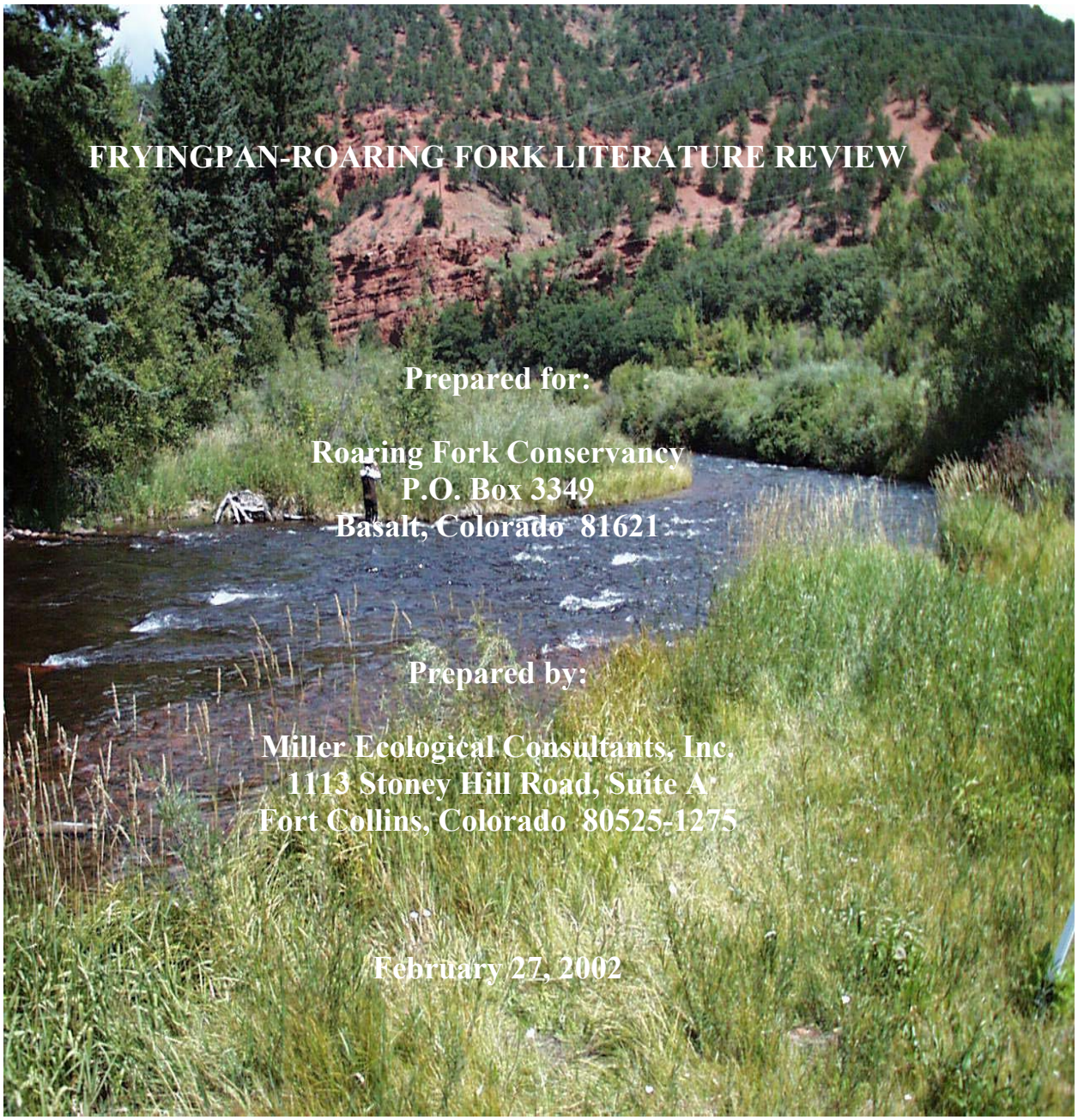

FRYINGPAN-ROARING FORK LITERATURE REVIEW

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February 27, 2002

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INTRODUCTION

This literature review was conducted as the first part of the Fryingpan Roaring Fork Fisheries Study for the Roaring Fork Conservancy. The literature review consisted of compiling data, reports and information on instream flows, fish populations and other factors related to the aquatic ecosystem for the Fryingpan and Roaring Fork rivers. The purpose of the literature review is to assemble a database of existing information from data sources including the Colorado Division of Wildlife, Bureau of Reclamation, Colorado River Water Conservation District, Roaring Fork Conservancy, and other entities. A total of 31 references were assembled. The annotated bibliography contains 28 references that pertain directly to fisheries, instream flow and fish population studies that date from 1943 to the present.

The literature review is organized first by an overview of the Fryingpan River and information pertaining to it. The second section addresses the Roaring Fork River and information that pertains directly to it. The third section is the annotated bibliography with a description of each of the references reviewed. This information will be used in the final fisheries report for historical information for the two rivers. This historical information will be used and put in context of the current studies on instream flow, spawning habitats and fishery information.

FRYINGPAN RIVER

The Fryingpan River and its associated fishery have been the focus of numerous historical studies. Earliest studies focused primarily on the trout population and potential as a sport fishery (Hunter and Parson 1943). Healthy reproducing trout populations were found from headwater streams down to the confluence with the Roaring Fork River. Species of trout that were found included: rainbow trout, brown trout, brook trout and cutthroat trout (Hunter and Parson 1943). Dominance of certain species depended on location and specific habitat features; however early reports suggested that rainbow trout were dominant in the lower reaches. Areas of suitable trout habitat could be found throughout the river system.

Ruedi Dam was constructed on the Fryingpan River, in 1964-1968 (U.S. Bureau of Reclamation 1975), 14 miles above the confluence with the Roaring Fork River. This flooded 7 miles of river upstream from the dam inundating 1,000 surface acres of meadow habitat. The capacity of Ruedi Reservoir was 102,360 acre/feet (Finnell 1972). During the early 1970's numerous studies were conducted to determine the effect of Ruedi Dam on trout populations in the Fryingpan River (Hoppe and Finnell 1970; Finnell 1972; Finnell and Bennet 1973; Finnell and Bennet 1974; Finnell and Bennet 1977). The results of these studies indicated that the average summer temperature of the Fryingpan River below the dam had dropped significantly. Healthy macroinvertebrate populations were found throughout the 14-mile reach especially in the lower section near the confluence with the Roaring Fork River. High populations of trout were found with

rainbow trout being the dominant species. Spawning areas were limited to two relatively small reaches. One area of spawning habitat was located directly below the dam and the other was near the confluence of Seven Castles Creek. Recommendations were made to maintain a flow of at least 100cfs whenever possible to enhance trout spawning success (Hoppe and Finnell 1970).

During the 1970's several studies reported information related to Ruedi Reservoir and the upstream portion of the Fryingpan River that could potentially influence the river downstream from the dam. The opossum shrimp, *Mysis relicta*, was released in Ruedi Reservoir in 1970 (Finnell 1972), but did not become well established for several years. Stratification of Ruedi Reservoir was found during the summer months with a thermocline extending to 75 feet deep in September. Water released from the reservoir was found to be high in pH, conductivity and hardness (Finnel and Bennet 1977). This was assumed to be a result of gypsum deposits near the dam. In 1977, surveys of headwater tributaries found brook trout and Colorado River cutthroat trout in several streams. Recommendations were made to maintain at least 50% of the surface area of the reservoir in order to protect lake dwelling fish species (Finnel and Bennet 1977).

