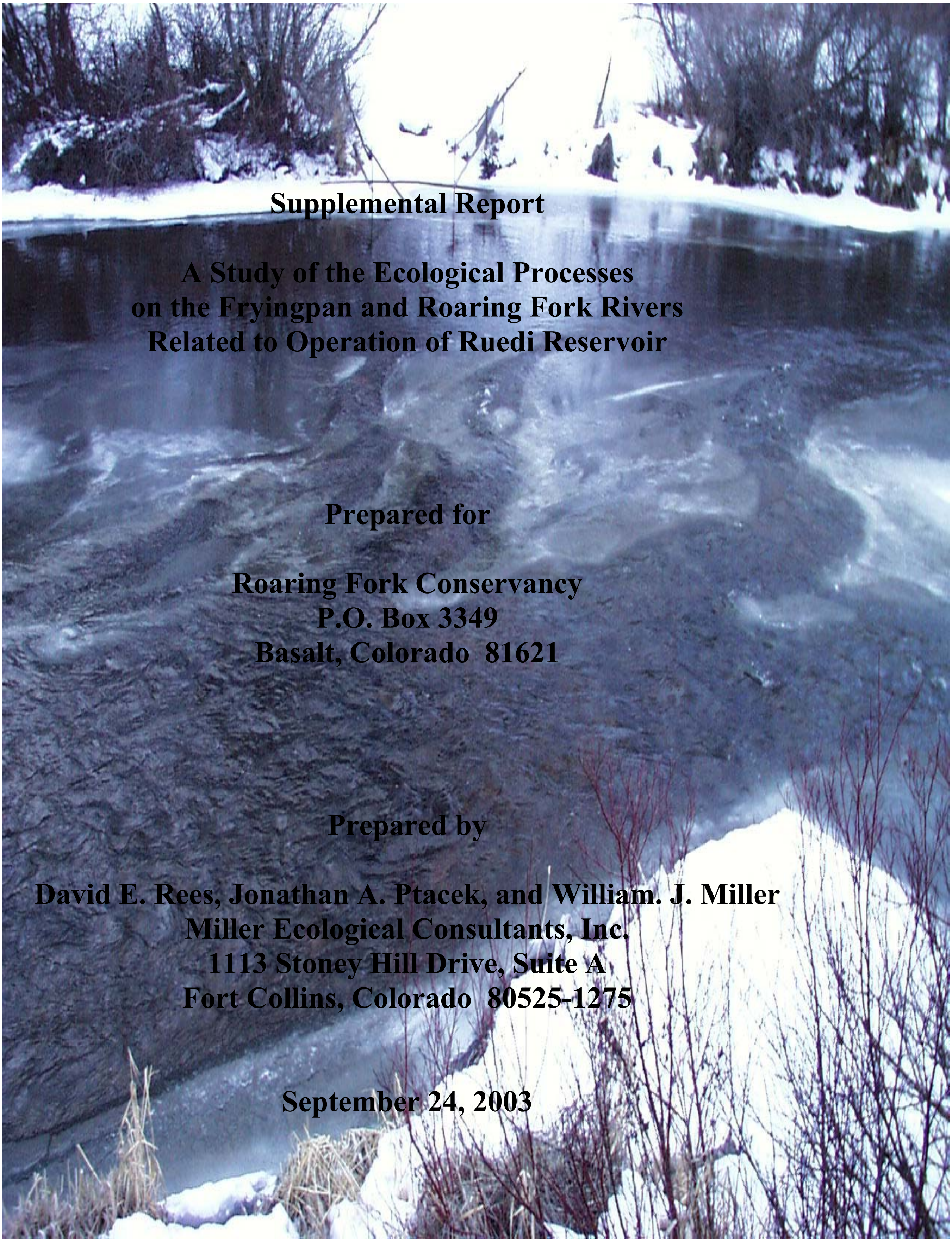

Supplemental Report

A Study of the Ecological Processes on the Fryingpan and Roaring Fork Rivers Related to Operation of Ruedi Reservoir

Prepared for

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INTRODUCTION

The mechanisms that govern the structure and function of benthic macroinvertebrate communities in the Fryingpan River are not entirely understood. For this reason, sampling continued during the Fall 2002 and Spring 2003 as a supplement to the study that occurred during the previous seasons (Ptacek et al. 2003). Releases from the impoundment at Ruedi Reservoir directly influence the benthic macroinvertebrate and fish communities that exist downstream. The influence of regulated discharge on the macroinvertebrate community can result in an increase in thermal stability and extended periods of flow stability. However, it is unknown 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. The results provided by macroinvertebrate monitoring and accurate identifications can provide a great deal of information pertaining to the flow regime and other aquatic conditions.

METHODS

MACROINVERTEBRATE SAMPLING

Benthic macroinvertebrate sampling was conducted during fall (12 Oct.) of 2002, and spring (29 Apr.) of 2003. Two sites on the Fryingpan River (FPR-Res and FPR-TC) were sampled on each occasion. 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

Figure 1. Satellite image of Fryingpan River study area from Ruedi Reservoir downstream to below Downey Creek (Macroinvertebrates: red, Thermographs: purple).

Figure 2. Satellite image of Fryingpan River study area from Downey Creek to Basalt (Macroinvertebrates: red, Thermographs: purple).

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 sometimes 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. Population densities and species lists were developed for each sampling site. A description of the metrics used in this study is provided in the final report.

THERMAL REGIME

To describe the 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. Capsules were placed in the river and attached to a permanent object by aircraft cable. Each capsule was drilled with holes to ensure adequate water circulation. Each thermograph was set to record hourly water temperature and was downloaded every few months using a Stowaway® Optic Shuttle™. Capsules were placed in out-of-the-way and inconspicuous mid-channel locations near the stream bottom at a depth where anchor ice is likely to form.

RESULTS

Additional macroinvertebrate sampling and analyses were conducted at sites on the Fryingpan River in the fall of 2002 and spring 2003 (Tables 1 and 2). Species lists are provided in Appendix A. The following section describes the changes observed in the applied metrics.

FALL 2002

In general, results of fall 2002 were similar to results the previous year; however, some slight differences were observed in taxa richness, density, and biomass (Table 1). Results of the fall 2002 sampling suggested that taxa richness had decreased slightly at both sights while density and biomass had increased. An increase in density (Figure 3) and biomass (Figure 4) at the FPR-RES site was particularly evident. The increase in these metrics can mostly be attributed to an increase in the number of flatworms (*P. coronata*) and chironomids that were collected during the fall of 2002. This slight variation in community structure was also reflected in community function (Figure 5). Functional groups exhibited similar composition during both years with slight variation occurring mostly in the scraper and predator groups.

