Water Leases and Yellowstone Cutthroat Trout Fry Outmigration from Four Tributaries of the Upper Yellowstone River, Project Year 2001

Prepared for:
Montana Department of Fish, Wildlife & Parks
1400 South 19th
Bozeman, MT 59718

Prepared by:
Leanne H. Roulson
Garcia and Associates
7550 Shedhorn Drive
Bozeman, MT 59718
406.582.0661
Fax 406.582.0659

March 2002
J5018

Table of Contents

List of Figures

List of Tables

List of Appendices:

Executive Summary

Garcia and Associates (GANDA) was contracted by Montana Fish, Wildlife, and Parks (FWP) to conduct streamflow and biological monitoring related to Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) fry outmigrations from four tributaries of the Yellowstone River in Park County, Montana. Yellowstone cutthroat trout fry outmigration has been monitored on Mill, Cedar, and Mol Heron creeks since 1996 to evaluate the effect of existing water leases on fry recruitment to the Yellowstone River, Montana. Yearly variations in water availability and demand have affected how well the leases have functioned to protect developing and outmigrating fry. Both 1996 and 1997 were record spring runoff years, resulting in plentiful water supplies and little contention over in-stream flows. However, the summers of 1998 and 1999 were warmer and drier than the two previous summers, inducing periods of low flows in both Mill and Cedar creek, and sustained periods of no measurable flow Mill Creek in mid-September 1998. Draft climatic data suggests that both 2000 and 2001 were drier than average for all four project streams, especially when evaluated in terms of water year, which takes into account the available moisture from the previous winter, rather than calendar year. The effect of the lack of moisture is compounded by the fact that precipitation in the project area has been below average for the past three years, and snow pack in the Yellowstone basin has been below average in three out of the four previous years.

GANDA examined how the existing water leases influenced in-stream flows and Yellowstone cutthroat trout fry outmigration from Mill, Big, Cedar, and Mol Heron creeks from July 15 to September 14, 2001. Water levels remained above the minimum amount leased in Big and Mol Heron creeks for the entire field season, but Cedar Creek declined below lease levels for 24 hours in mid-July. Mill Creek dropped below lease level on July 26, after which the water commissioner was unable to maintain lease level flows except during the flushing flow. Mill Creek had no measurable flow in late July and early August for at least 120 hours, and was only intermittently connected with the mainstem of the Yellowstone for the remainder of the monitoring period.

Total numbers of Yellowstone cutthroat trout fry captured were down in Mill, Big, and Mol Heron creeks from surveys conducted in 2000. Cedar Creek was the only project stream to show an increase, with a total of 18,032 Yellowstone cutthroat trout fry trapped, an increase of approximately 39% from 2000. Mill Creek experienced a 54% decrease in the number of fry trapped compared to 2000, and a 74% decrease compared to 1999. Big Creek outmigrants trapped returned to lower levels in 2001, showing a decrease of 62% as compared to 2000. However, trap catch had increased notably in 2000 in Big Creek, and the number of fry trapped in 2001 was actually 24% higher than that captured in 1999. The number of fry trapped decreased 36% in Mol Heron Creek as compared to 2000 counts, and 85% as compared to 1999.

1.0 Introduction

In-stream flow water leases between FWP and participating water right holders were in effect in 2001 on Mill, Big, Mol Heron, and Cedar creeks (Table 1-1). This was the third year that Big Creek has had a water lease in effect. Yellowstone cutthroat trout fry outmigration has been measured for the past five years on Mill, Cedar, and Mol Heron creeks. Monitoring began first as part of the water leasing effectiveness study which ran from 1996 to 1998 (Hennessey 1998, Roulson 1998), and since then as part of this monitoring effort which began in 1999 (Roulson 1999, Roulson 2001). Byorth (1990) monitored Yellowstone cutthroat trout fry outmigration from Big Creek in 1988 and 1989, but little study of the fishery has taken place since. The four water leases involved in this project were established to provide in-stream flows for Yellowstone cutthroat trout reproduction and to generally benefit the Yellowstone River fishery (Spence 1995). This project sought to examine how well the leases functioned in 2001, a second drought year. The specific objectives of this project were:

1. Monitor fry outmigration from Mill, Big, Cedar, and Mol Heron creeks, and compare results to available data from the previous years;
2. Monitor streamflows during the project and notify the water lease contact for each creek and FWP if flows drop below water lease levels;
3. Measure streamflow at staff gauges on Mill, Big, and Cedar creeks and verify them against existing United States Geological Survey (USGS) rating tables.
4. Measure streamflow at the staff gauge on Mol Heron Creek and verify results against the rating table developed by GANDA in 1999.
5. Recommend the timing for the Mill Creek flushing flow and to monitor fry outmigration to assess its effectiveness.

Table 1-1. Summary of water lease information for the four water lease project streams (Spence 1995, EQC 1998, K. Williams, FWP, pers. comm. 1999).

Location	Lessor	Priority of right	Total quantity[a]	Period of use	Date lease originated
Mill Creek	Mill Creek Water & Sewer District	95 rights with various priorities	up to 65 cfs	48 hours in August	August 1992
	individual	1880 and 1903	6.13 cfs	May 1 to October 4	October 1992
	individual	1891	2.64 cfs	May 1 to October 19	August 1995
Big Creek	3 individuals	1883	11.0- 26 cfs	April 15 to November 1	April 1999
Cedar Creek	USFS	1890,1893, 1898, 1904, and 1972	6.39- 9.64 cfs	May 1 to October 15	December 1993
Mol Heron Creek	Church Universal and Triumphant	1880	5 cfs	May 1 to October 15	May 1998[b]

[a] Actual flows leased may differ from the quantity protected at a downstream measuring device. The Mill Creek lease protects up to 4.4 cfs as measured at the East River Road staff gauge. The Big Creek lease protects 11 cfs as measured at the gauge above Highway 89. The Cedar Creek lease protects a minimum of 1.3 cfs as measured at the staff gauge below the Highway 89 culvert.

[b] An initial verbal agreement was reached 1996, but the water lease was not finalized until 1998.

2.0 Project Area

GANDA conducted this project in Park County, Montana on four tributaries of the upper Yellowstone River (Figure 1). Cedar and Mol Heron creeks are considered high quality spawning areas for Yellowstone cutthroat trout as defined by Clancy (1988). Lower Mill Creek and Big Creek were excluded from this distinction because of decades of dewatering during critical times in the Yellowstone cutthroat trout reproductive cycle. A detailed description of Mill, Cedar, and Mol Heron creeks, along with results from electrophoretic testing of fry from 1996 and 1997, is included in the study completed by Hennessey (1998).

Mill Creek, located near Emigrant, drains the largest contributing watershed of the Yellowstone River in Park County (Figure 1). Mill Creek is a fourth order stream with an approximate length of 21 miles (34 km), and a mean annual discharge of 160 cfs (4.5 m^3/s) (Parrett 1985). Stream order for all creeks is based on the occurrence of perennial streams on USGS 1:24,000 scale topographic maps. Much of the upper reach of Mill Creek is within the Gallatin National Forest, and its headwaters are contained within the Absaroka Beartooth Wilderness. The Mill Creek Water and Sewer District aqueduct, downstream of the National Forest Boundary, is the largest single diversion on the creek and serves over 95 water right holders. There are many additional irrigation diversions in the lower 10 miles (6.2 km) of Mill Creek. A water commissioner is appointed each year to administrate water rights and flow controls on Mill Creek, including the water leases (EQC 1998). Although the total amount of water involved in the two water leases that are in effect from May to October is 8.77 cfs (0.25 m^3/s), the lease is protected as a flow of 4.4 cfs (0.12 m^3/s) measured at the East River Road Bridge (Table 3)(FWP 1999). The difference in flow is due to water lost to natural seepage into the streambed between the upper headgate where leased rights were originally diverted for irrigation and the East River Road Bridge, where the flow is measured (Nelson 1980).

Big Creek flows out of the Gallatin Mountains from the west, and joins the Yellowstone River approximately 6 mi (9.7 km) south of the town of Emigrant (Figure 1). Big Creek is a second order stream with an approximate length of 18 mi (29 km) and a mean annual discharge of 61 cfs (USGS 1986). There are several major diversions within the lower 6 mi (9.7 km) of Big Creek after it leaves National Forest land; however, not all are currently active. Historically, Big Creek has supported significant Yellowstone cutthroat trout spawning runs, and it has been on the state list of designated water lease study streams since March, 1990 (EQC 1998).

Cedar Creek, near Corwin Springs, is a smaller tributary of the Yellowstone with most of its length under U.S. Forest Service jurisdiction and within the Absaroka Beartooth Wilderness (Figure 1). Cedar Creek is a fourth order stream with an approximate length of 7.5 miles (12 km), and a mean annual discharge of 9.1 cfs (0.26 m^3/s) (Parrett 1985). There are four irrigation diversions within the lower 0.4 miles (0.7 km) of Cedar Creek where it flows through privately held lands. A downstream water user assists in the administration of the Cedar Creek water lease.

Mol Heron Creek flows out of the Gallatin Range and enters the Yellowstone River near the town of Corwin Springs. Mol Heron Creek is a fifth order stream with an approximate length of 11 mi. (18 km), and a mean annual discharge of 25.4 cfs (0.69 m^3/s) (Parrett 1985). There are two irrigation diversions within 0.6 mi (1 km) of the mouth of Mol Heron Creek, and both are controlled by the lessor.

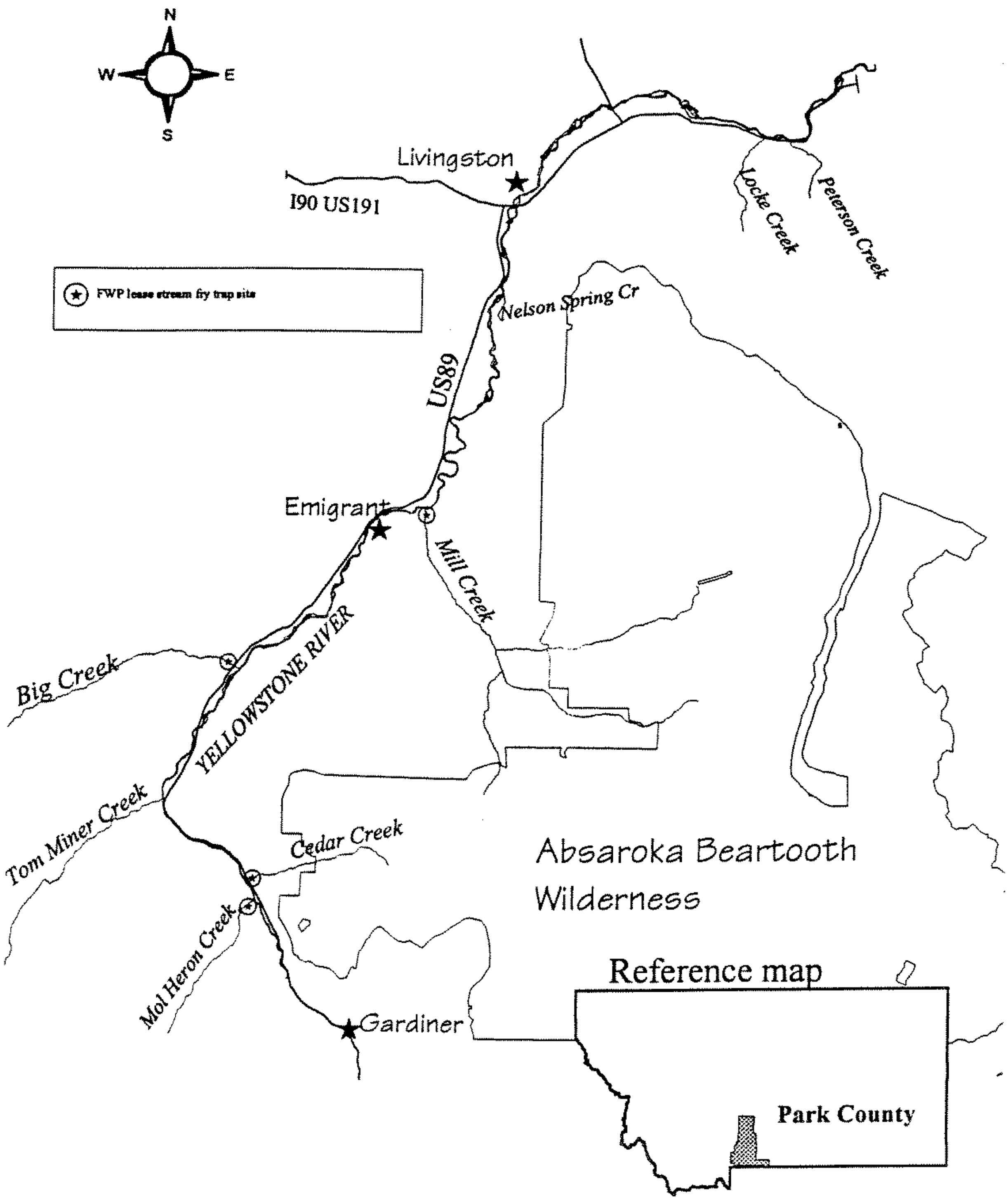


Figure 1. Map of the project area showing the four FWP leasing streams, associated trap sites, and additional high quality spawning tributaries as defined by Clancy (1988).

3.0 Methods

3.1 Stream Discharge and Temperature

Discharge was monitored during each field visit to project streams during spawning surveys, gauge calibrations, and fry monitoring. After fry monitoring was concluded for the season, gauges were checked at least once every two weeks until mid-September. Staff gauge readings were recorded and converted to discharge using USGS rating tables for Mill, Big, and Cedar creeks. The discharge rating table for Mol Heron Creek was based on bi-weekly measurements that GANDA collected in 1999 and verified in 2000 and 2001. Creek discharges were measured early in the season with a Gurley AA meter and checked against the existing rating tables to calibrate each gauge for the 2001 field season. Mean, minimum, and maximum seasonal (July to September) discharges were estimated for 2001 based on measurements taken, and compared to the previous four years for Mill, Cedar, and Mol Heron creeks. The gauge on Big Creek was installed during July of 1999; therefore, a complete comparison among 1999 and 2000 flows is not possible, but all available data is presented. Appendix A includes copies of each creek's rating table used in 2001.

Onset Optic StowAway® thermographs were installed at each staff gauge location on May 18, 2001 and programmed to record at 30 minute intervals until their removal on September 14, 2001. These thermographs are capable of measuring temperatures ranging from -40 °F to 167 °F (-40°C to 75°C) with an accuracy of +/- 0.36 °F (+/- 0.2 °C) and +/- 0.33 minutes/day. Temperature graphs for each project stream are included in Appendix B.

3.2 Spawning Activity

Spawning was monitored by walking sections of each creek once a week, beginning in mid-June, until activity was detected. After spawning fish were observed, daily monitoring was continued for up to 1 week. At each monitoring visit the number of fish observed, their approximate location, whether they were actively spawning, and time and weather information was recorded. Each monitoring visit lasted a minimum of 30 minutes, and observers walked upstream counting fish as they went. As this was a qualitative survey, only a 52 to 110 yard (50 to 100 meter) subsection of each creek was walked at any given visit. Mill and Big creeks were the sites farthest downstream, and they were monitored first and used to gauge approximate spawning times for other project streams.

3.3 Yellowstone Cutthroat Trout Fry Recruitment

3.3.1 Trapping Protocol

Fry recruitment, defined as the number of fry outmigrating from a tributary and entering the mainstem of the Yellowstone River, was estimated by setting fry traps within each study stream, in the first suitable trap site upstream of the creek mouth. A suitable site is one in which the trap can be placed to capture a large amount of the flow while still allowing the tail to sit in a quiet pool to avoid undue stress on the fry once they have entered the trap. Yellowstone cutthroat trout fry begin downstream outmigration after emergence from the gravel, and move into the mainstem within a short time (Thurow, Corsi, and Moore 1988). The number of fry trapped was used as an index of total fry recruitment (Byorth 1990, Shepard 1992, Hennessey 1998).

A consistent pattern in Yellowstone cutthroat trout fry outmigration from Locke, Mill, Cedar, and Mol Heron creeks was documented in 1996 and 1997, and confirmed by work on the same tributaries in 1998 (Hennessey 1998, Roulson 1998). A sampling protocol was developed based on the number of fry caught in each tributary as the outmigration period progressed, with the goal of concentrating sampling effort during the days when fry outmigration peaks (Hennessey 1998).

FWP decided to use Hennessey's (1998) protocol during the 1999, 2000 and 2001 surveys to monitor Yellowstone cutthroat trout fry numbers. This protocol allows a reduction in the overall field effort without compromising the accuracy of the index of total fry outmigration (Hennessey 1998, Roulson 1998). In 1999 and 2000, the protocol was tested on Big Creek and found to measure fry recruitment with accuracy levels consistent with the other three project streams (Roulson 1999 and 2001). Therefore, Hennessey's protocol was adopted for use in Big Creek in 2001.

Hennessey's (1998) protocol was used on all project creeks in 2001. The protocol prescribes trapping each creek 2 days, then skipping 2 days until fry are caught. Once fry are caught a 3 day running mean is calculated, but the trapping pattern is maintained. When trap catch exceeds 1.5 times the 3 day running mean or is greater than 50 fry, sampling increases to every day for the next 10 days. If trap catch on the 11th sampling day is greater than 0.25 times the previous 3 day running mean, then sampling continues for the next 5 days and then stops for the season. If trap catch does not meet the criteria, trapping stops with the 11th day. Hennessey's protocol was shown to sample 83-98% of the total outmigration, as measured by trap catch, on Mill, Cedar, and Mol Heron creeks from 1996-1998 (Hennessey 1998, Roulson 1998). Data analysis of the 1999 and 2000 survey results for Big Creek showed that Hennessey's protocol would have sampled 95.7% and 94.3% of the total fry caught, respectively. GANDA and FWP decided that use of the sampling protocol on Big Creek was appropriate for monitoring fry outmigration beginning in 2001, after this confirmation of the protocol's effectiveness.

Traps were placed on each study stream approximately 25 to 30 days after spawning activity was observed (Benson 1960). In Mill Creek, where no spawning was observed, temperature and historical fry trapping data were used to estimate the spawning date (Shepard 1992, Hennessey 1998, Roulson 1998). Based on the best estimate of when fry outmigration was likely to begin for each creek, fry traps were set overnight for two nights, then pulled for two nights, until protocol criteria for increasing sampling was met. Thereafter, traps were set and checked daily for the prescribed number of days. An effort was made to check traps early in the morning to minimize fry stress (Hennessey 1998). Number and species of fry caught, individual total lengths of a random subsample of 10 fry, water temperatures, and staff gauge readings were recorded.

3.3.2 Trapping Equipment and Locations

Fry outmigration was estimated using fry traps with openings 2.3 ft (80 cm) by 1.5 ft (47 cm), framed with ¼ inch (5 mm) diameter metal rods (McMullin and Graham 1981). A 4.5 ft (1.4 m), 1/16 inch (1.6 mm) mesh, net was sewn around the frame. The tapered net ended in a 4 inch (10 cm) threaded PVC and metal collar connected to the tail of the trap by screwing into a matching PVC pipe. The tails were approximately 3 ft (1m) in length, made of the same netting as the trap, and had a drawstring closure (Hennessey 1998).

