Summary Report

A Study of Macroinvertebrate Community Responses to Winter Flows on the Fryingpan River

Prepared for

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INTRODUCTION

The biological and physical processes that govern the structure and function of benthic macroinvertebrate communities in the Fryingpan River are not entirely understood. However, there is evidence to suggest that the flow regime may be an important physical influence on benthic communities (Rees et al. 2003). For this reason, macroinvertebrate sampling and thermal modeling continued during the fall 2004 and spring 2005 in the Fryingpan River as part of a study to assess the influence of releases from Ruedi Reservoir. Water releases from the impounded reservoir can influence benthic macroinvertebrates and fish communities through regulation of flow and alteration of the thermal regime. It has been hypothesized that erratic changes in discharge have a negative impact on benthic macroinvertebrates (Ptacek et al. 2003); however, it is not clear how the level of discharge during the winter months and the potential formation of anchor ice may influence these communities.

In many ways, the impoundment and physical variables associated with discharge are responsible for the development of an exceptional trout fishery in the Fryingpan River. The purpose of this extended sampling was to evaluate potential impacts associated with low winter flows. This information could be useful when determining management practices that will benefit the trout fishery.

METHODS

MACROINVERTEBRATE SAMPLING

Benthic macroinvertebrate sampling was conducted during fall (28 October) of 2004, and spring (29 April) of 2005. Three sites on the Fryingpan River (FPR-RES, FPR-TC, and FPR-BAS) were sampled on each occasion. These site locations are downstream from the reservoir (FPR-RES), near Taylor Creek (FPR-TDC), and in Basalt (FPR-BAS). At each location, three samples were taken in riffle habitat using a Hess Sampler with 500 μm mesh to provide quantitative macroinvertebrate data. All samples were taken in areas of similar size substrate and similar depth to avoid bias that may be directly related to habitat. Depth at each sample location ranged between 24.4 cm and 33.5 cm. Substrate within the Hess Sampler was thoroughly disturbed and individual rocks were scrubbed by hand to dislodge all benthic organisms. Benthic macroinvertebrates were preserved in ethanol and transported to the lab where they were sorted, enumerated and identified to the lowest practical taxonomic level (Merritt and Cummins 1996; Ward et al. 2002).

Identification to the "lowest practical taxonomic level" means that all specimens were identified down to the level that is permitted by the available morphological characteristics. Early life stages of many species lack certain anatomical characteristics that allow the specimen to be identified to the genus or species level. In these cases the "lowest practical taxonomic level" may mean only the family level; however, if the available characteristics are consistent with a species that has been previously confirmed during this study then the individual may be included as a member of that taxa. In these cases the species name is provided in parentheses.

As a means of QA/QC, qualified personnel inspected each sample after sorting and a minimum of 20% of all identified taxa were reviewed. Dr. Boris Kondratieff (Professor of Entomology at Colorado State University) confirmed identifications in all cases where the identification of a specimen was difficult or questionable.

In instances where proper identification was possible, the Orders Ephemeroptera, Plecoptera, and Trichoptera were identified to genus (and many down to the species level). Most specimens of other Orders, including Diptera, were identified to the genus level; however, members of the family Chironomidae were only identified to subfamily or tribe. Further identification would require mounting of head capsules – an expensive and time-consuming process. Data collected were used in various indices recommended by the Rapid Bioassessment Protocols (Plafkin et al. 1989) to provide information regarding macroinvertebrate community structure, function, and general aquatic conditions.

Indices used included Shannon-Weaver diversity (diversity) and evenness (evenness), EPT index, taxa richness (richness), and description of functional feeding groups. Diversity and evenness values were used to detect changes in macroinvertebrate community structure. In unpolluted waters diversity values typically range from near 3.0 to 4.0. In polluted waters this value is generally less than 1.0. The evenness value ranges between 0.0 and 1.0. Values lower than 0.3 are generally considered indicative of organic pollution (Ward et al. 2002).

The Ephemeroptera, Plecoptera, Trichoptera (EPT) index will be employed to assist in the analysis of the data. It is a direct measure of taxa richness among species that are typically considered more sensitive to pollution or other perturbations. This measurement is simply given as the total number of identified taxa in the orders Ephemeroptera, Plecoptera and Trichoptera found at each station.

Taxa richness was also reported for each sampling event during the study. This measurement is reported as the total number of different taxa collected on each date from each sampling location. It is similar to the EPT index, except that it includes all different identifiable benthic macroinvertebrate species. It is useful for describing differences in habitat complexity or aquatic conditions between rivers or site locations.

Benthic macroinvertebrate production at each site was estimated by measuring macroinvertebrate density and biomass. Density was reported as the mean number of macroinvertebrates/m^2 found at each location. Densities were compared among sites for each sampling occasion. Biomass values were obtained by drying the benthic macroinvertebrates from each sample in an oven at 100° C for 24-hours or until all water content had evaporated. Biomass was reported as the mean dry weight of macroinvertebrates per square meter at each site location. Biomass values provide information in terms of weight of macroinvertebrates produced by habitat at each site. Density and biomass provide a means of measuring and comparing productivity at each sampling location.

Separating invertebrate taxa into functional guilds based on food acquisition provided a measurement of macroinvertebrate community function. Aquatic macroinvertebrates were categorized according to feeding strategy to determine the relative proportion of various groups. The proportion of certain functional feeding groups in the macroinvertebrate community can provide insight to various types of stress in river systems (Ward et al. 2002)

THERMAL REGIME

To describe the winter thermal regime in the Fryingpan River we used Stowaway® Tidbit® temperature loggers (accuracy ±0.2°C) encased in a small (10 cm) section of pvc pipe for protection. We surveyed water temperatures at the following four locations in the Fryingpan River: downstream of Ruedi Dam at the USGS gaging station (Gaging Station), Pruessing Property (Pruessing Site), Roy Palm Property (Palm Site), and upstream of the confluence with the Roaring Fork River behind Taylor Creek Fly Shop (Fly Shop Site). At each site, capsules were placed in the river and attached to a permanent object by aircraft cable. Holes were drilled in each capsule to ensure adequate circulation of stream water. Each thermograph was set to record hourly water temperatures and was downloaded using a Stowaway® Optic Shuttle. Capsules were placed in inconspicuous mid-channel locations near the stream bottom at a depth where anchor ice is likely to form.

Thermal data was downloaded and input into a computer spreadsheet. We limited the thermal analysis to the months of December, January, and February, which are the months where anchor ice would typically occur. For analysis purposes, we defined an anchor ice event/occurrence as any hourly observation with a water temperature less than 32.3°F (0.2°C).

RESULTS

FALL 2004

Macroinvertebrate sampling and analyses was conducted at sites on the Fryingpan River in the fall of 2004 and spring 2005. In general, results of fall 2004 were similar to results from previous years; however, some slight differences were observed (Table 1). Diversity and evenness values indicated that conditions were similar to the fall of 2003. There was higher density at FPR-RES (Figure 1), but higher biomass at FPR-TC and FPR-BAS (Figure 2). The reason for the inconsistency between these metrics was due to changes in the abundance of specific taxa in each community. The number of small invertebrates at FPR-RES increased during the fall of 2004, while the density of some of the larger macroinvertebrates declined. This resulted in a slight increase in densities and a slight decrease in biomass at FPR-RES in the fall of 2003. The opposite effect of this process occurred at site FPR-TC. A slight variation in community structure was also reflected in the function analysis (Figure 3). Functional groups exhibited similar composition during all fall sampling events at all sites, with slight variation occurring mostly in the scraper and collector-filterer groups at FPR-TC.

The differences in metrics observed during three years of fall sampling may be well within the range of natural variation that occurs at these sites. Changes in metric values would not be considered substantial, or suggest that a major community altering event had recently occurred (Table 1). It is important to note the yearly similarities among fall samples because it suggests that changes in macroinvertebrate communities in spring samples are the result of events that occur during winter months.

Table 1. Metrics and comparative values for macroinvertebrate samples collected during the fall season from riffle habitat in the Fryingpan River, Colorado.