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	FBI	EPT	Taxa Richness	Density (#/m^2)	Biomass (g/m^2)
FPR-RES	2.29	0.453	5.86	19	33	16,509	1.3820
FPR-TC	3.76	0.701	4.76	23	41	10,318	2.4338
Fall 2002							
FPR-RES	2.34	0.478	6.62	14	30	28,220	2.0104
FPR-TC	3.35	0.639	5.27	19	38	17,530	2.4856

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	FBI	EPT	Taxa Richness	Density (#/m^2)	Biomass (g/m^2)
FPR-RES	2.03	0.406	5.72	17	32	36,770	7.4108
FPR-TC	3.71	0.707	3.97	21	38	18,366	8.7948
Spring 2002							
FPR-RES	2.37	0.471	6.06	20	33	62,996	9.2919
FPR-TC	3.66	0.683	4.86	22	41	21,458	4.3774
Spring 2003							
FPR-RES	2.03	0.470	5.90	9	20	25,198	4.3867
FPR-TC	1.93	0.386	5.66	18	32	20,970	2.0629

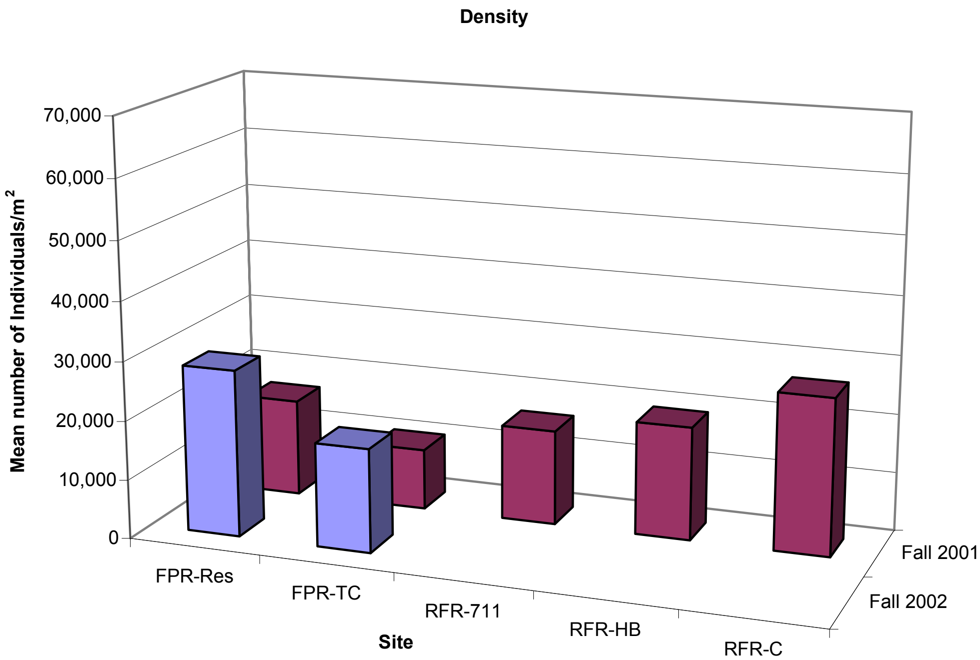


Figure 3. Density values obtained from fall sampling at sites on the Fryingpan River, Colorado.

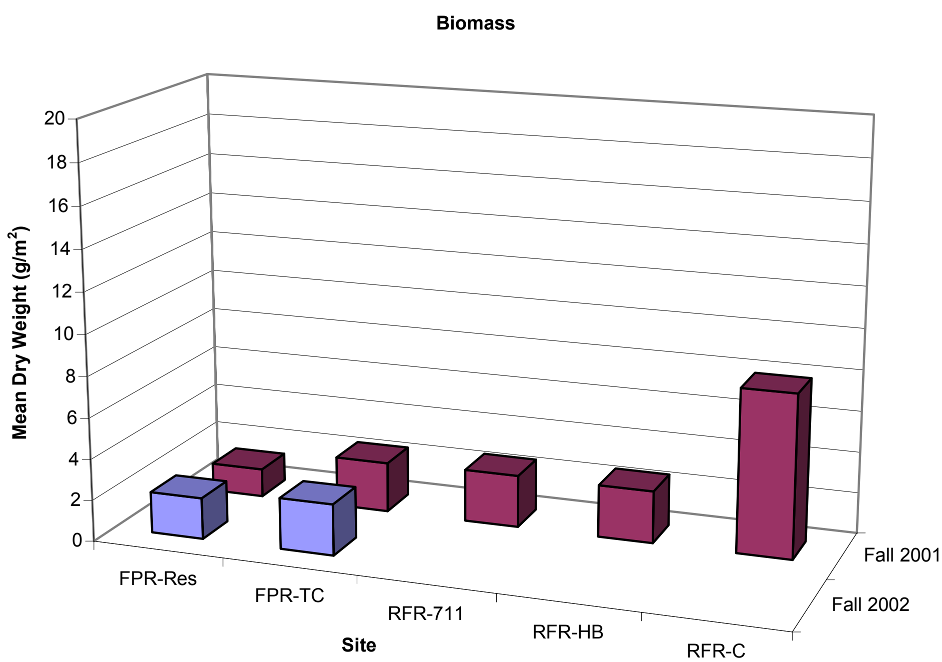
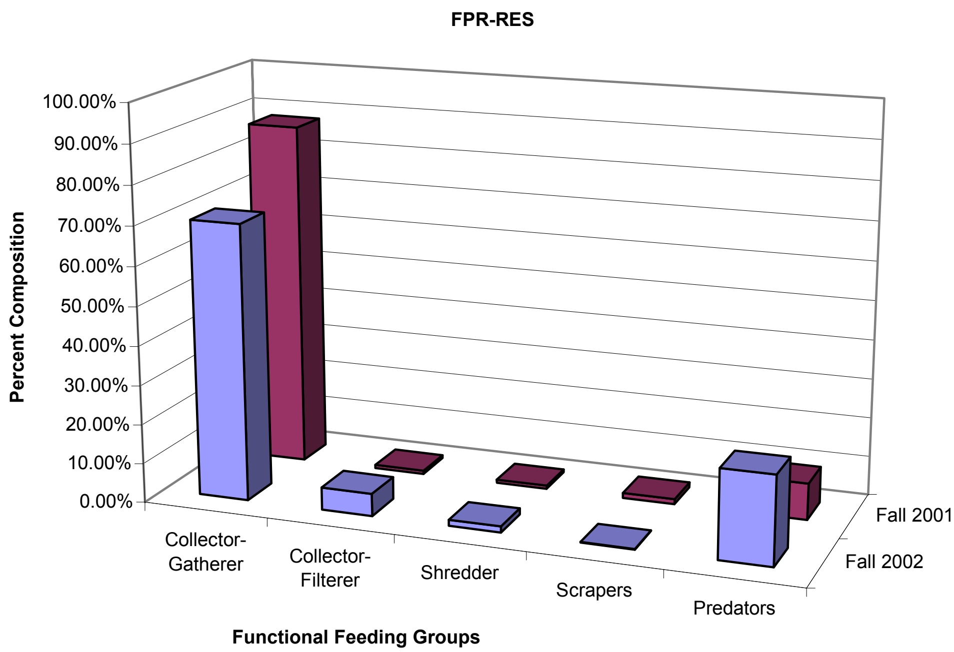


Figure 4. Biomass estimates obtained from fall sampling at sites on the Fryingpan River, Colorado.