Rainbow trout were stocked throughout the 1970's in Fryingpan River below Ruedi Dam. Studies on movement of stocked trout suggested that migration was minimal (Finnel and Bennet 1974). Rainbow trout growth rates were considered normal while brown trout growth rates were found to be above average for streams in that region (Finnel and Bennet 1977). During the late 1970's four methods of specific habitat quantification using computer analyses resulted in recommended minimum flows ranging from 47.5cfs to 65cfs in the Fryingpan River (Nehring 1979).

Studies conducted on the Fryingpan River during the 1980's focused primarily on trout populations and management using special regulations. Temperature and flow were found to be the primary changes in the Fryingpan River since the construction of the dam. Winter flows were increased while summer peak flows were decreased. Early reports from investigations into the recent implementation of a "catch-and-release" program suggested that there were noticeable improvements in the trout population (Nehring 1980). These reports were confirmed with numerous studies during the following years (Nehring and Anderson 1981; Nehring and Anderson 1984; Nehring and Anderson 1985). Fish, macroinvertebrates and periphyton communities were found to exhibit longitudinal variation within the Fryingpan River (Environmental Research and Technology 1981). Production of macrophytes, periphyton and macroinvertebrates was considered good (Simons, Li and Associates Inc. 1983).

A review of existing information conducted by Grieb (1983), indicated a decrease in rainbow trout numbers and biomass in two sections of the Fryingpan River. Losses in the upper reach were attributed to the release of cold water from Ruedi Dam. Although brook trout and brown trout were able to spawn just below the dam (Simons, Li and Associates Inc. 1983) studies indicated that lower temperatures below the dam could be affecting survival of rainbow trout eggs and the recruitment of juveniles (Nehring and Anderson 1982). Losses in the lower reaches were attributed to fishing pressure. New

recommendations were made for a 1 brown trout and 1 rainbow trout bag limit and additional stocking of rainbow trout fingerlings in the reach below the dam (Grieb, 1983).

Most studies during the 1980's indicated that the implementation of fishing regulations and stocking programs had resulted in an overall improvement in health and biomass of trout populations (Nehring and Anderson 1984; Nehring and Anderson 1985); however, declines observed specifically in rainbow trout populations caused further protections to be recommended (Nehring 1986).

Instream flow studies found poor correlations between Ruedi Dam flow regimes and trout population dynamics (Nehring 1988a). Minimum and optimum flows determined for various life stages of all species of trout ranged from 50 to 250 cfs (Nehring 1988b).

During the 1980's the Fryingpan River had become famous and was subject to heavy fishing pressures (Nehring 1987). The opossum shrimp, *Mysis relicta*, had been found to commonly occur in releases from the dam and had altered the normal trophic flow in the river (Nehring 1988a). The release of *Mysis relicta* from the dam was found to have a significant positive effect on the growth rate of rainbow trout in the Fryingpan River (Nehring 1991). Although *Mysis relicta* was found to cause increases in trout population and biomass below the dam in a favorable year. Years of poor shrimp production were found to cause severe declines in trout biomass below the dam. The rest of the river remained relatively unaffected (Nehring and Thompson 1994).

During the 1990's trout population studies continued in the Fryingpan River. The brook trout population was found to be declining while brown trout were found to be increasing (Nehring and Thompson 1996). It was speculated that brown trout predation was at least partially responsible for the brook trout decline.

Whirling disease was first detected in the Fryingpan River in 1995 though no population level affects on trout populations were detected (Nehring and Thompson 1996). In 1997, a slight decline in recruitment of juvenile rainbow and brown trout at the Seven Castles area was noticed in the Fryingpan River (Nehring 1998). Nehring, (1999) described several point sources of whirling disease in the Fryingpan River and its tributaries. In general, brown trout and rainbow trout fry showed no overt signs of whirling disease in the Fryingpan River except for a decline in numbers at the Taylor Creek site. Though whirling disease was present in several ponds that spill into the Fryingpan River, filtration studies found extremely low levels of spores in the main river. Whirling disease spores were mostly found in the downstream reaches (Nehring 1999).

ROARING FORK RIVER

The Roaring Fork River has been the subject of far fewer studies than the Fryingpan River. Nehring, (1980) described self-sustaining trout populations in the upper reaches of the Roaring Fork River. The upper reach had distinctly better trout habitat and greater habitat diversity, whereas less habitat diversity and limited spawning was described in the

lower reach (Simons, Li and Associates Inc., 1983). Operation of Ruedi Dam was expected to have little effect on trout habitat in the Roaring Fork River (Environmental Research and Technology, 1981). Flows in the Roaring Fork River ranged from 400 cfs to over 4,000 cfs. Periphyton and macroinvertebrate populations were found to be healthy. Mountain whitefish were the most numerous fish followed by, brown trout, rainbow trout and mountain sculpin. The Roaring Fork River was considered a high-quality trout fishery (Simons, Li and Associates Inc., 1983).

Population studies on the Roaring Fork River indicated that mountain whitefish were the dominant species with brown trout and rainbow trout also common (Nehring and Thompson 1996). The small percentage of juvenile rainbow trout was attributed to the presence of Whirling Disease. Nehring (1998) indicated that rainbow trout populations in the Roaring Fork River continued to be dominated by large fish. Mountain whitefish, rainbow trout and brown trout in the Roaring Fork River have all tested positive for whirling disease (Nehring et al., 2000).

ANNOTATED BIBLIOGRAPHY

Hunter G.N., and O.A. Parson. 1943. A Stream Census of the Fryingpan River, 1942-1943. Colorado Game and Fish Department.

Fryingpan River

This study provided an early description of the Fryingpan River and the existing fishery. The Fryingpan River at that time was fed by numerous tributaries, which were directly influenced by snowmelt. The amount of water removed for irrigation had no noticeable effects on trout populations. The average gradient was measured at 86 feet per mile. Pool and riffle habitat was abundant and river banks were generally open and accessible. Fish species included rainbow trout, brown trout, cutthroat trout, eastern brook trout, and sculpin.

A wide range of biological data was reported in the results of this study. Researchers found approximately 300 pounds/mile of food available to trout in the form of aquatic macroinvertebrates. Ephemeroptera, Trichoptera, and Diptera made up the majority of the food organisms. The populations of aquatic food organisms did not seem to fluctuate throughout the year. Examination of stomach contents indicated that a large percentage of terrestrial organisms were consumed along with aquatic organisms. Numerous areas of cover for fish were observed in the form of cut banks, tree roots, brush, logjams, and slow moving sections of water. Water temperature ranged from 47 to 62 degrees F. Stream width was measured between 40 and 100 feet with an average of 65. Diatoms and algae were found throughout the stream. No dead or diseased trout were found. Several tributaries were suspected of providing good spawning areas. Stocking Records were given for 1937 through 1941. Migration studies conducted in 1942 and 1943 showed an even division between upstream migration, downstream migration, and no migration.

Hoppe, R.A. and L.M. Finnell. 1970. Aquatic Studies on Fryingpan River, Colorado – 1969-1970. Colorado Division of Wildlife. Fort Collins, Colorado.

Fryingpan River

The purpose of this study was to make recommendations for improving the conditions for spawning of rainbow trout and brown trout in the Fryingpan River. Studies performed in the winter of 1969-1970 included thermographs, surveys of spawning redds and electro-fishing. It was recommended that the same outlet be used for water release from Ruedi Dam between October 15 and July 1. This was to ensure that adequate water flow would be maintained over the eggs for the duration of the incubation period. It was also recommended that temperature readings be reported daily starting October 1. Once water temperature has reached 48 F, or on October 15, whichever comes first, the release from

the dam should be adjusted to 100 cfs and maintained at that level until November 15. It was also recommended that the discharge be maintained as uniform as possible between November 15 and July 1 by adjusting flows as gradually as possible. The discharge between November 15 and July 1 should not be reduced below 100 cfs unless absolutely necessary to minimize downstream icing. If flows must be reduced due to icing problems, the flows should be returned to 100cfs as soon as possible. These recommended flow regimes were expected to increase survival of trout eggs in the Fryingpan River.

