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BIG HOLE RIVER ARCTIC GRAYLING RECOVERY PROJECT:

ANNUAL MONITORING REPORT 1994

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Submitted To:

Fluvial Arctic Grayling Workgroup

and

Beaverhead National Forest
Bureau of Land Management
Montana Chapter, American Fisheries Society
Montana Council, Trout Unlimited
Montana Department of Fish, Wildlife, and Parks
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ABSTRACT

Primary objectives included in this report included monitoring water temperatures and discharge in the upper Big Hole River, monitoring Arctic grayling population abundance, and maintaining minimum instream flows. Severe drought returned to the Big Hole basin in 1994: runoff of sub-normal snowpack occurred approximately six weeks before long-term average and lack of summer precipitation resulted in critically low stream flows. Discharge fell below the minimum "survival" flow of 20 cfs on 11 days in June due to irrigation withdrawals and on 55 days from August to October, primarily due to withdrawals of stock water. Water temperatures reached lethal levels in late July, resulting in an extensive fish kill. Attempts to preserve instream flows included eliciting cooperation from water users and providing alternative means of watering cattle. The grayling spawning population was lightly sampled, but age structure was balanced with the bulk of spawners age 3 and 4. Spawning success appeared to be good as indicated by the catch-per-effort of young-of-the-year grayling in Fall surveys. Fall population surveys in the Wisdom section indicated an increase in grayling abundance to 65 ± 50 age 1+ per mile. Age structure was well balanced. Investigations of the fall migration into Deep Creek were inconclusive. Surveys of grayling released into Skinner Meadows indicated that limited numbers returned to the release site after wintering elsewhere. The Axolotl Lake reserve brood was characterized and gametes were collected.

INTRODUCTION

Since 1991 the Arctic Grayling Recovery Program has endeavored to protect and restore the fluvial Arctic grayling (Thymallus arcticus) of the Big Hole River. This population is the only remaining, strictly fluvial, Arctic grayling population in the 48 contiguous United States (Kaya 1992). During the 1980's this population declined to low densities. The interagency recovery program was designed to monitor the population, to develop a brood stock to conserve their genetic integrity, to research limiting factors and develop strategies to mitigate them, and to reintroduce fluvial grayling into suitable streams within their native range (Byorth 1991). Progress of these efforts has been reported annually since 1991 (Byorth 1991, 1993, 1994, Magee and Byorth 1994). Activities conducted in 1994 were directed by the following objectives:

A. Monitor water temperatures and discharge in the Big Hole River,

B. Maintain minimum instream flows by promoting water conservation among Big Hole basin water users,

C. Monitor population abundance and distribution in the Big Hole basin,

D. Test the efficacy of using traps to sample spawning grayling,

E. Investigate the fall grayling migration into Deep Creek,

F. Monitor the grayling released into the Big Hole River at Skinner Meadows,

G. Monitor and collect gametes from the reserve stock of grayling at Axolotl Lakes,

H. Characterize and quantify grayling habitat in the Big Hole River and develop an integrated habitat database, and

I. Analyze microhabitat selection by grayling and test for potential competitive exclusion by sympatric species.

Data reported below were collected from October, 1993 to November, 1994. Results from objectives A through G are reported herein. Analysis of data under remaining objectives will be reported separately.

METHODS

Discharge and Water Temperature

Discharge and water temperatures in the upper Big Hole River have been monitored annually (Byorth 1993). Water temperatures were recorded by Omnidata DP-212 thermographs at four locations (stations 1, 3, 4, and 5 - Figure 1). Thermographs recorded temperature at 120 minute intervals on memory chips that were replaced every 85 days. Hourly water temperature and discharge were recorded at a U.S. Geological Survey (USGS) gaging station located near Wisdom, MT (station 2). These data were provided by USGS and were provisional during preparation of this report. Both data sets were downloaded to and analyzed using DBase IV (Ashton-Tate, Scotts Valley, Ca.).

Population Monitoring

The Arctic grayling population and its distribution in the Big Hole basin are monitored by electrofishing and trapping. A mobile-anode electrofishing unit mounted on a drift boat or Coleman Crawdad was used as described by Byorth (1993). Fish captured during sampling were held in a live-car until processing. Fish were anesthetized in a tricaine methanesulphonate (MS-222) bath, measured to the nearest 0.1 inches, and weighed to the nearest 0.01 lb. Fins were clipped as