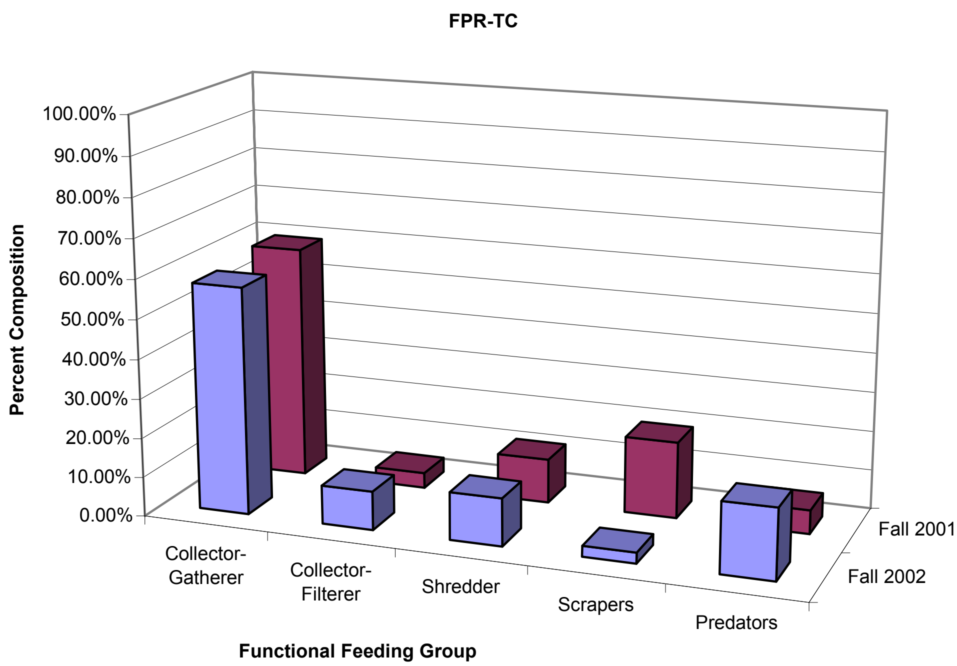


Figure 5. Functional feeding groups at site FPR-RES (top) and FPR-TC (bottom) during fall sampling on the Fryingpan River, Colorado.

The differences in metrics observed during two years of fall sampling may be well within the range of natural variation that occurs at these sites. It is difficult to determine what would be considered "normal", or what may cause slight variation among years using data from only two years. It is important to note that fall samples were similar between 2001 and 2002 when observing the substantial changes that occurred in spring samples (Table 1).

SPRING 2003

Evaluation of data collected during spring 2003 indicated that there had been substantial changes in macroinvertebrate communities compared to results from the previous spring sampling events (Table 2). The lack of similarities in response of the metric values at each site suggests that the changes in benthic macroinvertebrate communities were somewhat different at each location.

Some index values indicated substantial change in benthic macroinvertebrate communities at site FPR-RES (EPT, taxa richness, density and biomass), while others did not (diversity, evenness, FBI and functional feeding groups). The EPT and taxa richness indices were the result of the lack of stoneflies and caddisflies that were found in samples during spring 2003. These two Orders of aquatic insects accounted for eight (8) of the taxa collected in 2001 and ten (10) of the taxa collected in 2002. Only one (1) representative from these two Orders was collected in 2003. Density of benthic macroinvertebrates at FPR-RES decreased by more than 60% from what had been reported the previous year (Figure 6). The low density combined with the absence of larger size macroinvertebrates (stoneflies and caddisflies) resulted in a biomass number (4.3867 g) that was considerably lower that those reported for the previous spring samples (Figure 7). The metrics that remained relatively unaffected (diversity, evenness, FBI and functional feeding groups) are often more sensitive to pollution-related disturbance. These metrics have always indicated some disturbance that was thought to be an influence of the Ruedi Dam.

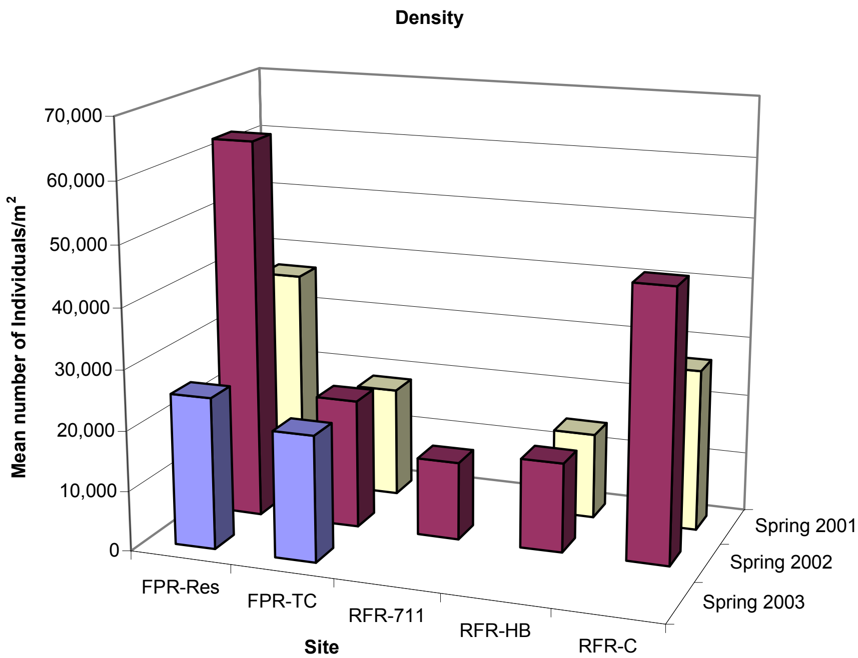


Figure 6. Density values obtained from spring sampling at sites on the Fryingpan River, Colorado.

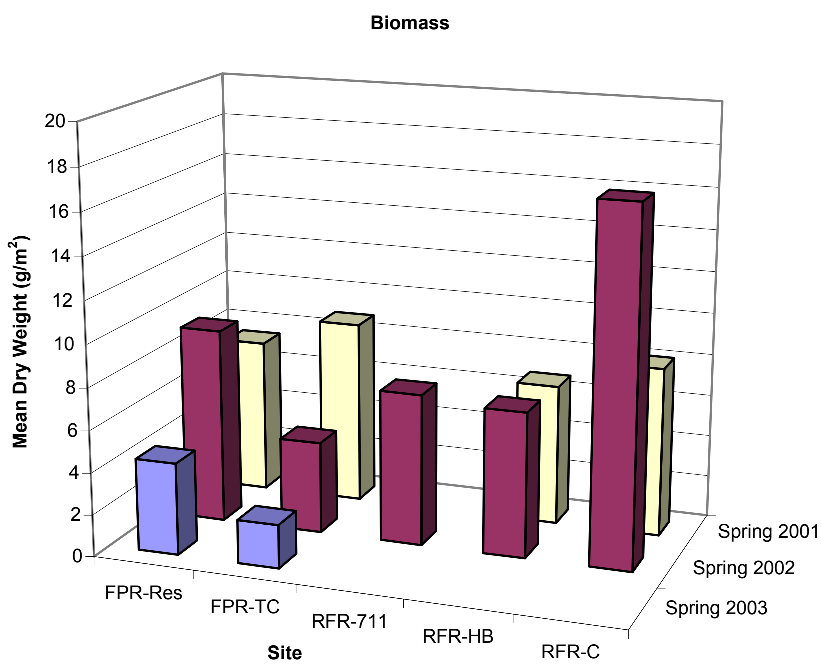
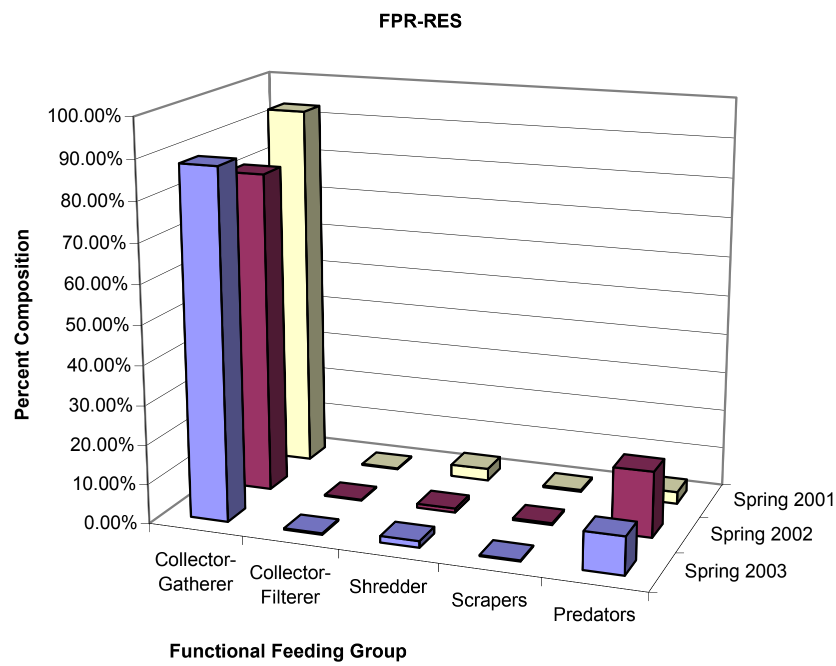