Finnell, L. M. 1972. Fryingpan-Arkansas Fish Research Investigations. Colorado Division of Wildlife. Project Report No. 1.

Fryingpan River

The purpose of this study was to determine the effects on fish and wildlife in the affected areas of the Fryingpan-Arkansas Project. Ruedi Dam was completed in 1968 on the Fryingpan River 14 miles above the confluence with the Roaring Fork River. This resulted in the inundation of 7 miles of the Fryingpan River and flooding of 1,000 surface acres. The capacity of the reservoir was 102,360 acre-feet.

Historically the Fryingpan River had been one of the most heavily fished trout streams in Colorado. Since the construction of the dam, average temperatures immediately downstream from the dam during July and August dropped from 59 to 46.5. Effects of the altered temperature regimes were not apparent during this study. An obvious effect of the reduced turbidity and altered temperature was an area of algae growth that extended for approximately 2 miles downstream from the dam. No adverse effects have been observed due to this phenomenon. Sources are cited which suggest that the outflow of organic matter, in the form of zooplankton and phytoplankton, from a dam such as Ruedi Dam may have an effect equivalent to that of mild organic pollution.

Population studies were performed through the use of electro-fishing. Details are given regarding size range and number of trout caught. Average population estimates for all sections of the river in April 1970 were 170 game fish/acre (85 pounds/acre). Estimates for August 1970 for rainbow and brown trout combined were 321 fish/acre (144 pounds/acre). Rainbow trout far outnumbered brown trout.

Age and growth determinations were made through examination of scale growth rings. Both species of trout averaged 3.0” at one year, 6.5” at two years, 10.0” at three years, 12.5” at four years and 14.5-15.0” at five years old. Failure to detect trout older than 5 years was attributed to fishing pressure.

Natural reproduction below the dam is severely restricted due to the lack of adequate spawning habitat. Only two general areas appeared to be capable of supporting spawning activity. One section was near the confluence of Seven Castles Creek. The other area was located immediately below the dam where rubble was removed for construction of

de-silting ponds. Flow regimes were recommended for releases of water from the dam to protect trout spawning areas. Requests were made to stop stocking operation of catchable trout in the upper 2.5 miles of the river in order to attempt to establish an area of "wild trout waters". In 1971, rubble was removed by bulldozer from two sections in the government owned portion of the river to induce trout spawning and recruitment.

Invertebrate fauna was said to be abundant in all sections of the river but especially in the lower reaches. It was suggested that the Fryingpan River would remain one of the most productive trout streams in Colorado. Flows of 100 cfs were recommended to maintain the health of his river.

Finnell, L. M. and G. L. Bennet. 1973. Fryingpan-Arkansas Fish Research Investigations. Colorado Division of Wildlife. Project Report No. 2.

The objectives of this project were to evaluate the physical, chemical and biological properties of all streams and reservoirs in the Fryingpan and Arkansas river basins prior to planned water diversion operations and to address problems that may arise during these operations. During the 1972-1973 study period the investigations that were conducted in Ruedi Reservoir and the Fryingpan River were in three general areas of concern: limnological studies, fish population studies, and special studies of exotic food organisms.

Fryingpan River

The purpose of this portion of the study was to determine the effects of planting of hatchery trout on wild trout populations, study the survival and migration of hatchery trout, and to determine whether or not wild trout are capable of maintaining an adequate population in the face of increasing fishing pressure. Samples were taken by electro-fishing in three sections of the river. Section one was the upper 3 miles that had been designated "wild trout waters". Section two was between the confluence of Frenchman Creek and the confluence of Taylor Creek. This section was to receive 5 plants of 1000 catchable rainbow trout each distributed at half-mile intervals between March and August. Section three was between the confluence of Taylor Creek and the confluence of the Roaring Fork River. Average length of rainbow trout captured in Section I was 7.3 inches. These fish were mostly naturally occurring. Sections II and III contained a higher percentage of adult and sub-adult rainbow trout. There was a noticeable lack of young trout. Conditions were assumed to be more beneficial for rainbow trout reproduction than for brown trout based on the fact that rainbow trout outnumbered brown trout 4 to1.

Headwater tributaries of the Fryingpan River were examined for the presence of Colorado River cutthroat trout. Brook trout were observed in Mormon Creek and the Middle Fork of Cunningham Creek. Cutthroat trout taken from North Cunningham Creek were identified as a pure strain of *Salmo clarki pleuriticus*, the original native trout of the upper Colorado River Basin.

Finnell, L. M. and G. L. Bennet. 1974. Fryingpan-Arkansas Fish Research Investigations. Colorado Division of Wildlife. Project Report No. 3.

Fryingpan River

This study was conducted in much the same way and at the same general locations as reported in Project No. 2. Section one was the upper 3 miles that had been designated "wild trout waters". Section two was between the confluence of Frenchman Creek and the confluence of Taylor Creek. Section three was between the confluence of Taylor Creek and the confluence of the Roaring Fork River. Insufficient recaptures were made during electrofishing to make estimates of rainbow trout populations. No adverse effects were detectable in the wild rainbow trout population due to the presence of hatchery fish. Migration of planted fish seemed to be minimal. No additional locations were found that contained native populations of cutthroat trout.

U.S. Department of Interior, Bureau of Reclamation. 1975. Ruedi Dam and Reservoir Fryingpan-Arkansas Project, Colorado. Technical Record of Design and Construction. Denver, Colorado. June 1975.

This technical record describes salient aspects of design and construction of Reudi Dam, the first major feature completed on the Fryingpan-Arkansas project in Colorado. Because this is the first technical publication relating a completed structure on the Fryingpan-Arkansas project to the project's operation, Part I of this record presents in summary the scope of the project as well as the rationale for its development and its plan of operation. The presentation thus not only provides information on the project, but it also affords additional insight into the purpose of Reudi Dam and its function in the project's operation. Part I also has a summary of cost data and a description of pertinent findings from geological investigations.

Part II of this technical record has three chapters covering the design of the dam and its component features. Part III contains one chapter on contract administration and three chapters comprising a concise narration of construction operations. The appendix summarizes construction costs and lists other information of interest.

This technical record was prepared by the Technical Services and Publications Branch of the Engineering and Research Center, Denver, Colorado, from final design reports submitted by the design branches, final construction reports and cost information submitted by the field offices, and various planning reports.

Finnell, L. M. and G. L. Bennet. 1977. Fryingpan-Arkansas Fish Research Investigations. Colorado Division of Wildlife. Final Report.

Fryingpan River

A variety of water quality measurements were taken in order to determine if Ruedi Reservoir has an influence on the Fryingpan River downstream from the dam. The water in the river below the dam was found to be higher in pH, hardness, and conductivity than the water flowing into the reservoir. This was presumed to be due to gypsum deposits adjacent to the reservoir. The average summer water temperature in the river was found to have dropped from 14.5 C to 8.1 C after the construction of the dam. It is speculated that these changes may slow trout growth, but may increase invertebrate production. The loss of scouring action in the reach below the dam has caused an increase in growth of algal mats. It has not been determined whether this algal growth has detrimental or beneficial effects. No detrimental or beneficial effects on the biology of the river could be ascertained.

A review of some earlier fish population studies was presented. It was suggested that growth rates of brown trout in the Fryingpan River were higher than the average for similar rivers in that area. Growth rates for rainbow trout appeared to be normal. The study was unable to determine the effects of planted trout on wild populations.