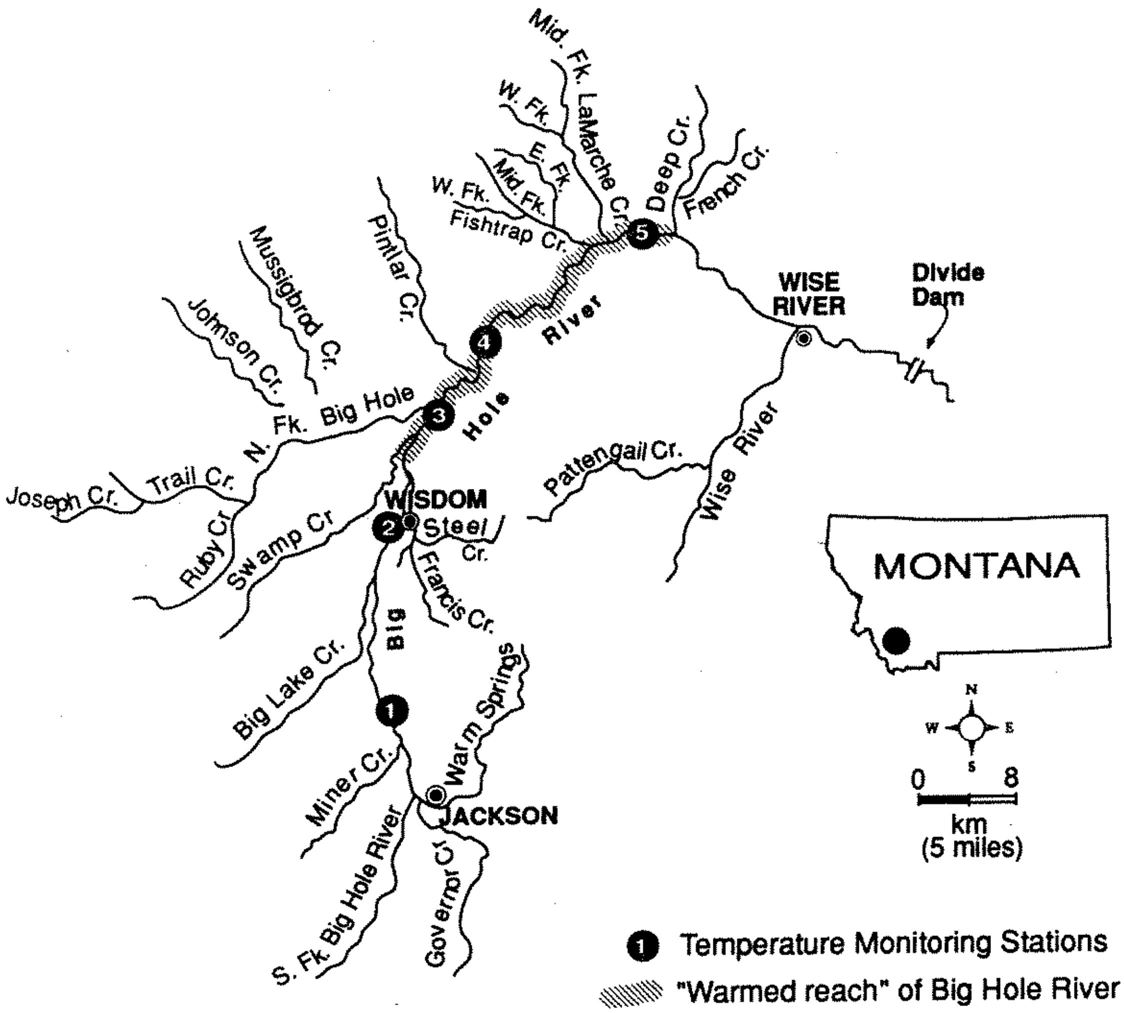

Figure 1. Map of study area indicating thermograph stations, USGS gage station, and the warmest reach of the Big Hole River. The Wisdom sampling section extends from the town of Wisdom to the upstream end of the warmest reach.

temporary marks. We tagged each grayling with a visible implant tag (Northwest Marine Technology, Inc.). We collected scale samples from most fish for age determination. However, scale samples were not available for aging during preparation of this report. Age determinations of spawning fish were based on lengths. A portion of each length group was assigned to an age class based on proportions comprised by each age class in scale samples collected from 1988 to 1993.

We attempted to sample the grayling spawning migration with traps to minimize the impacts of electrofishing on spawners. Traps were modified from Hetrick (1994) and Seelbach and Lockwood (1985). A trap was placed in the Big Hole River approximately 100 yds upstream from its confluence with Steel Creek. A second trap was placed in Steel Creek approximately 100 yds above the confluence. Each trap consisted of a 4 x 4 x 4 ft trap box and a weir constructed of electrical metal tubing strung on aircraft cable. We placed the trap at the upstream end of the weir which was placed diagonally across the channel. Traps were monitored daily from April 14 to April 26, 1994, and intermittently until May 1.

Due to high flows the traps were rendered ineffective. In order to sub-sample the spawning run sufficiently, we electrofished three subsections in a single pass: Wisdom West (Big Hole River), Clam Valley (lower 4.2 miles of the North Fork Big Hole River), and Rock Creek. We electrofished between April 18 and 26, 1994.

Fall population surveys were restricted because of extreme drought conditions. We postponed our limited surveys until flows improved in early October. Electrofishing was restricted to the Wisdom Section (East and West combined) and the Pools (Fishtrap, Sawlog, and Sportsmans Park). Fish were marked October 4 - 7 and recaptured October 27 and 31. We calculated a population estimate for the Wisdom Section using the Chapman Modification of the Peterson estimator (Chapman 1951, Vincent 1971).

We installed a trap to assess the fall migration of grayling into Deep Creek reported by Byorth (1994). The trapping apparatus was similar to that described above, except a trap was positioned at each end of the weir to capture up- and down-stream migrants. The trap was installed in Deep Creek at the Highway 43 bridge crossing, approximately 100 yds upstream from the mouth. We operated the trap intermittently between October 1 and 26, 1994.

In September, 1993 approximately 300 yearling grayling were released into the headwaters of the Big Hole River at Skinner Meadows. These fish had been the subjects of a study on competitive interactions between brook trout and grayling (Magee and Byorth 1994). After research was completed, the grayling were released to assess their survivability. In October, 1993 and May and July, 1994 we surveyed the area by walking the banks, by electrofishing, and snorkeling.

Axolotl Lake Brood

The Axolotl Lake brood reserve provides young grayling for brood stock and for experimental reintroductions. Grayling were sampled during May, 1994 using fyke nets and by hook-and-line. Initial catches were processed as indicated above, marked, and released for population estimation. Later catches were sorted by sex and held in large live cars in the lake. On May 17, 1994 Ennis National Fish Hatchery personnel spawned grayling by stripping eggs from a female grayling into a vial and fertilized them with milt from several males collected and pooled in an aspirator. Eggs were rinsed after a fertilization period, packaged, and transported to the USFWS Fish Technology Center in Bozeman for rearing. Samples of ovarian fluid and fecal material were collected for disease testing. A sample of grayling was also sacrificed for disease analysis. The remaining grayling were released back into the lake.

RESULTS

Discharge and Water Temperature

The hydrograph of the Big Hole River illustrates the severity of drought conditions in 1994 (Figure 2). Due to meager snowpack and warm, dry conditions in April, runoff peaked unusually early. The instantaneous peak discharge recorded at the Wisdom gage was 976 cfs on April 23. A second brief pulse peaked at 818 cfs on May 20. The first peak occurred during spawning, while the second occurred 9 days after the predicted date of emergence of newly-hatched grayling. Due to the early runoff and lack of mid-summer precipitation, flows became critically low in late June.