Figure 7. Biomass estimates obtained from spring sampling at sites on the Fryingpan River, Colorado.

The data provided by spring sampling during 2003 at site FPR-TC indicated a decline in aquatic conditions that was reflected by most metric values (Table 2). This change in metric values was the result of a severe reduction in the density of EPT taxa (mayflies, stoneflies and caddisflies) in spring samples during 2003. The data from the appendix in this and the previous report shows that the average number of EPT individuals collected in a sample during 2001 was 1,144. This number declined slightly in the spring of 2002 to 1,052. In the spring of 2003 the average number of individuals representing the EPT taxa had decreased to 261. At the same time as the density of EPT taxa was decreasing, the density of chironomids was increasing. This resulted in a mean density value that was similar to those reported in previous years (Figure 6), but the replacement of large-bodied taxa (stoneflies, caddisflies) with small-bodied taxa (chironomids) was resulted in a decrease in the mean biomass (Figure 7). The disproportion of chironomids to other taxa caused a decrease in diversity and evenness values (1.93 and 0.386, respectively) to levels that indicate a stressed or impacted community. Ward et al. (2002) indicates that optimum metric values range between 3.0 - 4.0 (for diversity), and 0.6 – 0.8 (evenness) in Colorado streams. The greater proportion of chironomids resulted in a shift in the composition of functional feeding guilds to a community dominated by collector-gatherers (Figure 8).

DISCUSSION

Aquatic macroinvertebrate communities were evaluated as a means to understand 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 and regulated discharge in the Fryingpan River provide a major influence on benthic macroinvertebrates.



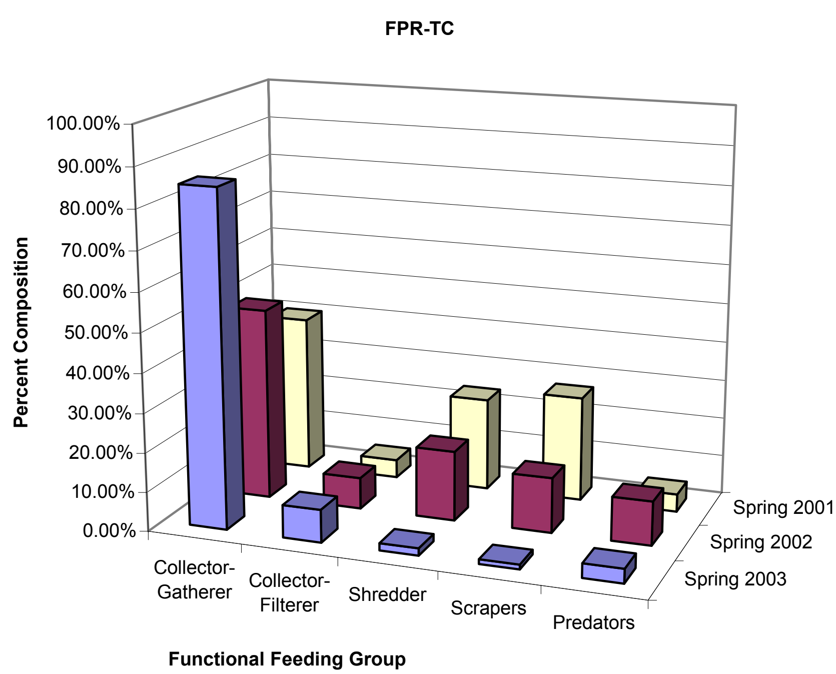


Figure 8. Functional feeding groups at site FPR-RES (top) and FPR-TC (bottom) during spring sampling on the Fryingpan River, Colorado.

Changes that were observed in benthic macroinvertebrate communities during the spring of 2003 were similar to those expected from various types of pollution. However, the lack of similar responses between sites FPR-RES and FPR-TC, and the season in which the degrading of these communities took place, did not support the idea that that these alterations were pollution induced. This suggests that benthic communities in the spring of 2003 were responding to physical processes associated with changes in discharge.

Discharge during the winter of 2002-2003 was unusually low due to drought conditions during previous years, (Figure 9). The difference in discharge between the winter 2001/2002 and 2002/2003 seasons may be directly responsible for much of the observed alterations in benthic macroinvertebrate communities. At site FPR-RES there are few other explanations for a decrease in sensitive taxa and a substantial decline in density. The mean daily water temperature below the dam was slightly lower during the early portion of the 2002-2003 winter (Figure 10), but anchor ice at this location should not have been an issue. Some other possible explanations could include changes in water quality (which was not measured) or human influence (increased wading traffic from fishermen).

The impact to benthic macroinvertebrate communities at site FPR-TC was different than that observed at FPR-RES. Densities of EPT taxa were reduced while chironomid densities increased. This difference may be the result of combined affects of low flows and anchor ice formation. Decreases observed in the density of EPT taxa may be the result of a scouring process that results from anchor ice formation. Many of the EPT taxa use microhabitat (surface areas) that would be susceptible to this scouring process, whereas the habitat used by most chironomids (subsurface) provides better protection. Thermograph data from December 2002, January 2003, and February 2003 identified periods of anchor ice formation immediately upstream from the FPR-TC site (Figures 11-13). The lack of water temperature data for the previous winter season (2001-2002) at FPR-TC makes it impossible to compare anchor ice formation; however, anchor ice were observed during that time period.