Ruedi Reservoir

At this time successful reproduction of opossum shrimp, *Mysis relicta*, in Ruedi Reservoir had not been confirmed. It was noted that high population levels of opossum shrimp had been found to reduce or eliminate populations of cladocerans. Future studies are planned to determine the extent of competition and predation between opossum shrimp and zooplankton.

Nehring, R. B. 1979. Evaluation of instream flow methods and determination of water quality needs for streams in the State of Colorado. Colorado Division of Wildlife. Fort Collins, Colorado.

Fryingpan River

A comparison using four methods of computer analysis to determine minimum flow for two sites on the Fryingpan River was presented. These methods included: Single R-2 Cross, Multiple R-2 Cross, IFG4, and the "Montana Method". The conclusions suggested that these four methods produced similar results at both locations on the Fryingpan River; however the "Montana Method" was less reliable on other streams. Minimum flow recommendations for the Fryingpan River at these two sites ranged between 47.5 cfs and 65 cfs depending on the method that was used.

Nehring, R. B. 1980. Stream Fishery Investigations Job Progress Report. Colorado Division of Wildlife. Federal Aid Project F-51-R-5. Fort Collins, Colorado.

Fryingpan River

This report reviews the results of several electro-fishing events at the Fryingpan River from 1972 through 1979. These results indicated that rainbow trout, brown trout and brook trout populations have demonstrated considerable variability over space (from Ruedi Dam downstream) and/or time (1972 through 1979). The sudden increase in brook trout immediately downstream from the dam was thought to be the result of an operation of the south outlet during August 1979. Previously this outlet had rarely been used and the pool immediately below the outlet was known to maintain a large population of brook trout. Other results produced by analysis of the data suggested that the majority of successful spawning and recruitment for brown and rainbow trout takes place in an area near Seven Castles. Implementation of a catch-and-release area had resulted in greater fishing success rates, and had overwhelming public support.

Roaring Fork River

Fish populations were studied at two sites on the Roaring Fork River. The sites were both located near Aspen, Colorado, which is outside of this study area. Self-sustaining trout populations were reported at both sites.

Environmental Research and Technology. 1981. Environmental assessment of the proposed sale of water from Ruedi Reservoir to Exxon Company, U. S.A., as operator of the Colony Shale Oil Project, Battlement Mesa, Inc., and the Basalt and West Divide Water Conservancy Districts. Submitted to Bureau of Reclamation. Denver, Colorado. Prepared for Exxon Company, U.S.A. Aurora, Colorado.

Fryingpan River

This document reviews physical, chemical and biological components of the Fryingpan River. Much of the information presented in this document was obtained from sampling that was conducted by ERT during 1981; however, some comparisons were made to data provided by other sources. Biological components of the Fryingpan River appeared to be influenced by the altered temperature and flow regime in the section of the river directly below Ruedi Dam. Fish, macroinvertebrates, and periphyton communities were found to exhibit considerable change between sites located below the dam and sites located several miles downstream. The PHABSIM model was also employed to evaluate fish habitat at several various flow scenarios based on the proposed action. Data was for this model was collected at one site on the Fryingpan River approximately 7 miles downstream from Ruedi Dam.

Roaring Fork River

This document provides a brief description of physical/chemical characteristics, periphyton communities, benthic macroinvertebrates, and fish communities in the Roaring Fork River downstream from its confluence with the Fryingpan River. Most of this data was collected by ERT during 1981. The PHABSIM model was used to determine how trout habitat in the Roaring Fork River would be affected by the proposed change in flows in the Fryingpan River. The results suggested that the influence on the Roaring Fork River would be minimal because of the relatively small contribution of flow provided by the Fryingpan River.

Nehring, R. B. R. M. A. 1981. Stream Fisheries Investigations Job Progress Report. Colorado Division of Wildlife. Federal Aid in Fish and Wildlife Restoration Project F-51-R-6. Fort Collins, Colorado.

Fryingpan River

Fisherman success rate and fish population data that was collected during 1980 was compared to data collected during 1979 and some earlier years. Fisherman success rate was much greater in the recently established catch-and-release area. Fish populations remained relatively stable in the catch-and-release area, but had declined at most other locations. Some discussion on the impact from the altered temperature regime created by Ruedi Dam suggests that fish health and growth rate show no negative impacts.

Roaring Fork River

Catch and release regulations are believed responsible for maintaining a high percentage of adult rainbow trout at study sites near Aspen, Colorado. These sites were located outside of the study area for this project.

Nehring, R. B. and R. Anderson. 1982. Stream Fisheries Investigations Job Progress Report. Colorado Division of Wildlife. Federal Aid in Fish and Wildlife Restoration Project F-51-R-7. Fort Collins, Colorado.

Fryingpan River

Data concerning fisherman success and fish populations during 1981 is compared to data from previous years. General trends suggested that the overall trout population and particularly larger size trout were declining due to over harvest in the section of river with 8 trout/day bag limits. Despite successful angling in the catch-and-release section of the Fryingpan River the population of rainbow trout appeared to be declining due to inadequate reproduction in this reach. Successful spawning by brook and brown trout below Ruedi Dam indicated that temperature could be the limiting factor in successful rainbow trout recruitment.

Nehring, R. B., R. Anderson, D. Winters. 1983. Stream Fisheries Investigations. Colorado Division of Wildlife. Federal Aid Study F-51-R. Fort Collins, Colorado.

Fryingpan River

The objective of this report was to evaluate trends in fish populations and recommend special regulations that would help maintain a quality trout fishery. Ten years of biomass estimates from two sections of the Fryingpan River were reviewed. Density and biomass data indicated that rainbow trout populations were declining in both sections of the river. The primary impact in the reach below the dam was thought to be poor spawning success due to relatively cold water released during spawning. The primary impact in the lower reach was thought to be the result of high angling harvest. Monitoring of stocked fingerling rainbow trout indicated a high rate of survival after one year. New management and regulations that were implemented included a 1 rainbow trout and 1 brown trout limit in the lower reach, and supplemental stocking of fingerling rainbow trout in both reaches of the Fryingpan River.

Simons, Li and Associates Inc. 1983. Fryingpan-Arkansas Project, Ruedi Resevoir, Colorado, Round 2 Water Sale, Environmental Assessment. Prepared for Bureau of Reclamation. Denver, Colorado.

The purpose of this study was to evaluate the environmental consequences of several alternatives that would result in various levels of water sales from Ruedi Reservoir. Ten plans were presented and evaluated. The issues addressed during the evaluation of these plans included: physical and chemical effects on fisheries in the reservoir and streams, salinity effects on the Colorado River, potential increases in scouring and erosion of stream banks, effects on threatened and endangered species, effects on terrestrial wildlife and vegetation, effects on area recreation usage, degree of reservoir drawdown and minimal pool level, use of winter sales of water to preserve a high summer reservoir level, capability to deliver water during the winter months, and compliance with authorizing legislation. Much of the fishery and aquatic data presented in this document was a compilation and review of previous research.

Effects on fisheries were evaluated by the amount and duration of habitat loss under each plan. Alternatives 2, 4, and 5 would cause the longest periods of the greatest habitat loss. Alternatives 3 and 7 showed less habitat loss while alternatives 6 ,8, 9, and 10 showed the least impact.

Ruedi Reservoir

A review of the physical and biological components of Ruedi Reservoir was provided. Water in Ruedi Reservoir was found to be high in alkalinity, hardness, pH, and conductivity due to abundant gypsum present in the reservoir basin. Primary production in open water sections of Ruedi Reservoir was determined to mainly come from the colonial alga *Volvox*. Periphyton, mostly *Glocotrichia* and *Nostoc*, and macrophytes ,

Nitella, Elodea, Potamogeton and mosses, provided important primary input in shallower inlet areas. Zooplankton consisted primarily of the rotifer *Synchaeta* and the crustaceans *Cyclops, Daphnia and Bosmina*. Populations of zooplankton usually peaked in July. Deeper benthic portions of the reservoir contained mostly oligochaetes and chironomids that varied in population levels. Benthic communities in the shallower bay areas were quite variable with the samples being dominated by chironomids and gastropods. Macroinvertebrate densities ranged from 1,804/m^2 to 14,485/ m^2. Biomass ranged from 0.93 g/m^2 to 25.5 g/m^2. This community structure was indicative of clean water and oligotrophic conditions.