Traps were placed by pounding a 3 ft (1m) length of rebar into the streambed on either side of the trap mouth. The frame rested against the rebar and was secured with wire. Current flowing through the trap kept it open and straight. The bottom of the trap frame was covered with rocks to prevent fry from swimming under the trap. Captured fry were retained in the tail of the trap where the PVC collar presented a velocity barrier to escapement.

Traps were placed near the first suitable pool upstream from the mouth, so that the tails sat in the deepest portion of the pool just below a riffle. Care was taken not to place the trap over an active redd. Whenever possible, traps were placed in the same location as in previous surveys to maintain comparable trap efficiencies (Hennessey 1998, Roulson 1998). Photos of the 2001 fry trap sites for each of the four water lease project streams are included in Appendix C.

The main channel of Mill Creek was blocked by a rock berm constructed by a landowner in 1998, and all of the flow was diverted to the North channel. A pool at the end of a low velocity run section in the newly widened North channel of Mill Creek was chosen as the1998 trap site, and was used again in 1999, 2000, and in 2001. A second trap was set on the opposite side of the North channel in 2000 and 2001, in an attempt to catch a larger percentage of fry. The two traps used in Mill Creek spanned approximately 20% of the active channel width (Appendix C). A map showing the Mill Creek trap sites, North and South channels, and the East River Road Bridge is provided in Appendix D.

Spring flows in 2000 altered the stream channel in Big Creek and reshaped the pool that had formed the 1999 trap site. This prompted GANDA to move the trap approximately 218 yards (200 m) downstream in 2000, to a small eddy behind a snag on the outside of a bend, near the south bank of the creek, approximately 55 yards (50 m) upstream from the mouth (Appendix C). The same trap site was used in 2001. The Big Creek trap sampled approximately 30% of the channel width.

The single trap in Cedar Creek was placed in the same location as the past five years, and sampled approximately 50% of the width at higher flows; however, during lower flow periods in 2001 the trap sampled the majority (approximately 65 to75%) of the actual flow (Appendix C).

In Mol Heron Creek, a single trap was placed in the thalweg near the south bank in approximately the same site as 1999 and 2000. The thalweg site was chosen to increase trap efficiency, and a plywood box was constructed around the trap tail to reduce stream velocity and stress on the fry. The Mol Heron trap sampled approximately 25% of the creek width.

3.3 Mill Creek Flushing Flow

An annual 48-hour flushing flow is included in the Mill Creek lease, and is intended to help move recently emerged fry out to the Yellowstone River before flows drop to critically low levels during late summer irrigation. The flushing flow occurred from August 11 to 13 in 2001. Ideally, the flushing flow should coincide with expected end of peak fry emergence based on outmigration patterns in other study area streams. During the flushing flow, the pipeline diversion maintained by the Park County Water and Sewer District is closed.

The success of 2001 flushing flow was evaluated with two traps at the previously described Mill Creek trap sites. The staff gauge was read and the traps were checked at 6-hour intervals for the first 12 hours, and every 24 hours throughout the remainder of the flush. Catch records before and after the flush were used to evaluate its timing and effectiveness.

3.4 Climatic Data

Climate data from the two National Climatic Data Center (NCDC) weather stations in the upper Yellowstone River region, Livingston 12S (NCDC station number 245080), and Gardiner (NCDC station number 243378), were obtained for 2001 and compared to the average readings over the period of record for the climate stations. The Gardiner station has been gathering data for 52 years, while the Livingston 12S station has records dating back 19 years for temperatures and 50 years for precipitation (WRCC 2001). Data examined included average maximum and minimum daily temperature, monthly precipitation, and annual precipitation. This report examines data for trends from January to August for Livingston 12S station, and from January to October for the Gardiner station (WRCC 2001).

4.0 Results

4.1 Stream Discharge and Temperature

4.1.1 Discharge

Two previous low water years, and below average snowpack resulted in shorter duration runoff flows in Mill Creek in July, with the 2001 seasonal peak on July 17 at 31.6 cfs (0.89 m^3/s) considerably lower than seasonal peaks in previous years (Table 4-1). Flows declined rapidly from this seasonal peak, falling to below the lease quantification level of 4.4 cfs (0.12 m^3/s) by July 26 (Figure 2). Mill Creek had no measurable flow for the first time this trapping season on July 29, 2001, earlier than in any of the previous survey years. Minimal flows were restored the following day, but Mill Creek did not meet or exceed the lease level again until the flush that began on August 11. The rate of decline in discharge was similar to that seen in 1999 and 2000, but occurred approximately twelve days earlier, leaving much of the main channel width dry by the middle of July (Figure 3). Mill Creek was completely dry from above the East River Road Bridge to the mouth with little interstitial flow from August 7 to 10, and there was only a minimal amount of intermittent surface flow to the Yellowstone from July 28 to August 6. GANDA telephoned the water lease enforcement contact for Mill Creek daily to request additional flows from July 25 until August 10 and from August 13 to August 17, 2001. Additional contacts were made after the trapping season concluded until September 14 when the monitoring season was over.

Despite these communications and the lease contact's subsequent numerous attempts to restore flows consistent with the lease, after the first occurrence of no measurable flow on July 29, the high permeability of the substrate and extended dry period prevented the creek from reaching its confluence with the Yellowstone for most of the remainder of the trapping season, except during the flushing flow (Figure 2). Mill Creek's highly permeable substrate causes it to be a "losing stream" when flows are low (Nelson 1991). In essence, this means that water percolates through the substrate and into the groundwater zone, leaving the creek's surface dry. FWP estimates that Mill Creek loses approximately 44% of its surface flow between the Allen-Sexton Ditch, located just upstream from the East River Road Bridge, and the mouth (Nelson 1991). GANDA measured the loss in flow downstream from the East River Road Bridge to the mouth on July 6, 2001, and found that the creek loses another 13% over that distance. There were several occasions when there was flow at the East River Road Bridge gauge, but no flow at the mouth. For the purposes of this report, Mill Creek was designated as having a flow of 0 cfs when there was no measurable flow at the East River Road Bridge gauge. Discharge readings from the beginning of the field season in June through final observations made in September 2001 ranged from 0 cfs to 31.6 cfs (0.0 m^3/s to 0.89 m^3/s)(Appendix B, Table 4-1).

Flows in Big Creek remained above lease level throughout the entire summer (Figure 4). Early season peak flows declined rapidly until mid-August when flows stabilized just above the lease level of 11.0 cfs (0.31 m^3/s). Based on Byorth's (1990) work, it is unlikely that any redds were dewatered during the 2001 season under these flow conditions.

Flows on Cedar Creek were documented as below the lease quantification level of 1.33 cfs (0.04 m^3/s) only once this season, on July 20, 2001 (Figure 5). Flows were restored to lease quantification level within 24 hours of notifying the water lease liaison, which probably minimized adverse effects to redds and newly emerged fry. Based on previous years' redd marking data, short-term dewatering of redds can be assumed (Byorth 1990, Hennessey 1998). Discharge was much more consistent during the 2001 field season than the past two seasons, and flows exceeded the water lease quantification level for almost the entire field season (Figure 5). In 2001, flows from mid-July through September ranged from 0.97 cfs (0.027 m^3/s) to 1.89 cfs (0.05 m^3/s), compared with the 2000 range of 0.97 cfs (0.027 m^3/s) to 2.08 cfs (0.06 m^3/s) (Figure 6) (Table 2).

Because there are three established gauges on Cedar Creek, it is possible to track the water available upstream of the diversions and compare it to the water that reaches the fry trapping site. In 2001, the amount of water available declined gradually through out the season, and withdrawals peaked in mid-July when 90% of the available water was diverted and/or lost to channel permeability (Appendix E). However, the difference in flows from the OTO gauge, near the headwaters, and the gauge nearest the mouth averaged 71% throughout the season, and had declined to 57% by the end of August.

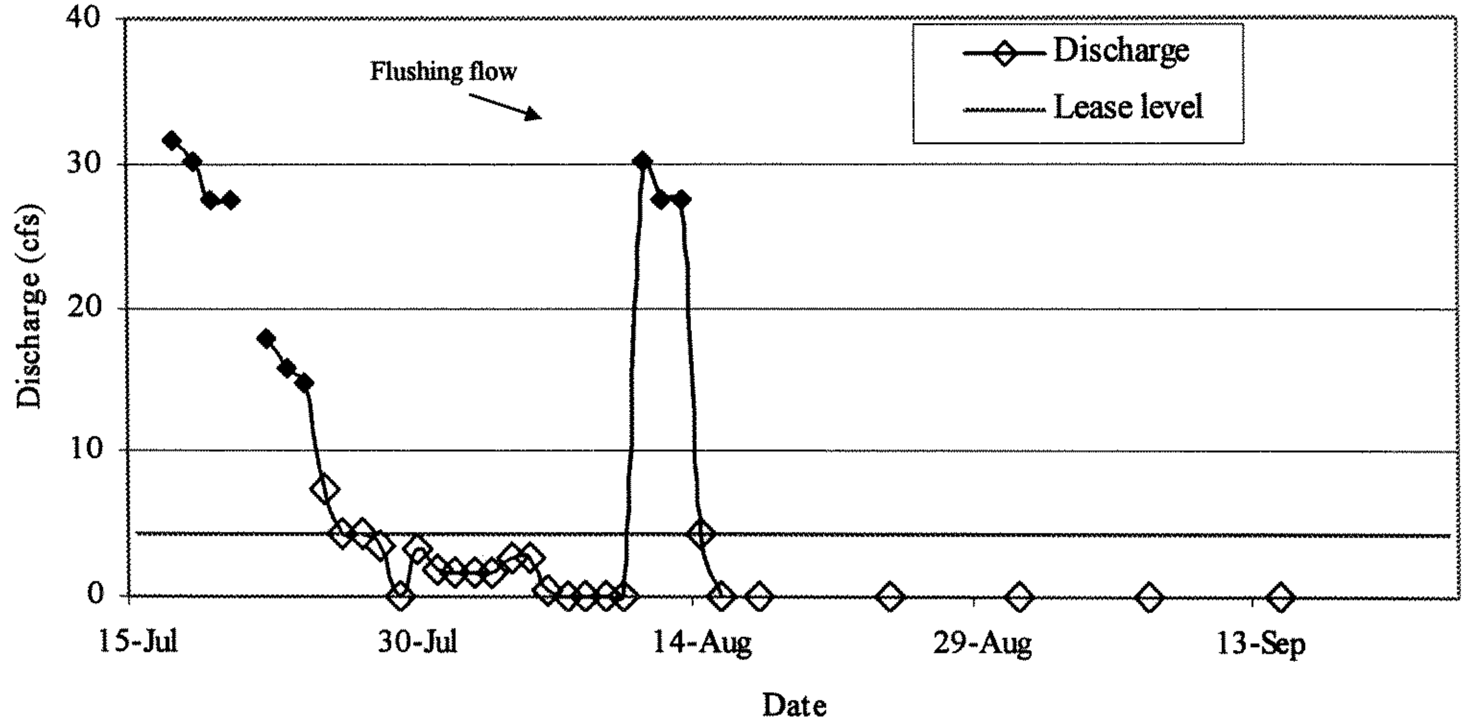


Figure 2. Comparison of daily flows on Mill Creek, Montana, during the 2001 Yellowstone cutthroat trout fry trapping season with the water lease level (4.4 cfs). Open squares indicate dates when the water lease enforcement contact was notified to improve flows. The peak of the flushing flow is also indicated.

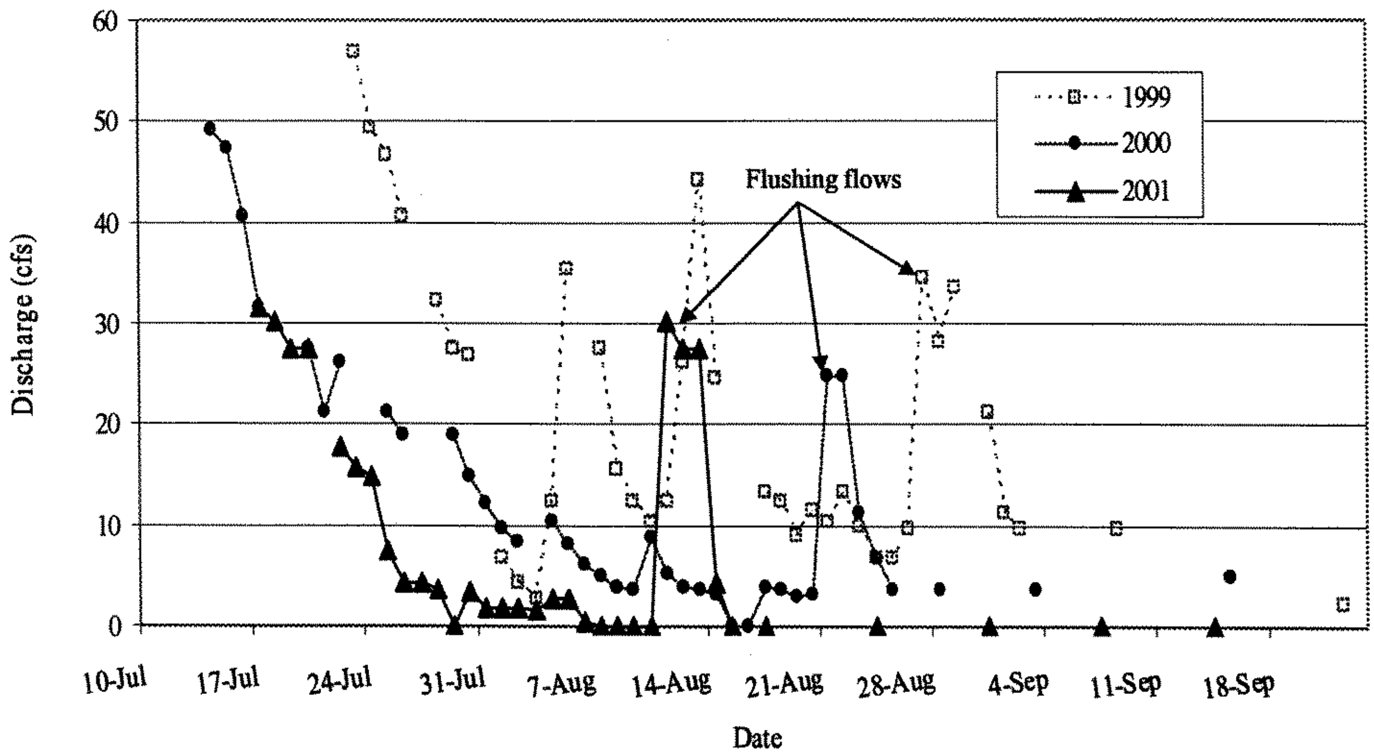


Figure 3. Comparison of daily discharge readings for Mill Creek, Montana, during the 1999, 2000, and 2001 Yellowstone cutthroat trout fry trapping seasons. The annual flushing flows are indicated by arrows.

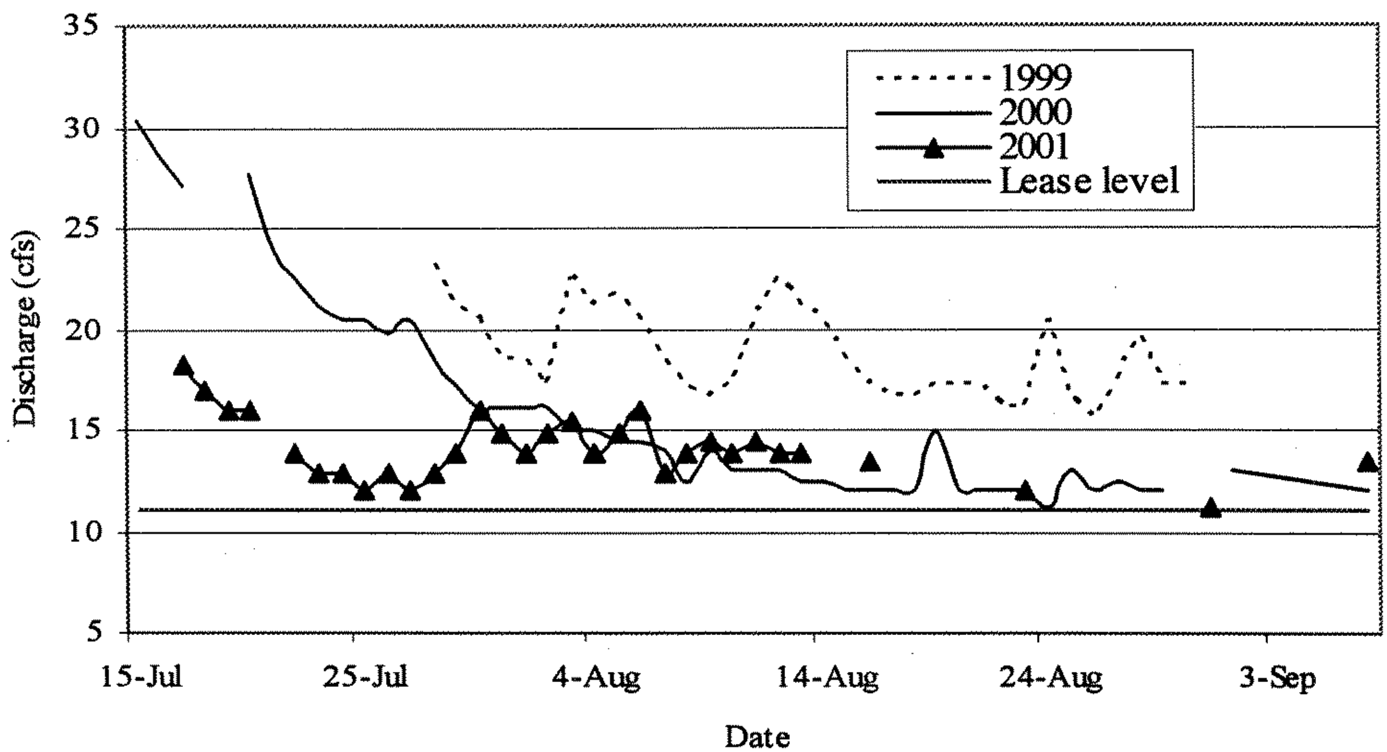


Figure 4. Comparison of daily discharge readings for Big Creek, Montana, during the 1999, 2000, and 2001 Yellowstone cutthroat trout fry trapping seasons and the lease level (11 cfs).