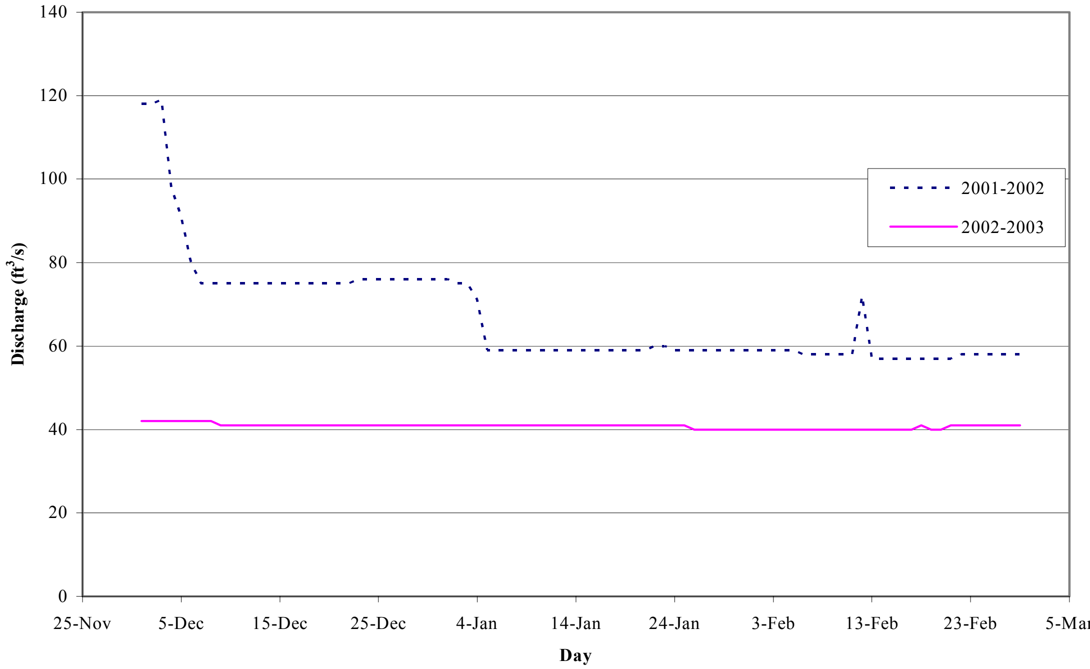


Figure 9. Winter discharge (December-February) for the Fryingpan River below Ruedi Reservoir, Colorado.

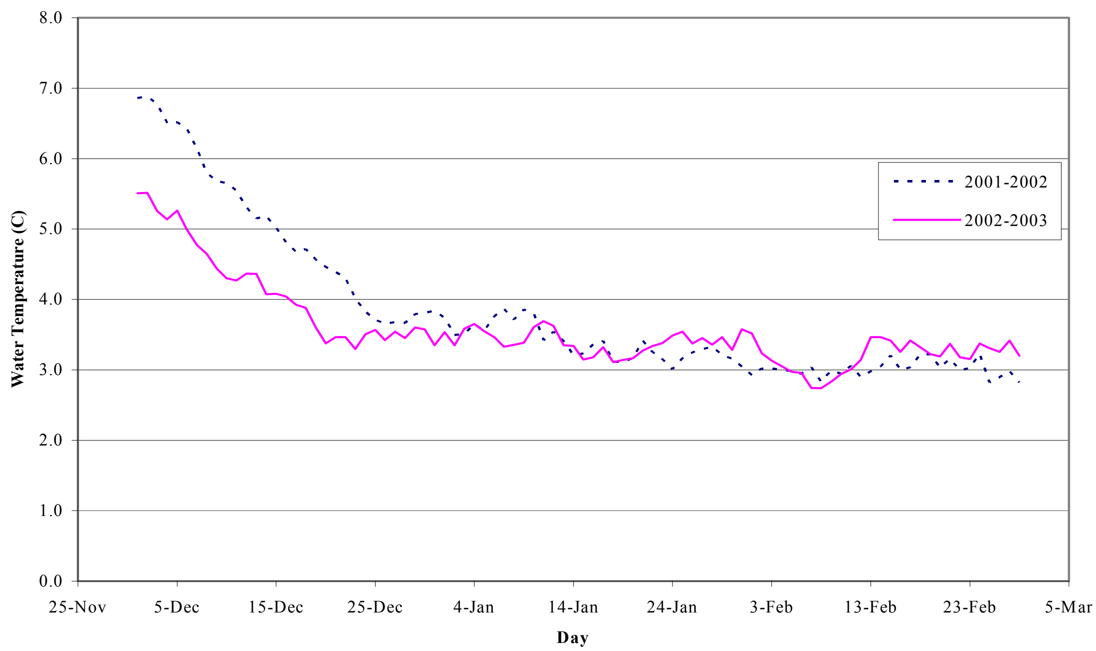


Figure 10. Winter water temperatures for Fryingpan River below Ruedi Reservoir, Colorado.

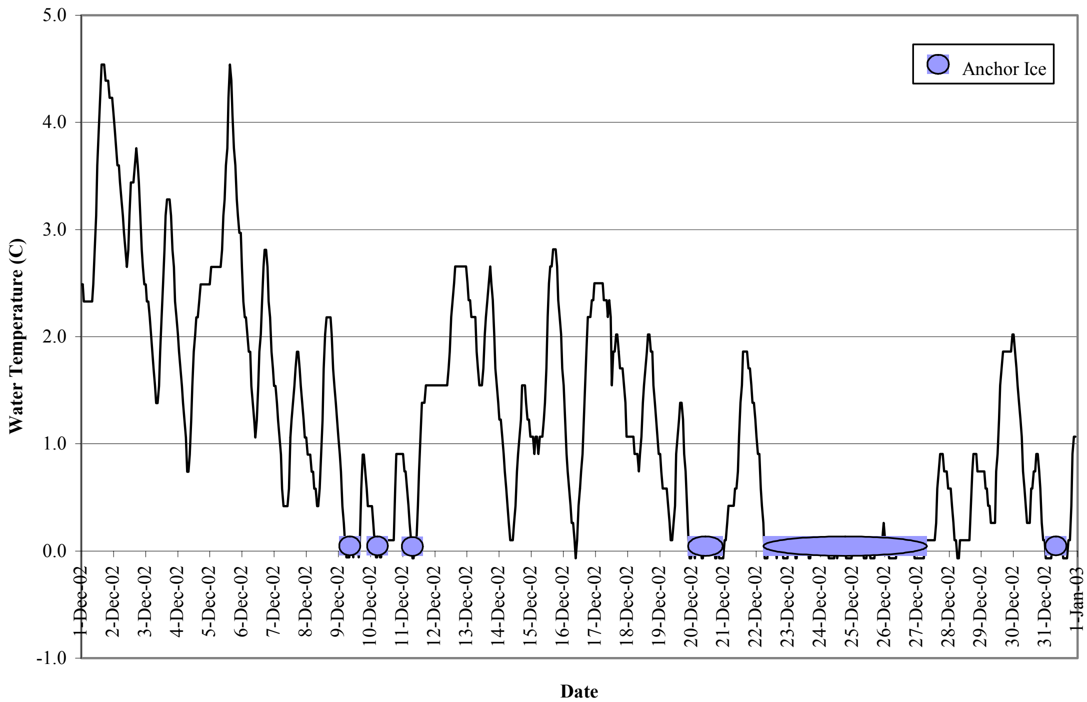


Figure 11. Hourly water temperatures during December 2002 at Palm Site.