Seven species of fish were found in Ruedi Reservoir including: rainbow trout, brown trout, brook trout, lake trout, kokanee salmon, bluehead sucker and mottled sculpin. Native cutthroat trout were stocked in 1972 but recent surveys have not found this species to be present. Habitat requirements for adults juveniles and spawning, of each species were summarized. Historically brown trout have been the most abundant species. However, numbers of brown trout have been declining over the past several years.

Fryingpan River

The study area on the Fryingpan River included the 14-mile stretch from Ruedi Dam to the confluence with the Roaring Fork River. The chemical and physical characteristics in this stretch indicated that there was quality habitat for trout. Temperature and flow were the two primary physical components that had been altered since the completion of Ruedi Dam. Average winter flows in the Fryingpan River were 111 cfs while unregulated winter flows would average about 39 cfs. Average peak summer flows were 296 cfs while unregulated peak flows would average 1,024 cfs. Temperature seemed to be the primary limiting factor for fisheries in this stretch. The ratio of pools and runs to riffles was found to be 0.7. A 0.8-mile section near the confluence with Seven Castles Creek was found to have an abundance of deep pools and runs providing excellent habitat for adult and juvenile trout. Cobble and boulder substrates dominated most of the river. Spawning gravels are limited to several sections in the upper portion of the river, and locations near the confluences of Seven Castles Creek and Taylor Creek.

Diatoms and green algae typical of cold, rapid streams were the main components of the periphyton community found in the Fryingpan River. The macrophyte *Ranunculus aquaticus* was found to be an important source of primary production in the sections immediately below the dam and again seven miles below the dam. The macroinvertebrate community was found to vary longitudinally in the river. The chironomid *pseudodiamesa* was the dominant taxa immediately below the dam, but decreased in abundance gradually downstream. The filter-feeding caddisfly *Brachycentrus* increased progressively from the dam downstream, possibly due to the increasing abundance of fine particulate matter. Except for the noted longitudinal variation, the macroinvertebrate community in the Fryingpan River was typical for streams with excellent water and habitat quality.

Surveys that reviewed the fishery in the Fryingpan River had indicated the presence of brown trout, rainbow trout, brook trout, cutthroat, mountain whitefish and mottled sculpin. Brook trout and cutthroat trout were restricted to the upper 4 to 5 miles of river below Ruedi Dam. Brown trout and rainbow trout were most abundant in the lower 13-mile section. Historically the river was dominated by rainbow trout, but brown trout had come to outnumber rainbow trout in recent years. Reasons given for the decline of rainbow trout were; over harvest by sportsmen and poor recruitment due to cold-water releases from Ruedi Dam. Brook trout were the third most numerous species and had been increasing in number below the dam during the previous few years. The current standing crop of trout was estimated in a range from 2,181 fish/acre to 5,945 fish/acre with an average of 3,334 fish/acre. Brook trout and brown trout use the section immediately below the dam for spawning in the fall. Rainbow trout have had some success spawning in the Seven Castles area as water temperatures and other conditions were more favorable in this section. The rainbow trout spawned in this area were typically recruited to reaches farther downstream. Low-temperature water released from Ruedi Reservoir caused high mortality to rainbow trout eggs during the spring in the section directly below the dam.

The Colorado River cutthroat trout, which was listed as threatened in 1983, had been reported to occur in a two mile section of the Fryingpan River. This population is not able to spawn in this river, therefore there is no recruitment to maintain the population. Other endangered and threatened species under consideration occur in the Colorado River.

Roaring Fork River

The upper and lower reaches of the Roaring Fork River differ drastically in their habitat characteristics. The reach below Carbondale contains a much higher percentage of runs and pools providing much better trout habitat. This section contains 57% pools and runs while only 30% exists in the upper portion. Boulder and cobble substrate types are dominant throughout the river. Limited areas containing spawning gravels were found in the mainstem of the river. Spawning gravel was found to be 0.5% of the total area in two of the study sections. Average peak flows on the Roaring Fork River ranged from around 400 cfs in winter to over 4,000 cfs in summer.

The primary periphyton group in the Roaring Fork River was diatoms with 42 taxa present. The caddisflies *Brachycentrus* and *Glossosoma* were the dominant macroinvertebrates with densities increasing in the downstream reaches. Occurrence and abundance of each taxa was recorded for each sampling site. The macroinvertebrate community in the Roaring Fork River was typical of high water quality and habitat quality.

The Roaring Fork River contains rainbow trout, brown trout, mountain whitefish, bluehead sucker and mottled sculpin. Mountain whitefish were found to be the most abundant with brown trout and rainbow trout the next most abundant. The Roaring Fork

River is considered to be a high-quality trout fishery with standing crops of trout estimated at 200 fish/acre.

Nehring, R. B. and R. M. Anderson. 1984. Stream Fisheries Investigations. Colorado Division of Wildlife. Federal Aid Study F-51. Fort Collins, Colorado.

Fryingpan River

The purpose of this study was to evaluate the success of newly imposed fishing regulations in improving the health of the rainbow trout population in the Fryingpan River. In 1981, stricter regulations were placed on fishing downstream of the dam in response to declining rainbow trout populations. Due to high egg mortality caused by hypolimnetic releases from Ruedi Dam, rainbow trout populations were augmented by the release of fingerlings in 1981 and 1982. Through the use of electro-fishing and creel studies, the rainbow trout population was found to be increasing by 1983. Planted fingerlings were surviving, growing, and competing well with the existing brown trout. The new fishing regulations and stocking programs were supported as the causes responsible for the improved condition of the rainbow trout population in the Fryingpan River.

Nehring, R. B. and R. M. Anderson. 1985. Stream Fisheries Investigations. Colorado Division of Wildlife. Federal Aid Study F-51. Fort Collins, Colorado.

Fryingpan River

The purpose of this study was to evaluate the continuing success of a management strategy for the Fryingpan River that consisted of catch and release restrictions and a fingerling release program. Success was seen in catch and release areas with the increase of rainbow trout populations. This was in contrast to areas with a one rainbow trout one brown trout limit where the populations are still not showing sufficient recruitment. Rather than expand fishing restrictions, it was recommended that the population be further augmented by advanced fingerling introductions.

Nehring, R. B. 1986. Stream Fisheries Investigations. Colorado Division of Wildlife. Federal Aid Project F-51-R. Fort Collins, Colorado.

Fryingpan River

This study sought to evaluate the progress of the management program for rainbow trout in the Fryingpan River. Continued monitoring of fish populations has shown that rainbow trout numbers have increased in the catch and release areas. Evidence is reviewed which demonstrates that the rainbow trout population will not remain viable without further protection and augmentation. Low survival was seen in the 5-8 cm plants

as opposed to excellent survival in the 10-12 cm plants. Recommendations on management involve a two sixteen-inch fish bag limit in addition to the stocking of 10,000 10-12 cm rainbow trout fingerlings.

Nehring, R. B. 1987. Stream Fisheries Investigations. Colorado Division of Wildlife. Federal Aid Project F-51-R. Fort Collins, Colorado.