Fall 2001	Diversity	Evenness	EPT	Taxa Richness	Density (#/m^2)	Biomass (g/m^2)
FPR-RES	2.29	0.453	19	33	16,509	1.3820
FPR-TC	3.76	0.701	23	41	10,318	2.4338
Fall 2002						
FPR-RES	2.34	0.478	14	30	28,220	2.0104
FPR-TC	3.35	0.639	19	38	17,530	2.4856
Fall 2003						
FPR-RES	2.49	0.508	14	30	31,665	1.8435
FPR-TC	3.39	0.656	18	36	15,792	3.2179
Fall 2004						
FPR-RES	2.33	0.515	12	23	20,161	1.4948
FPR-TC	3.44	0.656	20	38	15,332	3.0058
FPR-BAS	4.00	0.756	23	39	11,321	2.6318

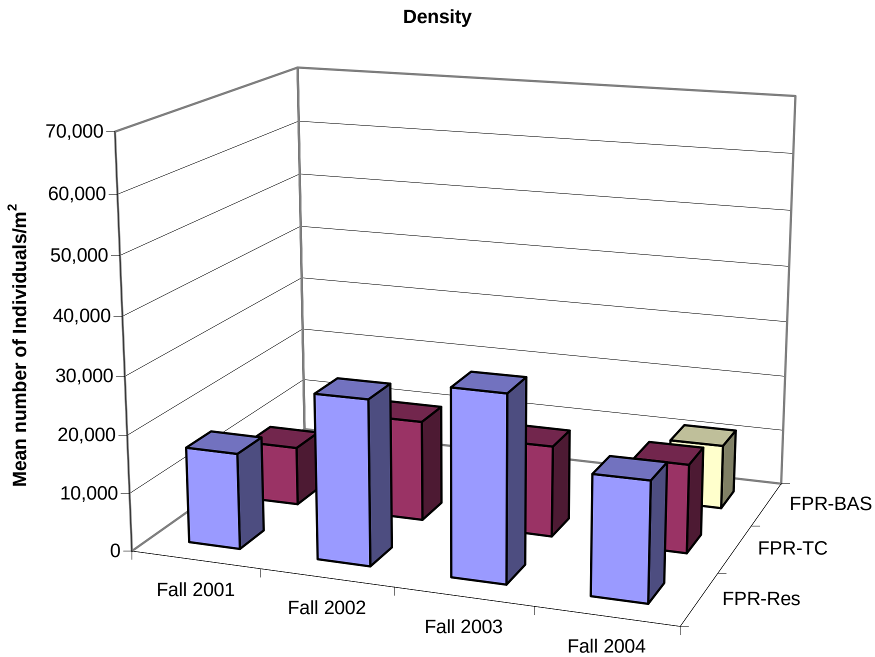


Figure 1. Density values obtained from fall sampling at sites on the Fryingpan River, Colorado.

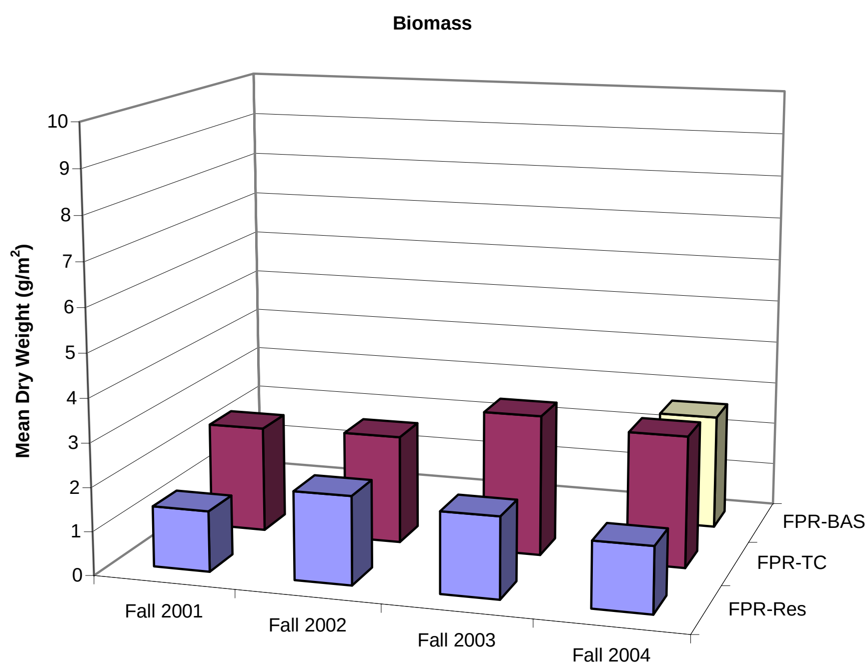
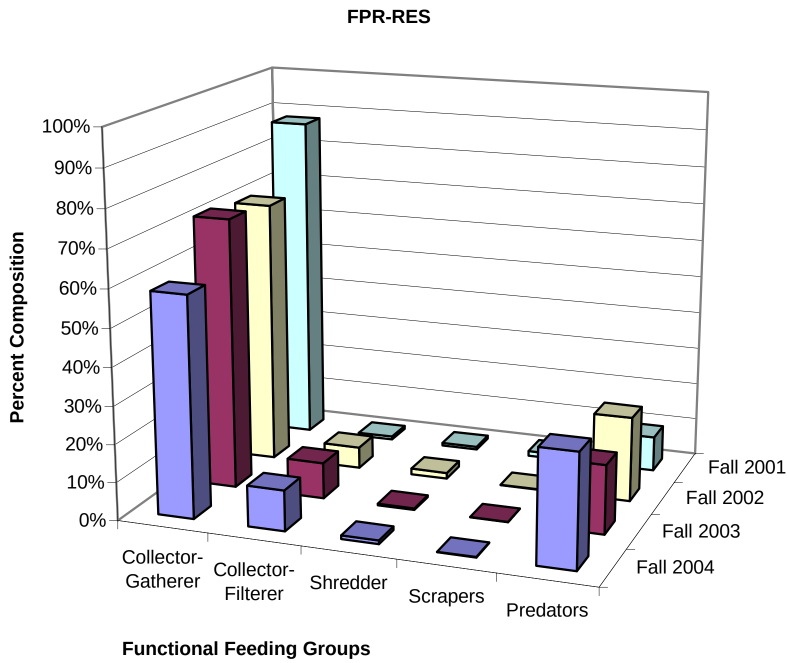


Figure 2. Biomass estimates obtained from fall sampling at sites on the Fryingpan River, Colorado.



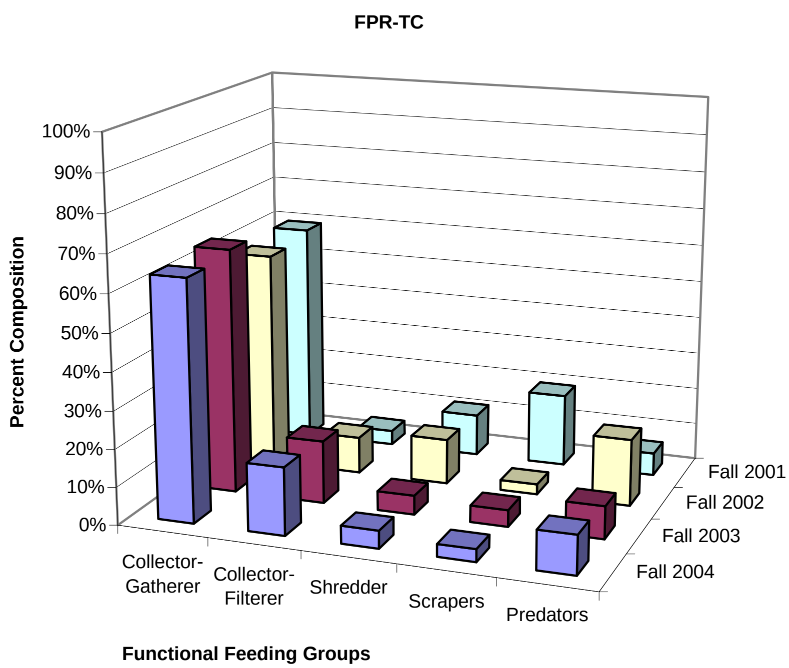


Figure 3. Functional feeding groups at site FPR-RES (top) and FPR-TC (bottom) during fall sampling on the Fryingpan River, Colorado.

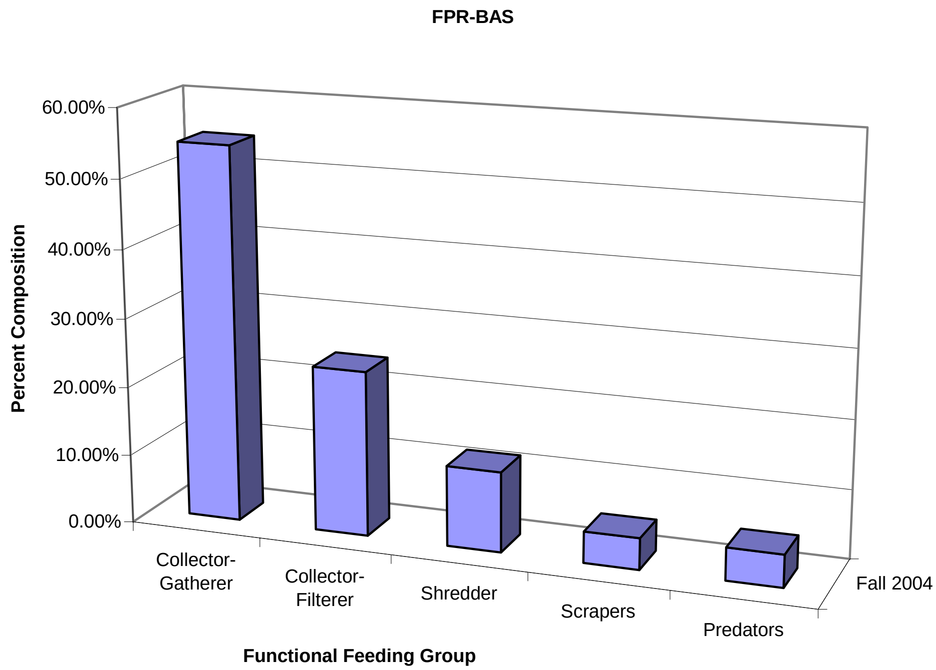


Figure 3 (concluded). Functional feeding groups at site FPR-BAS during fall sampling on the Fryingpan River, Colorado.