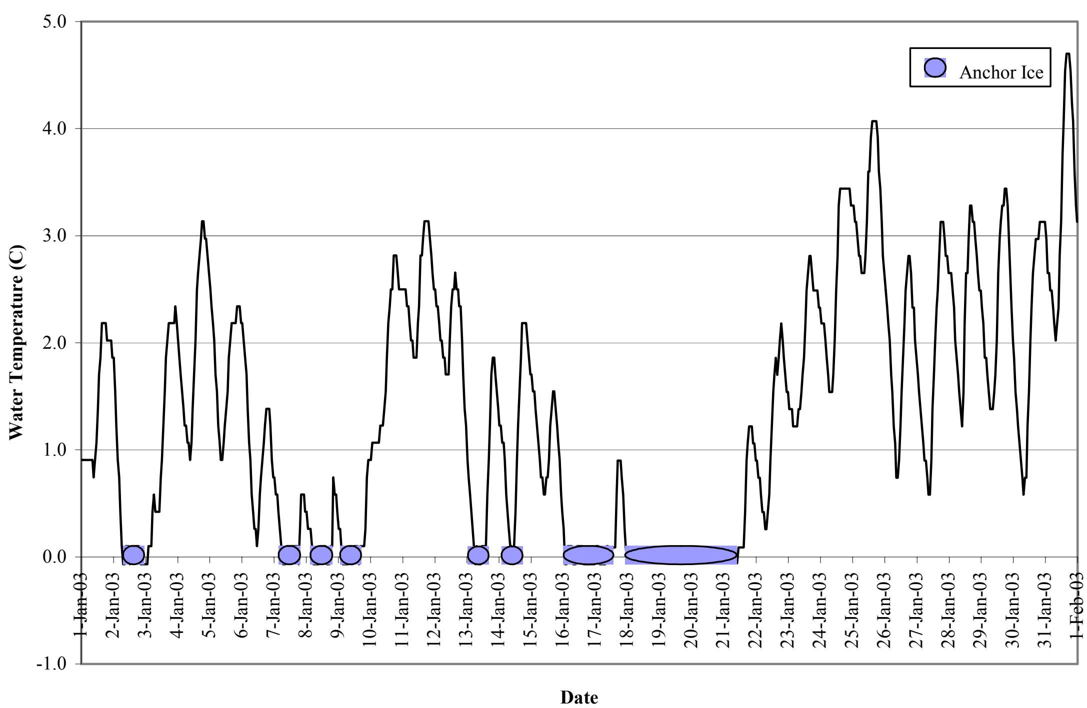


Figure 12. Hourly water temperatures during January 2003 at Palm Site.

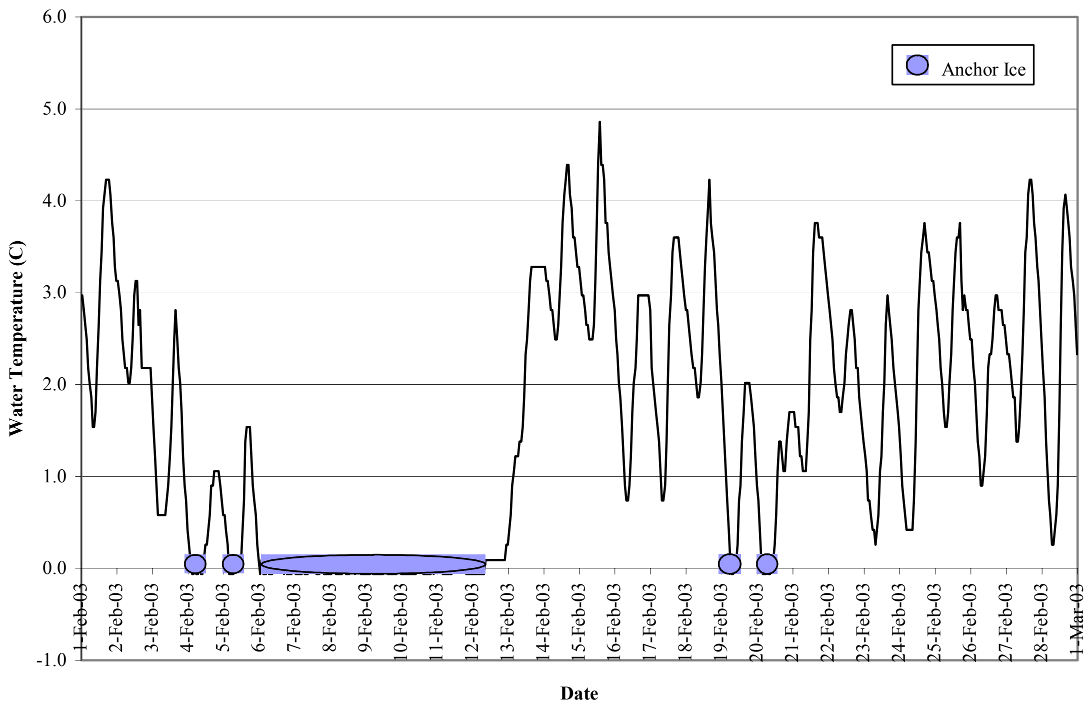


Figure 13. Hourly water temperatures during February 2003 at Palm Site.

The lower discharge at site FPR-TC in 2003 should have been much more conducive to the formation of anchor ice than the higher flows during the previous winter. Lower flow would be cooled more rapidly than at higher flows. However, air temperature data indicates that the 2002-2003 winter was milder than the previous winter (Table 3). If anchor ice formation is at least partially responsible for the degraded conditions observed at site FPR-TC during the spring of 2003, then conditions could have potentially been worse with colder air temperatures during the winter months.

Table 3. Mean monthly air temperatures (^{o}F) taken at Meredith, Colorado.

	Mean Maximum	Mean Minimum	Mean Average
December 2001	31.1	-1.2	14.9
January 2002	29.0	-1.9	13.5
February 2002	29.1	-6.9	11.1
December 2002	35.5	6.5	21.0
January 2003	37.5	11.3	24.4
February 2003	29.2	8.1	18.7

RECOMMENDATIONS

Questions for future studies include:

- Are benthic macroinvertebrates more influenced during the winter by changes in discharge or anchor ice formation?

- What is the specific relationship between anchor ice formation, discharge and air temperature at site FPR-TC (or other locations in the Fryingpan River)?

- In a winter with average air temperatures and cloud cover, what is the discharge that would be necessary to maintain high densities of macroinvertebrates.

- What is the time and extent of recovery that can be expected after impact to macroinvertebrate communities?

To answer the preceding questions, macroinvertebrate sampling and air and water temperature monitoring should continue in the spring and fall for at least the next year. Ideally, it would be good to compare sampling before and after winters with different base lows and different air temperature patterns. Sites for temperature monitoring and macroinvertebrate sampling should at least include FPR-RES and FPR-TC, and could be expanded if there are other areas of concern. Water quality data (collected frequently) from this reach of the Fryingpan River would also be useful.

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APPENDIX A

Table 1. Macroinvertebrate data collected from the Fryingpan River at site FPR-RES on 12 October 2002.