Fryingpan River

This paper provides a summary for the management of the rainbow trout population in the Fryingpan River during the preceding eleven years. The current management strategy at that time involved maintaining a catch and release, flies and lures only area in the two-mile stretch immediately below Ruedi Dam. A bag limit of two trout sixteen inches or longer is maintained on the remaining twelve miles of river. The rainbow trout population was further augmented by stocking of advanced fingerlings. This management plan was shown to be working while fishing demand had dramatically increased. High numbers of large trout were caught during all parts of the year. This report states that the Basalt Chamber of Commerce estimated total sales directly attributable to the Fryingpan fishery at $1.2 million or more in 1986.

Nehring, R. B. 1988a. Stream Fisheries Investigations. Colorado Division of Wildlife. Federal Aid Project F-51-R. Fort Collins, Colorado.

Fryingpan River

The purpose of this study was to quantify the interrelationships between flow regimes and trout population dynamics in selected streams. No correlations were found for the Fryingpan River. Reasons sited for the lack of correlation included: variation in management practices, hypolimnetic release from Reudi Dam, stocking of fingerling trout, and the recent addition of a hydroelectric power station to the dam resulting in the release of opossum shrimp, *Mysis relicta*, into the river.

Nehring, R. B. 1988b. Stream Fisheries Investigations. Colorado Division of Wildlife. Federal Aid Project F-51-R. Fort Collins, Colorado.

Fryingpan River

This document simply lists minimum flows and optimum flows for rainbow and brown trout at various life-stages in the Fryingpan River. These flows were found to range between 50 cfs and 250 cfs depending on species and life-stage.

U.S. Department of Interior, Bureau of Reclamation, Simons, Li and Associates Inc., Environmental Research and Technology, Inc. 1989. "Ruedi Reservoir, Colorado, Round II Water Marketing Program, Final Supplement to the Environmental Statement, Fryingpan Arkansas Project. Denver, Colorado.

The purpose of this study was to analyze three possible alternatives for water delivery and one mitigation scenario. The No Action Alternative and Preferred Alternative are considered along with the Preferred Alternative with Conservation Measures Alternative as recommended by the United States Fish and Wildlife Service in the Biological Opinion. Environmental impacts were expected due to decreases in Ruedi Reservoir stage and streamflow patterns in the rivers downstream. The stream flows in the Fryingpan River, and to a lesser degree in the Roaring Fork, would be decreased in wet years and increased in dry years in comparison to the No Action Alternative. Summaries are given concerning the potential monthly effects on streamflow in the Fryingpan and Roaring Fork rivers. Changes in streamflow were expected to cause minor losses in fish habitat.

Ruedi Reservoir

Predicted impacts on the reservoir resulted from loss of bottom area. The effects of this action would be loss of rearing areas for juvenile trout, loss of feeding areas for adult trout, reductions in macroinvertebrate production and decrease in macrophyte production. The magnitude of the effects would depend on the extent and duration of changes in reservoir level. The loss of habitat would be mostly in the northern bays due to loss of littoral areas. Average loss of total littoral areas in the reservoir would be 10 % increasing to 29% in dry years. The extent of this habitat loss was predicted to reduce the numbers and or growth of trout.

Fryingpan River

The emphasis of this report was to use available data, much of which came from previous studies, to predict how proposed changes in flow could impact the current physical and biological conditions. The potential adverse effects from changes in flow regimes included; a greater percent loss of incubating trout eggs, habitat loss for trout at various life stages, loss of cover for fish, and reduction in benthic macroinvertebrate production. During some months benefits to the fishery would come from additional habitat gained due to increased flows.

Habitat loss for the limiting life stage of each trout species was calculated using IFIM. Data was collected at two study sites, the Castle Rock and Old Faithful sites. No significant habitat losses for rainbow or brown trout fry were predicted. Losses of habitat for rainbow trout fry and juveniles in the 10% to 25% category were expected in 4 months in a dry year, 3 months in an average year. A wet year was expected to result in some habitat gains. Brown trout fry could have losses of habitat during one or two months in each type of year. The Preferred Alternative with Conservation measures was not predicted to reduce the numbers of rainbow and brown trout fry or juveniles.

Reductions in brown trout spawning habitat were predicted to be 29 to 65% in a dry year, 35 to 65% in an average year and 34 to 54 % in a wet year. This level of spawning habitat loss is predicted to result in lower reproduction and recruitment to the brown trout population. There were small losses predicted for rainbow trout spawning habitat but not enough to impact the rainbow trout population. Various scenarios that could result in egg mortality or loss of cover were also discussed.

Reductions in flow between November and April were predicted to adversely impact benthic macroinvertebrates, periphyton, and macrophyte populations. These effects were predicted because of the loss of habitat that would result from the reduced perimeter and reduced depth in the streambed. Reductions in macroinvertebrate populations could limit the amount of food available to fish especially in densely populated areas. Reductions in periphyton and macrophyte populations would limit cover for fish and food sources for macroinvertebrates.

Roaring Fork River

Implementation of the proposed alternatives was also expected to have minor impacts on the Roaring Fork River. Most of the observable impacts to trout habitat were expected to occur above the confluence with Crystal River. No net change for brown trout habitat would occur in an average year, the loss of habitat one month being offset by the gain of habitat one month. A dry year would have a net loss with 2 months of losses and one month of gains. A wet year would result in 3 months of gained habitat. Rainbow trout would have gains in 6 months of a wet or average year. A slight reduction in habitat would be expected in dry years even below the confluence with Crystal River.

U.S. Department of Interior, Bureau of Reclamation. 1990. Ruedi Reservoir , Fryingpan-Arkansas Project, Final Supplement to the Environmental Statement, Round II Water Marketing Program, Record of Decision. Denver, Colorado.

This document was essentially an announcement of the decision by the Bureau of Reclamation to use the Preferred Alternative with Conservation Measures augmented by the Green Mountain Mitigation Scenario.

Nehring, R. B. 1990. Stream Fisheries Investigations. Colorado Division of Wildlife. Federal Aid Project F-51-R. Fort Collins, Colorado.

Fryingpan River

This document provides a table with population data for trout species derived from electro-fishing at seven locations on the Fryingpan River. The calculated number and mass of each species in each reach was provided.

Nehring, R. B. 1991. Effects of reservoir escapement of mysids on two Colorado tailrace trout fisheries. American Fisheries Society Symposium 9:134-143.

Fryingpan River

The objective of this research was to determine the influence of the opossum shrimp (*Mysis relicta*) on the rainbow trout population in the reach of the Fryingpan River below Ruedi dam. *Mysis relicta* was stocked into Ruedi Reservoir in 1970, but first appeared in the Fryingpan River in releases below the dam in 1985. Conclusions for this study were based on a comparison of current rainbow trout data (1986-1988) to data collected during premysid years (1978-1985), as well as to data collected approximately 8 km downstream. The presence of *Mysis relicta* in releases from Ruedi Reservoir was found to have a significant positive effect on rainbow trout condition, growth rate, and populations in the first 5 km below the reservoir outlet.

Nehring, R. B. and K. G. Thompson. 1994. Stream Fisheries Investigations. Colorado Division of Wildlife. Federal Aid Project F-51-R. Fort Collins, Colorado.

Fryingpan River

The purpose of this study was to monitor trout densities, biomass, and species composition, and evaluate the potential harmful effects of electro-fishing. The availability of *Mysis relicta* was found to be a major factor in determining the size and structure of the fish community immediately below the dam. A five-year period with above average precipitation resulted in releases from Ruedi Dam that were conducive to a high rate of entrainment of *Mysis relicta*. This period of augmented food supply sustained trout populations near 1000 kg/ha. The following four years produced below normal precipitation. The subsequent decrease in releases from Ruedi Dam during the winter months resulted in a severe decline in *Mysis relicta* entrainment. Rainbow trout and brook trout populations declined sharply during this period while brown trout became dominant. Trout populations at lower sites on the Fryingpan River seemed to be relatively unaffected by these events.