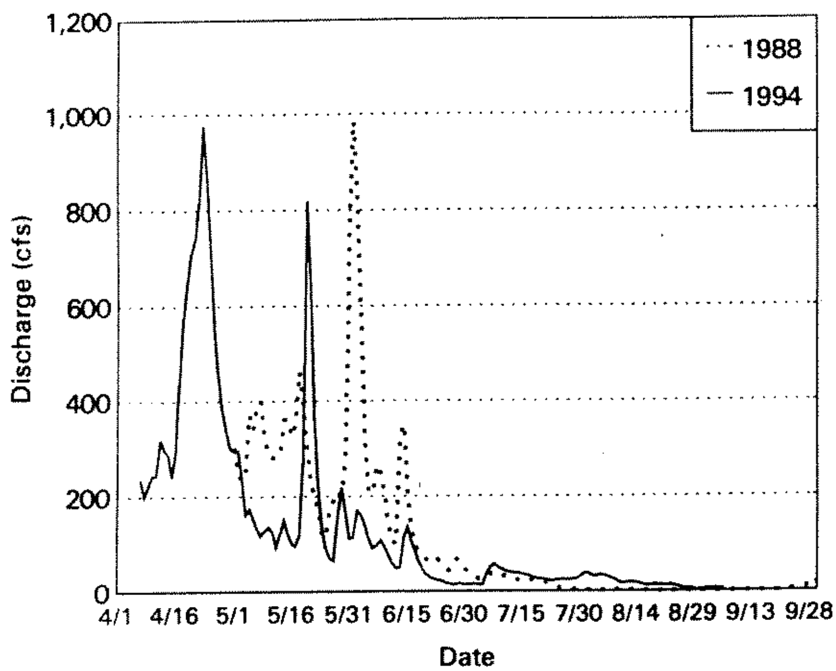

Figure 2. Mean daily discharge (cfs) of the Big Hole River measured at Wisdom gage station, April through September, 1988 and 1994.

We consider the minimum flow (measured at Wisdom), below which fish survival is severely threatened, to be around 20 cfs. Discharge fell slightly below that level for 11 days in June, during the last two weeks of the irrigation season. After the majority of irrigation withdrawals were discontinued and a rainstorm on July 6, flows increased to 57 cfs. Discharge began a steady decline thereafter and was below 20 cfs from August 9 through October 4, a total of 55 days. The minimum flow recorded in 1994 was 1.9 cfs on August 30. In 1988, discharge was recorded at 0 cfs on 24 days and was less than 20 cfs for 78 days.

Efforts to maintain instream flows entailed personal contacts with water-users to encourage conservation. In addition, a grant was secured from the Governor's Environmental Contingency Fund to exchange stock tanks and well development for water diverted from the Big Hole River. These efforts are described in greater detail in Appendix A.

The severity of drought in 1994 was also manifested in high water temperatures. A maximum temperature of 79.7°F was recorded on July 25, 1994 at the Christianson Ranch thermograph station (Table 1). This exceeded the upper incipient lethal temperature reported by Lohr et al. (in review - see appendices of Byorth 1994). Lethal temperatures were also exceeded or nearly exceeded at the Wisdom Bridge (station 2) and Buffalo Ranch (station 3) (Figure 1). The period of highest water temperatures occurred between July 21 and 26. Water temperatures exceeded lethal limits for greater than 4.2 hours, the median resistance time reported by Lohr et al. (in review, Byorth 1994), on three days at station 4 and on 1 day at station 3. The highest mean daily temperature was also recorded at station 4, 71.2°F on July 25, 1994. Temperatures at station 5, the furthest down river, were more moderate than all but the uppermost station.

We investigated a fish kill on July 27, 1994 near the confluence of Pintler Creek, approximately mid-way between thermograph stations 3 and 4 (Figure 1). We counted 96 mountain whitefish (Prosopium williamsoni), 4 white suckers (Catostomus commersoni), 12 longnose suckers, (Catostomus catostomus), over 60 longnose dace (Rhynichthys cataractae), 18 burbot (Lota lota), over 100 mottled sculpin (Cottus bairdi), and 2 brook trout (Salvelinus fontinalis) while walking 500 yards along each river bank. Mortalities were representative of all age classes and had apparently occurred over several days as evidenced by varying degrees of decomposition. Mortalities were observed intermittently for up to 2 miles below the confluence of Pintler Creek, where two yearling grayling and several brook trout were found dead. At the Highway 43 bridge near the mouth of Squaw Creek only 1 mottled sculpin mortality was found. We also surveyed segments of the Big Hole River near Sawlog Creek and at Sportsmans Park and observed a total of 3 mountain whitefish and one mottled sculpin mortality. On July 28, we surveyed the area near thermograph station 3. Three white suckers, 1 longnose sucker, 1 mountain whitefish, 1 brook trout, and 1 unidentifiable mortality were observed there. The extent of the fish kill between the mouth of the North Fork Big Hole River and Pintler Creek is unknown.

Table 1. Maximum daily (T_{max}) and maximum mean daily water temperature and days over lethal thresholds at thermograph stations in the Big Hole River 1994.

Station	T_{max} (°F)	Max T_{mean} (°F)	Days > 77°F	Lethal Periods*
1	75.2	65.8	0	0
2	77.7	69.4	4	0
3	77.0	70.4	2	1
4	79.7	71.2	7	3
5	76.1	66.1	0	0

* Number of days with periods of 4 hours or greater in which temperatures exceeded lethal levels (Lohr et al. in Byorth 1994).

In response to the thermal stress placed on fish due to low flows and near lethal temperatures, the fishing season was closed on July 30 by order of the Montana Fish, Wildlife, and Parks Commission. The closure extended from the confluence of the North Fork Big Hole River to Dickie Bridge. The remainder of the Big Hole River was closed to angling on August 29.

Population Monitoring

Spawning and Recruitment

We captured a total of 87 spawning grayling: 22 in traps and 65 by electrofishing. Of the electrofishing sample, 41 were captured in the Wisdom Sections and 22 were captured in the North Fork Big Hole River, which appears to provide important spawning habitat. The sex ratio of the combined sample was 1.87 males per female. The bias toward males indicates that sampling was conducted prior to the peak of spawning, when sex ratios are close to 1:1. We believe that peak spawning occurred on April 26. During spawning discharge ranged from 200 to 976 cfs. Shepard and Oswald (1989) reported that grayling generally spawn between lowland and highland runoff peaks. This year, the grayling appeared to spawn during peak flows when water temperatures ranged between 34 and 56°F.

Age ratios demonstrate that the grayling population is stabilizing. The spawning population consisted of 19% Age 2, 40% Age 3, 33% Age 4, and 10% Age 5. This age structure is very similar to that of the 1993 spawning run (Figure 3).