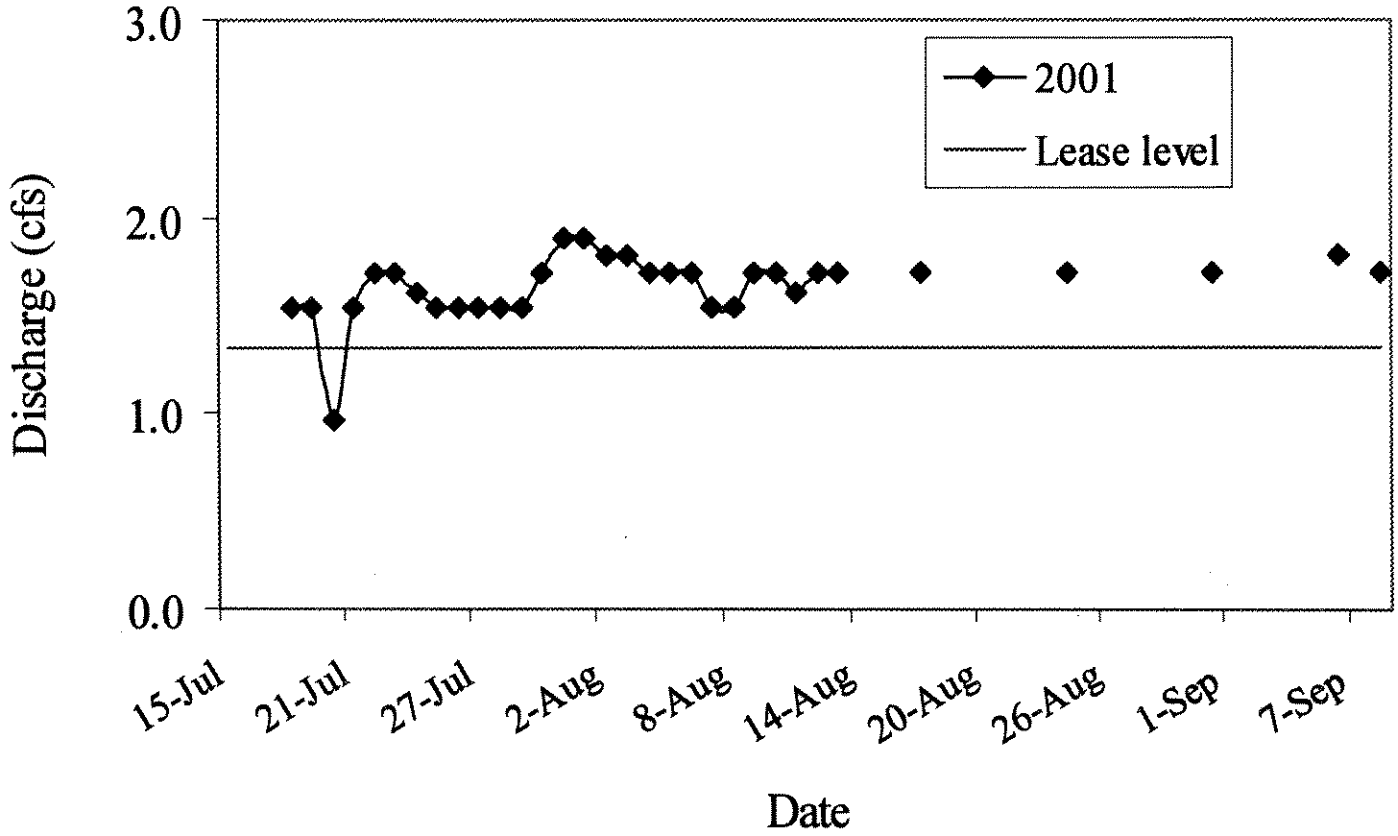


Figure 5. Comparison of daily discharge readings on Cedar Creek, Montana, during the 2001 Yellowstone cutthroat trout fry trapping season with the water lease level (1.33 cfs). The water lease enforcement contact was notified on July 20 to improve flows.

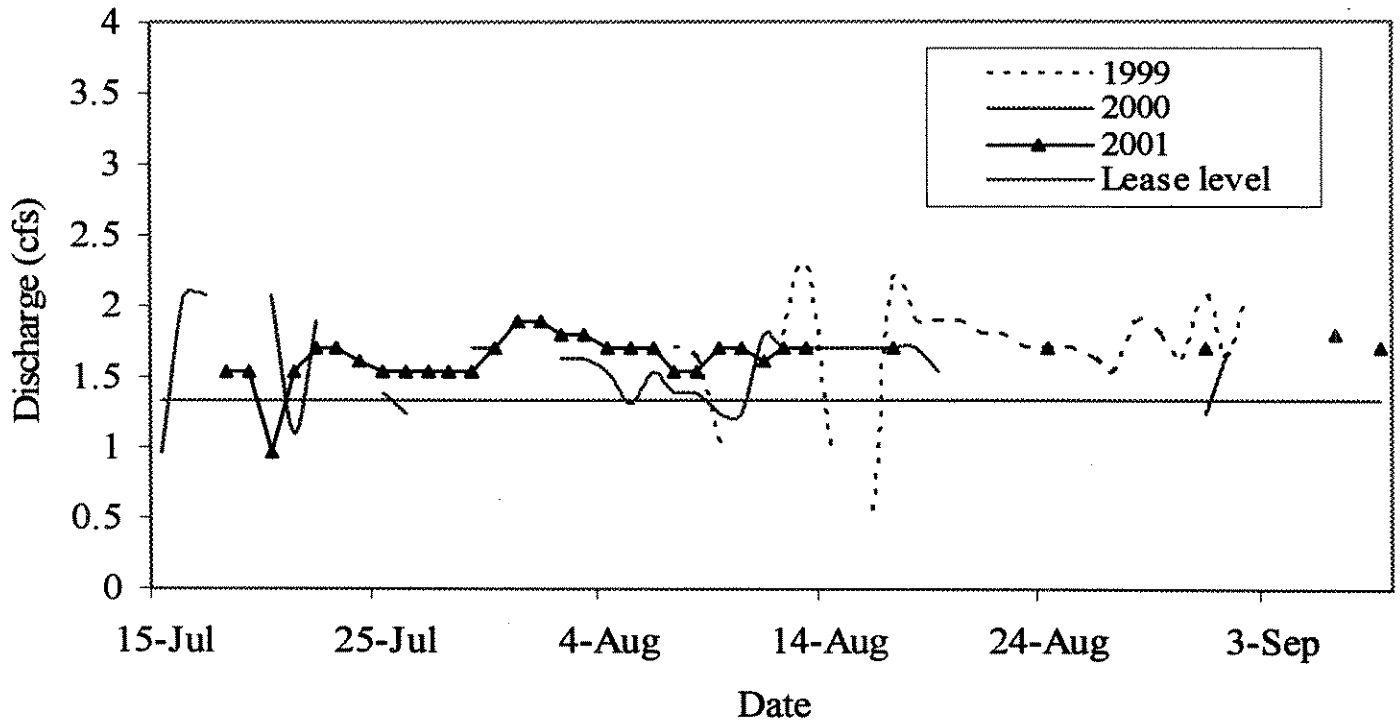


Figure 6. Comparison of daily discharge readings on Cedar Creek, Montana, during the 1999, 2000, and 2001 Yellowstone cutthroat trout fry trapping seasons with the water lease level (1.33 cfs).

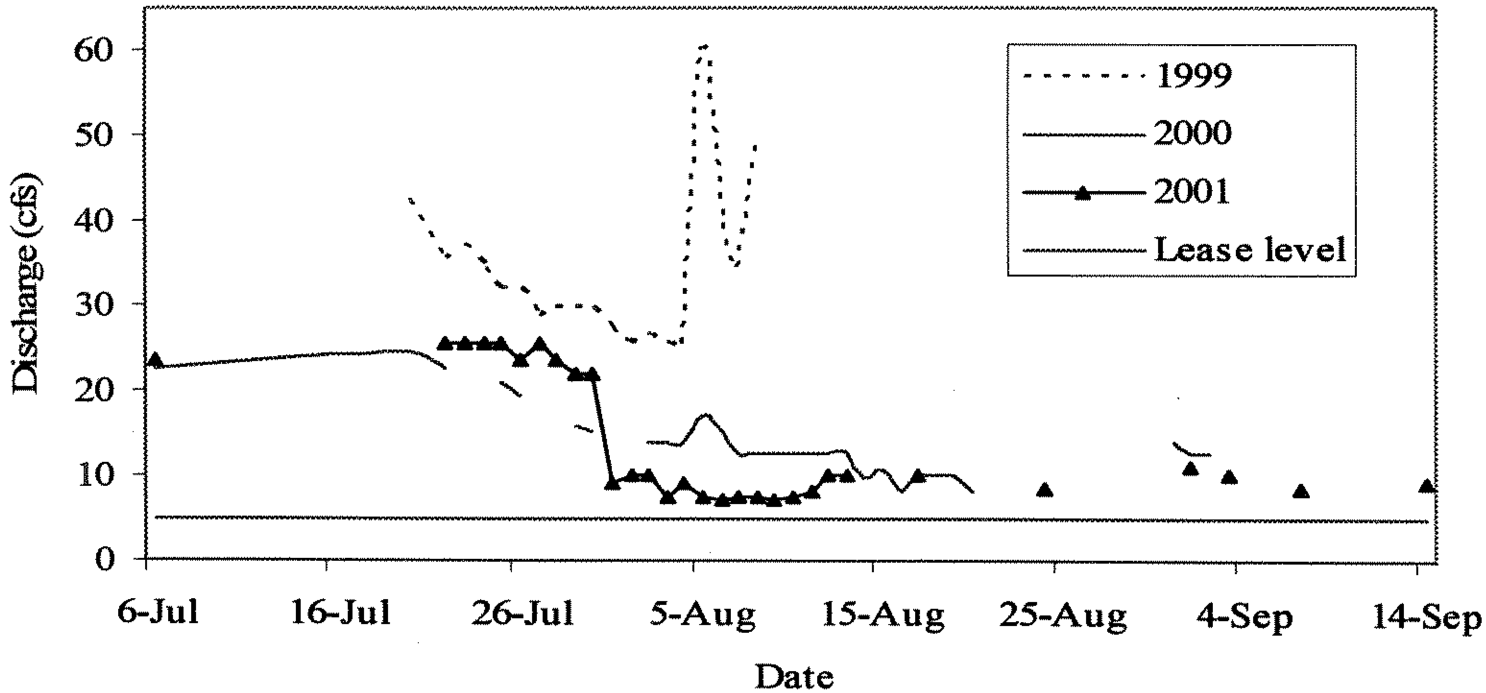


Figure 7. Comparison of daily discharge readings on Mol Heron Creek, Montana, during the 1999, 2000, and 2001 Yellowstone cutthroat trout fry trapping season with the water lease level (5.0 cfs).

Table 4-1. Summary of discharge readings for the four project streams from mid-July to September 1996-2001. These statistics do not include flow measurements gathered during spawning surveys; for pre-trapping season flows, please see Appendix B.

Project stream	Year	Seasonal mean cfs	Seasonal mean m³/s	Maximum cfs	Maximum m³/s	Date	Minimum cfs	Minimum m³/s	Date
Big	1999	18.7	0.53	23.3	0.66	July 29[a]	15.6	0.44	August 27
	2000	18.9	0.54	61.7	1.75	July 1	11.24	0.32	August 24
	2001	**14.2**	**0.40**	**18.2**	**0.51**	**July 17**	**11.24**	**0.32**	**August 31**
Mill	1996	22.2	0.63	38.8	1.10	August 22	10.2	0.29	August 31
	1997	38.5	1.09	95.3	2.70	September 12	17.7	0.50	August 31
	1998	27.9	0.79	78.7	2.23	July 31	0	0	September 17 & 18
	1999	21.64	0.61	56.95	1.61	July 23	2.75	0.08	August 3
	2000	12.94	0.37	40.7	1.15	July 15	0	0	August 16 & 17
	2001	**10.24**	**0.29**	**31.6**	**0.89**	**July 17**	**0**	**0**	**July 28**[b]
Cedar	1996	1.06	0.03	3.2	0.09	August 2	0.21	0.006	August 15
	1997	2.6	0.075	3.8	0.108	August 8	1.56	0.06	September 15
	1998	1.9	0.053	2.8	0.08	August 24	0.4	0.01	August 23
	1999	1.1	0.03	1.54	0.04	August 13	0.4	0.01	August 16
	2000	1.58	0.04	2.1	0.06	July 16	0.97	0.03	July 15
	2001	**1.65**	**0.4**	**1.8**	**0.05**	**August 2**	**0.97**	**0.03**	**July 15**
Mol Heron	1996	20.7	0.586	24.4	0.69	September 8	16.2	0.46	August 28
	1997	52.0	1.474	54.7	1.55	August 16 &19	49.2	1.39	September 15
	1998	31.3	0.886	38.7	1.10	August 19	25.2	0.71	September 17
	1999	32.3	0.92	60.1	1.70	August 28	21.9	0.62	August 8
Mol Heron	2000	14.1	0.40	24.6	0.70	July 21	7.9	0.22	August 16 & 20
	2001	**14.4**	**0.4**	**25.6**	**0.72**	**July 22**	**7.2**	**0.20**	**August 6 & 9**

[a] July 29, 1999 was the day that the staff gauge was installed on Big Creek.
[b] Mill Creek also had no flow at the mouth of the creek on August 7, 8, 9, 10, 14, 17, 24, and 31; and September 7, 14, and 26, 2001.

Discharge in Mol Heron Creek in 2001 was similar to that seen in 2000, but lower than in 1999. The seasonal mean stream discharge was less than half of that seen in 1999 (Figure 7, Table 2). Discharge varied from 7.2 cfs (0.20 m^3/s) to 25.6 cfs (0.72 m^3/s) in 2001 (Table 2). Flows declined sharply during the third week in July, and remained low, but above the 5.0 cfs (0.14 m^3/s) protected by the lease (Figure 9).

4.1.2 Stream Temperatures

Mean daily water temperatures in all creeks climbed as flows declined and air temperatures warmed in late June (Appendix F). All creeks warmed faster and reached higher temperatures in the first weeks in July than in 2000 or 1999. Although early season temperatures averaged as much as 3° to 4° F (1.7° to 2.2 °C) warmer than in 2000, the remainder of the 2001 season's temperatures were only slightly warmer than those seen in 2000 (Appendix B). The highest mean temperatures recorded in each creek (peaks) are reported each year to give the reader an idea of the relative stress level for trout fry. The Upper Incipient Lethal Temperature (UILT) for most trout species is in the range of 68° to 79°F (20° to 26°C) (Allan 1995). All creeks showed a decline in mean daily water temperature on or around September 6, 2001, but stream temperatures increased again around September 10, and were similar to the warm levels seen in 2000 (NOAA 1999, NOAA 2000) (Appendix B).

Mean daily stream temperatures in Mill Creek were consistent with those seen in 1999 and 2000 during the early part of the season. Mean temperatures peaked near 61°F (16°C) several times in late July when flows began to recede. However, much of the season the creek had no measurable flow and no water temperatures could be recorded. The average daily water temperature in Mill Creek fluctuated 11.2° F (5.9° C) in 2001 compared to 13.7° F (7.6° C) in 2000; however, the 2001 data covers through the end of July only because chronic dewatering precluded collecting temperature data for most of the rest of the season (Roulson 2001)(Appendix F).

Mean daily water temperatures in Big Creek varied little throughout the field season and only exceeded 60.0° F (16 °C) twice in early August despite prolonged lower flows early in the season (Figure 4). Daily water temperature fluctuation averaged 10.6°F (5.8°C) in 2001, compared to 11.3°F (6.3°C) in 2000 (Roulson 1999).

Mean daily water temperatures in Cedar Creek peaked near 57.0° F (14 °C) briefly in late July2001. Daily water temperature fluctuation averaged 8.6°F (4.7 °C) in 2001, compared to 7.9° F (4.4° C) in 2000 (Appendix B)(Roulson 2001).

Mean daily water temperatures in Mol Heron Creek were slightly higher throughout the season than in 2000. However, mean water temperatures still remained below 60.8° F (16 °C) in 2001. Daily water temperature fluctuation averaged 11.3° F (6.2 ° C) compared to 10.6° F (5.9 ° C) in 2000 (Roulson 2001)(Appendix B).

4.2 Spawning Activity

GANDA sighted spawning Yellowstone cutthroat trout in Big, Cedar, and Mol Heron creeks at least four days earlier than in the 2000 surveys. GANDA monitored Mill Creek from June 16 to July 2, but flows were too high and turbulent for locating spawning fish. Mean discharge during spawning surveys on Mill Creek was 267 cfs (7.56 m^3/s) (Appendix B). Big Creek was monitored from June 18 to June 25 with a total of 227 fish observed and 48 actively spawning (Table 4-2). GANDA saw spawning fish in Big Creek nine days earlier than in 2000 and ten days earlier than in 1999. The number of fish observed actually excavating or otherwise actively spawning was more than twice that observed in 2000. Mean water temperature during spawning observations on Big Creek was 49.7°F (9.7°C). Mean discharge during spawning surveys on Big Creek was 67.2 cfs (1.91 m^3/s). Spawning activity was concentrated near the Highway 89 Bridge, and only a few spawners were observed above the Bar X diversion, located a few miles upstream. The distribution of spawners was consistent with what was observed in 1999 and 2000 and with Byorth's (1990) report; however, the timing of spawning was approximately two weeks earlier than in Byorth's 1988 surveys.

Cedar Creek was monitored daily from June 18 to June 26. Spawning fish were observed on the second survey date, and a total of 409 fish were observed during the later surveys with 49 observed actively spawning. GANDA first observed actively spawning fish five days earlier in 2001 than in 2000, but because active spawners were observed during the second survey, it is likely that some spawning actually occurred even earlier (Table 4-2). Mean water temperature during spawning observations on Cedar Creek was 48.4° F (9.1 °C), and mean discharge was 6.31 cfs (0.17 m^3/s). Discharge in 2001 was approximately half the average discharge during the 2000 spawning survey, and only one-fourth of that seen during the 1999 survey. Field crews observed actively spawning fish above and below the Highway 89 culverts, but the majority of fish were observed below the culvert. The culverts have degraded significantly as the stream has downcut its channel over the past four years, and the installed fish ladder is no longer functional; however, it appears that some fish are still able to negotiate it and move upstream successfully (Appendix C). No spawners were observed at the upper gauge sites near the OTO Ranch or above the main ditch upstream of the Highway 89 culverts.

Mol Heron Creek was monitored from June 18 to June 26, 2001. GANDA first observed actively spawning fish four days earlier in 2001 than in 2000(Table 4-2). No actively spawning fish were observed on June 18, and a total of 138 fish were observed during the later surveys with 14 observed actively spawning. Fish were seen spawning up to approximately 100 yards upstream of the trap site. New "no trespassing" signage near Mol Heron Creek indicated that we should limit our surveys to the area near the trap site. This did require the field crew to reduce the normal extent of our spawning surveys. Mean water temperature during spawning observations on Mol Heron Creek was 52.9° F (11.6 °C), and mean discharge was 37.2 cfs (1.05 m^3/s).

Table 4-2. Summary of spawning survey data from 1999 to 2001 for the four water leasing project streams in Park County, Montana. It should be noted that spawning surveys for this project were qualitative and spanned a period of only 7 days. Therefore, these numbers and dates are not all inclusive of the individual spawning runs. This data is presented to give the reader an indication of the level of spawning activity observed each year.