Trout collected at stations in the Fryingpan River were evaluated to assess the impact from electro-fishing. Preliminary results suggested that a significant percentage of the fish sustained some injuries due to the electro-fishing process. The percentage varied with technique and increased with fish size.

Nehring, R. B. and K. G. Thompson. 1995. Stream Fisheries Investigations. Colorado Division of Wildlife. Federal Aid Project F-237R-2. Fort Collins, Colorado.

Fryingpan River

The purpose of this study was to monitor trout densities, biomass, and species composition, and evaluate the potential harmful effects of electro-fishing. Results of electro-fishing during the fall of 1994 are compared to results from previous years. A slight decline in brown trout populations and a slight increase in rainbow trout populations were observed. This was a desired change in the trout population that may be a direct result of the implementation of a bag limit of two brown trout < 14 inches. The stocking program in 1994 included cutthroat trout in addition to fingerling rainbow trout. This was expected to continue during 1995.

Trout collected at stations in the Fryingpan River were evaluated to assess the impact from electro-fishing. Results suggested that a significant percentage of the fish sustained some injuries due to the electro-fishing process. Boat electro-fishing resulted in the highest percentage of fish with injuries compared to walk electro-fishing. Injuries also increased with fish size.

Nehring, R. B. and K. G. Thompson. 1996. Stream Fisheries Investigations. Colorado Division of Wildlife. Federal Aid Project F-237R-3. Fort Collins, Colorado.

Fryingpan River

The purpose of this study was to monitor trout densities, biomass, and species composition. The results of sampling during the fall of 1995 indicated that brown trout populations at all sites were increasing, while rainbow trout populations varied only slightly among sampling sites. Brook trout numbers continued in a pattern of general decline. It was suggested that predation by brown trout may be the primary cause for the decrease in brook trout density and biomass. Sampling during the fall of 1995 also produced 13 cutthroat trout. The size and color of these fish suggested that they had come from stocking that occurred in 1993.

Results of tests conducted during November 1995 were the first to indicate the presence of whirling disease in the Fryingpan River. No evidence of a population level effect could be observed at that time.

Roaring Fork River

The reach of the Roaring Fork River extending from the confluence with the Fryingpan River downstream for approximately 4 km was sampled by boat electro-fishing for the first time during the late fall of 1995. Whitefish were the most abundant species in this

reach, although brown trout and rainbow trout were also common. A wide range of sizes was reported for whitefish and brown trout; however, older fish dominated the rainbow trout population. It was suggested that whirling disease might be responsible for the unbalanced structure of the rainbow trout population.

Nehring, R. B. and K. G. Thompson. 1997. Stream Fisheries Investigations. Colorado Division of Wildlife. Federal Aid Project F-237R-4. Fort Collins, Colorado.

Fryingpan River

The purpose of this study was to monitor trout populations, species composition and determine potential impacts from whirling disease. The results of sampling during the fall of 1996 indicated that populations of brown trout, rainbow trout and brook trout had varied only slightly since 1995. It was suggested that predation by brown trout was still the primary cause for the decrease in brook trout density and biomass. Unlike most other Colorado streams the presence of whirling disease had not had a noticeable impact on the density, size or age structure of the rainbow trout population in the Fryingpan River at this time.

Roaring Fork River

The Roaring Fork River was not sampled during 1996.

Nehring, R. B. 1998. Stream Fisheries Investigations. Colorado Division of Wildlife. Federal Aid Project F-237R-5. Fort Collins, Colorado.

Fryingpan River

The purpose of this study was to monitor trout populations, species composition and determine potential impacts from whirling disease. The results of sampling during the fall of 1997 indicated that populations of brown trout, rainbow trout and brook trout had varied only slightly at all stations since 1995. Most of the data indicated that trout populations in the Fryingpan River had been relatively unaffected by whirling disease; however, rainbow trout recruitment near the confluence of Taylor Creek was lower during 1996 and 1997 than it had been prior to 1996. It was suggested that large rainbow and brown trout might be foraging on small brook trout in the reach below the dam.

Roaring Fork River

The reach of the Roaring Fork River extending from the confluence with the Fryingpan River downstream for approximately 4 km was sampled by boat electro-fishing during the fall of 1997. These results were compared to the data collected from the same reach during 1995. On both occasions whitefish were the most abundant species, although

brown trout and rainbow trout were also common. A wide range of sizes was reported for whitefish and brown trout; however, larger fish dominated the rainbow trout population. A general decline in the number of rainbow trout was also observed. It was suggested that whirling disease is responsible for the unbalanced structure and general decline of the rainbow trout population.

BRW, Dames and Moore, and Colorado State University. 1999. Roaring Fork and Fryingpan Rivers Multi-Objective Planning Project. Prepared for Colorado Water Conservancy Board.

The purpose of this study was to investigate problems related to recent flooding on the Roaring Fork and Fryingpan Rivers and development of a multi-objective management plan to mitigate future flood losses and improve irrigation supply within the State of Colorado.

Field surveys of the Fryingpan and Roaring Fork Rivers provided evidence of historic negative impacts to the riparian habitat, streambank stability, and instream fish habitat. Causes of historic and current impacts include; channelization, road and highway construction, encroachment into riparian zones, degradation of stream banks, diking to reduce flooding potential, and a host of lesser habitat modifications. The cumulative impacts from these sources have reduced the capacity of these rivers to retain and maintain historical resource values. It was recommended that vigilant proactive conservation measures be put into place. Guidelines for implementing the proposed projects intended to enhance trout habitat and flow characteristics in the Fryingpan and Roaring Fork Rivers were given.

Short-term episodes of increased sediment and turbidity caused by development projects in these rivers did not have noticeable impact on the trout populations. Excessive sedimentation on trout redds may reduce the rate of egg survival and hatching success. Descriptions are given of trout spawning seasons and habitat. It was recommended that construction projects be scheduled at times that do not interfere with trout spawning activities. One specific area highlighted in the report was Seven Castles Creek, a tributary of the Fryingpan River, and its significant contribution of natural sediment to the system. Sediment loading from Seven Castles Creek is thought to impact trout habitat and aquatic insects in the Fryingpan River.

A portion of this document was used to describe the life cycle of whirling disease and fish related problems. New bag limits and stocking programs were implemented in 1998 because of the presence of whirling disease in many of the state's fish hatcheries and major rivers. Total west slope stocking was decreased from 2 million to around 300,000. Prior to this report rainbow trout had not been stocked into the Roaring Fork and Fryingpan rivers since 1996. At that time additional stocking had not been scheduled.

Fryingpan River

Discussion of the Fryingpan River was divided into three parts: the portion upstream of the reservoir, Ruedi Reservoir, and the 14 mile section below the dam. Above the reservoir the river was similar to the upper section of the Roaring Fork River with fast flowing riffles interspersed with a variety of pool and glide habitat. Healthy trout populations exist throughout the river system. A trophy catch and release area was established in 1979 for the upper two miles of river below the dam. The 12 miles of river above the confluence with the Roaring Fork River was protected by special regulations and was designated "Gold Metal Waters".

Evidence of population level affects of whirling disease in rainbow trout was described from studies that occurred in the years prior to this report. Declines in 1+ aged rainbow trout have continued from 1995-1998 resulting in proportionally large brown trout populations. Declines in brook trout populations were blamed (at least in part) on suspected brown trout predation. New bag limits have increased the biomass of rainbow and brown trout in the river. Release of *Mysis relicta* from Ruedi Dam was responsible for an increased size of trout in the two-mile catch and release area below Ruedi Dam.