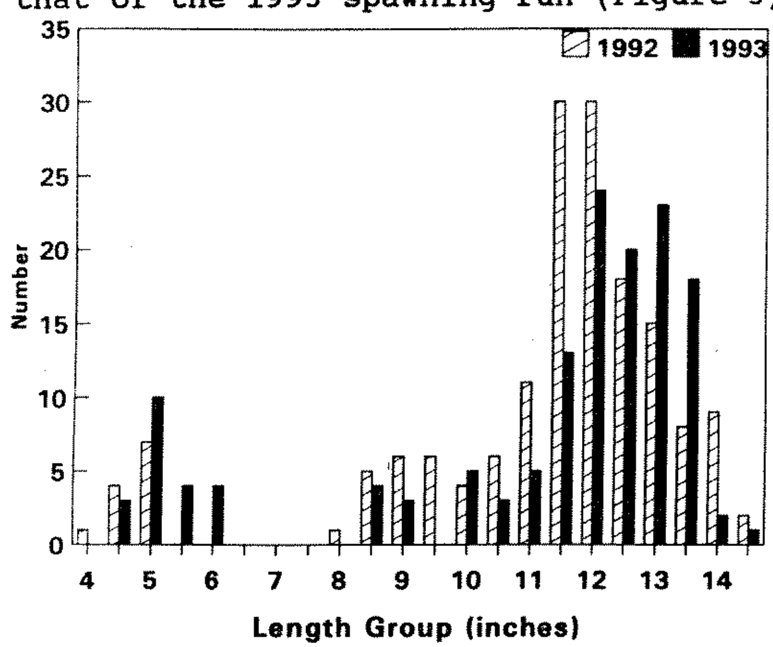

Figure 3. Length frequency histogram of spawning Arctic grayling sampled in the Big Hole River and tributaries, 1993 and 1994.

The efficacy of trapping spawning grayling in the Big Hole River is questionable. Due to abnormally high flows during spawning the traps were rendered ineffective. Trapping may be feasible under a more typical hydrograph.

The second runoff event may have impacted spawning success. Grayling larvae should have hatched between May 7 and 9, based on degree-days, and emerged on May 10 through 12 (Wojcik 1955, Kratt and Smith 1977, Byorth 1993). A major peak in flows occurred on May 20 when flows increased by 700 cfs. However, catch rates of young-of-the-year (YOY) grayling in limited fall surveys indicate moderately successful recruitment relative to past years (Table 2). A total of 39 YOY grayling were captured in two passes.

Population Estimates

Due to extreme drought conditions, we limited our fall sampling to the Wisdom sections (East and West) and The Pools survey. The density of Age 1+ grayling in the Wisdom sections was estimated to be 65 (± 50) per mile. This estimate is an approximate two-fold increase over estimates calculated from 1989 to 1993 surveys. The grayling population has apparently increased to levels last observed in 1984. Parameters used to calculate the estimate are listed in Table 3.

While yearling grayling were predominant in the Wisdom Section sample, older and larger fish (> 13 inches) were more abundant in the Pools areas (Figure 4). The combined sample indicates a well-balanced age distribution. Contrary to indications that recruitment was poor in 1993, yearling grayling were abundant in the 1994 survey (Byorth 1994).

Table 2. Catch rates (catch-per-effort (CPE)) of young-of-the-year (YOY) grayling captured in the McDowell and Wisdom sections of the Big Hole River, 1983 - 1994.

Year	McDowell Section			Wisdom Section		
	# YOY	# Runs	CPE	#YOY	# Runs	CPE
1983	---	---	---	2	6	0.33
1984	---	---	---	5	7	0.71
1985	0	3	0	0	3	0
1986	145	4	38.2	---	---	---
1987	3	1	3.0	0	1	0
1988	---	---	---	---	---	---
1989	178	2	89.0	90	2	45.0
1990	58	2	29.0	98	4	24.5
1991	10	2	5.0	41	2	20.5
1992	42	2	21.0	83	4	20.75
1993	2	2	1.0	31	4	7.75
1994	---	---	---	39	2	17.5

Table 3. Parameters used to estimate Arctic grayling density in the Wisdom Section during Fall, 1994: M = number grayling marked, C = number captured in 2nd pass, R = number marked grayling in 2nd sample.

Age	M	C	R	Ñ	Ñ/mi	95% CI
0	29	10	2	109	22	18.6
1	39	24	3	249	51	40.8
2+	17	14	3	67	14	9.3
Age 1+				316	65	50.1

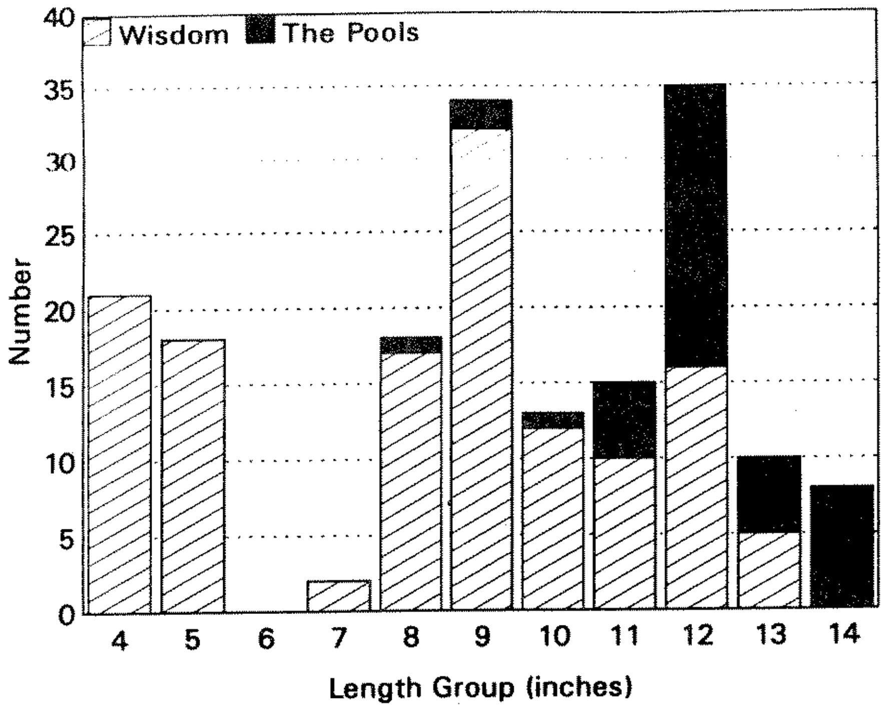

Figure 4. Length frequency histogram of Arctic grayling captured in Fall 1994 electrofishing surveys of the Big Hole River.