Project Stream	Year	First survey date	Date fish first observed	Date first active spawning observed	Last date surveyed	Total fish observed	Total observed actively spawning
Mill[a]	1999	June 25	NA	NA	July 8	0	0
	2000	June 19	NA	NA	July 3	0	0
	2001	June 16	NA	NA	July 2	0	0
Big	1999	June 25	June 25	June 28	July 8	61	18
	2000	June 19	June 23	June 26	July 3	168	18
	2001	June 18	June 18	June 18	June 25	227	48
Cedar	1999	June 25	July 1	July 3	July 8	52	17
	2000	June 19	June 23	June 23	July 3	377	43
	2001	June 18	June 18	June 19	June 26	409	49
Mol Heron	1999	June 25	July 1	July 1	July 8	74	20
	2000	June 19	June 23	June 23	July 3	119	19
	2001	June 18	June 18	June 20	June 26	138	14

[a] Mill Creek experienced high, turbid flows in all project years that precluded sighting any fish.

4.3 Yellowstone Cutthroat Trout Fry Recruitment

Fewer fry were trapped per day of trapping in Mill, Big, and Mol Heron creeks in 2001 than in 2000 (Table 4-3). Outmigration peaked at least five days, and as much as 11 days earlier in all creeks in 2001. Incidental trapping mortalities decreased in all creeks except Mill Creek (3%) from 2000 levels. The other three project creeks all had less than 1% percent mortality rate.

4.3.1 Mill Creek

Fry trap catch continued to decline in 2001, with a total trap catch of 54% less than the number captured in Mill Creek in 2000. Catch per unit of effort (CPUE) averaged 1.4 fry per day in 2001, compared to 2.4 fry per day in 2000 and 5 fry per day in 1999. Peak outmigration occurred in during the flush, much later than in 2000 (Figure 8). However, since there was no measurable flow early in the season, it is highly likely that fry outmigration would have been precluded for much of the monitoring period (Figure 8). Fry outmigration was first detected on July 18, only three days later than in 2000, but still a full month earlier than in 1999, and peaked on August 13, with 24 fry captured. Outmigration was much more erratic than in previous years. Over 73% of the fry captured were caught on the peak day in August, during the flushing flow. The lack of measurable flow, or on some occasions, flows too low to allow the traps to function properly, precluded trapping from July 28 until August 11, when the flush began. August 13 was the last successful trapping day in 2001 (Figure 8). A total of 33 fry were caught over 24 trapping days (Table 4-3). Incidental mortality due to trapping was 3% this season, compared to 0% in 2000 (Table 4-3).

4.3.2 Big Creek

This was the third year of monitoring on Big Creek, and CPUE remained high, with 236 fry captured per day compared to 254 in 2000. Fry were first captured in Big Creek on July 18, approximately the same timing as in 2000, at a mean water temperature of 53.8°F (12.1 °C), and trap catch peaked on July 28 with 611 fry. This was the first year that Hennessey's protocol was employed on Big Creek; therefore fewer days were trapped, and trapping was concluded on August 4 (Figure 9). However, the protocol is based on Hennessey's (1998) finding that after the initial peak in outmigration, fry numbers decline significantly, and that sampling the latter portion of outmigration does not add to the quality of the total outmigration estimate. This finding was tested during the first two years of this project on Big Creek, and found to hold true; therefore, the truncated sampling season does not translate into a lack of quality data (Hennessey 1998, Roulson 2001). A total of 4,249 fry were trapped in Big Creek in 2001 compared to 11,202 in 2000 (Table 4-3). Incidental mortality declined to 0.3% in 2001 from 1.0% in 2000.

4.3.3 Cedar Creek

Total fry captured in Cedar Creek in 2001 was 39% greater than that captured in 2000 (Table 4-3). CPUE was 820 fry per day in 2001, and 479 fry per day in 2000. The first fry was captured July 23, at a mean water temperature of 53.4°F (11.9 °C). The 2001 outmigration began approximately six days later than in 2000, but the 2001 trap catch peak was ten days earlier than the 2000 peak (Figure 10); (Byorth 1990, Hennessey 1998, Roulson 1998, Roulson 2001). When the past three years are plotted on the same graph, the peak regions do not even overlap. In fact, the 2001 trapping period ended only two calendar days before the 2000 peak. Outmigration peaked on August 1 with 2,501 fry captured, and trapping was suspended on August 9 when trap catch dropped to 516 fry, and the requirements for the sampling protocol had been met (Figure 10). A total of 18,032 fry were caught over 22 trapping occasions (Table 3). Incidental mortality decreased from 0.6% in 2000 to 0.3% (Table 3).

Table 4-3. Summary of fry trapping results from July to September 1996-2001, for the four Yellowstone water leasing project streams.

Project Stream	Year	Total fry caught	Total days trapped	CPUE[a] (fry/day trapped)	Total days fry caught	Incidental mortalities	% mortality
Mill Creek	1996	59	26	2.2	19	66	9.9
	1997	2,316	46	50	36	109	4.7
	1998	752	36	21	20	7	0.9
	1999	125	28	5	11	7	5.9
	2000	61	25	2.4	11	0	0
	2001	**33**	**24**	**1.4**	**7**	**1**	**3.0**
Big Creek	1999	3,429	35	98	28	87	2.6
	2000	11,202	44	254	41	116	1.0
	2001	**4,249**	**18**	**236**	**18**	**12**	**0.3**
Cedar Creek	1996	13,251	24	552	20	74	0.5
	1997	25,781	41	629	35	89	0.3
	1998	3,791	38	100	27	49	1.3
	1999	14,658	23	637	20	1,413	10.7
	2000	12,940	27	479	23	82	0.6
	2001	**18,032**	**22**	**820**	**18**	**52**	**0.3**
Mol Heron Creek	1996	1,865	10	187	10	200	23.1
	1997	1,128	35	32	29	87	7.7
	1998	1,251	31	40	20	3	0.2
	1999	4,159	25	166	22	778	26
	2000	1,586	26	61	24	258	16
	2001	**1,026**	**22**	**44**	**22**	**4**	**0.4**

[a] Catch per unit effort

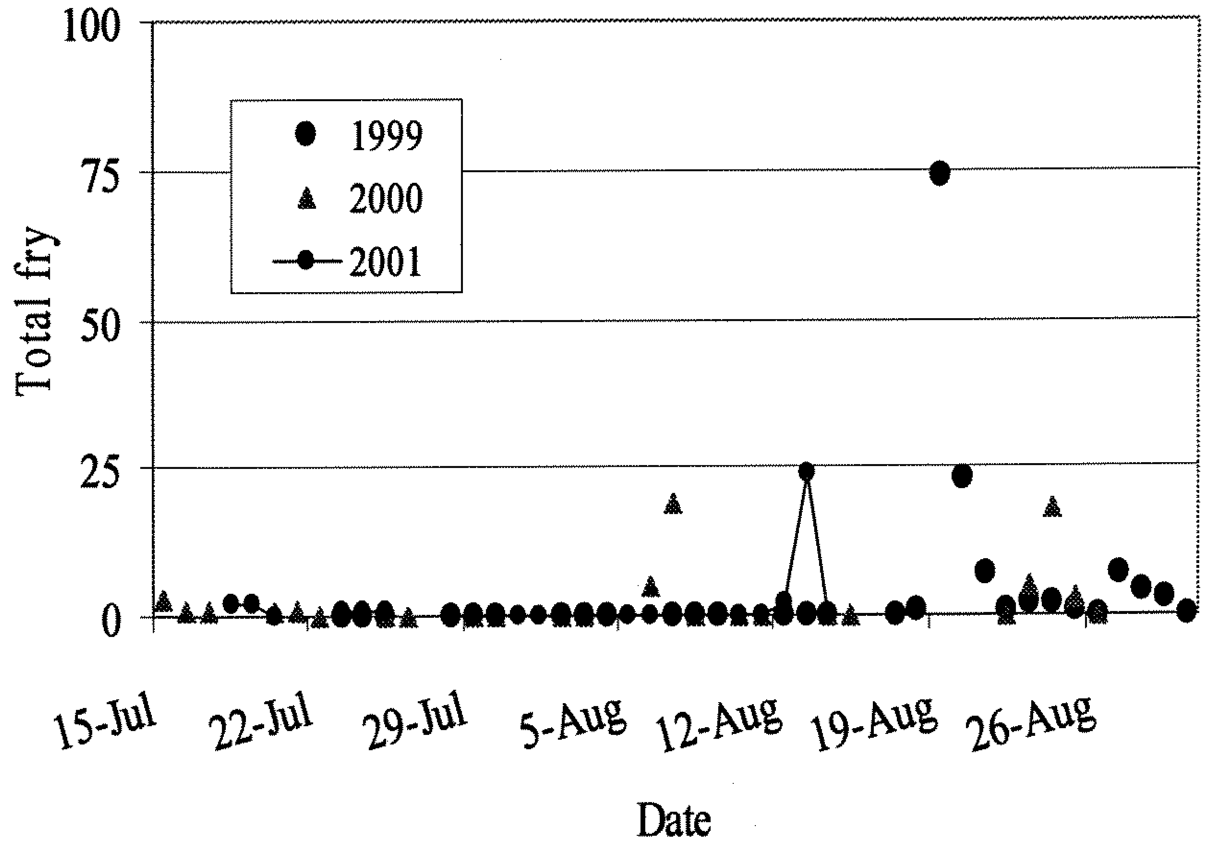


Figure 8. Comparison of total fry captured each day in Mill Creek, Montana, from July to September 1999 to 2001.

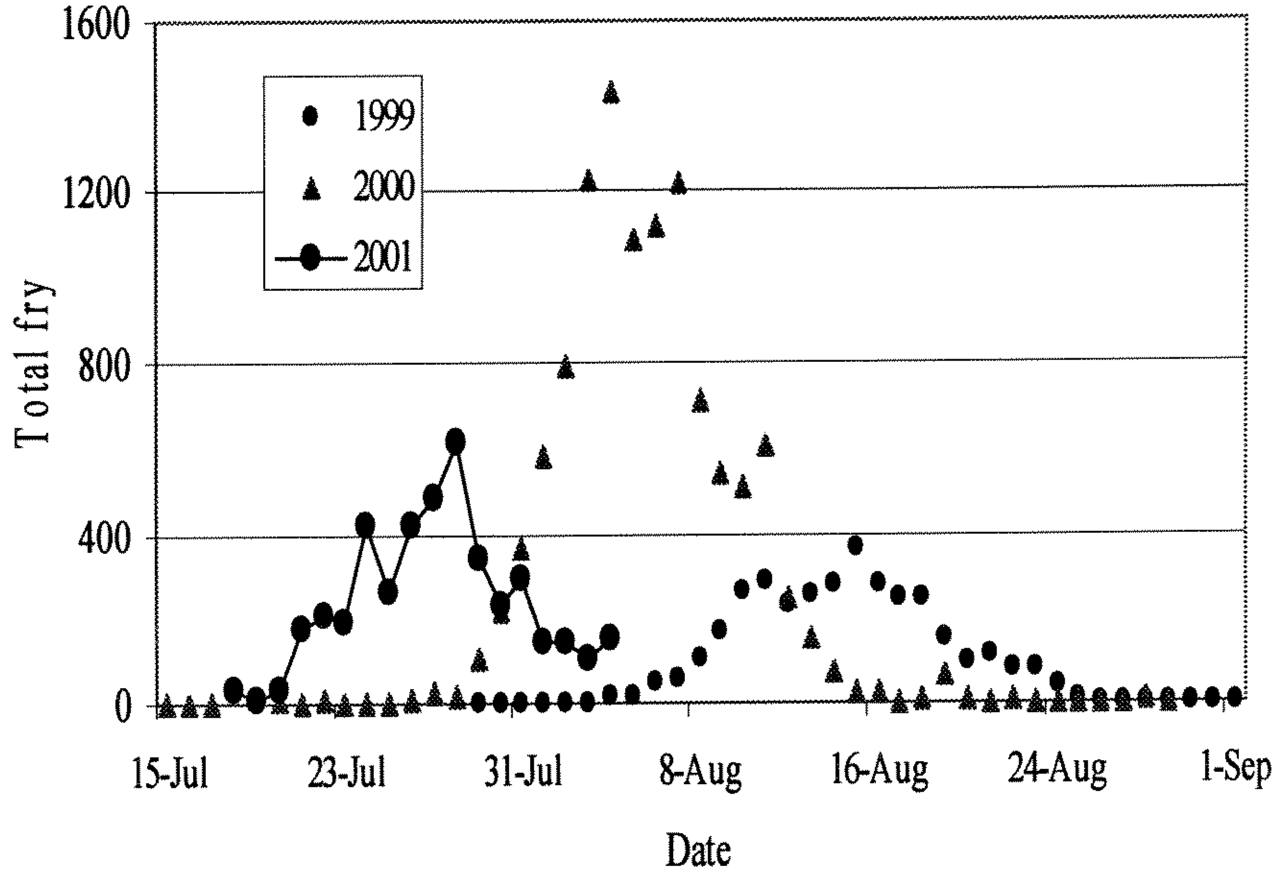


Figure 9. Comparison of total fry captured each day in Big Creek, Montana, from July to September 1999 to 2001.

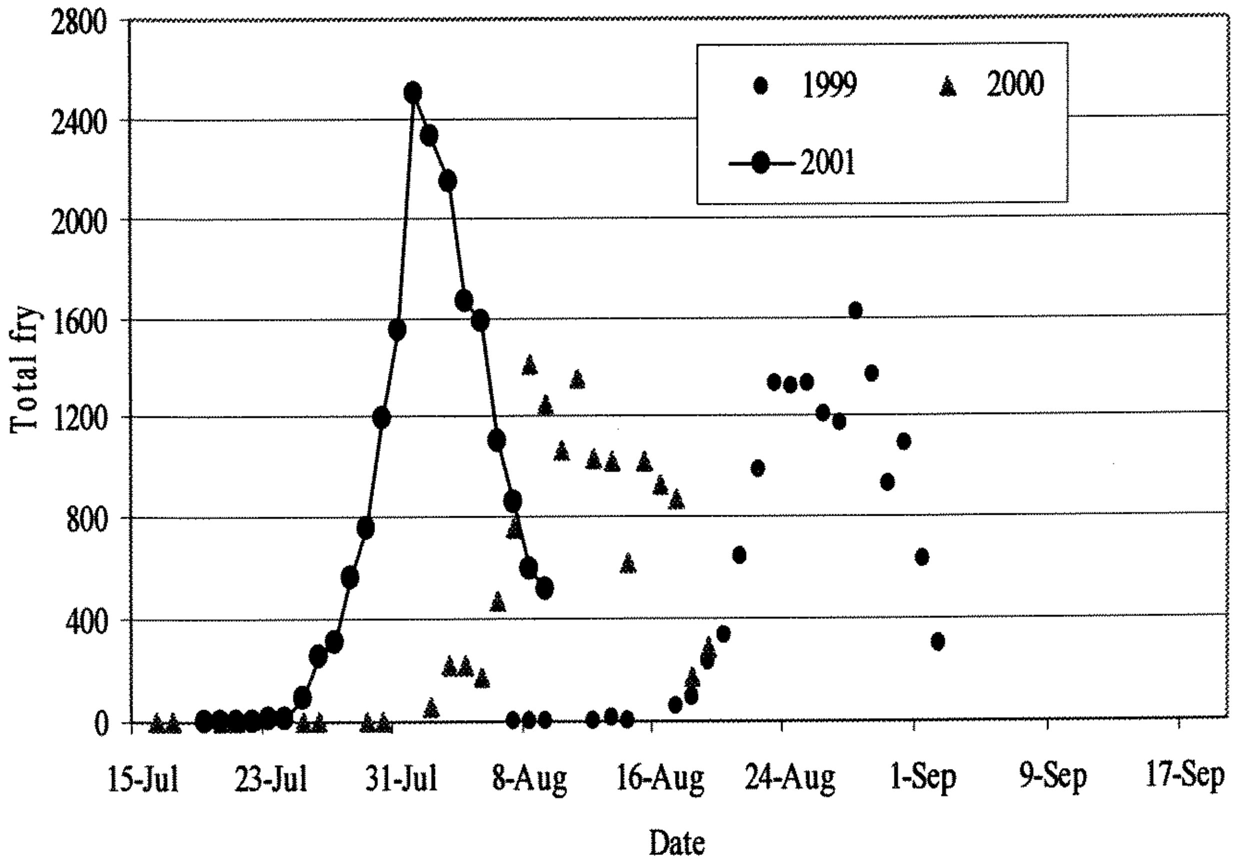


Figure 10. Comparison of total fry captured each day in Cedar Creek, Montana, from July to September 1999 to 2001.

4.3.4 Mol Heron Creek

Total fry catch in 2001 was consistent with surveys over the past five years, with the exception of 1999 when Mol Heron Creek had a large increase in fry captured (Table 4-3). CPUE decreased to 44 fry per day as compared to 61 fry per day in 2000 (Table 4-3). The first fry was trapped on July 23, at a mean water temperature of 56.1 °F (13.4 °C). Outmigration increased slowly over the next two weeks, and peaked on August 3 with 137 fry captured, and then dropped quickly, with trap catches in the teens by August 7 (Figure 11). A total of 1,026 fry were caught over 22 trapping occasions (Table 4-3). Incidental mortalities declined to less than 1% (0.4%) from the high levels of 26.2% in 1999 and 16% in 2000. Since trap placement and management were virtually identical to past years, the drop in mortalities was most likely due to lower water levels and velocities.

