers: perspectives for ecological management. John Wiley & Sons, New York.

Resh, V.H., A.V. Brown, A.P. Covich, M.E. Gurtz, H.W. Li, G.W. Minshall, S.R. Reice, A.L. Sheldon, J.B. Wallace, and R. Wissmar. 1988. The role of disturbance in stream ecology. J.N. Am. Benthological Society 7(4): 433-455.

Rosgen, D. 1996. Applied river morphology. Wildland Hydrology. Pagosa Springs, CO.

Rosgen, D. 1994. A classification of natural rivers. Catena, 22:169-199.

Sheath, R.G., J.M. Burkholder, M.O. Morrison, A.D. Steinman, and K.L. Van Alstyine. 1986. Effect of tree canopy removal by gypsy moth larvae on the macroalgae community of a Rhode Island headwater stream. Journal of Phycology 22:567-570.

Steinman, A.D. and C. D. McIntire. 1990. Recovery of lotic periphyton communities after disturbance. Environmental Management 14:589-604.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. Can. J. Fish. Aquati. Sci. 37 (1): 130-137.

Ward, J.V. and J.A. Stanford. 1983. The serial discontinuity concept of lotic ecosystems. Pages 29-42 *in* T.D. Fontaine and S.M. Bartell, editors. Dynamics of Lotic Ecosystems. Ann Arbor, MI; Ann Arbor Science.

Wolman, M.G. and J.P. Miller. 1960. Magnitude and Frequency of Forces in Geomorphic Processes, *J. Geol.* 68:54-74.

Wolman, M.G. 1954. A method of sampling coarse river-bed material. Transactions American Geophysical Union. 35(6):951-956.