Fryingpan River										
FPR-RES		Sample			Mean	ni*LOGni	Count	TV		FBI
12 Oct. 02	1	2	3							
Acentrella insignificans	1	9	12		7.33	6.35	1	4		0.0120
Baetis (flavistriga)										
Baetis (tricaudatus)	279	401	200		293.33	723.76	1	4		0.4785
Drunella grandis	3	1	4		2.67	1.14	1	1		0.0011
Drunella coloradensis										
Drunella doddsi	3	7	9		6.33	5.08	1	1		0.0026
Ephemerella sp.	44	36	29		36.33	56.69	1	1		0.0148
Cinygmula sp.										
Epeorus longimanus										
Rhithrogena sp.										
Paraleptophlebia sp.	2	5	2		3.00	1.43	1	2		0.0024
Tricorythodes minutus										
Caenis sp.										
Pteronarcella badia										
Capnia sp.										
Zapada sp.		1			0.33	-0.16	1	2		0.0003
Paraperla frontalis										
Sweltsa sp.										
Triznaka signata										
Claassenia sabulosa										
Hesperoperla pacifica										
Skwala americana										
Isoperla fulva										
Isoperla sp. 2			1		0.33	-0.16	1	2		0.0003
Brachycentrus americanus	1				0.33	-0.16	1	1		0.0001
Brachycentrus occidentalis										
Agapetus boulderensis										
Culoptila sp.										
Glossosoma sp.		1			0.33	-0.16	1	0		0.0000
Arctopsyche grandis										
Hydropsyche cockerelli										
Hydropsyche occidentalis			1		0.33	-0.16	1	4		0.0005
Hydropsyche sp. (oslari)										
Hydroptila sp.	6	4	1		3.67	2.07	1	1		0.0015
Lepidostoma sp.										
Ceraclea sp.										
Oecetis sp.										
Dolophilodes aequalis										
Rhyacophila brunnea	1				0.33	-0.16	1	0		0.0000
Rhyacophila coloradensis		1			0.33	-0.16	1	0		0.0000
Neothremma alicia										
Oligophlebodes minuta										
Orthocladiinae	1582	1026	512		1040.00	3137.71	1	6		2.5445
Tanypodinae										
Tanytarsini	6	11	6		7.67	6.78	1	6		0.0188
Chironomini		1			0.33	-0.16	1	8		0.0011
Diamesinae		1			0.33	-0.16	1	6		0.0008
Simulium sp.	50	283	58		130.33	275.66	1	6		0.3189
Protanyderus margarita										
Chelifera sp.										
Clinocera sp.										
Hemerodromia sp.										
Antocha sp.	21	20	11		17.33	21.47	1	3		0.0212
Dicranota sp.										
Hexatoma sp.										
Atherix pachypus										
Pericoma sp.		1			0.33	-0.16	1	10		0.0014
Optioservus sp.										
Heterlimnius corpulentus	20	5	10		11.67	12.45	1	4		0.0190
Zaitzevia parvula	1				0.33	-0.16	1	4		0.0005
Microcylloepus sp.										
Narpus concolor										
Hydracarina sp.	8	8	2		6.00	4.67	1	8		0.0196
Gammarus sp.	3	1			1.33	0.17	1	4		0.0022
Physa sp.		1			0.33	-0.16	1	8		0.0011
Pisidium sp.	1		1		0.67	-0.12	1	8		0.0022
Dugesia sp.										
Polycelis coronata	336	611	655		534.00	1456.51	1	8		1.7420
Oligochaeta	372	552	106		343.33	870.60	1	10		1.4000
Nematoda	2	4	4		3.33	1.74	1	10		0.0136
Totals	2742.0	2991.0	1624.0		2452.33	6582.25	30			
										6.62
Shannon Weaver Diversity						2.34				
Shannon Weaver Evenness						0.478				

Table 2. Macroinvertebrate data collected from the Fryingpan River at site FPR-TC on 12 October 2002.

Fryingpan River										
FPR-TC		Sample			Mean	ni*LOGni	Count	TV		FBI
12 Oct. 02	1	2	3							
Acentrella insignificans										
Baetis (flavistriga)										
Baetis (tricaudatus)	483	447	448		459.33	1222.80	1	4		1.2061
Drunella grandis	17	9	6		10.67	10.97	1	1		0.0070
Drunella coloradensis										
Drunella doddsi	1	2	3		2.00	0.60	1	1		0.0013
Ephemerella sp.	10	3	13		8.67	8.13	1	1		0.0057
Cinygmula sp.	8	5	19		10.67	10.97	1	4		0.0280
Epeorus longimanus										
Rhithrogena sp.										
Paraleptophlebia sp.	47	56	99		67.33	123.10	1	2		0.0884
Tricorythodes minutus										
Caenis sp.										
Pteronarcella badia										
Capnia sp.										
Zapada sp.										
Paraperla frontalis										
Sweltsa sp.										
Triznaka signata										
Claassenia sabulosa										
Hesperoperla pacifica	2	2	3		2.33	0.86	1	1		0.0015
Skwala americana										
Isoperla fulva	4	2	6		4.00	2.41	1	2		0.0053
Isoperla sp. 2										
Brachycentrus americanus	53	14	26		31.00	46.23	1	1		0.0204
Brachycentrus occidentalis										
Agapetus boulderensis		1	1		0.67	-0.12	1	0		0.0000
Culoptila sp.										
Glossosoma sp.		1			0.33	-0.16	1	0		0.0000
Arctopsyche grandis	12	14	9		11.67	12.45	1	4		0.0306
Hydropsyche cockerelli	1				0.33	-0.16	1	4		0.0009
Hydropsyche occidentalis										
Hydropsyche sp. (oslari)	3	4			2.33	0.86	1	4		0.0061
Hydroptila sp.	1				0.33	-0.16	1	1		0.0002
Lepidostoma sp.	236	149	139		174.67	391.64	1	4		0.4586
Ceraclea sp.										
Oecetis sp.										
Dolophilodes aequalis	1				0.33	-0.16	1	3		0.0007
Rhyacophila brunnea	3	2	2		2.33	0.86	1	0		0.0000
Rhyacophila coloradensis										
Neothremma alicia										
Oligophlebodes minuta	22	16	17		18.33	23.16	1	4		0.0481
Orthocladiinae	92	88	255		145.00	313.40	1	6		0.5711
Tanypodinae	7	3	3		4.33	2.76	1	6		0.0171
Tanytarsini	10	14	12		12.00	12.95	1	6		0.0473
Chironomini										
Diamesinae			2		0.67	-0.12	1	6		0.0026
Simulium sp.	2	4	6		4.00	2.41	1	6		0.0158
Protanyderus margarita										
Chelifera sp.	6	3	1		3.33	1.74	1	6		0.0131
Clinocera sp.										
Hemerodromia sp.										
Antocha sp.	41	14	22		25.67	36.17	1	3		0.0505
Dicranota sp.	1				0.33	-0.16	1	3		0.0007
Hexatoma sp.										
Atherix pachypus		1			0.33	-0.16	1	2		0.0004
Pericoma sp.	1	1			0.67	-0.12	1	10		0.0044
Optioservus sp.	1				0.33	-0.16	1	4		0.0009
Heterlimnius corpulentus	76	91	87		84.67	163.21	1	4		0.2223
Zaitzevia parvula										
Microcylloepus sp.			1		0.33	-0.16	1	4		0.0009
Narpus concolor										
Hydracarina sp.	16	8	20		14.67	17.11	1	8		0.0770
Gammarus sp.										
Physa sp.			2		0.67	-0.12	1	8		0.0035
Pisidium sp.	50	141	70		87.00	168.74	1	8		0.4569
Dugesia sp.										
Polycelis coronata	189	269	238		232.00	548.79	1	8		1.2184
Oligochaeta	147	61	74		94.00	185.47	1	10		0.6171
Nematoda	5	6	7		6.00	4.67	1	10		0.0394
Totals	1548.0	1431.0	1591.0		1523.33	3310.71	38			
										5.27
Shannon Weaver Diversity						3.35				
Shannon Weaver Evenness						0.639				

Table 3. Macroinvertebrate data collected from the Fryingpan River at site FPR-RES on 29 April 2003.