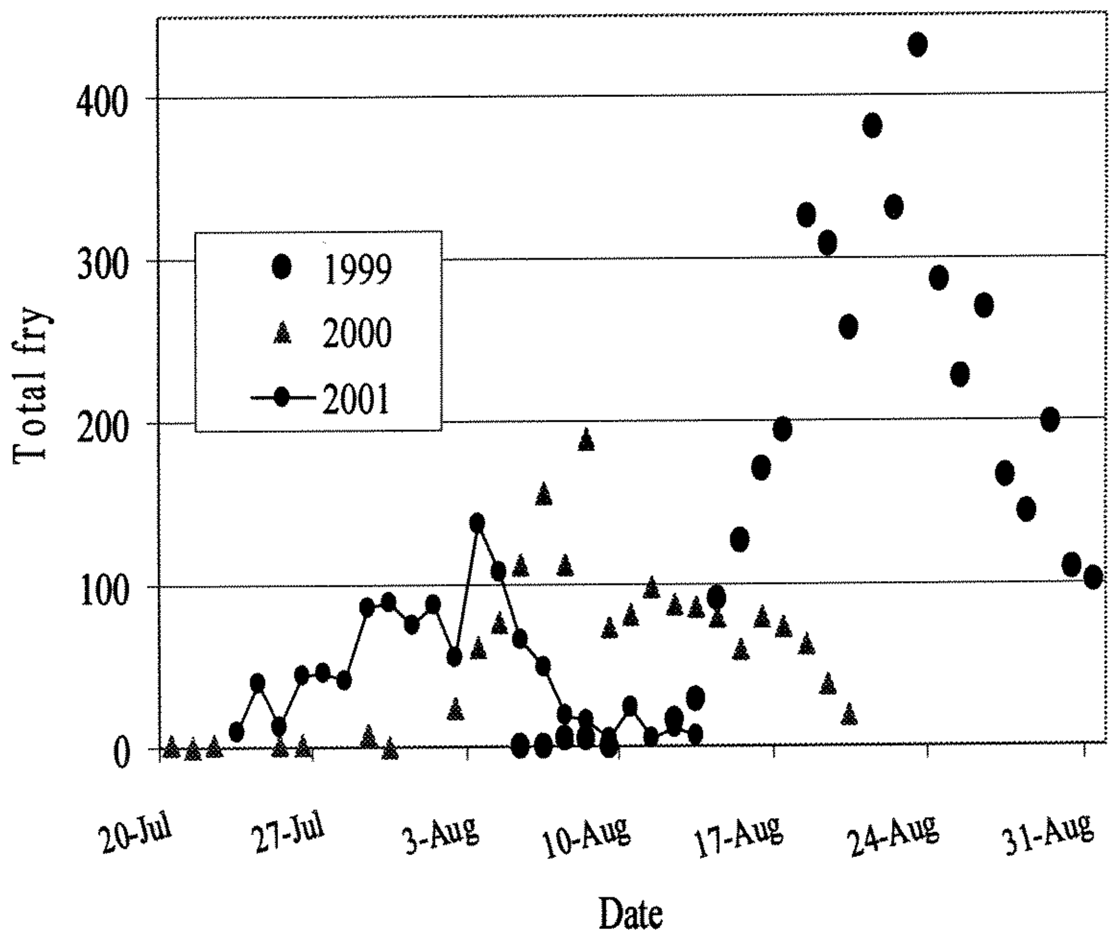


Figure 11. Comparison of total fry captured each day in Mol Heron Creek, Montana, from July to September 1999 to 2001.

4.3.5 Fry Length and Residence Time

Mean fry length and the range of lengths were consistent throughout the field season in 2001, a pattern similar to what was seen in 1999 and 2000 (Roulson 1999, 2001). Newly emerged fry (< 25 mm TL) were captured during the last weeks of trapping in each creek, and increases in fry length were much less linear than in the studies conducted before 1999 (Kelly 1993, Hennessey 1998, Roulson 1998). Trapping began as much as three weeks earlier in 2001 than in the 1999 or earlier field seasons, and some of the initial fry trapped in Mill, Big, and Cedar creeks were longer than the standard for newly emerged fry. One possible explanation is that the Yellowstone cutthroat trout fry outmigration may have begun before all of the rainbow trout (*Oncorhynchus mykiss*) fry had emigrated to the mainstem.

Cutthroat trout appear to ripen for spawning in response to a combination of increasing water temperature, declining (post-peak) tributary flow levels, and light or day-length (Thurow and King 1994, Brown and Mackay 1995) Unfortunately, it is virtually impossible to distinguish between rainbow trout fry and Yellowstone cutthroat trout fry (10- 44 mm), or their hybrids in the field (Martinez 1984). GANDA biologists propose that some of these early fry probably were rainbow trout based on the life history information from previous work and the fact that rainbow trout generally spawn, and consequently outmigrate, as much as six weeks earlier than Yellowstone cutthroat trout in Yellowstone River tributaries (Behnke 1992, Shepard 1992).

Fry length gradually increased throughout the trapping season in all creeks in 2001. There were a few fry measuring > 30 mm in Mill Creek in the first days of trapping, suggesting that these may have been rainbow trout (Figures 12-13). Mean fry length remained below 25 mm in all but Mill and Mol Heron creeks, and very few individual fry longer than 30 mm were captured from any of the project streams (Figures 12-13).

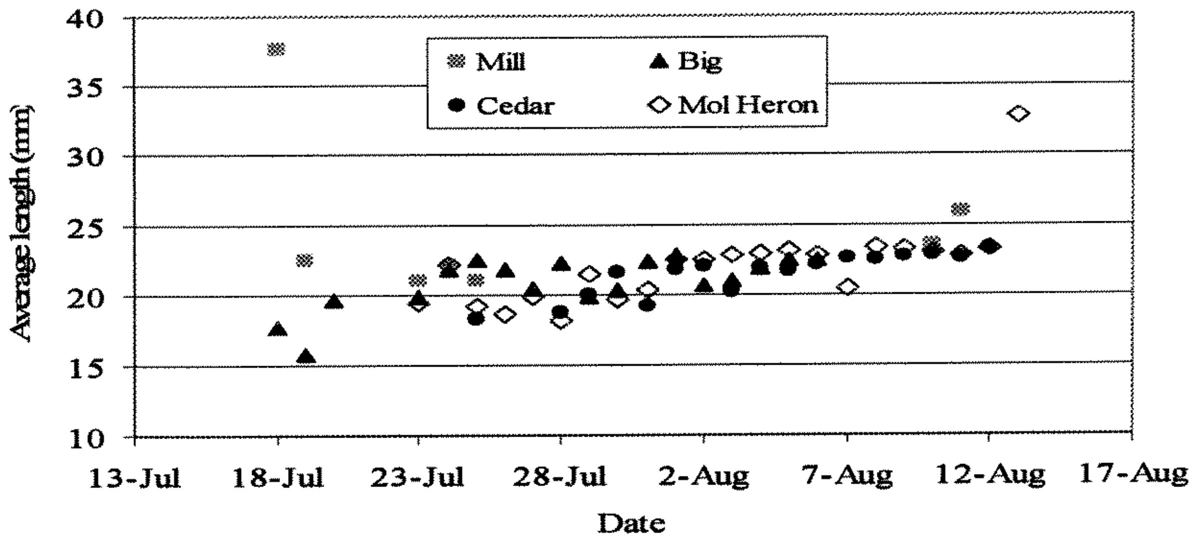


Figure 12. Average total length of a random subsample of Yellowstone cutthroat trout fry by date collected from the four project streams in Park County, Montana, 2001.

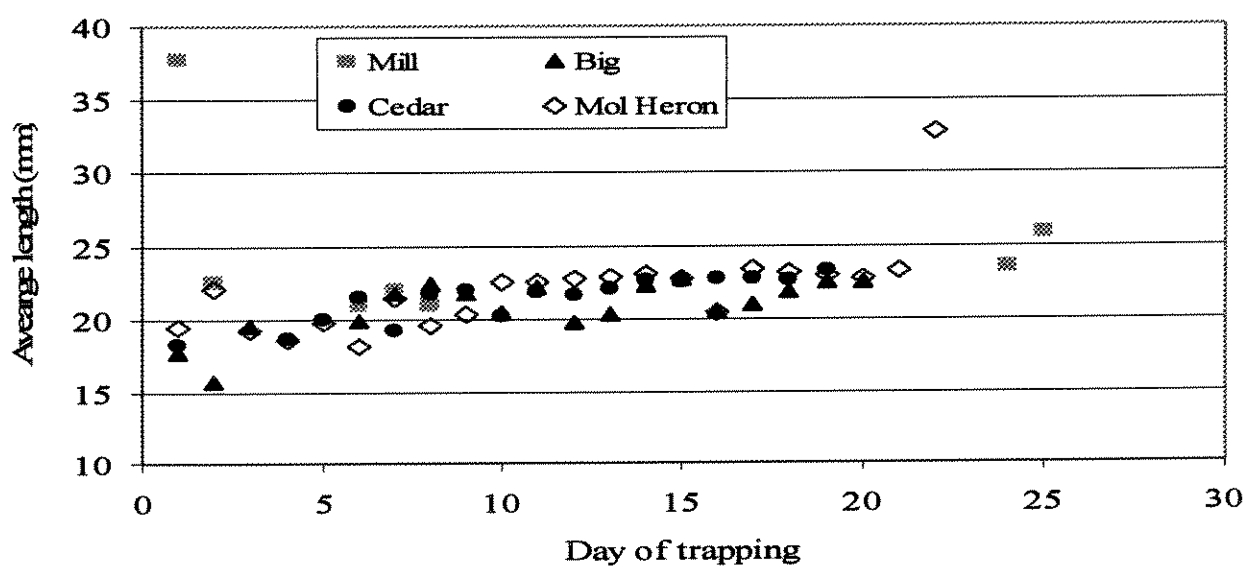


Figure 13. Average total length of a random subsample of Yellowstone cutthroat trout fry by day of sampling period for the four project streams in Park County, Montana, 2001.

4.3.6 Flushing Flows

The Water and Sewer District irrigation diversion on Mill Creek was closed at approximately 0700 hours on August 11 and reopened by 0700 hours on August 13, 2001. There had been no measurable flow at the East River Road Bridge for four days prior to the flush, and it took several hours longer for the flushing flow to reach the bridge in 2001 than in previous years. Discharge at the East River Road Bridge increased to 21.3 cfs (0.60 m^3/s) by 1430 hours on August 11, and peaked at 30.2 cfs (0.85 m^3/s) by 1730 hours on the same day (Figure 2). Discharge declined rapidly after the flush and had dropped to 4.31 cfs (0.12 m^3/s) by 1245 hours on August 13. The creek again had no measurable flow by the following morning, and remained dry until September 14, the last day of data collection. No fry had been captured during the 17 days before the flush. However, there was no measurable flow to the mouth of Mill Creek for 11 of those days which precluded actually running the traps. No additional fry were trapped after August 13 (Figure 8).

4.4 Climatic Data

The Livingston 12S station recorded lower precipitation than historical means for most months in 2001. However, the station received 5.08 inches (13 cm) of precipitation in June, accounting for almost half of the annual mean (Figure 14) (WRCC 2000). At the end of August 2001, annual precipitation accumulation was 90% of normal for Livingston 12S, compared with 95% in 2000 (WRCC 2000, Roulson 1999).

Precipitation recorded at the Gardiner station fluctuated near average levels throughout the year with no month experiencing extremely high or low precipitation. Total precipitation accumulated at Gardiner by October 2001 was approximately 85% of average, compared with 49% by the same month in 2000 (WRCC 2001). The level of moisture for 2001 is well within one standard deviation from the mean for the period of record (WRCC 2001).

Snowpack provides an additional measure of how much water was available to the upper Yellowstone basin in each project year. Based on NRCS and SNOTEL data, snowpack generally peaks on or around April 1 each year. NRCS generates graphs and tables of snowpack, precipitation, and snowwater equivalent accumulation to date relative to the percent of the April 1 average accumulation for their representative 30 year period (1961 to 1990) based on SNOTEL data stations throughout each river basin (NRCS 2002). An examination of this data for the years 1998-2001 reveals that snowpack in three of the past four years has been below average (Table 4-4). The deficit in snowpack has only been extreme in 2001; however, the duration of these deficits has probably intensified the effects seen throughout the watershed (Table 4-4).

Table 4-4. Summary of snowpack data for the upper Yellowstone basin based on SNOTEL data (USDA, NRCS 2002).

	Percent of April 1 average (1961-1990)	
Year	**Average snow water equivalent[a]**	**Average precipitation accumulation[b]**
1998	84	86
1999	112	106
2000	90	85
2001	59	63
Maximum[c]	---	~155
Minimum	---	~60

[a]The snow water equivalent percent of average represents the snow water equivalent found at selected SNOTEL sites in or near the basin compared to the average value for those sites.

[b]The total precipitation percent of average represents the total precipitation (beginning October 1st) found at selected SNOTEL sites in or near the basin compared to the average value for those sites.
[c] The Maximum and Minimum are for the 30 years of record (1961-1990).

Another variable that may have contributed to the low water availability throughout the watershed is air temperatures. February's average daily maximum temperature was more than 2° F colder than the historical mean, but temperatures from March through September 2001 averaged 4° F higher than the historic pattern at Gardiner (WRCC 2001). Average maximum daily temperatures recorded at the Livingston 12 S station were also much colder than historical average in February, but were only slightly higher than historical average from March through August of 2001. The exception was May, which was 5.8 °F warmer than the average for the period of record (WRCC 2001)(Figures 14 and 15). All of these factors, low precipitation, below average snowpack, and slightly warmer temperatures culminate in a drying climate that would only serve to reduce water availability and increase water demand.

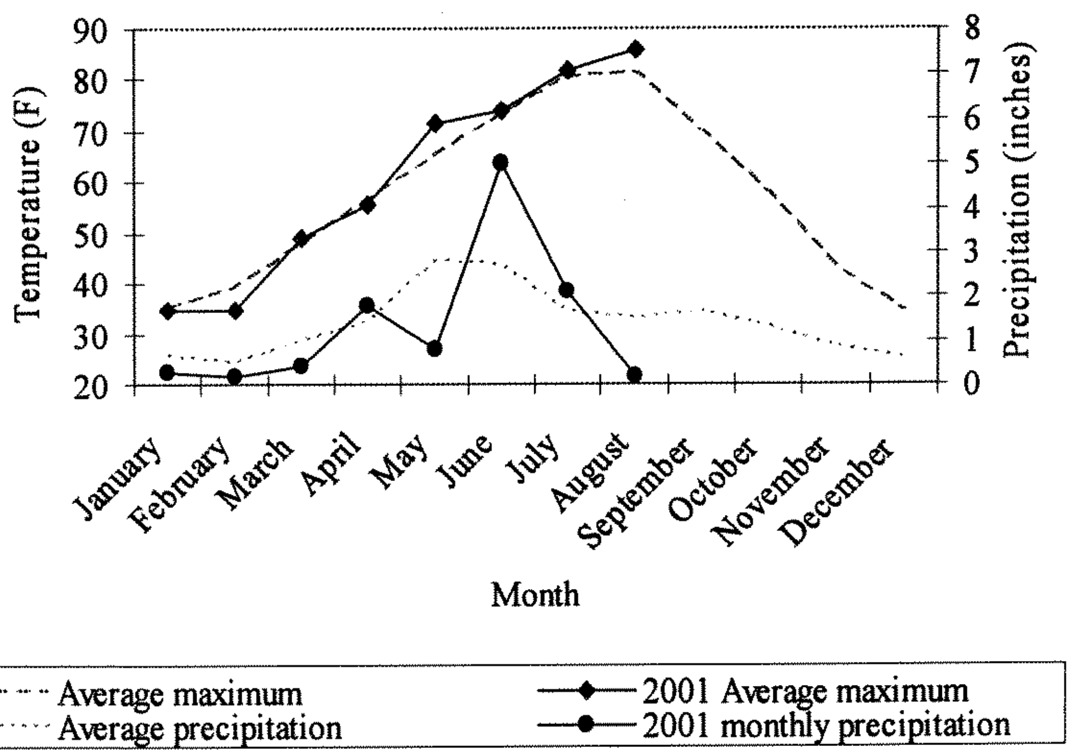


Figure 14. Comparison of the average daily maximum temperature (19 years of record) and monthly precipitation (49 years of record) for the Livingston 12S, Montana climate station with the data collected through August 2001 (WRCC 2001).

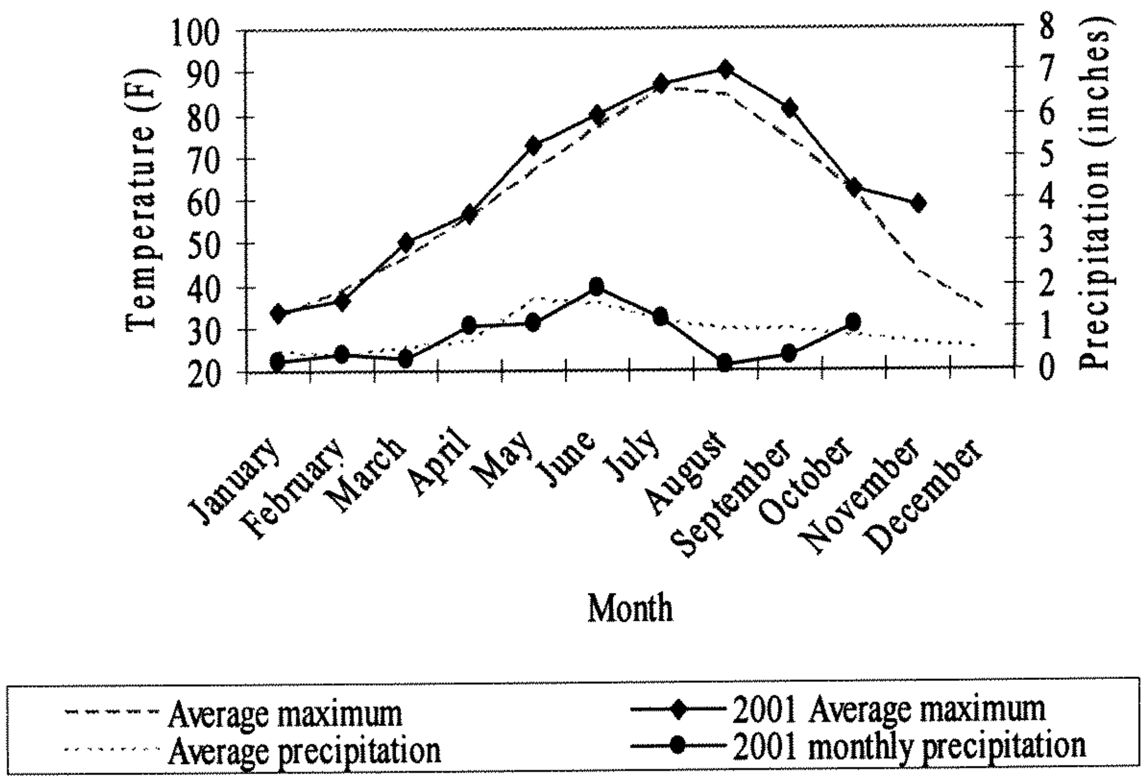


Figure 15. Comparison of the average daily maximum temperature and monthly precipitation for the Gardiner, Montana climate station with the data collected through October 2001 (WRCC 2001).

5.0 Discussion of Findings

In contrast with the previous summer, 2001 was much closer to normal in terms of precipitation and temperatures in the upper Yellowstone River basin. However, early summer season temperatures continued to be slightly warmer, and precipitation was still slightly lower than the historical average, and the available snowpack was much lower than average (Table 5-1). It is a credit to the water leasing program that lease levels on the upper Yellowstone basin project streams; Big, Cedar, and Mol Heron creeks, were maintained for the majority of the season despite the continued reduced availability of water in this portion of the watershed. Accumulated precipitation in Park County was 85% of normal at the Gardiner station by October 2001, and average temperatures were significantly higher than the historic averages from March through September (WRCC 2001). These conditions were much less extreme than those in 2000, when accumulated precipitation was only 49% of normal by October (WRCC 2001). Again, the snowpack data may provide the explanation as to why, despite the moderate precipitation deficit, water availability was apparently much more compromised in 2001 throughout the upper Yellowstone basin (Table 4-4).