Deep Creek Migration

In 11 trap-days of effort in Deep Creek, we captured 12 grayling, 56 brook trout, 13 brown trout (Salmo trutta), 20 rainbow trout (Oncorhyncus mykiss), 289 mountain whitefish, 83 longnose suckers, 61 white suckers, and 1 burbot. The majority of fish were captured between October 6 and 12, as maximum daily temperatures decreased to under 50°F. Daily trapping records are summarized in Appendix B. Nine of 12 grayling and 95% of white and longnose suckers were captured in the downstream trap, although a grayling was captured in the upstream trap as late as October 26. This apparent out-migration occurred while brook trout spawned, but prior to mountain whitefish or brown trout spawning. About 2/3 of mountain whitefish were captured after

October 20, indicating that they probably spawned a minimum of two weeks after the brook trout. The migration reported in Byorth (1994), must have occurred prior to trapping; therefore, the grayling migration must occur independently of spawning activities of other species. The majority of fall grayling movements reported by Byorth (1991) also occurred in early October. Of all rainbow trout captured, 95% were captured in the upstream trap. They may be exploiting the spawning runs as a food source or using Deep Creek for winter habitat. Few brown trout were captured entering Deep Creek. Either brown trout spawning is limited in Deep Creek or traps were removed prior to the peak of immigration and spawning.

Skinner Meadows Reintroduction

In October 1993, 6 weeks after 300 grayling marked with VI tags were released into the Big Hole River at Skinner Meadows, we counted 146 in the vicinity of their release. Of those observed, 66% remained in the study reach of Magee and Byorth (1994). The remainder had moved downstream as far as 0.5 miles. During May, 1994, no fish were observed in the study reach or nearby. This is consistent with observations of brook trout made in June 1993: winter habitat is limited in the area and adult fish winter elsewhere. We electrofished Skinner Creek, a spring fed stream, and captured 73 brook trout and no grayling. During a July 1994 survey, 8 grayling were in the study reach and 1 grayling was observed in beaver ponds 0.25 mi downstream of the study reach.

Axolotl Brood Reserve

We sampled the Axolotl Lake brood reserve to determine the status of the 1988 year class, survivorship of yearling grayling planted in 1993, and to collect gametes for experimental introductions. A mark/recapture experiment indicated that approximately 290 (± 152) Age 6 grayling from the 1988 cohort remain in Axolotl Lake. Their average length was 13.5 inches (range: 12.7 - 14.6 inches, N = 98), which indicates that they did not grow significantly since 1993. The sex ratio of Age 6 grayling favored males by 2.25 to 1.

Approximately 3,000 age 1 grayling were planted in the lake in 1993. Half originated from the Axolotl Lake brood and half from the Big Hole River. Based on differential fin markings, approximately 840 (± 417: N=365) of Big Hole origin and 371 (± 265: N=122) of Axolotl brood origin survived to Age 2. Their mean length was 8.6 inches (range: 7.0-10.3 inches). Growth rates did not differ significantly between groups. Approximately 5% of age 2 grayling were immature; therefore, probability of capture was not equivalent for the entire cohort and the sample may have been biased.

Eggs were collected from 16 age 6 and 5 age 2 females and fertilized with 30 males from both cohorts. After hatching it was apparent that gametes from the Age 2 grayling had limited viability (W. P. Dwyer, pers. comm.).

DISCUSSION

While the drought of 1994 was second only in severity to 1988 in this century (USGS files), its impact on the Arctic grayling population was moderated by an improved age structure and efforts to maintain minimum flows (Table 4). Discharge in the upper Big Hole River near Wisdom during the years 1988 to 1994 generally reached critical levels (i.e. less than 20 cfs) in August and September. Irrigation of hay crops is generally discontinued in early July. Diversions for irrigation have resulted in critical flows in only 2 of the last 7 years (Table 4). In years of moderate precipitation, snow-pack is sufficient to supply irrigation requirements and maintain stream flows. In extremely dry years, water conservation practices will be necessary to maintain flows.

Critical flows in late summer were attributable to lack of precipitation and diversions for stock water. Our efforts to encourage stockgrowers to minimize late summer diversions and toward developing alternative sources of stock water resulted in maintaining flows at levels much less severe than 1988 (Appendix A). In 1988, discharge fell to 0 cfs at the Wisdom bridge for 27 days. Water yield, or total volume of water passing the gage, in August and September, 1988 was only 213 acre-ft (Table 4). In contrast, the 1994 minimum flow was 1.9 cfs on 1 day and August-September water yield was 1821 acre-ft. Alternative sources of stock water, such as wells and pipelines, along with conservative withdrawals from the river should be sufficient to maintain flows above 20 cfs even in the driest years.

Water temperatures reached lethal levels during July 1994. The Big Hole River from the mouth of the North Fork to Squaw Creek acts as a heat sink because of its braided, broad, shallow channel morphology. A combination of this channel shape, long, hot days, and low flows led to water temperatures near 80°F. The resultant fish kill was substantial, affecting all age classes of all species resident in the warmed reach of the Big Hole River. Temperature problems may be alleviated by increasing flows and/or concentrating flows into a single channel.

Table 4. Comparisons of Big Hole River discharge parameters measured at the USGS gage at Wisdom, 1988 to 1994. Yield is the total volume of water passing the Wisdom gage during August and September.

Year	# Days less than 20 cfs		Max Flow (cfs)	Min Flow (cfs)	Dates at Min	Yield Aug-Sept (ac-ft)
	Apr-June	July-Sept				
1988	0	78	1080	0	8/27-9/21	213
1989	0	4	978	12	8/20	3790
1990	1	0	667	18	5/23	5820
1991	0	16	4300	10	9/4	3690
1992	18	32	479	3.3	5/26	2760
1993	0	0	1700	55	10/5	17490
1994	11	55	976	1.9	8/30	1821

In spite of the severity of drought conditions in 1994, the Arctic grayling population appears to be increasing. For the first time since 1984 the estimated age 1+ population has surpassed 60 per mile in the Wisdom Section. The 1994 estimate may be somewhat biased because we delayed sampling until October. Grayling are known to move considerably during October (Byorth 1991). However, the parameters used to estimate the population are comparable to those of past years (Table 3). The apparent increase is attributable to a balanced age distribution. After poor recruitment to the population from 1983 to 1987, the population declined. After the decline, the spawning population was skewed toward age 2 and 3 grayling. Because age 2 fish are not fully mature, their contribution to spawning success is questionable. In effect, only one significant age class was contributing significantly to spawning. Since 1992, however, Age 3+ fish have comprised over 80% of the spawners (Byorth 1993, 1994). Three mature age classes: age 3, 4, and 5 have been represented in the past two spawning years.