Roaring Fork River

This document briefly describes the habitat and fishery in the Roaring Fork River; although the basis for these descriptions was not clearly defined. The upper 30 miles of the Roaring Fork River was characterized as a small, narrow, high gradient stream; whereas the section from the Fryingpan River confluence downstream to the Colorado River was described as having a lower gradient with more meanders. Numbers of fish in the Roaring Fork River had exhibited a general decline in the years prior to this report due to the mortality of young fish infected with whirling disease. The high numbers of adult fish that remain support the rivers' continued ranking as "Gold Metal Waters". In recent years, brown trout have become the dominant species in all population categories. Almost no rainbow trout spawned in the river survived beyond one or two years of age. In 1998, bag limits were reduced from 8 to 2 trout for western slope rivers in response to concerns about the impacts of whirling disease.

Nehring, R. B. 1999. Stream Fisheries Investigations. Colorado Division of Wildlife. Federal Aid Project F-237R-6. Fort Collins, Colorado.

Fryingpan River

Trout Population Structure

Brook, brown and rainbow trout population structure changed very little in 1998 when compared with the period from 1995 to 1997. Rainbow trout fry collected from all sampling sights had shown little to no signs of whirling disease as opposed to other rivers being studied. Age 1+ trout of all three species were present at all sights. A decline was

seen in the number of age 1+ rainbow trout recruited between 1996 and 1998 at the Taylor Creek sight when compared to earlier years. Brook trout populations exhibited a drastic decline between 1986 and 1996. It was hypothesized that this decline was due to brown trout predation. Brown trout populations showed a drastic increase in numbers during the same 10-year period. The release of *Mysis relicta* from Ruedi Dam caused the trout populations to consist of a high number of large fish. It was believed that these larger individuals become highly piscivorous when releases of *Mysis relicta* were lower than usual. Monitoring of fish populations planned for the following 5 years was intended to determine whether or not whirling disease is affecting the trout population structure in the Fryingpan River.

Whirling Disease

Samples filtered, in 1998, from Ruedi Reservoir and the Fryingpan River immediately below Ruedi Dam tested negative for the presence of the *M. cerebralis* parasite. Effluent flowing into the Fryingpan River from a private pond on the Cap K Ranch had tested positive in 8 out of 10 tests over the same period. Effluent from several ponds on the Roy Palm property had also tested positive for the presence of the *M. cerebralis* parasite in 4 out of 12 tests over the same period. Samples taken 0.2 km upstream from the confluence of Taylor Creek tested positive on 4 out of 11 occasions during the testing period.

Nehring, R. B., K. Thompson, J. Padia, and B. Neuschwanger. 2000. Whirling Disease Investigations. Colorado Division of Wildlife. Federal Aid Project F-237R-7. Fort Collins, Colorado.

Fryingpan River

Stream Trout Population Studies

Trout population characteristics have changed very little in 1999 when compared to the previous 4 years at the upstream sites. Recruitment and survivorship of age 1+ rainbow trout has been noted at the Taylor Creek sampling site. A small decline has been seen at all sampling sites since a peak in 1995-1996. Survivorship decline was seen starting in 1997 for the Old Faithful site and in 1998 for the Ruedi Dam site. Rainbow and brown trout fry collected at all sites showed no overt signs of whirling disease except for a decline in numbers at the Taylor Creek site. Whirling disease was first detected in feral trout from this river in 1995. By the time of this study (1999), declines in density and biomass were observable. The brook trout population has also continued to decline in density and biomass. Brown trout predation is still the best explanation for this decline, although a decline this drastic seems more complicated than simple predation.

Filtration Studies

Filter samples were taken monthly since 1998 from the Fryingpan River immediately below Ruedi Dam. All of these samples tested negative for the presence of whirling disease. Samples taken from 1.9 km upstream from the inflow from ponds on the Cap K Ranch tested positive in 3 of 8 tests performed. The low densities detected indicate that whirling disease infectivity was very low in the Fryingpan River. Densities of spores found in the effluent from these ponds had increased over the past year. Water diverted from the river 3 km downstream from the Cap K Ranch flows through ponds on the Roy Palm Property. On 7 of 16 occasions the effluent from these ponds tested positive for whirling disease at very low densities. This indicated that these ponds added very little to the ambient level of spores present in the river. The site 0.2 km upstream from the confluence of Taylor Creek had tested negatively for all 9 tests in 1999 as opposed to the 4 positive tests in 1998.

Myxospore Burden Studies

Rainbow and brown trout had been screened for the presence of whirling disease in the Fryingpan River since 1994. Since then the incidence and severity of whirling disease has been very low. Evidence indicates that the heaviest infection of whirling disease occurs in the downstream reaches of the river. This indicates two possibilities for the source of infection: migration of infected trout upstream out of the Roaring Fork River or a point source of infection within the Fryingpan River. CDOW records indicated that the river had not been stocked with any infected trout. Ponds on the Cap K Ranch seem to be a point source of infection. Future studies are planned to develop a system for removing whirling disease infection from the ponds on the Cap K Ranch and the rest of the river and also to screen for other sources of infection in local private ponds.

Roaring Fork River

Whirling disease was introduced to the Roaring Fork River when trout exposed to the parasite were stocked into the river by a private aquaculturist in the late 1980's. Rainbow trout, brown trout and mountain whitefish tested positive for the presence of cranial myxospores between 1994 and 1997. Myxospore burdens in all three species were low.

Table 1. Data contained in bibliographic sources.

					Type of Data		
	Fish Population	Life History	Spawning	Whirling Disease	IFIM	Macroinvertebrate	Water Quality
Hunter, 1943	X		X			X	
Hoppe, 1970			X				
Finnell, 1972	X	X	X			X	X
Finnell, 1973	X						
Finnell, 1974	X						
Finnell, 1977	X						X
Nehring, 1979					X		
Nehring, 1980	X	X	X		X		
ERT, 1981	X		X		X	X	X
Nehring, 1981	X	X	X				X
Nehring, 1982	X	X	X				X
Grieb, 1983	X	X	X				X
Simons, 1983	X	X	X		X	X	X
Nehring, 1984	X	X	X				
Nehring, 1985	X	X	X				
Nehring, 1986	X	X	X				
Nehring, 1987	X		X				
Nehring, 1988a					X		
Nehring, 1988b					X		
BOR, 1989	X	X	X		X	X	X
BOR, 1990							
Nehring, 1990	X						
Nehring, 1991						X	
Nehring, 1994	X	X	X			X	
Nehring, 1995	X	X	X				
Nehring, 1996	X	X		X			
Nehring, 1997	X			X			
Nehring, 1998	X			X			
BRW, 1999	X	X	X	X			
Nehring, 1999	X	X		X			
Nehring, 2000	X	X		X			

ACKNOWLEDGEMENTS

We would like to thank the project partners, Roaring Fork Conservancy, Colorado River Water Conservation District and Ruedi Water and Power Authority, for funding this study on the Fryingpan and Roaring Fork rivers. These three entities have provided the support necessary to conduct this study on this treasured resource. Additional funding for this study has been generously provided by: Trout Unlimited's Embrace-A-Stream Program, Homestake Partners, General Service Foundation, and Eagle County. Kristine Crandall (Roaring Fork Conservancy) has been extremely helpful and instrumental in the coordination of this study. Paul Hempel and Cindy Bingham (Roaring Fork Conservancy) have also provided insight and aid to the project. Thanks go to Roy Palm, Dick Stahura and Bart Chandler for allowing access to the Fryingpan River on their property. These individuals were willing to sit down and discuss the state of the Fryingpan River as only a landowner can. Tim Heng has been instrumental in acquiring access to the river as well as providing valuable information on the Fryingpan River in general. The U.S. Forest Service gave permission that allowed portions of the study to be conducted on National Forest lands.

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