Conditions in the northern portion of the valley were less extreme than those seen in the upper basin, following the pattern observed in 1999 and 2000 (Roulson 1999, 2001). The Livingston 12S weather station recorded 90% of the normal precipitation by August in 2001. By the same time in calendar year 2000 the Livingston 12S station had accumulated almost 95% of normal precipitation (WRCC 2001). However, this level of precipitation proved insufficient to meet the needs of the multiple water users in the Mill Creek watershed, and still maintain the water lease level on that creek. This was the third consecutive year that precipitation was below normal for the Livingston 12S station, and the third consecutive year that water lease levels could not be maintained on Mill Creek for a significant portion of the Yellowstone cutthroat trout incubation and outmigration period.

Drought is a cumulative phenomenon. The longer a watershed experiences lower than normal precipitation, the greater the water deficit becomes in the form of reduced soil moisture and vegetative stress. Therefore, although conditions in the Mill Creek watershed were improved from 2000 in terms of precipitation, the improvement may not have been enough to overcome the watershed's snowpack and stored water deficit and keep up with irrigation needs in the Mill Creek valley for 2001. Flows in Mill Creek declined rapidly in early July, slightly earlier than the decline seen as in 2000. However, instead of stabilizing at a moderate level for the rest of July, as had been the pattern in 2000, flows dropped much faster and to much lower levels. By the third week in July flows in Mill Creek were less than one-third that seen during the same week in 2000 (Figure 3). Big Creek saw a similar early decline in flows, but stabilized at a slightly higher level than in 2000 (Figure 4). Cedar Creek also maintained higher and more consistent flows in 2001 (Figure 6). Mol Heron began the 2001 season with flows similar to those seen in 2000, but dropped much closer to lease level in early August than in 2000, and remained low the rest of the monitoring season (Figure 7).

An examination of the preceding winter's precipitation data may shed some light on why the drought conditions persist in the northern portion of the Yellowstone watershed, while the upper reaches did not experience as much water-related stress in 2001. In the winter of 2000, both the Gardiner and Livingston 12S had lower than average precipitation from October to March, when watersheds begin storing water for the following summer, creating dry soil conditions and a potential water deficit coming into spring. By looking at the data in the context of the water year, which begins in October and ends in September of the following year, instead of the calendar year, it becomes apparent that the watersheds near Mill Creek probably held much less water relative to "normal conditions" at the beginning of the summer 2001, than those near Cedar and Mol Heron creeks (Table 5-1). As noted previously, the water normally stored in snowpack was much lower than average as well with accumulated snowpack water equivalent at approximately 60% of normal for the Yellowstone basin by April 1, 2001 (NRCS 2002). In addition, the Livingston 12S station received over half of the April to September precipitation in June, when spring runoff is also usually at its peak (Figure 14).

Table 5-1. Summary of precipitation in inches by water year (October to September) for the Gardiner and Livingston 12S climate data stations for 1999 through 2001 (WRCC 2001). Standard deviation (s.d.) is provided for the historical averages.

Water year	Gardiner			Livingston 12 S		
	October to March	April to September	Total	October to March	April to September	Total
1999	4.63	6.39	11.02	4.76	9.46	14.22
2000	2.22[a]	2.82	5.04	2.58	8.75	11.33
2001	3.22	5.70	8.92	3.24	9.93[b]	13.17
Historical average[c]	3.19	6.82	10.01 (s.d. 1.96)	4.95	11.65	16.60 (s.d. 3.09)

[a] No data were available from WRCC for February 2000
[b]No data were available from WRCC for September 2001 at the time of this report.
[c]Historical average as computed for the 2001 water year (historical monthly averages for October to December 2000 and January to September 2001).

Despite our efforts to begin spawning surveys earlier in the season, the fish began spawning even earlier. On the first day of monitoring, GANDA biologists observed 10 to 19 fish in the three project streams where observing conditions were favorable, despite beginning surveys one to three days earlier than in 2000 (Table 4-2). However, the only creek where actively spawning fish were observed on these first monitoring days was Big Creek, setting the spawning season at least 9 days earlier than in 2000. Spawning fish were observed 5 and 4 days earlier on Cedar and Mol Heron creeks, respectively in 2001(Table 4-2). As in 2000, the subsequent Yellowstone cutthroat trout fry outmigrations were documented in Big, Cedar, and Mol Heron creeks even earlier than would be expected given the 2001 spawning dates. Again, higher air temperatures and lower flows probably resulted in a faster accumulation of thermal degree days, which would account for the earlier emergence of Yellowstone cutthroat trout fry from the gravels (Benson 1960, Kelly 1993). Low flows prevented proper functioning of the Mill Creek traps in late July, when fry would probably have begun their outmigrations.

Irrigation withdrawals created severe and abrupt reductions in flow which left much of the spawning gravels in Mill Creek exposed and dry during the first two weeks of July, coinciding with the beginning of the probable Yellowstone cutthroat trout egg incubation and emergence period for 2001. Similar flow reductions have exposed this gravel area in both previous project years, but never as early as in 2001 (Roulson 1999, 2001). Recent natural restructuring of the Mill Creek channel after the 1997 floods has created a high gravel bar near the mouth that is submerged during spring runoff, but is quickly dried out as flows recede. Even with flows above the lease quantification level of 4.4 cfs (0.11 m^3/s), much of these spawning-quality gravels in the section nearest the creek mouth are exposed when flows drop early in the irrigation season. Since salmonid eggs and newly emerged fry require a moist environment and flowing water to maintain their development, it is highly likely that redds in the portions of Mill Creek with no measurable flow did not produce fry in any of the three project years (1999-2001)(Benson 1960, Clancy 1988, Kelly 1993).

Recruitment from Mill Creek has been falling since a high point in 1997, and in the past three years, there have been fewer than 130 fry trapped in any field season (Table 3). Mill Creek dropped to a point of no measurable flow at the East River Road Bridge 17 days earlier this season than in 2000, and flows remained much lower throughout the 2001 field season than in previous years. The lower channel of Mill Creek near the mouth had no flow and no standing water pools for at least four consecutive days, and did not have enough water to cover the base of the fry traps for the majority of the season despite repeated efforts to maintain lease level flows at the East River Road Bridge. Given the warm daytime temperatures, the extended duration of these no-flow periods and the dwindling interstitial flow near the mouth it can be assumed that any stranded fish would have died before the flush on August 11 briefly reconnected Mill Creek with the mainstem.

Fry trapping results of 1999, 2000, and 2001 demonstrate that, at a minimum, the lease administration in these years was not adequate to prevent large Yellowstone cutthroat trout fry losses in low to average water years in Mill Creek (Roulson 1998, Roulson 1999). The water lease was designed to protect Yellowstone cutthroat trout eggs and fry in "8 out of 10 years", by augmenting the flows that should normally exist in the creek despite withdrawals (Spence 1995, K. Williams pers. comm. 2001). It is also important to note that public expenditures on the Mill Creek pipeline project, at least in part, were justified by the projected generation of salvage water to benefit the downstream fishery (Hunter 1993, EQC 1998). These facts coupled with the seniority of the FWP-leased water right for maintaining in-stream flow from May to October support the maintenance of 4.4 cfs (0.11 m^3/s) of water in Mill Creek during the lease period (Hunter 1993, Spence 1995).

In spite of these facts, in 2001, arguably another drought year, the water lease enforcement contact was unable to maintain flows at the lease quantification point in Mill Creek despite almost daily efforts. Mill Creek is a wide, flat, cobble and gravel-bottomed creek, and the amount of water necessary to ensure a specific level of streambed coverage or redd success has not been quantified. If the lease is to meet its prescribed intent to "maintain and enhance streamflows for the benefit of fisheries" (Spence 1995, EQC 1998), an evaluation of the minimum amount of water required to cover a prescribed wetted perimeter should be undertaken to determine what amount of water is truly needed to meet this goal. It is critical that the water commissioner be more diligent and forceful in maintaining lease levels. Given the trapping data from 1997, there is no doubt that Mill Creek is capable of recruiting substantial numbers of Yellowstone cutthroat trout fry when flows are adequate throughout the incubation and emergence period (Hennessey 1998). However, continuing the lease may not be cost-effective unless reliable and sufficient flows can be maintained (Hennessey 1998). Given the average life cycle of a Yellowstone cutthroat trout, 2001 should have been the second year that the large recruitment from 1997 would have shown up in the spawning runs (Behnke 1992). However, most successfully spawned eggs would probably have been desiccated early on in the season given the timing of sudden and abrupt reductions in flow due to irrigation withdrawals in 2001.

Cedar Creek maintained consistent lease level flows all season, with the exception of one 24-hour period in early July (Figure 5). Most stages of fry incubation can withstand short-term (<48 hours) dewatering since gravels hold some water in the interstitial spaces (Becker et al. 1983). The rapid response time of the water lease contact to the single low flow situation at Cedar Creek this year probably prevented any significant fry losses (Figure 5). Recruitment as measured by trap results in Cedar Creek was up approximately 40% as compared to 2000, but was within the range from the previous four years (Table 3).

Water levels on Big Creek met the water lease agreement in 2001, but Big Creek was not immune to the valley-wide water shortage, and discharge dropped earlier and stabilized at a much lower level in 2001 than in 1999, but was actually a little higher than in 2000. Although fry recruitment increased substantially in 2000, total trap catch in 2001 decreased from the previous year's high to a level near that seen in 1999 (Table 4-3). It is difficult to assess whether the large increase in 2000 was due solely to the water lease, or if it represents the natural variation in spawning and recruitment for Big Creek. However, anecdotal evidence from 1996 through 1998 suggests that the lease has substantially increased the water available in Big Creek during the summer months which can only facilitate Yellowstone cutthroat trout recruitment (L. Roulson, pers. field notes 1996-1998). Hopefully maintenance of in-stream flows in Big Creek will support continued higher recruitment in the future.

The discharge situation on Mol Heron Creek was very similar to that on Big Creek in 2001, and the creek did not fall below lease level.

GANDA used Hennessey's protocol on Mill, Cedar, and Mol Heron creeks for the third year in 2001 and for the first time in Big Creek. Despite much earlier spawning and onset of outmigration, the protocol was able to detect the ascending limb in Big, Cedar, and Mol Heron creeks. Mill Creek was again sampled more frequently because of a lack of a distinct ascending limb, but sampling was suspended when flows became insufficient to connect the mouth of the creek with the Yellowstone mainstem.

The 2001 sampling season was considerably shorter than in 1999 and 2000 because of the use of Hennessey's protocol on all four project streams. Because the descending limbs of fry outmigrations were not monitored, data on fry lengths may have been truncated. If FWP wants to collect information on the life history of Yellowstone cutthroat trout fry concerning their residence time in natal tributaries, then this late-season data may be valuable. Should further research on fry residence time become a priority, it would be important to sample the latter end of outmigration and perhaps sample well into late September or October to ensure that late moving fry are documented.

Based on the results from this survey and a review of results from 1996-2000, GANDA recommends the following management actions to secure continued protection of Yellowstone cutthroat trout populations in the four project streams:

1. Maintain the water leases on all four project streams and pursue renewal of leases shown to be effective for the maximum time allowed when available;
2. FWP staff should continue to resolve issues that may be allowing junior water users to receive water out of priority to FWP's leases;
3. Re-evaluate the current level of leases on Mill Creek and determine the flows necessary to effectively, and consistently increase the wetted streambed perimeter in the section up to ½ mile from the mouth of the creek. If sufficient flows cannot be maintained either by more stringent enforcement/ administration of the current leases or by obtaining additional flows in an economical manner, FWP should seriously consider discontinuing the Mill Creek lease;
4. Continue annual monitoring of fry outmigration using Hennessey's protocol on all four project streams; and
5. Pursue additional water leases on other Yellowstone cutthroat trout spawning streams to further protect the species.

6.0 References Cited

Becker, C.D., D.A. Neitzel, and C.S. Abernathy. 1983. Effects of dewatering on chinook salmon redds: tolerance of four developmental phases to one-time dewatering. North American Journal of Fisheries Management 3:373-382.

Behnke, R.J. 1992. Native trout of western North America. American Fisheries Society Monograph 6. American Fisheries Society, Bethesda, Maryland.

Benson, N.C. 1960. Factors influencing production of immature cutthroat trout production in Arnica Creek, Yellowstone Park. Transactions of the American Fisheries Society 89:169-175.

Brown, R.S. and W.C. Mackay. 1995. Spawning ecology of cutthroat trout in the Ram River, Alberta. Canadian Journal of Fisheries and Aquatic Sciences 52: 983-992.

Byorth, P. A. 1990. An evaluation of Yellowstone cutthroat trout production in three tributaries of the Yellowstone River, Montana. Master's thesis. Montana State University, Bozeman.

Carlander, K.D. 1969. Handbook of freshwater fishery biology, Volume 1, 3rd edition, Iowa State University Press, Ames.

Clancy, C. 1988. Effects of dewatering on spawning by Yellowstone cutthroat trout in tributaries of the Yellowstone River, Montana. Pages 37-41 *in* R.E. Gresswell, editor. Status and management of interior stocks of cutthroat trout. American Fisheries Society Symposium 4. American Fisheries Society, Bethesda, Maryland.

Environmental Quality Council (EQC). 1998. Montana Department of Fish, Wildlife & Parks' water leasing study. Final report to the 56th legislature. Environmental Quality Council, Helena, Montana.

Hennessey, L.E. 1998. An evaluation of Yellowstone cutthroat trout fry recruitment related to water leases on four tributary streams of the Yellowstone River, Master's Thesis. Montana State University Bozeman.

Hunter, C. 1993. Letter to Kathy Hadley of Montana Wildlife Federation, January 20, 1993. Montana Fish, Wildlife and Parks, Helena.

Kelly, B.A. 1993. Ecology of Yellowstone cutthroat trout and an evaluation of potential effects of angler wading in the Yellowstone River. Mater's Thesis. Montana State University, Bozeman.

Leary, R. 1998. Letter to Brad Shepard; electrophoretic analysis of young of the year trout collected from Cedar Creek, Locke Creek, Mill Creek, and Mol Heron Creek. University of Montana Wild Trout and Salmon Genetics Lab, Missoula.

Martinez, A. 1984. Identification of brook, brown, rainbow, and cutthroat trout larvae. Transactions of the American Fisheries Society 113: 252-259.

McMullin, S. J., and P. J. Graham. 1981. The impact of Hungry Horse Dam on the kokanee fishery of the Flathead River. Montana Department of Fish, Wildlife and Parks, Kalispell.

Montana Fish, Wildlife and Parks (FWP) 1999. Request for proposal # FWP 990164, monitor streamflow and Yellowstone cutthroat trout fry emigration. Issued April 12, 1999. Montana Fish, Wildlife and Parks, Helena.

Natural Resources Conservation Service, Montana (NRCS). 2002. Past Montana SNOTEL snowpack/precipitation update reports. Available on-line at: http://www.mt.nrcs.usda.gov/swcs/snow/past_up.html

National Oceanic and Atmospheric Administration (NOAA) 2000. Climatological data, Montana, unedited- June 2000 to August 2000, volume 103, numbers 6-8. National Climatic Data Center, Asheville, North Carolina.

Nelson, F. 1991. Office memorandum: Flow measurements, Mill Creek, Montana, April 3, 1991. - unpublished data. Montana Fish, Wildlife and Parks, Bozeman.

Nelson, F. 1999. Features of Montana Fish, Wildlife & Parks in-stream water leases- October 1999. Montana Fish, Wildlife & Parks, Bozeman.

Parrett, C., and J.A. Hull. 1985. Streamflow characteristics of mountain streams in western Montana. Water Supply Paper 2260. U.S. Geological Survey, Alexandria, Virginia.

Roulson, L.H. 1998. An evaluation of Yellowstone cutthroat trout fry outmigration from four tributaries of the upper Yellowstone River during a low water year. Montana Department of Fish, Wildlife and Parks, Bozeman.

Roulson, L.H. 1999. Water leases and Yellowstone cutthroat trout fry outmigration from four tributaries of the upper Yellowstone River. Garcia and Associates. Prepared for Montana Department of Fish, Wildlife and Parks, Helena.

Roulson, L.H. 2001. Water leases and Yellowstone cutthroat trout fry outmigration from four tributaries of the upper Yellowstone River, project year 2000. Garcia and Associates. Prepared for Montana Department of Fish, Wildlife and Parks, Helena.

Shepard, B. B. 1990. Talk for the Mill Creek water district. Presented at a meeting on September18, 1990.

Shepard, B. B. 1992. Fisheries of the upper Yellowstone River including tributary recruitment: report for years 1989, 1990 and 1991. Montana Department of Fish, Wildlife and Parks, State Project 3312, Bozeman.

Spence, L. E. 1995. Water leasing for in-stream flow. Presented to the Second Annual Conference on Montana Water Law, Helena

Thurow, R. F., C. E. Corsi, and V. K. Moore. 1988. Status, ecology and management of Yellowstone cutthroat trout in the upper Snake River drainage, Idaho. Pages 25-36 *in* R.E. Gresswell, editor. Status and management of interior stocks of cutthroat trout. American Fisheries Society Symposium 4. American Fisheries Society, Bethesda, Maryland.

Thurow, R.F. and J.G. King. 1994. Attributes of Yellowstone cutthroat trout redds in a tributary of the Snake River, Idaho. Transactions of the American Fisheries Society 123: 37-50.

USGS (United States Geological Survey). 1986 Water resources data for Montana water year 1985. U.S. Geological Survey Water Data Report MT-85-1.

USGS. 1997. Montana surface-water data. U.S. Geological Survey, Helena, Montana.

USGS. 2000. Montana climate station data. U.S. Geological Survey, Helena, Montana.

Varley, J.D and R.E. Gresswell. 1988 Ecology, status, and management of the Yellowstone cutthroat trout. pages 13 to 24 *in* Status and management of interior stocks of cutthroat trout, American Fisheries Society Symposium 4. American Fisheries Society, Bethesda, Maryland.

WRCC (Western Regional Climate Center). 2001. Climate data for Montana as of December 19, 2001 for Gardiner (243378) and Livingston 12S (245080) stations. (http://www.wrcc.sage.edi)

Appendices

Appendix A:
Staff Gauge Rating Tables Used to Quantify Flows in 2001

The following are reproductions of staff gauge rating tables that were verified by GANDA at the beginning of the 2001 field season. It should be noted that each gauge may require a correction factor or "shift" when converting the gauge reading as seen in the field to a flow measurement on the rating table. For example, the Cedar Creek gauge required a +0.02 shift to make the 1998 rating curve read 2001 flows accurately. This requires that a gauge reading of 1.00 be translated to 1.02 as read off the 1998 rating table to quantify the flow on the creek.