SPRING 2005

Evaluation of data collected during spring 2005 indicated that benthic macroinvertebrate communities improved from conditions existing in 2003 (Table 2). Macroinvertebrate communities exhibited an increase in density and biomass at FPR-RES and decreased at FPR-TC (Figures 4 and 5). The changes to community composition were mostly site dependant.

The greatest influence on metric values at FPR- RES during the spring of 2005 resulted from a large increase in the density of mayflies, and the continued presence of additional EPT taxa (mostly caddisflies) that were not accounted for in the spring of 2003. Results of applied metrics indicated that there was an increase in density and biomass at FPR-RES, while EPT and taxa richness values achieved values that were similar to those reported during 2003 (Table 2). Other metrics and the composition of benthic macroinvertebrates based on function have remained relatively consistent at this site (Figure 6). The metrics that remained relatively unaffected (diversity, evenness, and functional feeding groups) are often more sensitive to pollution-related disturbance. These metrics have always indicated some disturbance at FPR-RES that was thought to be an influence of Ruedi Dam.

The applied metrics for site FPR-TC were also influenced by lower densities of macroinvertebrates, but community composition remained similar to that observed in 2004. In the spring of 2005 a decrease in density and biomass were observed at FPR-TC. This resulted from a general decrease in abundance of several species, and was not restricted to a specific taxonomic group. The number of EPT taxa remained constant but individuals in these groups decreased at FPR-TC during 2005. The number of chironomids exhibited a similar trend. EPT and taxa richness values were at levels that would be expected based on the first two years of this study.Diversity and evenness values were similar to those reported in 2001 and 2002 (Table 2). The distribution of functional feeding groups reaffirms these results by depicting an allocation of species (based on function) that was similar to what was reported in 2003 (Figure 6).

Several of the species that increased in abundance at FPR-TC in the spring 2005 were caddisflies. This is noteworthy because caddisflies are large-bodied insects that may be sensitive to anchor ice formation, but are known to be sensitive to rapid changes in discharge. The increase of caddisflies may signify a reduction in rapid flow changes.

Table 2. Metrics and comparative values for macroinvertebrate samples collected during the spring season from riffle habitat in the Fryingpan River, Colorado.

Spring 2001	Diversity	Evenness	EPT	Taxa Richness	Density (#/m^2)	Biomass (g/m^2)
FPR-RES	2.03	0.406	17	32	36,770	7.4108
FPR-TC	3.71	0.707	21	38	18,366	8.7948
Spring 2002						
FPR-RES	2.37	0.471	20	33	62,996	9.2919
FPR-TC	3.66	0.683	22	41	21,458	4.3774
Spring 2003						
FPR-RES	2.03	0.470	9	20	25,198	4.3867
FPR-TC	1.93	0.386	18	32	20,970	2.0629
Spring 2004						
FPR-RES	2.11	0.430	16	30	33,191	5.8627
FPR-TC	2.11	0.398	20	39	40,909	7.3951
Spring 2005						
FPR-RES	1.75	0.356	15	30	54,522	7.6601
FPR-TC	3.47	0.661	19	38	15,501	3.0725
FPR-BAS	3.68	0.675	26	44	8,323	1.8174

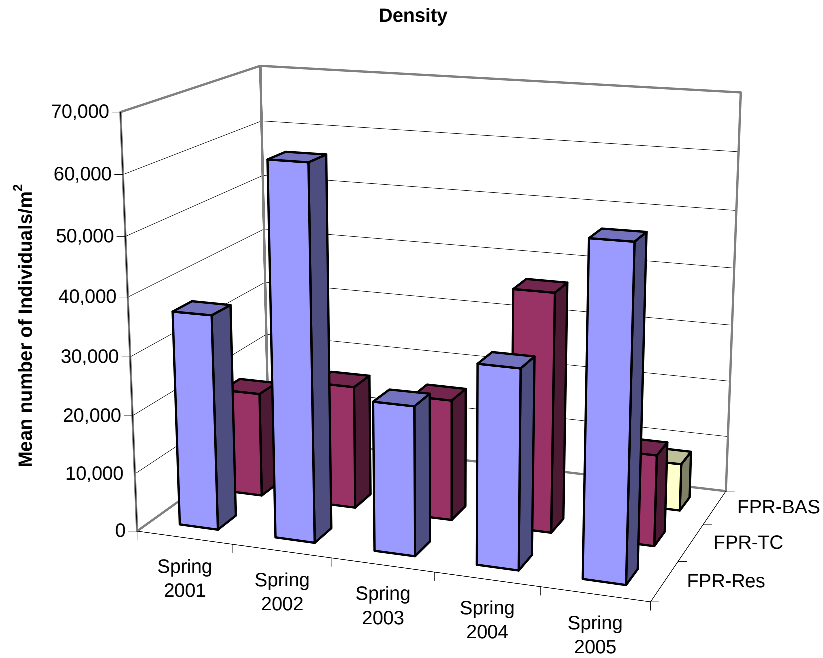


Figure 4. Density values obtained from spring sampling at sites on the Fryingpan River, Colorado.

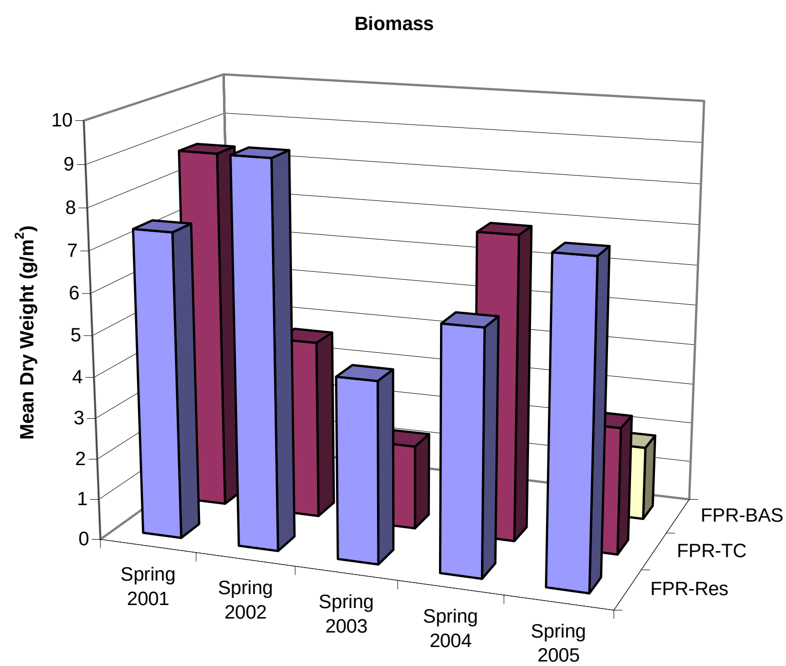
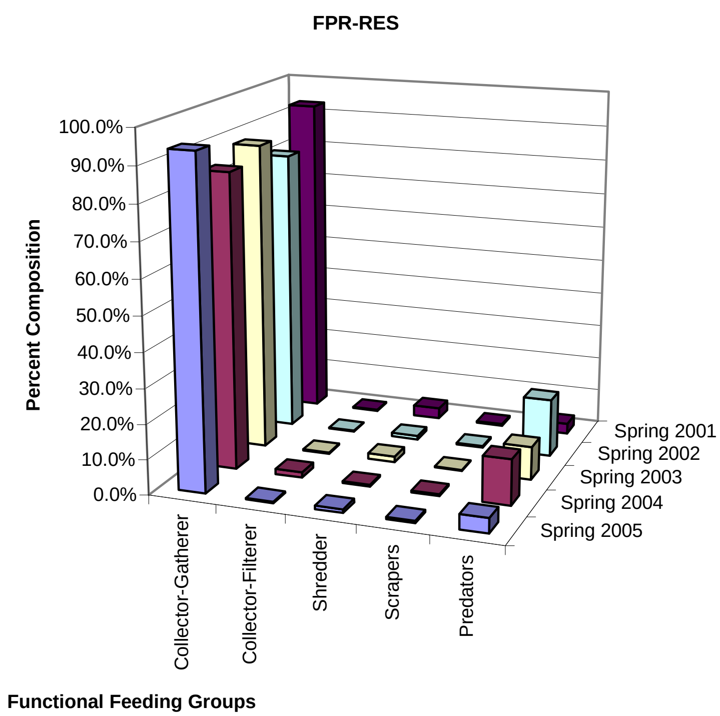


Figure 5. Biomass estimates obtained from spring sampling at sites on the Fryingpan River, Colorado.