Our index of recruitment is catch-per-unit-effort of YOY grayling in fall surveys (Table 2). In the Wisdom Section, that index has been stable since 1989, except in 1993. Recruitment in the McDowell section has been less stable. The 1993 survey draws the index into question. Whereas the catch of YOY in 1993 was low, our 1994 population estimate reveals an abundant yearling age class. Apparently, the higher flows during 1993 rendered our sampling less effective. Young-of-the-year grayling were also distributed more uniformly throughout the basin than in past years (Byorth 1994). Nevertheless, excellent 1992 and 1993 year class strength and good potential recruitment in 1994 should result in a continued strengthening of the fluvial Arctic grayling population of the Big Hole River.

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APPENDIX A

Byorth, P. A. 1995. Upper Big Hole River instream flow protection project, Environmental Contingency Grant Program completion Report. Montana Fish, Wildlife, and Parks, Submitted to: Office of the Governor and Dept. of Natural Resources and Conservation, Helena.

BIG HOLE RIVER INSTREAM FLOW PROTECTION PROJECT

Environmental Contingency Grant Program Completion Report

Prepared by:

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Submitted To:

Office of the Governor

Department of Natural Resources and Conservation

January 1995

PROJECT SUMMARY

The Big Hole River of southwestern Montana sustains the last remnant population of fluvial, or river-dwelling, Arctic grayling in the 48 contiguous United States. In the mid-1980's, this population underwent a serious decline in abundance. An interagency recovery program led by Montana Fish, Wildlife, and Parks (FWP) was instituted in 1988 to address the factors responsible for the decline and to devise a program to conserve this unique native salmonid. In October 1991, a petition was submitted to the U. S. Fish and Wildlife Service (USFWS) requesting fluvial Arctic grayling in Montana be classified as "Endangered" and be given full protection under the Endangered Species Act. The status review of the grayling resulted in a finding, published in the Federal Register, that "...listing...is warranted but precluded..." The rationale behind the finding included a lessening threat to the population "...primarily as a result of the cooperative efforts that have been initiated..."(Nordstrom 1994).

A predominant factor limiting Arctic grayling in the Big Hole River during the 1980's has been drought. Water yield in the Big Hole Basin was the lowest on record between 1988 and 1994 (USGS Files). During years of poor snowpack and scarce mid-summer precipitation, increased agricultural demand for water resulted in periodic dewatering of the upper Big Hole River, particularly between July and September. Diminished flows contribute to high water temperatures, higher susceptibility to predators, decreased habitat volume, and increased mortality of very old and very young fish. Water temperatures lethal to grayling have been documented in 5 of the last 7 years in the upper Big Hole River (Byorth 1994).

It is well documented that fish abundance is regulated by food and space which are primarily determined by water volume (Chapman 1966). Limits of productivity in a riverine fish community are set by discharge during critical periods. Nelson (1980) described two minimum flow levels for salmonid populations: an "absolute minimum" below which standing crops of fish are reduced and a "most desirable minimum" which are necessary to maximize standing crops. In the Big Hole River the absolute minimum was determined to be 60 cfs in a reach near Wisdom (Mt. Dept. of Natural Resources and Conservation (DNRC) 1992). However, in 6 of the past 7 years, discharge in the upper Big Hole River at Wisdom has been under 60 cfs on a majority of days between June and October. During extremely dry years it is appropriate to define a third critical flow level. This "minimum survival" flow would merely maintain a wetted channel and facilitate survival of the fish population only in a short term. This level was estimated to be 20 cfs. Our goal during Summer 1994 was to maintain instream flows above this level to mitigate further declines in, or reduce the risk of extinction of the Arctic grayling population. Flows were monitored at a U. S. Geological Survey (USGS) gage located at Wisdom (Figure 1).