1 UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY WATER RESOURCE DIVISION

EXPANDED RATING TABLE

TYPE: LOG

6192050 DATE PROCESSED : 07-24-2001 @ 13:53 BY slynn

Mill Creek near Mouth near Pray, MT DD: 1 TYPE: 001 RA TING NO: 5.0

OFFSET: .04 START DATE/ TIME :04-01-1999 (0015)

BASED ON _ BASED ON ______DISCHARGE MEASUREMENTS, NOS _____, AND ______. WELL DEFINED BETWEEN ____ AND ____ ___ CFS

COMP BY ____ DATE____, CHK BY______ DATE______

STAFF GAUGE ON BRIDGE ABUTMENT STAFF GAGE WITH 1999 REVISED DATUM

GAUGE HEIGHT (FEET)	DISCHARGE IN CU. FEET PER SECOND					(EXPANDED PRECISION)					DIFF IN Q PER
	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	TENTH FT
0.1											
0.2											
0.3											
0.4											
0.5											
0.6											
0.7	3.800*	4.053	4.314	4.584	4.861	5.146	5.44	5.741	6.05	6.367	2.893
0.8	6.693	7.026	7.367	7.716	8.073	8.438	8.811	9.192	9.58	9.977	3.687
0.9	10.38	10.79	11.21	11.64	12.08	12.52	12.97	13.43	13.9	14.38	4.48
1	14.86	15.35	15.85	16.36	16.87	17.4	17.93	18.46	19.01	19.56	5.27
1.1	20.13	20.7	21.27	21.86	22.45	23.05	23.66	24.28	24.9	25.53	6.04
1.2	26.17	26.82	27.48	28.14	28.81	29.49	30.18	30.87	31.57	32.28	6.83
1.3	33.00*	33.73	34.47	35.22	35.97	36.73	37.5	38.28	39.07	39.86	7.66
1.4	40.66	41.47	42.29	43.11	43.95	44.79	45.64	46.49	47.36	48.23	8.45
1.5	49.11	50	50.9	51.8	52.71	53.63	54.56	55.5	56.44	57.39	9.24
1.6	58.35	59.32	60.29	61.28	62.27	63.27	64.27	65.29	66.31	67.34	10.03
1.7	68.38	69.43	70.48	71.54	72.61	73.69	74.77	75.87	76.97	78.08	10.82
1.8	79.2	80.32	81.45	82.59	83.74	84.9	86.06	87.23	88.41	89.6	11.6
1.9	90.8	92	93.21	94.43	95.66	96.89	98.13	99.38	100.6	101.9	12.4
2	103.2	104.5	105.8	107	108.4	109.7	111	112.3	113.7	115	13.1
2.1	116.3	117.7	119.1	120.5	121.8	123.2	124.6	126	127.4	128.9	14
2.2	130.3	131.7	133.2	134.6	136.1	137.6	139	140.5	142	143.5	14.7

1 UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY WATER RESOURCE DIVISION

EXPANDED RATING TABLE

TYPE: LOG

6192050
DATE PROCESSED : 07-24-2001 @ 13:53
BY slynn

Mill Creek near Mouth near Pray, MT
DD: 1 TYPE: 001 RA TING NO: 5.0

OFFSET: .04
START DATE/ TIME :04-01-1999 (0015)

BASED ON _ BASED ON ______DISCHARGE MEASUREMENTS, NOS _____, AND ______. WELL DEFINED BETWEEN ____ AND ____ ___ CFS

COMP BY ____ DATE_____, CHK BY______ DATE______

STAFF GAUGE ON BRIDGE ABUTMENT
STAFF GAGE WITH 1999 REVISED DATUM

GAUGE HEIGHT (FEET)	DISCHARGE IN CU. FEET PER SECOND					(EXPANDED PRECISION)					DIFF IN Q PER TENTH FT
	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
2.3	145	146.6	148.1	149.6	151.1	152.7	154.2	155.8	157.4	159	15.5
2.4	160.5	162.1	163.7	165.4	167	168.6	170.2	171.9	173.5	175.2	16.3
2.5	176.8	178.5	180.2	181.9	183.6	185.3	187	188.7	190.4	192.2	17.1
2.6	193.9	195.7	197.4	199.2	201	202.7	204.5	206.3	208.1	210	17.9
2.7	211.8	213.6	215.4	217.3	219.1	221	222.9	224.7	226.6	228.5	18.6
2.8	230.4	232.3	234.2	236.1	238.1	240	242	243.9	245.9	247.8	19.4
2.9	249.8	251.8	253.8	255.8	257.8	259.8	261.8	263.9	265.9	267.9	20.20*
3	270.0*										

Big Creek at Kendall Bridge Emigrant, MT

UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY WATER RESOURCE DIV PAGE 1

EXPANDED RATING TABLE E TYPE: LOG

6191820 DATE PROCESSE 7-16-01@10:54 By Slynn

Big Creek at Kendall Bridge Emigrant, MT DD: 1 TYPE: 001 RATING NO: 1.0

OFFSET: 0.00 START DATE/Time:07-01-1999(01500)

BASED ON ______DISCHARGE MEASUREMENTS, NOS _____, AND ______. WELL DEFINED BETWEE ___ CFS

COMP BY ____ DATE_____, CHK BY______ DATE______

GAGE HEIGHT (FEET)	DISCHARGE IN CU. FEET PER SECOND (EXPANDED PRECISION) 0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
0.2	.620*	0.684	0.751	0.821	0.894	0.971	1.05	1.133	1.219	1.308	0.78
0.3	1.400*	1.496	1.594	1.697	1.802	1.91	2.022	2.136	2.254	2.376	1.1
0.4	2.500*	2.63	2.763	2.9	3.039	3.183	3.329	3.479	3.633	3.79	1.45
0.5	3.950*	4.126	4.306	4.49	4.679	4.872	5.069	5.27	5.476	5.686	1.95
0.6	5.900*	6.136	6.376	6.623	6.874	7.132	7.394	7.662	7.936	8.215	2.6
0.7	8.500*	8.817	9.141	9.473	9.812	10.16	10.51	10.87	11.24	11.62	3.5
0.8	12.00*	12.45	12.91	13.39	13.87	14.37	14.87	15.39	15.93	16.47	5.02
0.9	17.02	17.59	18.17	18.77	19.37	19.99	20.62	21.26	21.92	22.59	6.26
1	23.28	23.98	24.69	25.41	26.15	26.91	27.67	28.46	29.25	30.07	7.61
1.1	30.89	31.73	32.59	33.46	34.35	35.25	36.17	37.1	38.05	39.02	9.11
1.2	40.00*	41.01	42.03	43.07	44.12	45.2	46.29	47.4	48.52	49.67	10.83
1.3	50.83	52.01	53.2	54.42	55.65	56.91	58.18	59.47	60.77	62.1	12.62
1.4	63.45	64.81	66.2	67.6	69.03	70.47	71.94	73.42	74.93	76.45	14.55*
1.5	78.00*										

Received from Steve Lynn, 07-17-2001

1 UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY WATER RESOURCE DIVISION

EXPANDED RATING TABLE

TYPE: LOG

6191600

DATE PROCESSED : 07-24-2001 @ 13:53 BY slynn

Cedar Creek near OTO Ranch near Corwin Springs, MT

DD: 1 TYPE: 001 RA TING NO: 2.0

OFFSET: 0.03

START DATE/ TIME :04-01-1997 (0015)

BASED ON _ BASED ON _____DISCHARGE MEASUREMENTS, NOS _____, AND _____. WELL DEFINED BETWEEN ____ AND ____ ___ CFS

COMP BY ____ DATE_____, CHK BY_____ DATE_____

STAFF GAUGE ON BRIDGE ABUTMENT STAFF GAGE WITH 1999 REVISED DATUM

DISCHARGE IN CU. FEET PER SECOND (EXPANDED PRECISION)

GAUGE HEIGHT (FEET)	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
0.8	4.000*	4.271	4.555	4.852	5.163	5.486	5.824	6.176	6.543	6.924	3.321
0.9	7.321	7.733	8.161	8.606	9.067	9.546	10.04	10.55	11.09	11.64	4.879
1	12.2	12.79	13.4	14.03	14.67	15.34	16.03	16.74	17.47	18.22	6.8
1.1	19.00*	19.81	20.65	21.51	22.39	23.30*	24.37	25.47	26.61	27.79	10
1.2	29.00*	30.41	31.88	33.39	34.97	36.6	38.28	40.03	41.83	43.7	16.63
1.3	45.63	47.63	49.69	51.82	54.02	56.29	58.64	61.06	63.55	66.12	23.14
1.4	68.77	71.5	74.31	77.21	80.19	83.27	86.43	89.68	93.02	96.46	31.23*
1.5	100.0*										

1 UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY WATER RESOURCE DIVISION

EXPANDED RATING TABLE

TYPE: LOG

6191600 DATE PROCESSED : 07-24-2001 @ 13:53 BY slynn

Cedar Creek above diversion near Corwin Springs, MT

DD: 1 TYPE: 001 RA TING NO: 2.0

OFFSET: -0.20

START DATE/ TIME :04-01-1997 (0015)

BASED ON _ BASED ON _____DISCHARGE MEASUREMENTS, NOS _____, AND _____. WELL DEFINED BETWEEN ____ AND ____ ___ CFS

COMP BY ____ DATE____, CHK BY______ DATE______

STAFF GAUGE ON BRIDGE ABUTMENT STAFF GAGE WITH 1999 REVISED DATUM

GAUGE HEIGHT (FEET)	DISCHARGE IN CU. FEET PER SECOND					(EXPANDED PRECISION)					DIFF IN Q PER TENTH FT
	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
0.7	8.000*	8.287	8.58	8.881	9.188	9.503	9.826	10.16	10.49	10.84	3.19
0.8	11.19	11.55	11.92	12.29	12.68	13.07	13.47	13.88	14.3	14.72	3.97
0.9	15.16	15.6	16.05	16.52	16.99	17.46	17.95	18.45	18.96	19.47	4.84
1	20.00*	20.61	21.24	21.88	22.53	23.2	23.88	24.58	25.29	26.01	6.75
1.1	26.75	27.51	28.28	29.06	29.87	30.68	31.52	32.37	33.24	34.12	8.27
1.2	35.02	35.94	36.87	37.83	38.8	39.78	40.79	41.81	42.86	43.92	9.980*
1.3	45.00*										

1 UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY WATER RESOURCE DIVISION

EXPANDED RATING TABLE

TYPE: LOG

6191600 DATE PROCESSED : 07-24-2001 @ 13:53 BY slynn

Cedar Creek at mouth near Corwin Springs, MT

DD: 1 TYPE: 001 RA TING NO: 4.0

OFFSET: 0.00

START DATE/ TIME :04-01-1998 (0015)

BASED ON _ BASED ON ______DISCHARGE MEASUREMENTS, NOS _____, AND _____. WELL DEFINED BETWEEN ____ AND ____ ___ CFS

COMP BY ____ DATE____, CHK BY_____ DATE______

GAUGE HEIGHT (FEET)	DISCHARGE IN CU. FEET PER SECOND 0	0.01	0.02	0.03	0.04	(EXPANDED PRECISION) 0.05	0.06	0.07	0.08	0.09	DIFF IN Q PER TENTH FT
0.3	.400*	0.436	0.474	0.515	0.557	0.601	0.648	0.696	0.747	0.8	0.456
0.4	0.856	0.914	0.974	1.036	1.101	1.168	1.238	1.311	1.386	1.464	0.688
0.5	1.544	1.627	1.712	1.801	1.892	1.986	2.083	2.183	2.286	2.391	0.956
0.6	2.500*	2.615	2.733	2.854	2.979	3.107	3.239	3.374	3.512	3.654	1.3
0.7	3.800*	3.96	4.124	4.292	4.465	4.643	4.825	5.012	5.203	5.399	1.8
0.8	5.600*	5.815	6.035	6.26	6.492	6.728	6.971	7.219	7.474	7.734	2.4
0.9	8.000*	8.295	8.597	8.907	9.224	9.55	9.883	10.22	10.57	10.93	3.3
1	11.3	11.67	12.05	12.44	12.84	13.25	13.67	14.1	14.53	14.98	4.13
1.1	15.43	15.9	16.37	16.86	17.35	17.85	18.37	18.89	19.42	19.97	5.09
1.2	20.52	21.09	21.66	22.25	22.85	23.46	24.08	24.71	25.35	26.01	6.15
1.3	26.67	27.35	28.04	28.74	29.46	30.18	30.92	31.67	32.44	33.21	7.330*
1.4	34.00*										

Mol Heron Rating Table 1999

gauge height	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	^/0.1 ft
0.90	4.021	4.251	4.492	4.743	5.005	5.279	5.565	5.863	6.174	6.497	
1.00	6.834	7.185	7.551	7.931	8.326	8.737	9.164	9.607	10.068	10.546	2.813
1.10	11.042	11.557	12.090	12.644	13.217	13.811	14.426	15.063	15.723	16.405	4.208
1.20	17.111	17.841	18.595	19.375	20.181	21.014	21.874	22.762	23.678	24.624	6.068
1.30	25.600	26.607	27.645	28.716	29.819	30.956	32.128	33.335	34.578	35.857	8.490
1.40	37.175	38.531	39.926	41.362	42.838	44.357	45.918	47.524	49.173	50.869	11.575
1.50	52.611	54.400	56.238	58.125	60.063	62.052	64.093	66.188	68.338	70.543	15.436
1.60	72.805	75.124	77.502	79.941	82.440	85.002	87.627	90.316	93.072	95.894	20.194
1.70	98.784	101.744	104.775	107.877	111.053	114.303	117.629	121.031	124.513	128.074	25.980
1.80	131.716	135.441	139.250	143.144	147.125	151.194	155.353	159.603	163.946	168.383	32.932
1.90	172.916	177.545	182.274	187.103	192.034	197.069	202.209	207.456	212.811	218.276	41.199
2.00	223.854	229.545	235.351	241.275	247.317	253.480	259.766	266.176	272.712	279.376	50.938

*1.56 is the highest actual measured discharge

**for 2000 use a -0.25 shift
for 2001 use a +0.10 shift

Appendix B:
Daily Mean, Minimum, and Maximum Stream Temperatures for the Four Project Streams in Park County, Montana from May to September 2001.

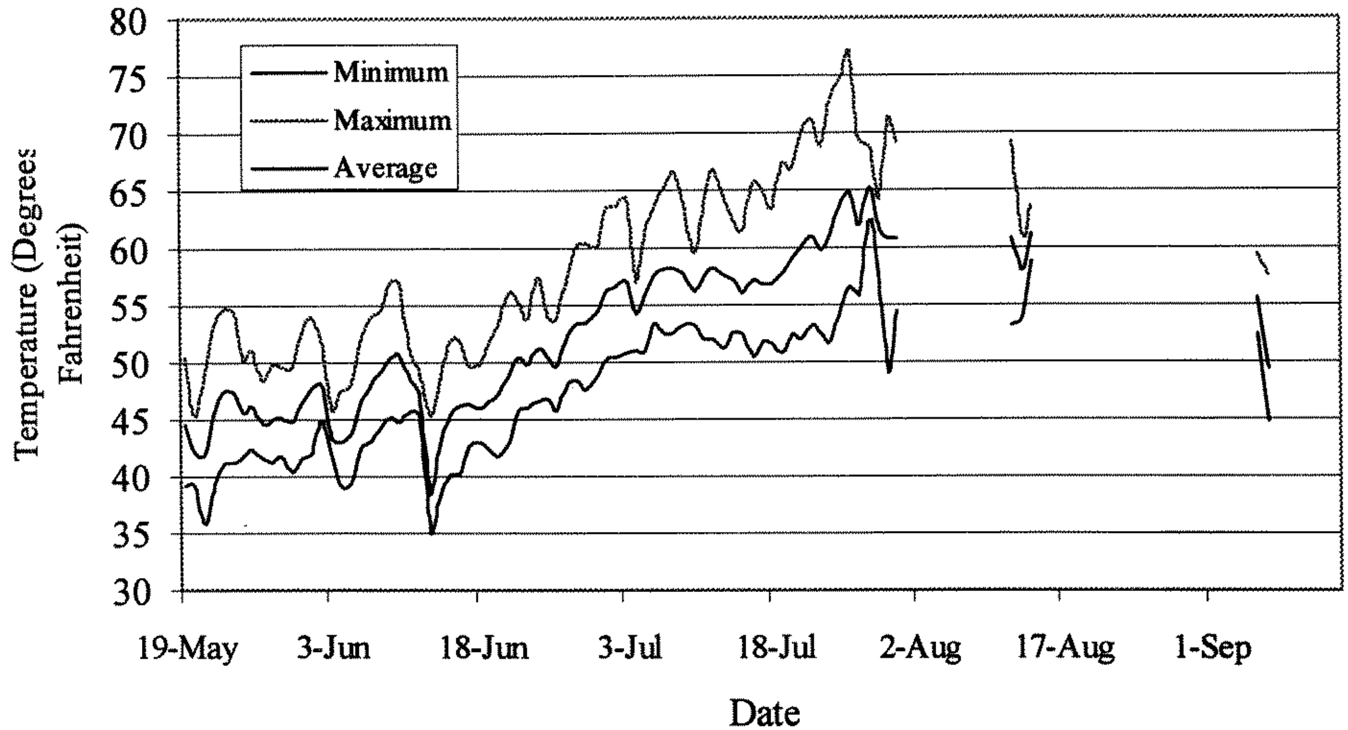


Figure B-1. Daily water temperature readings for Mill Creek, Park County, Montana from May to September 2001.Data were edited to remove readings from when the thermograph was out of the water.

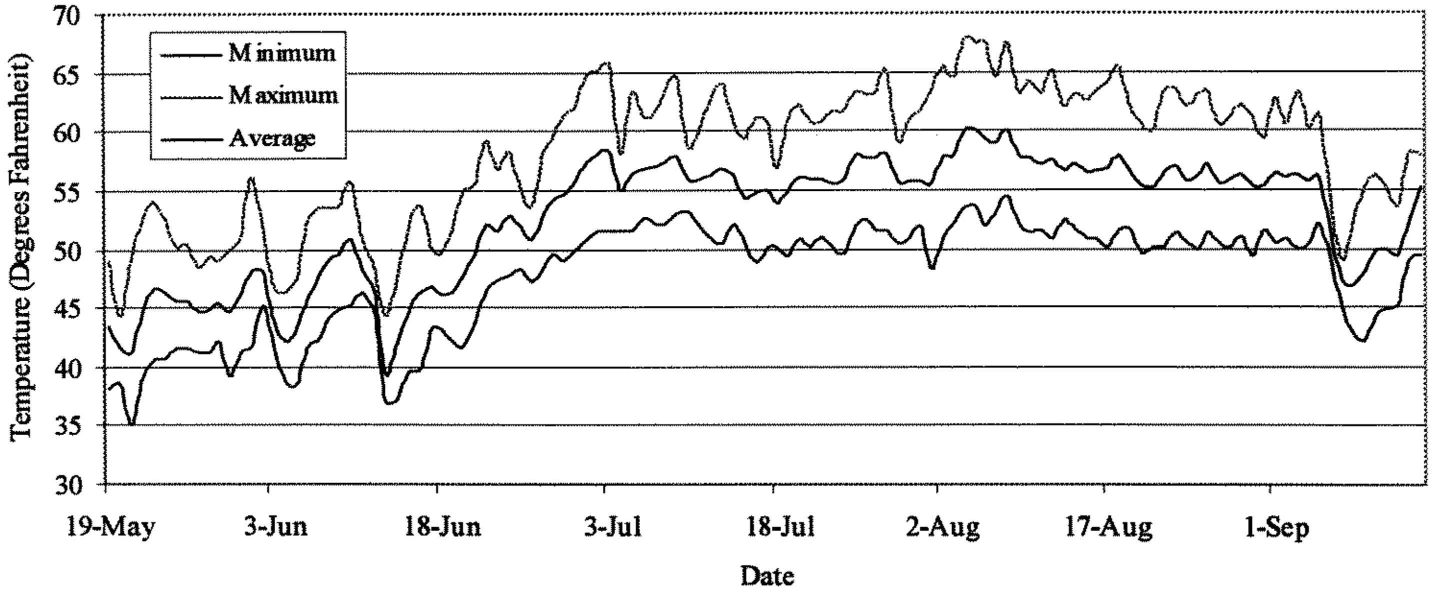


Figure B-2. Daily water temperature readings for Big Creek, Park County, Montana from May to September 2001.