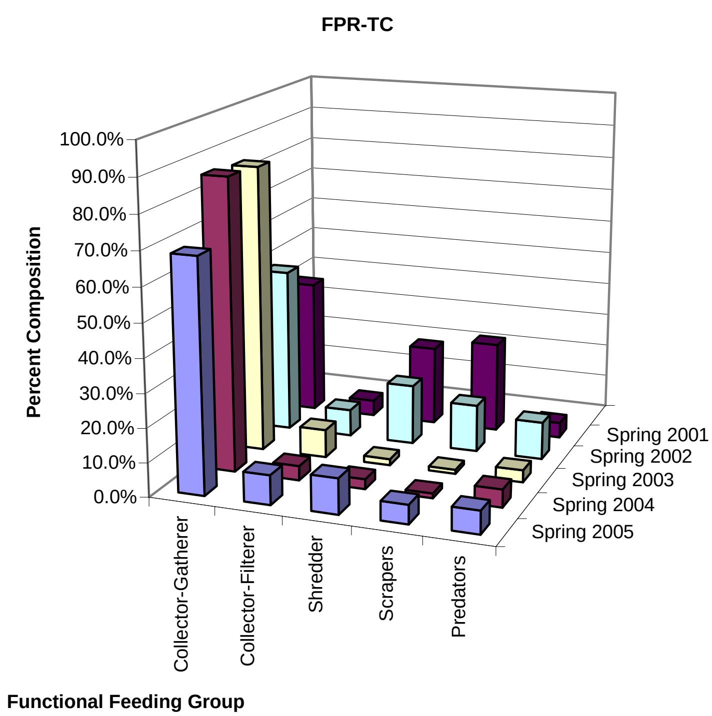


Figure 6. Functional feeding groups at site FPR-RES (top) and FPR-TC (bottom) during spring sampling on the Fryingpan River, Colorado.

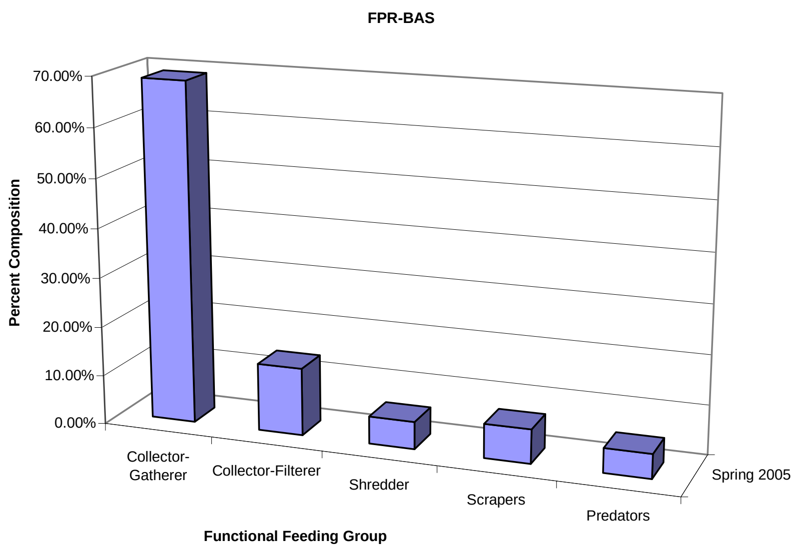


Figure 6 (concluded). Functional feeding groups at site FPR-BAS during spring sampling on the Fryingpan River, Colorado.

DISCUSSION

Aquatic macroinvertebrate communities were evaluated as a means to examine the relationships between winter base flows, anchor ice and macroinvertebrates community structure. The results provide a description of the composition of existing macroinvertebrate communities at the time and location of sampling. The mechanisms that influence the community assemblages are numerous and include variables not directly related to flow manipulations (biological interactions, air temperature, etc.). However, the direct and indirect effects of the flow regime resulting from the regulated discharge in the Fryingpan River appear to influence benthic macroinvertebrate communities.

The magnitude of discharge may be the most important factor that influences macroinvertebrates during the winter months. In the winter of 2002-2003 base flows were recorded at an average 40.8 cfs below Ruedi Dam from December through February (Figure 9). Metrics used to describe benthic macroinvertebrate communities in the spring indicated that conditions had declined at both sites in spring 2003. It was hypothesized that benthic communities in the spring of 2003 were responding to physical processes associated with lower discharge (Rees et al. 2003). During the winter of 2003-2004 the mean discharge was approximately 85.2 cfs and some apparent recovery of macroinvertebrate communities was observed at both sites on the Fryingpan River. During the winter of 2004-2005 mean discharge was approximately 74.2 cfs (Figure 7). Metric values for 2005 were very similar to spring 2004, however biomass decreased.

Results of metric values from site FPR-RES are likely influenced primarily by discharge because water temperature does not allow anchor ice formation. The mean daily water temperature below the dam was slightly lower during the early portion of the 2002-2003 winter, but water temperature during the coldest months has been similar during each winter season of this study including 2004-2005 (Figure 8).

Although macroinvertebrate impact and recovery seem to be associated with the magnitude of discharge at both sites on the Fryingpan River, the data suggests that the community at FPR-TC is also influenced by some indirect effects of discharge. The data for FPR-BAS suggests more influence of ambient conditions at this site than release from the dam. The formation and frequency of occurrence of anchor ice at FPR-TC appears to be a contributing influence on macroinvertebrate community structure and function.

The results of sampling in 2004 after higher winter flows indicated that densities of many EPT taxa had recovered but chironomid numbers had increased as well. This recent data suggests that two or more concurrent winters with higher flows may be necessary to achieve an optimum balance in the macroinvertebrate community at FPR-TC.

Results of sampling in 2005 after winter flows showed that the densities of many EPT taxa were similar to 2004 indicating the continued higher winter flows were beneficial to the system. This result was hypothesized after the 2004 sampling that winter flows higher than 40 cfs would be beneficial for the invertebrates in the Fryingpan River.

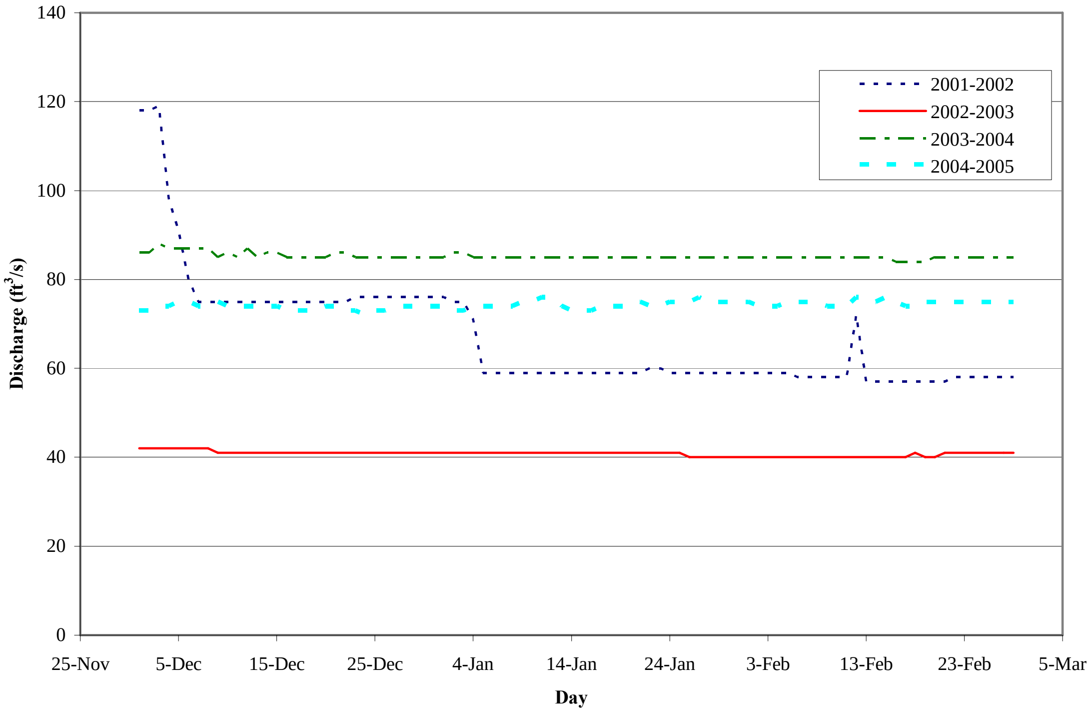


Figure 7. Winter discharge (December-February) for the Fryingpan River below Ruedi Reservoir, Colorado.

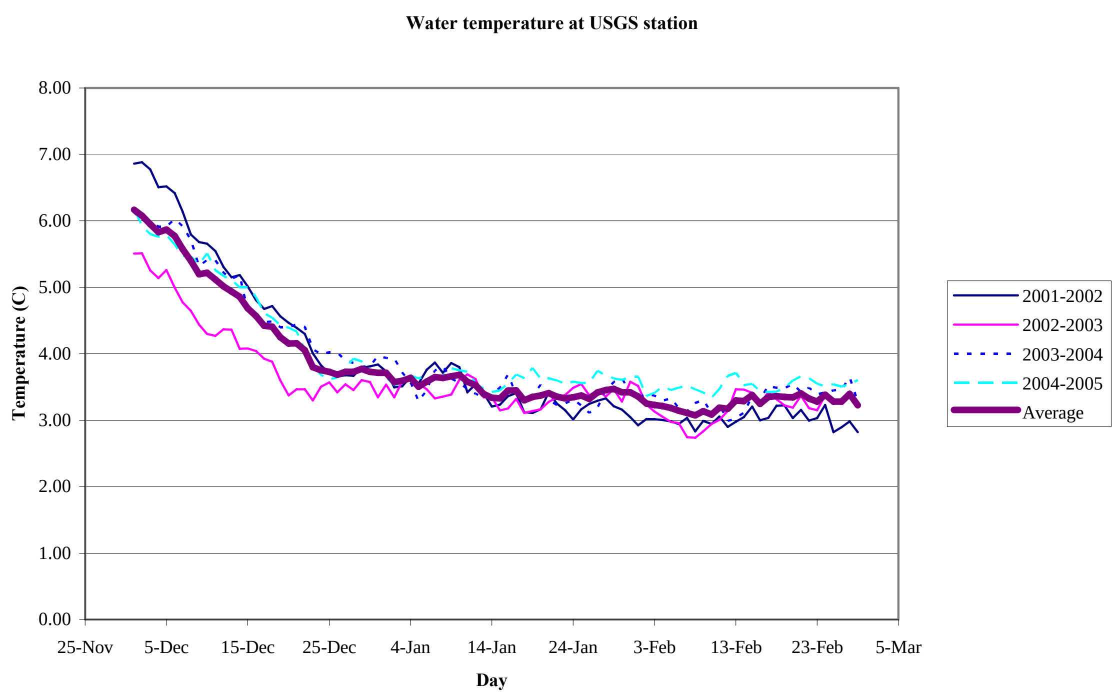


Figure 8. Winter water temperatures for Fryingpan River below Ruedi Reservoir, Colorado.