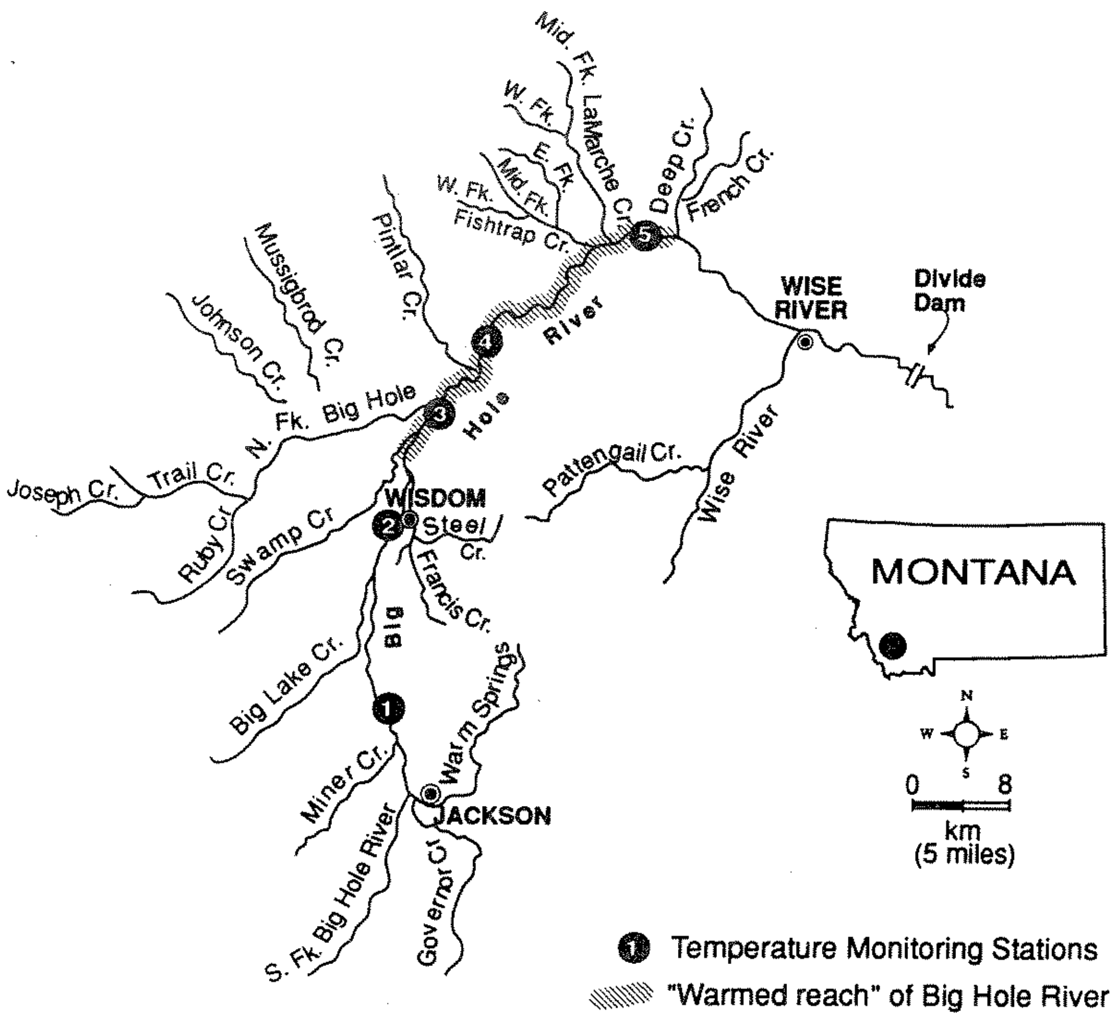

Figure 1. Map of the upper Big Hole River study area including thermograph stations, USGS gage station (2), and warmest reach of the Big Hole.

Due to early snow-melt and lack of rain, water withdrawals for agriculture were the primary regulator of instream flows in the Big Hole River and its tributaries. Therefore, to maintain minimum survival flows, it was necessary to seek cooperation from the agricultural community in conserving the limited available water. We contacted water-users, in person and by phone, requesting that they minimize their withdrawals. In spite of efforts to conserve water, however, flows became critical in early August. By that time, irrigation season had ended but water was still being diverted for stock. It was apparent that the only way to maintain a minimum flow was to find alternative sources of stock water.

The upper Big Hole River has been dewatered most severely in the reach near Wisdom, which is among the most critical habitats for Arctic grayling. Several diversions and canals upstream of Wisdom are used to transport water over long distances to cattle. Evaporation and leakage renders this water delivery system extremely inefficient. To provide an alternative to diverting water, we contacted water-users on three ranches and offered to supply stock water in tanks. After a ranch owner expressed interest in cooperating, we requested financial support for the project from the Environmental Contingency Grant Program through the Governor's Office and DNRC. The grant was secured which enabled FWP to purchase ten 1,000 gallon stock tanks and to lease a tank truck and driver from the East Bench Irrigation District. Eight stock tanks were installed in several large pastures which were kept filled by water truck from September 7 through October 1, 1994. Water was pumped into the tanker from the Big Hole River at the ranchers' established points of diversion. Two additional stock tanks were placed at an existing well site, which we developed to constantly supply tanks with water.

RESULTS

Discharge in the upper Big Hole River declined to critical levels during two periods in 1994. Mean daily flows were below 20 cfs from June 25 through July 5 (Figure 2). The lowest flow during this period was 14 cfs. Diverting water to irrigate hay was a primary factor reducing stream flow. In the upper Big Hole Basin, the irrigation season traditionally extends from May to early July. After water users were contacted, on June 28 and July 6, the majority of irrigation diversions were closed. A rain storm also occurred as irrigation season ended and flows increased to 57 cfs by July 8 (Figure 2).

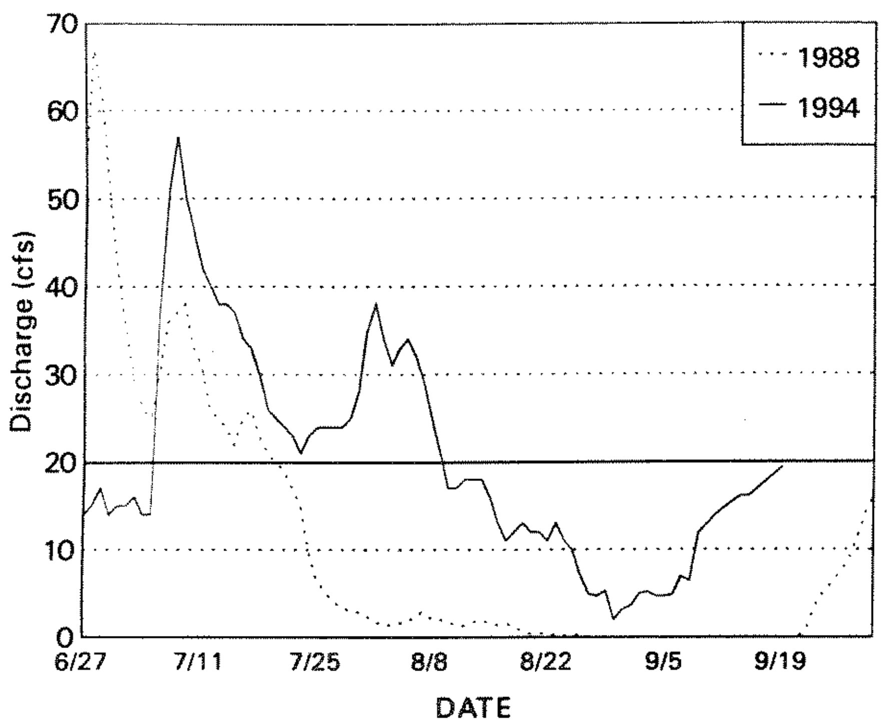

Figure 2. Mean daily discharge of the Big Hole River measured at the USGS gage near Wisdom, June 27 to September 30, 1988 and 1994.

A second critical flow period began in late July as hot, dry weather persisted. Between July 24 and 27, a fish kill due to lethal water temperatures was documented near the confluence of the Big Hole River and Pintler Creek. Several hundred fish of most resident species and age classes were found dead. The full extent of the fish kill was unknown, but mortalities were documented from the mouth of the North Fork of the Big Hole River to the Squaw Creek area, a distance of approximately 13 miles (the "warmest reach" in Figure 1). In response to critical conditions, Governor Racicot convened a public meeting in Butte to discuss strategies to address the drought, especially in the Big Hole and Clark Fork basins. He emphasized using cooperative efforts to alleviate water shortages. On July 30, the Fish, Wildlife, and Parks Commission closed the fishing season from the mouth of the North Fork to Dickie Bridge to protect the Arctic grayling population. FWP initiated a second round of water-user contacts requesting increased water conservation. FWP also hired a water commissioner to survey Big Lake and Big Swamp Creeks for surplus water. As a result of these efforts, flows increased to 38 cfs by August 1 (Figure 2). However, flows returned to critical levels by August 10.