Fryingpan River										
FPR-RES		Sample			Mean	ni*LOGni	Count	TV		FBI
29 Apr. 03	1	2	3							
Acentrella insignificans										
Baetis (flavistriga)										
Baetis (tricaudatus)	177	340	255		257.33	620.30	1	4		0.4701
Drunella grandis	2	3			1.67	0.37	1	1		0.0008
Drunella coloradensis	2				0.67	-0.12	1	1		0.0003
Drunella doddsi		5	2		2.33	0.86	1	1		0.0011
Ephemerella sp.	15	45	51		37.00	58.02	1	1		0.0169
Serratella tibialis										
Cinygmula sp.	4	5	4		4.33	2.76	1	4		0.0079
Epeorus longimanus		3	4		2.33	0.86	1	4		0.0043
Rhithrogena sp.										
Paraleptophlebia sp.	4	7	3		4.67	3.12	1	2		0.0043
Tricorythodes minutus										
Pteronarcella badia										
Prostoia besametsa										
Triznaka signata										
Sweltsa sp.										
Claassenia sabulosa										
Hesperoperla pacifica										
Isoperla fulva										
Isoperla sp. 2										
Skwala americana										
Brachycentrus americanus										
Brachycentrus occidentalis										
Micrasema bactro										
Culoptila sp.										
Glossosoma sp.										
Arctopsyche grandis										
Hydropsyche cockerelli										
Hydropsyche occidentalis										
Hydropsyche sp. *(oslari)*										
Hydroptila sp.										
Lepidostoma sp.										
Ceraclea sp.										
Oecetis sp.										
Rhyacophila brunnea										
Rhyacophila coloradensis	1				0.33	-0.16	1	0		0.0000
Neothremma alicia										
Oligophlebodes minuta										
Orthocladiinae	1165	1223	858		1082.00	3283.03	1	6		2.9648
Tanypodinae										
Tanytarsini	3	1	4		2.67	1.14	1	6		0.0073
Chironomini			1		0.33	-0.16	1	8		0.0012
Diamesinae	596	585	459		546.67	1496.62	1	6		1.4979
Simulium sp.	2	11			4.33	2.76	1	6		0.0119
Protanyderus margarita										
Bibiocephala grandis										
Chelifera sp.										
Clinocera sp.										
Hemerodromia sp.										
Tipula sp.										
Antocha sp.	2	1			1.00	0.00	1	3		0.0014
Dicranota sp.										
Hexatoma sp.										
Atherix pachypus										
Pericoma sp.										
Optioservus sp.										
Heterlimnius corpulentus	1	2	4		2.33	0.86	1	4		0.0043
Zaitzevia parvula										
Narpus concolor										
Hydracarina sp.	7	11	20		12.67	13.97	1	8		0.0463
Gammarus sp.										
Physa sp.										
Planorbidae										
Pisidium sp.	1				0.33	-0.16	1	8		0.0012
Dugesia sp.										
Polycelis coronata	145	139	294		192.67	440.21	1	8		0.7039
Oligochaeta	53	20	29		34.00	52.07	1	10		0.1553
Nematoda										
Totals	2180.0	2401.0	1988.0		2189.67	5976.35	20			
										5.90
Shannon Weaver Diversity						2.03				
Shannon Weaver Evenness						0.470				

Table 4. Macroinvertebrate data collected from the Fryingpan River at site FPR-TC on 29 April 2003.

Fryingpan River										
FPR-TC		Sample			Mean	ni*LOGni	Count	TV		FBI
29 Apr. 03	1	2	3							
Acentrella insignificans										
Baetis (flavistriga)										
Baetis (tricaudatus)	109	263	37		136.33	291.02	1	4		0.2993
Drunella grandis	2	2	2		2.00	0.60	1	1		0.0011
Drunella coloradensis										
Drunella doddsi										
Ephemerella sp.		2	8		3.33	1.74	1	1		0.0018
Serratella tibialis	12	18			10.00	10.00	1	1		0.0055
Cinygmula sp.	18	8	14		13.33	15.00	1	4		0.0293
Epeorus longimanus	3	18	1		7.33	6.35	1	4		0.0161
Rhithrogena sp.										
Paraleptophlebia sp.	10	44	45		33.00	50.11	1	2		0.0362
Tricorythodes minutus										
Pteronarcella badia										
Prostoia besametsa										
Triznaka signata										
Sweltsa sp.										
Claassenia sabulosa			3		1.00	0.00	1	1		0.0005
Hesperoperla pacifica	4	1	3		2.67	1.14	1	1		0.0015
Isoperla fulva		1	1		0.67	-0.12	1	2		0.0007
Isoperla sp. 2										
Skwala americana										
Brachycentrus americanus	2	13	8		7.67	6.78	1	1		0.0042
Brachycentrus occidentalis										
Micrasema bactro		1			0.33	-0.16	1	1		0.0002
Culoptila sp.										
Glossosoma sp.										
Arctopsyche grandis	8	6	6		6.67	5.49	1	4		0.0146
Hydropsyche cockerelli										
Hydropsyche occidentalis										
Hydropsyche sp. *(oslari)*										
Hydroptila sp.	1				0.33	-0.16	1	1		0.0002
Lepidostoma sp.	23	23	44		30.00	44.31	1	4		0.0658
Ceraclea sp.										
Oecetis sp.										
Rhyacophila brunnea	1		2		1.00	0.00	1	0		0.0000
Rhyacophila coloradensis	1				0.33	-0.16	1	0		0.0000
Neothremma alicia										
Oligophlebodes minuta	4	5	5		4.67	3.12	1	4		0.0102
Orthocladiinae	901	1460	1495		1285.33	3996.12	1	6		4.2319
Tanypodinae	8	14	22		14.67	17.11	1	6		0.0483
Tanytarsini	53	103	211		122.33	255.38	1	6		0.4028
Chironomini										
Diamesinae	12	8	6		8.67	8.13	1	6		0.0285
Simulium sp.										
Protanyderus margarita										
Bibiocephala grandis										
Chelifera sp.		3	6		3.00	1.43	1	6		0.0099
Clinocera sp.		1	1		0.67	-0.12	1	6		0.0022
Hemerodromia sp.										
Tipula sp.										
Antocha sp.	6	11	21		12.67	13.97	1	3		0.0209
Dicranota sp.										
Hexatoma sp.										
Atherix pachypus										
Pericoma sp.										
Optioservus sp.			4		1.33	0.17	1	4		0.0029
Heterlimnius corpulentus	20	25	76		40.33	64.76	1	4		0.0885
Zaitzevia parvula										
Narpus concolor										
Hydracarina sp.	4	15	16		11.67	12.45	1	8		0.0512
Gammarus sp.										
Physa sp.										
Planorbidae										
Pisidium sp.	10	14	21		15.00	17.64	1	8		0.0658
Dugesia sp.										
Polycelis coronata	17	52	15		28.00	40.52	1	8		0.1229
Oligochaeta	24	21	3		16.00	19.27	1	10		0.0878
Nematoda		2	4		2.00	0.60	1	10		0.0110
Totals	1253.0	2134.0	2080.0		1822.33	4882.49	32			
										5.66
Shannon Weaver Diversity						1.93				
Shannon Weaver Evenness						0.386				