Because anchor ice is known to have a negative impact on aquatic biota it is important to identify causes and areas of potential formation. Thermograph data for 2004-2005 show that December was the coldest month during the monitoring period which is reflected in both the minimum daily and average daily temperatures (Tables 3 and 4). December of 2004 had the highest number of occurrences of hourly water temperatures less than 0.2 ^{o}C for the entire 2004-2005 winter season. 2004-2005 was also warmer than any of the previous winter time periods. Even with this warmer temperature, there were periods of time when anchor ice could form in the system. Thermograph data from December 2004, January 2005, and February 2005 identified periods of anchor ice formation immediately upstream of the FPR-TC site (Figures 9-11). Thermograph data from the Fryingpan River in Basalt indicated an increased frequency and duration of anchor ice formation (Figures 12-14). The frequency of occurrence and duration of anchor ice formation seems to increase with distance downstream.

Results of this study suggest that magnitude of discharge and air temperature work together to influence anchor ice formation. Thermograph data from two consecutive winter seasons at the Palm site (immediately upstream of FPR-TC) indicated that anchor ice formation at this location was less frequent during the winter of 2004-2005 compared to the previous winter (Table 3). The average length of an anchor ice occurrence was also much less in 2004-2005. It is possible that the magnitude of the effect of anchor ice formation on the macroinvertebrate community may be amplified as the length of the event increases. December 2004 had extended periods of anchor ice at the Palm site (Figure 9) and Basalt (Figure 11).

The available data suggests that discharge was similar in the study area during 2003-2004 and 2004-2005 (Figure 7), but air temperature was different (Table 4). The discharge at site FPR-TC in 2004-2005 was less conducive to the formation of anchor ice than the lower flows during the 2002-2003 winter.

Table 3. Number of anchor ice occurrences (hourly water temperature less than 0.2°C) during winters (December-February) of 2002-2003, 2003-2004 and 2004-2005 at Palm Site.

Month	Year		
	2002-2003	**2003-2004**	**2004-2005**
December	229	6	113
January	214	164	50
February	200	86	66

Table 4. Average monthly air temperature (°F) recorded at Aspen, Colorado (Station: Aspen 1 SW, Coop ID: 050372).

Month/Year	Average Max Temperature (°F)	Average Min Temperature (°F)	Count of days with Min Temperature ≤ 5°F
December 01	35.2	8.2	13
January 02	35	8.6	10
February 02	37	5.2	12
December 02	36.5	12.6	6
January 03	40.8	16.3	0
February 03	36.8	12.3	5
December 03	36.6	12.3	7
January 04	36.5	8.8	8
February 04	37.4	10.2	8
December 04	35.97	11.26	9
January 05	39.90	16.55	3
February 05	39.61	14.25	5

The available data suggest that anchor ice was at least partially responsible for the degraded condition of the macroinvertebrate community at FPR-TC during the spring of 2005. To alleviate anchor ice related stress to the macroinvertebrate community, an effort should be made to avoid low wintertime releases out of Ruedi Reservoir.

The water temperature at Basalt appears to be the result of ambient conditions more than at the Palm site. During December 2004, there were extended periods of anchor ice formation. December 2004 was the coldest month of the 2004-2005 winter. This extended period of anchor ice likely had an impact on the macroinvertebrate community, even with discharges over 70 cfs.

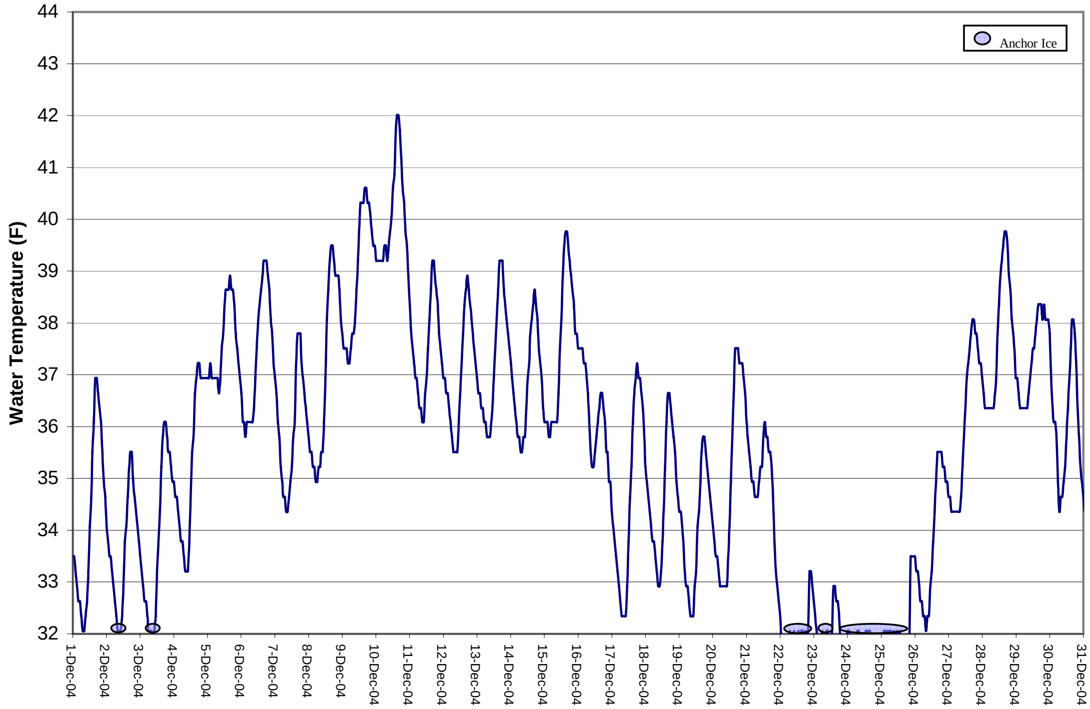


Figure 9. Hourly water temperatures during December 2004 at Palm Site.

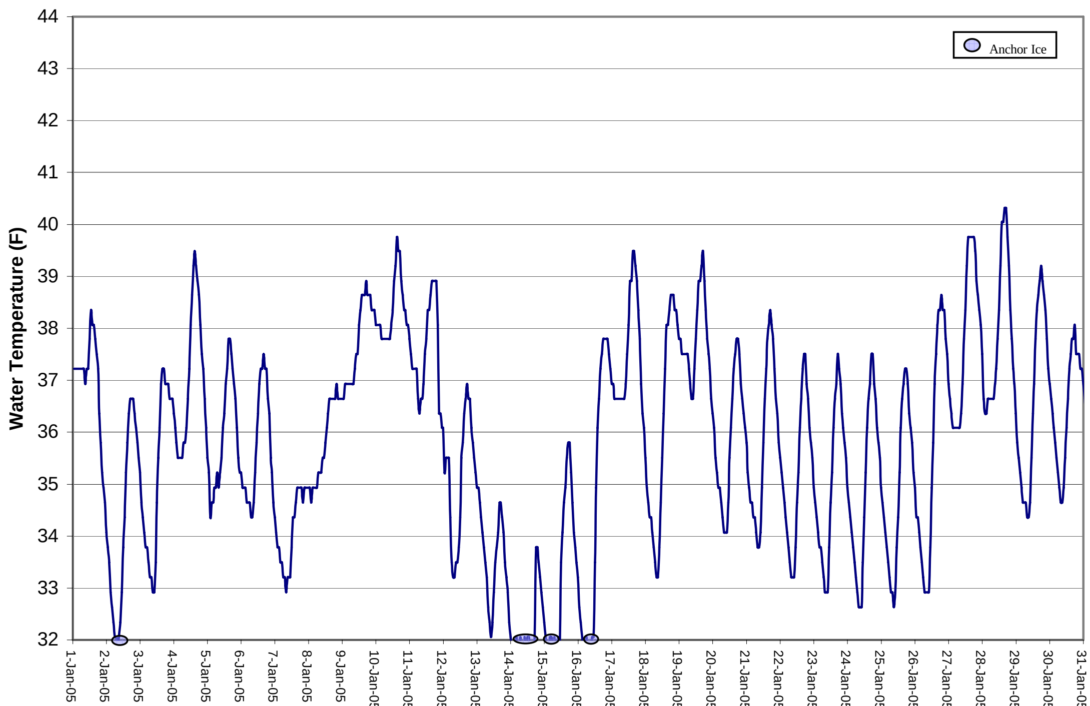


Figure 10. Hourly water temperatures during January 2005 at Palm Site.