While very little water was entering the Big Hole River from tributaries or precipitation, stock water was still being diverted in mid-August. By August 25, water users were contacted a third time to reduce consumption. In spite of those efforts, a water-user opened a diversion on August 30 in an unsuccessful attempt to divert water to cattle. As a result, flows reached the low point of 1.9 cfs on that date. In response to FWP's calls for assistance, that diversion and eight others were closed or reduced to a minimum to keep the Big Hole River flowing.

After the Environmental Contingency Grant was secured, stock tanks were distributed and filled by September 7. As a result, the "Spokane" ditch was closed. Prior to its closing, approximately 5 cfs had been diverted and transported over 8 miles to water approximately 2,500 cattle. After the Spokane ditch and the other diversions were closed or withdrawals reduced, flows at Wisdom increased to near 20 cfs by September 16. Flows fluctuated between 15 and 20 cfs until early October, when fall precipitation provided relief from drought conditions.

The success of delivering water to stock tanks as an alternative to providing water through ditches is illustrated by Table 1. We delivered water to stock tanks for 25 days. Had the Spokane ditch remained open at a rate of 5 cfs, approximately 81 million gallons of water would have been diverted from the Big Hole River. We delivered approximately 227,375 gallons of water over the 25 day period in addition to approximately 150,000 gallons provided by a well. The volume of water required via the alternative means was approximately 0.5% of that required by ditch delivery.

The summer of 1988 provided a useful comparison to gauge the success of this summer's efforts. In 1988, the Big Hole River ceased to flow (i.e. 0 cfs) at Wisdom for 24 days in August and

September. In 1994, flows were as low as 1.9 cfs on one day, and were below 5.0 cfs on only 6 days.

Table 1. Comparison of efficiency of providing stock water via ditch at 5.0 cfs versus delivering water by stock tanks and a well between September 7 and October 1, 1994.

Water Volume	Ditch	Tanks	Well	Tank + Well
Flow (cfs)	5.0	0.014	0.005	0.019
Gallons per Day	3,231,580	9,095	3,000	12,095
Total Gallons	8.1×10^7	227,000	150,000	377,000
% of Ditch Volume	100	0.34	0.19	0.53

While substituting water delivery for stock water canals proved to be a successful way of maintaining a minimum instream flow, it was merely an emergency measure. The expense and limited scope would render water delivery ineffective in the long term. More permanent solutions to water allocation during drought years must be addressed. A positive step was made during 1994 as water-users made an effort to conserve water. An increased awareness of the status of the Arctic grayling population and a conscious effort to monitor water consumption will facilitate future efforts at preserving in-stream flow. The efficacy of providing water via wells and pipelines was tested and will be pursued further. Plans to drill wells and pump water to cattle served by the Spokane Ditch are in development. The concept of "conjunctive use", or tapping deep aquifers in drought years, is also being investigated.

The Arctic grayling population of the Big Hole River has recently shown signs of increasing abundance (Byorth 1995). Fall 1994 sampling revealed an increase in grayling abundance to approximately 65 per mile in the Wisdom area, a level last observed in 1984. Continued recovery of the population depends on providing a satisfactory minimum instream flow. While 20 cfs may allow the grayling population to survive critical periods in a short-term crisis, the "absolute minimum" flow of 60 cfs should be our goal in the future. By seeking out alternatives for watering stock and through improved conservation in irrigation practices the last fluvial Arctic grayling population in the lower 48 United States will remain a testament to Montana's commitment to its natural heritage.

BUDGET SUMMARY

The Environmental Contingency Grant was $ 7,245.00. Total expenses for the project at completion were $ 8,970.52. We had estimated costs based on delivering water for two weeks. However, the drought persisted and we continued delivering water for two additional weeks. The major additional expense was providing wages for water truck drivers. While only 40 hours per week were allotted, drivers delivered water up to 19 hours per day. Additional driving time was provided by FWP fisheries personnel. FWP also provided additional funding for a water commissioner and rented high volume pumps to fill the water tank more efficiently.

Table 2. Summary of budget and expenses for the upper Big Hole River Flow Protection Project.

Item	**$ Budgeted**	**$ Spent**	
		E.C.G Grant	**FWP**
Stock Tanks (10)	2250.00	2269.00	
Delivery	150.00		
Truck Drivers	600.00	1623.08	1367.00
Water Truck	2800.00	3150.00	
Maintenance/Repair	500.00	200.94	270.50
Contingency	945.00		
Water Commissioner			90.00
TOTAL	**7245.00**	**7243.02**	**1727.50**

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APPENDIX B.

Appendix B. Daily catches of grayling (GR), brook trout (EB), mountain whitefish (MWF), brown trout (LL), rainbow trout (RB), longnose sucker (LNSU), and white sucker (WSU) in upstream (up) and downstream (dn) traps in Deep Creek, October, 1994. Recaptured fish are excluded.

Date	GR		EB		MWF		LL		RB		LNSU		WSU		Water Temp (°F)	
	up	dn	up	dn	up	dn	up	dn	up	dn	up	dn	up	dn	max	min
10/1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	73	43
10/3	0	0	0	1	0	0	0	0	0	0	1	0	0	1	58	38
10/6	1	7	13	12	16	8	2	0	7	1	1	43	1	48	48	31
10/7	0	1	7	2	43	1	2	0	5	0	1	7	2	7		
10/10	0	0	0	0	0	1	0	0	0	0	0	6	0	2	52	36
10/12	1	0	4	1	5	2	0	0	4	0	0	0	0	0	48	44
10/17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	33
10/18	0	0	4	5	0	0	1	0	0	0	0	0	0	0	44	37
10/20	0	1	0	0	71	77	3	0	3	0	0	4	0	0	47	38
10/21	0	0	0	6	0	0	0	5	0	0	0	0	0	4	44	32
10/26	1	0	0	0	2	63	0	0	0	0	0	0	0	0	42	33
Total	3	9	29	27	137	152	8	5	19	1	3	60	3	58		