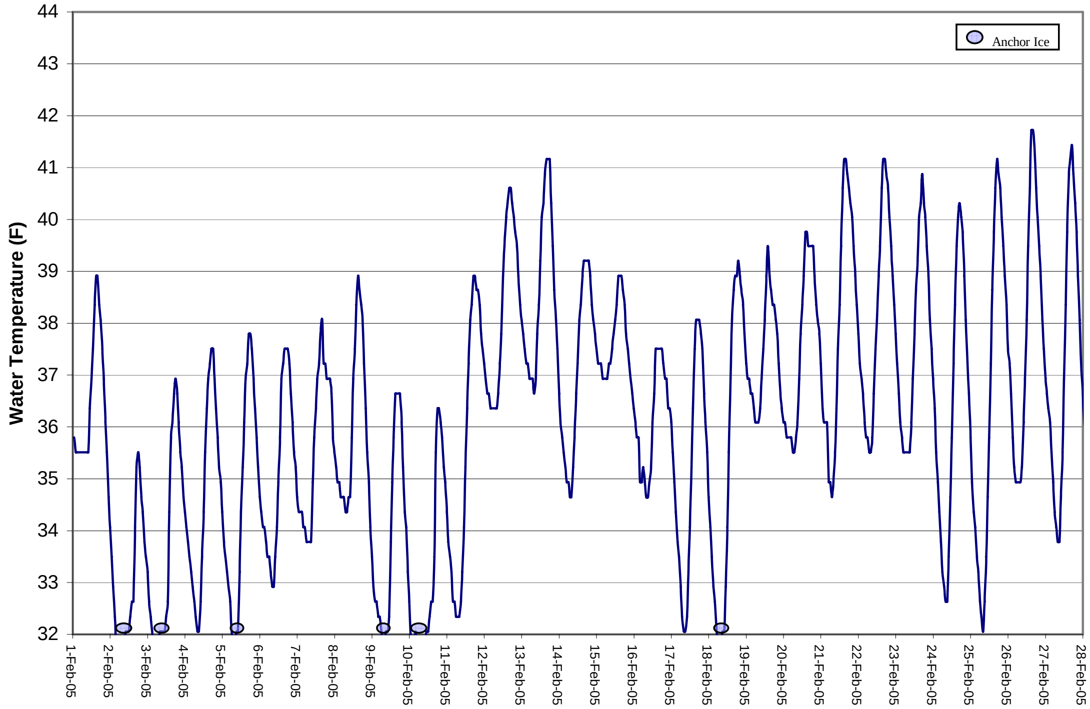


Figure 11. Hourly water temperatures during February 2005 at Palm Site.

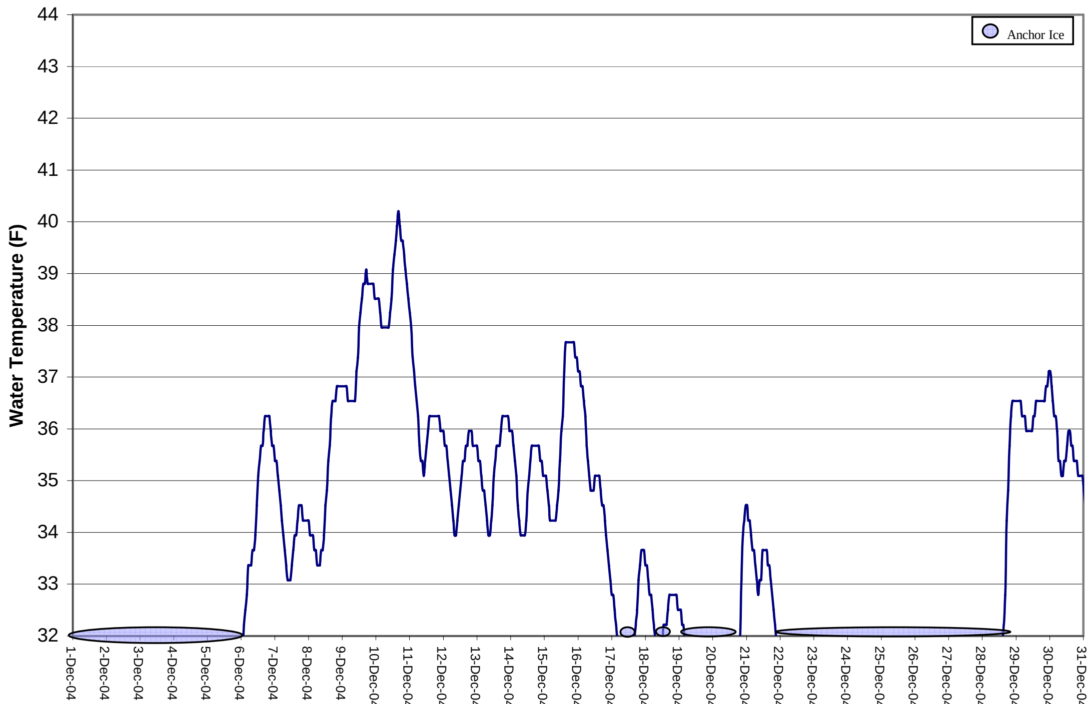


Figure 12. Hourly water temperatures during December 2004 on the Fryingpan River, at Basalt.

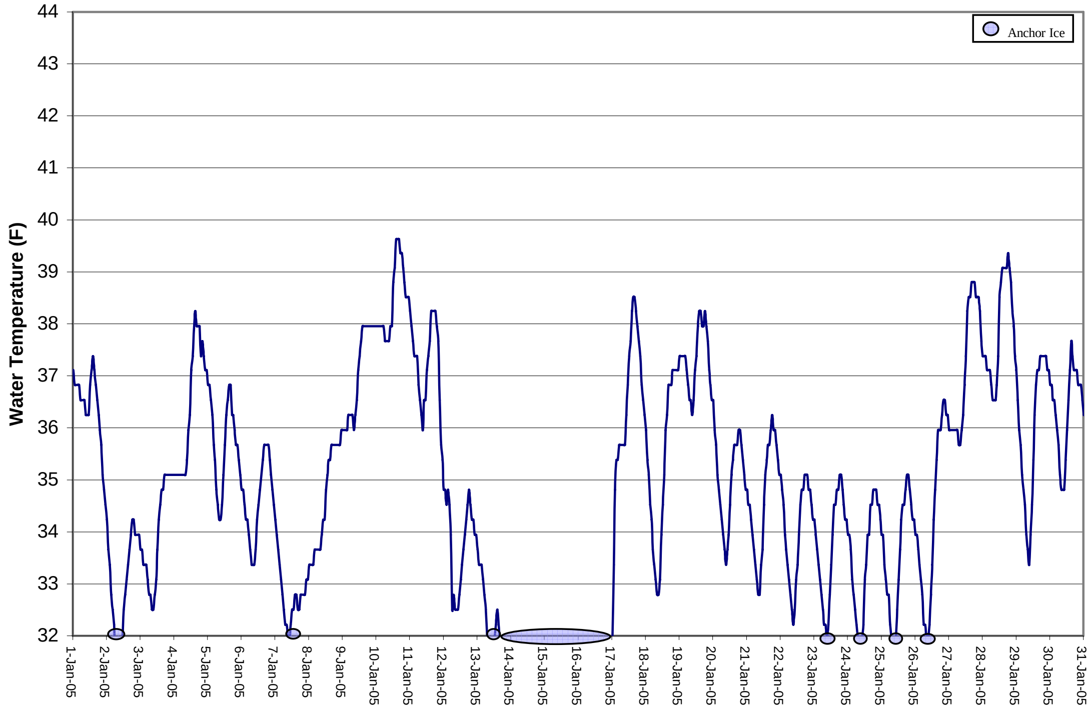


Figure 13. Hourly water temperatures during January 2005 on the Fryingpan River, at Basalt.

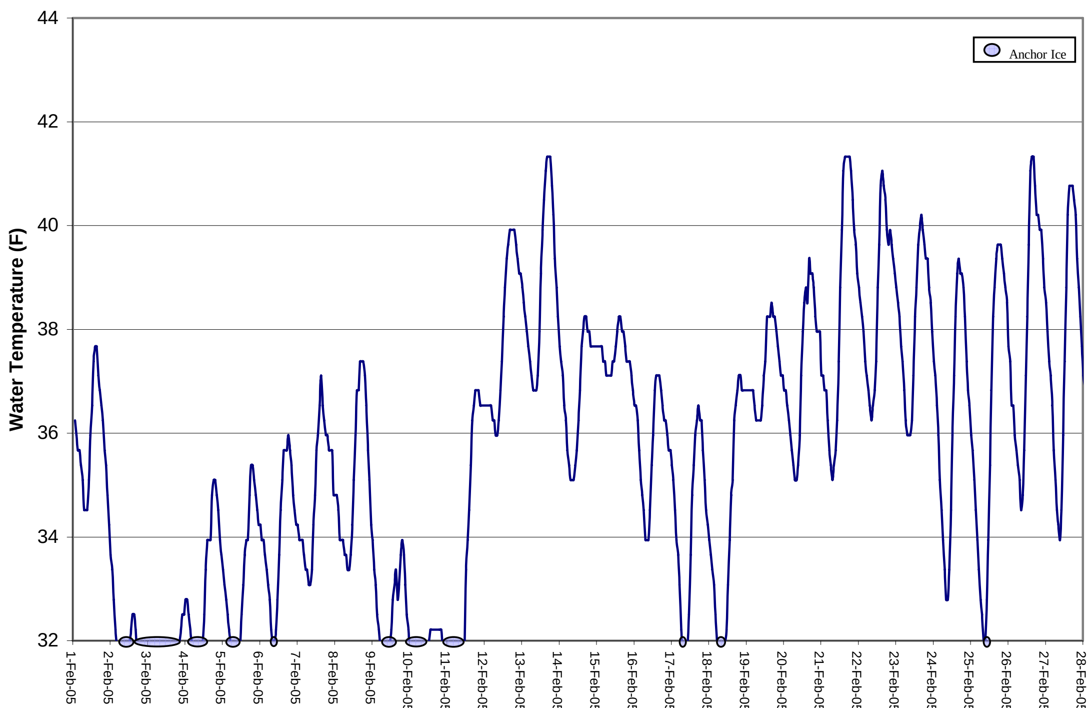


Figure 14. Hourly water temperatures during February 2005 on the Fryingpan River, at Basalt.

CONCLUSIONS

- The impact to the macroinvertebrate community at Basalt from anchor ice appears to be more influenced by ambient conditions than reservoir release.

- The warmer January and February air temperatures in combination with the higher winter discharges appeared to result in fewer occurrences of anchor ice at site FPR-TC.

- It appears that macroinvertebrate diversity and evenness recover in one to two years after severe anchor ice formation if winter flows remain greater than 70 cfs.

- Flows greater than 70 cfs seem to result in less anchor ice in the upper half of the river than flows of approximately 40 cfs.

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APPENDIX A

Table 1. Macroinvertebrate data collected from the Fryingpan River at site FPR-RES on 28 October 2004.

Fryingpan River				
FPR-RES		Sample		
28 Oct. 04	1	2	3	
	rep1	rep2	rep3	total
Acentrella insignificans	2	5	5	12
Baetis (flavistriga)				
Baetis (tricaudatus)	410	573	950	1933
Drunella grandis		3	2	5
Drunella coloradensis				
Drunella doddsi	5	2	3	10
Ephemerella sp.	10	18	24	52
Cinygmula sp.	1			
Epeorus longimanus				
Rhithrogena sp.				
Paraleptophlebia sp.	2	5	1	8
Tricorythodes minutus				
Caenis sp.				
Pteronarcella badia				
Capnia sp.				
Zapada sp.			2	2
Paraperla frontalis				
Sweltsa sp.				
Triznaka signata				
Claassenia sabulosa				
Hesperoperla pacifica				
Skwala americana				
Isoperla fulva				
Isoperla sp. 2				
Brachycentrus americanus			1	1
Brachycentrus occidentalis				
Agapetus boulderensis				
Culoptila sp.				
Glossosoma sp.			1	1
Arctopsyche grandis				
Hydropsyche cockerelli				
Hydropsyche occidentalis				
Hydropsyche sp. (oslari)				
Hydroptila sp.			2	2
Ochrotrichia sp.				
Lepidostoma sp.				
Ceraclea sp.				
Oecetis sp.				
Dolophilodes aequalis				
Rhyacophila brunnea			1	1
Rhyacophila coloradensis	1			1
Neothremma alicia				
Oligophlebodes minuta				
Orthocladiinae	130 (5P)	326 (4P)	338 (3P)	794
Tanypodinae				
Tanytarsini	5	3	15	23
Chironomini				
Diamesinae	6 (1P)	11	19 (1P)	36
Simulium sp.	370(15P)	71 (1P)	80 (3P)	521
Protanyderus margarita				
Chelifera sp.				
Clinocera sp.				
Hemerodromia sp.				
Antocha sp.	2	3	1	6
Dicranota sp.				
Hexatoma sp.				
Tipula sp.				
Atherix pachypus				
Pericoma sp.				
Optioservus sp.				
Heterlimnius corpulentus	0	12	8	20
Zaitzevia parvula				
Microcylloepus sp.				
Narpus concolor				
Acari		1	1	2
Hydracarina sp.				
Gammarus sp.				
Physa sp.				
Pisidium sp.	3	14	2	19
Dugesia sp.				
Polycelis coronata	355	518	666	1539
Oligochaeta	33	49	175	257
Nematoda	3	5	3	11
Totals	832.0	1222.0	1863.0	3306

Table 2. Macroinvertebrate data collected from the Fryingpan River at site FPR-TC on 28 October 2004.

Fryingpan River				
FPR-Taylor Creek		Sample		
28 Oct. 04	1	2	3	
	rep1	rep2	rep3	total
Acentrella insignificans	1	1	2	4
Baetis bicaudatus	362	307	365	1034
Baetis (flavistriga)				
Baetis (tricaudatus)				
B. quilleri			2	2
Drunella grandis	12	22	8	42
Drunella coloradensis				
Drunella doddsi				
Ephemerella sp.	20	18	26	64
Cinygmula sp.	7	7	20	34
Epeorus sp.		1	1	2
Rhithrogena sp.				
Paraleptophlebia sp.	27	39	76	142
Tricorythodes minutus				
Caenis sp.				
Pteronarcella badia				
Capnia sp.				
Zapada sp.		2		2
Paraperla frontalis				
Sweltsa sp.				
Triznaka signata				
Claassenia sabulosa				
Hesperoperla pacifica	1		4	5
Skwala americana				
Isoperla fulva	3	4	6	13
Isoperla sp. 2				
Brachycentrus americanus	33	85	68	186
Brachycentrus occidentalis				
Agapetus boulderensis				
Culoptila sp.				
Glossosoma sp.	4 (3P)	3	2	9
Arctopsyche grandis	5	15	7	27
Hydropsyche cockerelli	1		2	3
Hydropsyche occidentalis				
Hydropsyche sp. (oslari)	4			4
Hydroptila sp.				
Ochrotrichia sp.				
Lepidostoma sp.	28	46	47	121
Ceraclea sp.				
Oecetis sp.				
Dolophilodes aequalis				
Rhyacophila brunnea		3	12	15
Rhyacophila coloradensis	2		2	4
Neothremma alicia				
Oligophlebodes minuta	6	16	12	34
Orthocladiinae	90 (1P)	258 (3P)	654 (5P)	1002
Tanypodinae	1		2	3
Tanytarsini		1	37	38
Chironomini				
Diamesinae	3	2	6	11
Simulium sp.	204	51	22	277
Protanyderus margarita				
Chelifera sp.		2	1	3
Clinocera sp.				
Hemerodromia sp.			2	2
Antocha sp.	7	22	46	75
Dicranota sp.		1		1
Hexatoma sp.				
Tipula sp.				
Atherix pachypus				
Pericoma sp.				
Optioservus sp.			13	13
Heterlimnius corpulentus	15 (2A)	41	43	99
Zaitzevia parvula				
Microcylloepus sp.				
Narpus concolor				
Hydracarina sp.	4	10	14	28
Gammarus sp.				
Physa sp.		1		1
Pisidium sp.	21	60	102	183
Dugesia sp.				
Polycelis coronata	41	55	216	312
Oligochaeta	66	55	56	177
Nematoda	8	9	8	25
Totals	867.0	879.0	1230.0	2959

Table 3. Macroinvertebrate data collected from the Fryingpan River at site FPR-BAS on 28 October 2004.

Fryingpan River				
FPR-BAS		Sample		
28 Oct. 04	1	2	3	
	rep1	rep2	rep3	total
Acentrella insignificans				
B. quilleri	1	2		3
Baetis (tricaudatus)	99	113	144	356
Drunella grandis	3	6	4	13
Drunella coloradensis				
Drunella doddsi				
Ephemerella sp.	21	29	58	108
Cinygmula sp.	8	11	8	27
Epeorus sp.	1			
Rhithrogena sp.		1		1
Paraleptophlebia sp.	24	19	22	65
Tricorythodes minutus				
Caenis sp.			1	1
Pteronarcella badia				
Capnia sp.				
Zapada sp.				
Paraperla frontalis				
Sweltsa sp.	1	1		2
Triznaka signata				
Claassenia sabulosa				
Hesperoperla pacifica	5	3	1	9
Skwala americana				
Isoperla fulva	3	2	9	14
Isoperla sp. 2				
Brachycentrus americanus	18	21	70	109
Brachycentrus occidentalis				
Agapetus boulderensis				
Culoptila sp.			1	1
Glossosoma sp.	46 (4P)	39 (4P)	56 (1P)	
Arctopsyche grandis	9	9	32	50
Hydropsyche cockerelli	26	17	66	109
Hydropsyche occidentalis	4	2	20	26
Hydropsyche sp. (oslari)	12	8	66	86
Hydroptila sp.				
Ochrotrichia sp.				
Lepidostoma sp.	29	31	32	92
Ceraclea sp.				
Oecetis sp.				
Dolophilodes aequalis				
Rhyacophila brunnea		2	3	5
Rhyacophila coloradensis	1	2	4	7
Neothremma alicia				
Oligophlebodes minuta		1		1
Orthocladiinae	36	36	55 (3P)	127.00
Tanypodinae	2			2
Tanytarsini				
Chironomini				
Diamesinae		4		4
Simulium sp.	7	4	1	12
Protanyderus margarita				
Chelifera sp.		1	1	2
Clinocera sp.				
Hemerodromia sp.	2	2	9	13
Antocha sp.	38	49	52	139
Dicranota sp.	1			1
Hexatoma sp.				
Tipula sp.				
Atherix pachypus	1	2		3
Pericoma sp.				
Optioservus sp.	12 (2A)	18 (3A)	6 (1A)	36
Heterlimnius corpulentus				
Zaitzevia parvula				
Microcylloepus sp.				
Narpus concolor				
Acari	3	4	1	8
Gammarus sp.				
Physa sp.				
Pisidium sp.	5	10	5	20
Dugesia sp.				
Polycelis coronata	7	5	6	18
Oligochaeta	47	86	108	241
Nematoda	2	3		5
Totals	416.0	486.0	724.0	1716

Table 4. Macroinvertebrate data collected from the Fryingpan River at site FPR-RES on 29 April 2005.

Fryingpan River			
FPR-RES		Sample	
29 Apr. 2005	1	2	3
	Rep1	Rep2	Rep3
Acentrella insignificans			
Baetis (flavistriga)			
Baetis (tricaudatus)	2331	981	790
Drunella grandis	6	6	5
Drunella coloradensis	5	1	3
Drunella doddsi	4	5	3
Ephemerella sp.	66	22	49
Serratella tibialis			
Cinygmula sp.	17	18	36
Epeorus longimanus			
Epeorus sp.		1	1
Rhithrogena sp.			
Paraleptophlebia sp.			
Tricorythodes minutus			
Leptophlebiidae	1	2	3
Pteronarcella badia			
Prostoia besametsa			
Zapada sp.			
Triznaka signata			
Sweltsa sp.			
Claassenia sabulosa			
Hesperoperla pacifica			
Isoperla fulva			
Isoperla sp. 2			
Skwala americana			
Chloroperlidae			1
Podmosta sp.	1		
Brachycentrus americanus	2		
Brachycentrus occidentalis			
Micrasema bactro			
Culoptila sp.			
Glossosoma sp.			
Arctopsyche grandis	1		
Hydropsyche cockerelli			
Hydropsyche occidentalis			
Hydropsyche sp. *(oslari)*			
Hydroptila sp.	3		
Lepidostoma sp.		2	
Ceraclea sp.			
Oecetis sp.			
Rhyacophila brunnea	4		1
Rhyacophila coloradensis	5	1	1
Neothremma alicia			
Oligophlebodes minuta			
Orthocladiinae	4957	1470	1460
Tanypodinae	1		
Tanytarsini		1	1
Chironomini		1	
Diamesinae	540	412	233
Simulium sp.	21	18	10
Chelifera sp.			
Clinocera sp.			
Hemerodromia sp.			
Oreogeton sp.			
Tipula sp.			
Antocha sp.	5	1	1
Dicranota sp.			
Hexatoma sp.			
Atherix pachypus			
Pericoma sp.			
Neoplasta sp.	1		
Optioservus sp.			
Heterlimnius corpulentus	13		4
Zaitzevia parvula			
Narpus concolor			
Hydracarina sp.			
Gammarus sp.			
Physa sp.			
Planorbidae			
Pisidium sp.			
Dugesia sp.			
Polycelis coronata	91	103	363
Sperchon sp.	19	5	
Sphaeriidae	1	1	
Oligochaeta	39	38	23
Nematoda		3	
Totals	8134.0	3092.0	2988.0

Table 5. Macroinvertebrate data collected from the Fryingpan River at site FPR-TC on 29 April 2005.

Fryingpan River			
FPR-TC		Sample	
29 Apr. 05	1	2	3
	Rep1	Rep2	Rep3
Acentrella insignificans			1
Baetis (flavistriga)	1	26	18
Baetis (tricaudatus)	38	261	285
Drunella grandis		15	19
Drunella coloradensis			
Drunella doddsi			
Ephemerella sp.		22	40
Serratella tibialis	1	1	7
Cinygmula sp.	5	24	62
Epeorus longimanus	1	28	19
Rhithrogena sp.			
Paraleptophlebia sp.	9	112	312
Tricorythodes minutus			
Pteronarcella badia			
Prostoia besametsa			
Zapada sp.			
Triznaka signata			
Sweltsa sp.			
Claassenia sabulosa			
Hesperoperla pacifica	3	4	3
Isoperla fulva	2	4	2
Isoperla sp. 2			
Skwala americana			
Brachycentrus americanus	84	63	93
Brachycentrus occidentalis			
Micrasema bactro			
Culoptila sp.			
Glossosoma sp.	6	13	10
Arctopsyche grandis	10	25	14
Hydropsyche cockerelli			
Hydropsyche occidentalis			
Hydropsyche sp. *(oslari)*			1
Hydroptila sp.			
Lepidostoma sp.	86	43	230
Ceraclea sp.			
Oecetis sp.			
Rhyacophila brunnea	1	5	4
Rhyacophila coloradensis			
Neothremma alicia			
Oligophlebodes minuta	10	12	19
Hesperophylae		2	
Orthocladiinae	236 (25P)	791 (63P)	269 (24P)
Tanypodinae	10	10	16
Tanytarsini		7	11
Chironomini			
Diamesinae	9		1
Simulium sp.	2		
Chelifera sp.		1	1
Clinocera sp.	1	1	
Hemerodromia sp.			
Oreogeton sp.			3
Tipula sp.	1		
Antocha sp.	24	23	15
Dicranota sp.		2	
Hexatoma sp.			
Atherix pachypus			
Pericoma sp.	1		
Optioservus sp.	9 (3A)	5 (2A)	15 (12A)
Heterlimnius corpulentus	54	43 (11A)	50 (3A)
Zaitzevia parvula			
Narpus concolor			
Hydracarina sp.	1	7	3
Gammarus sp.			
Physa sp.			3
Planorbidae			
Pisidium sp.		41	
Dugesia sp.			
Polycelis coronata	149	35	14
Oligochaeta	86	19	16
Nematoda			
Totals	595.0	806.0	1222.0

Table 6. Macroinvertebrate data collected from the Fryingpan River at site FPR-BAS on 29 April 2005.

Fryingpan River			
FPR-BAS		Sample	
29 Apr. 05	1	2	3
	Rep1	Rep2	Rep3
Acentrella insignificans			
Baetis (flavistriga)	4		
Baetis (tricaudatus)	197	89	61
Drunella grandis	4	3	3
Diphetor hageni		4	
Drunella coloradensis			
Drunella doddsi			
Ephemerella sp.	43	21	18
Serratella tibialis			
Cinygmula sp.	20	13	5
Epeorus longimanus	8	15	1
Epeorus sp.			3
Rhithrogena sp.	1		
Paraleptophlebia sp.	33	13	
Tricorythodes minutus			
Leptophlebiidae			3
Pteronarcella badia			
Prostoia besametsa			
Zapada sp.			
Triznaka signata			
Sweltsa sp.			
Claassenia sabulosa	3	2	
Hesperoperla pacifica	2	1	1
Isoperla fulva	11		
Isoperla sp. 2	10	4	1
Skwala americana			
Perlidae		1	
Perlodidae		2	
Brachycentrus americanus	121	6	6
Brachycentrus occidentalis			
Micrasema bactro			
Culoptila sp.			
Glossosoma sp.	6	17	15
Arctopsyche grandis	29		1
Hydropsyche cockerelli	32		
Hydropsyche occidentalis			
Hydropsyche sp. *(oslari)*	46	39	11
Hydroptila sp.			
Lepidostoma sp.	12	7	6
Ceraclea sp.			
Oecetis sp.			
Rhyacophila brunnea	25	5	
Rhyacophila coloradensis	1		
Neothremma alicia			
Oligophlebodes minuta		1	
Orthocladiinae	412 (13P)	44	26
Tanypodinae	6	3	1
Tanytarsini	2	2	0
Chironomini			
Diamesinae	2	33	5
Simulium sp.	1		1
Chelifera sp.	2		
Clinocera sp.			
Hemerodromia sp.			
Oreogeton sp.	7		
Tipula sp.			
Antocha sp.	69	39	28
Dicranota sp.	6		1
Hexatoma sp.			
Atherix pachypus		1	
Pericoma sp.			
Wiedemannia sp.		2	3
Optioservus sp.	37 (6A)	18	7
Heterlimnius corpulentus	1		
Zaitzevia parvula	1		
Narpus concolor			
Hydracarina sp.			
Gammarus sp.			
Physa sp.			
Planorbidae			
Pisidium sp.			
Dugesia sp.	8		
Polycelis coronata		5	1
Oligochaeta	218	140	51
Nematoda			1
Totals	931.0	530.0	260.0

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