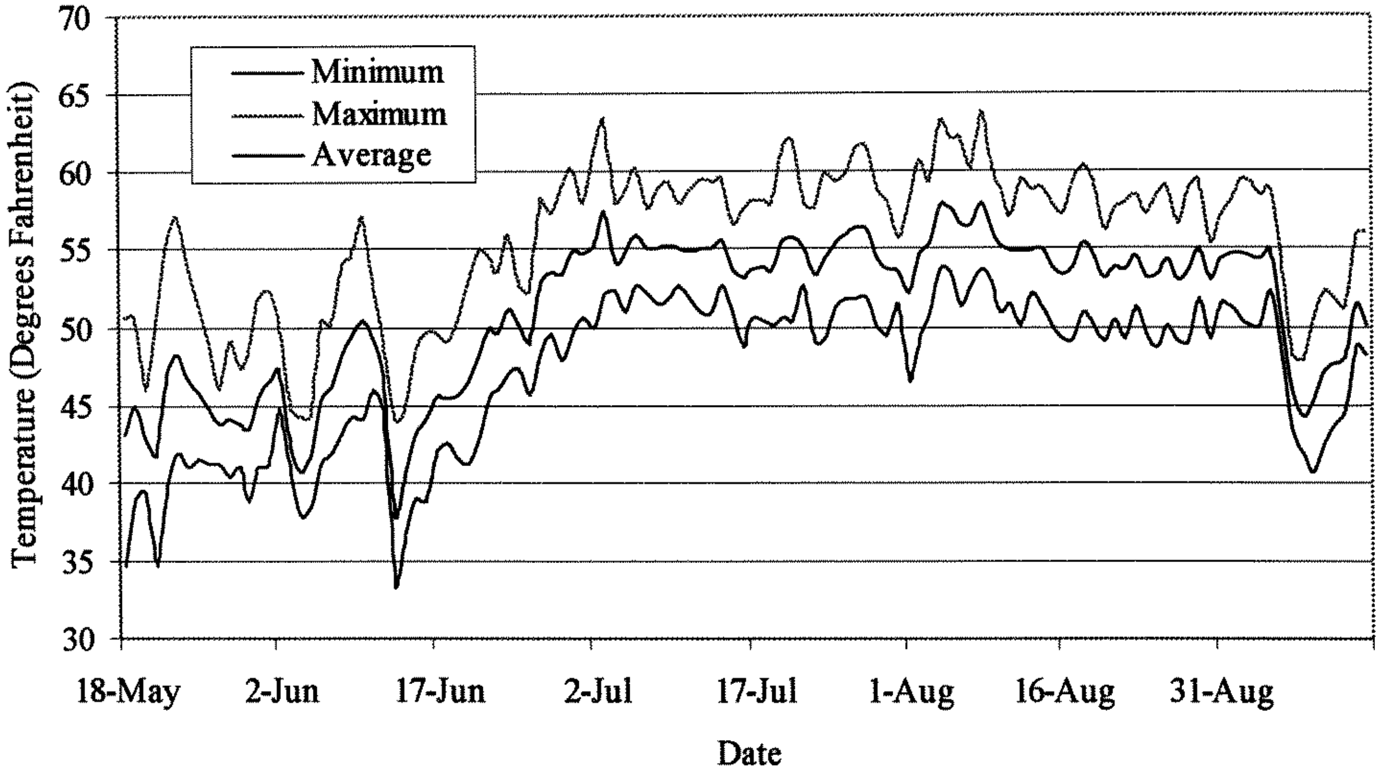


Figure B-3. Daily water temperature readings for Cedar Creek, Park County, Montana from May to September 2001.

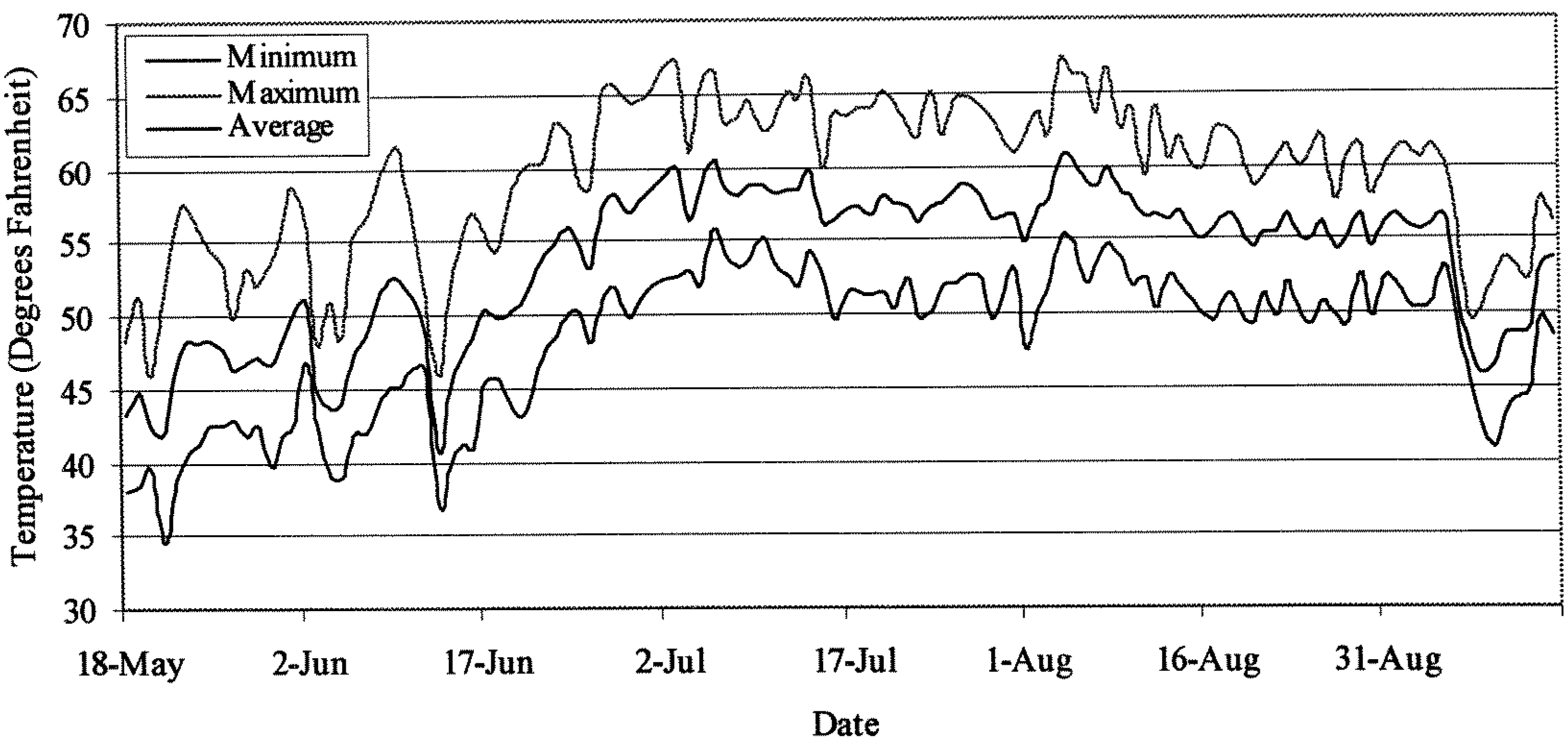


Figure B-4. Daily water temperature readings for Mol Heron Creek, Park County, Montana from May to September 2001.

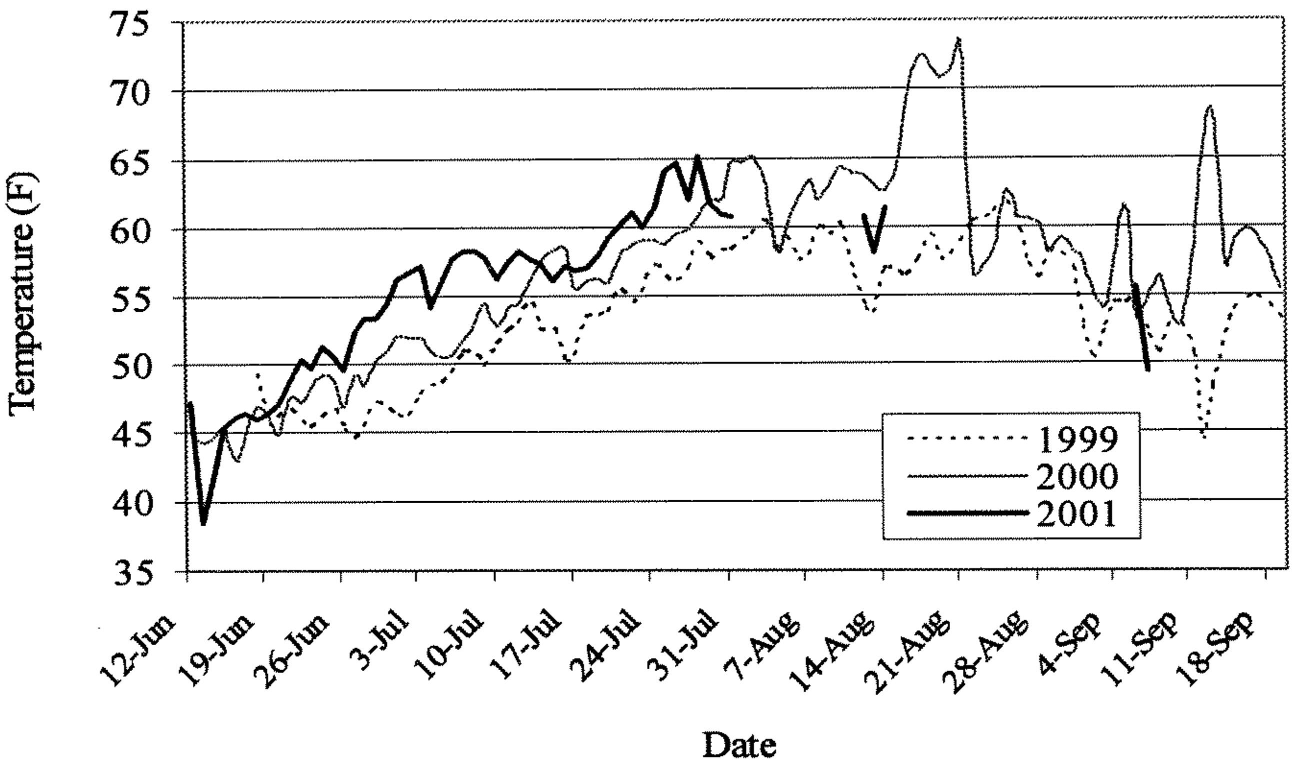


Figure B-5. Comparison of daily mean stream temperatures for Mill Creek, Montana from June through September 1999, 2000, and 2001. The blank portions of the 2001 data represent times when the thermograph was out of the water due to the creek being dry.

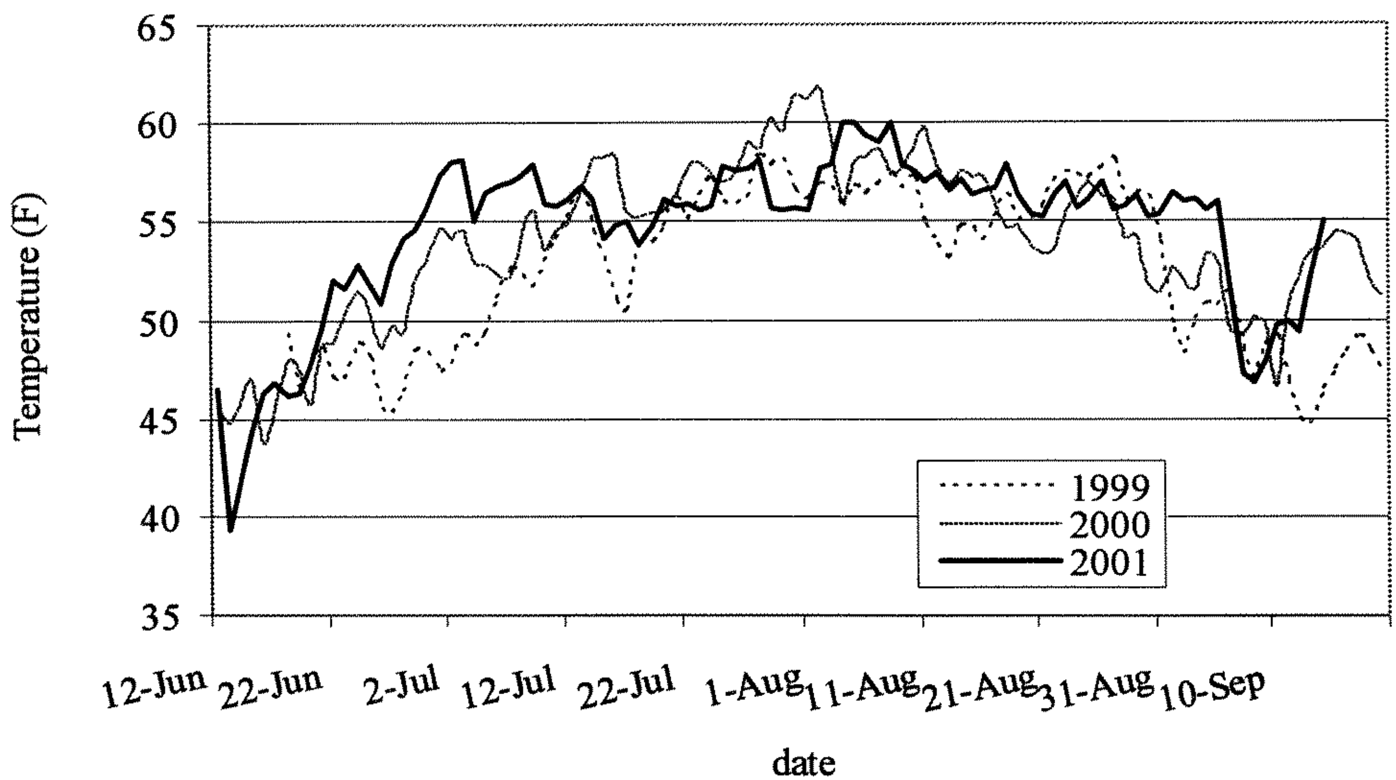


Figure B-6. Comparison of daily mean stream temperatures for Big Creek, Montana from June through September 1999, 2000, and 2001.

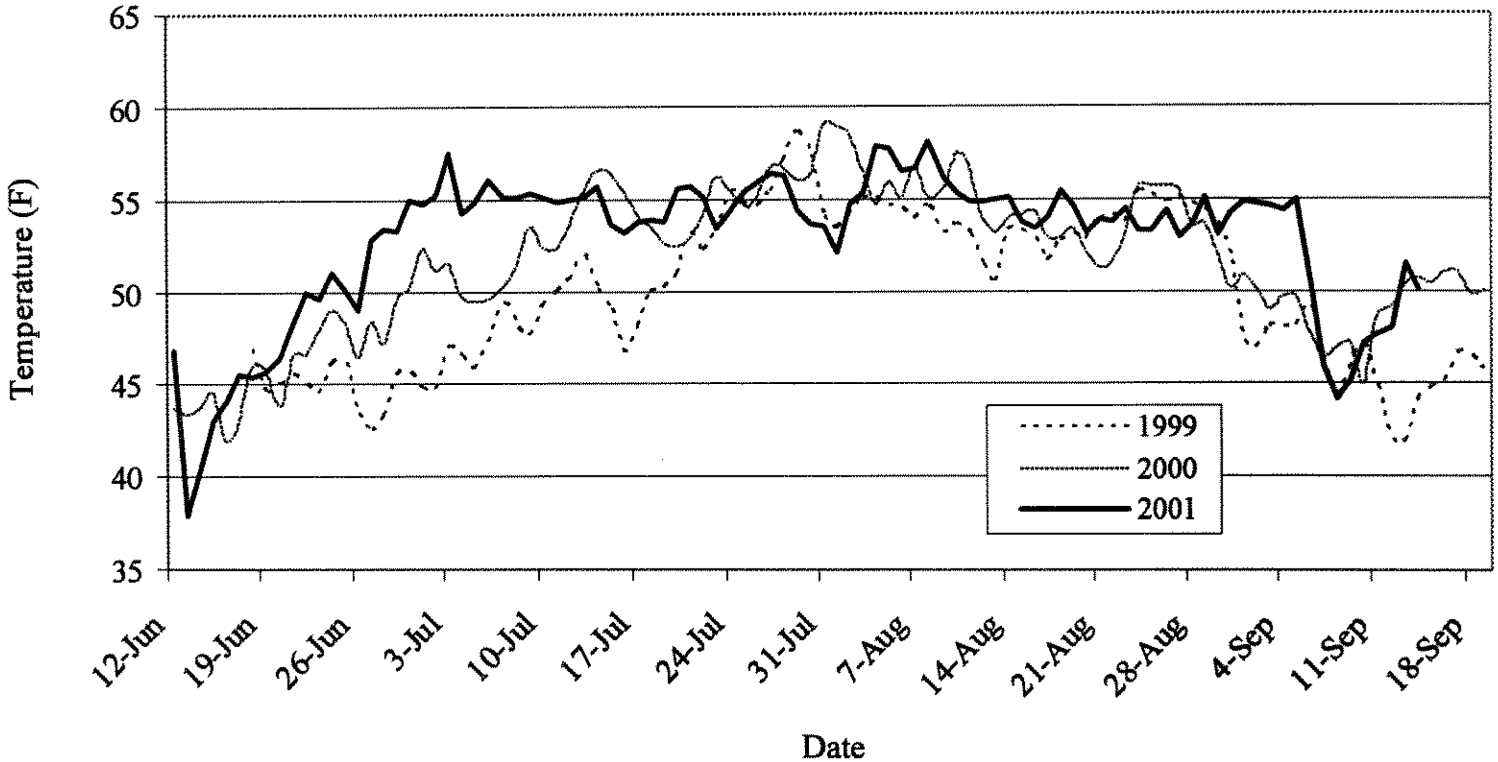


Figure B-7. Comparison of daily mean stream temperatures for Cedar Creek, Montana from June through September 1999, 2000, and 2001.

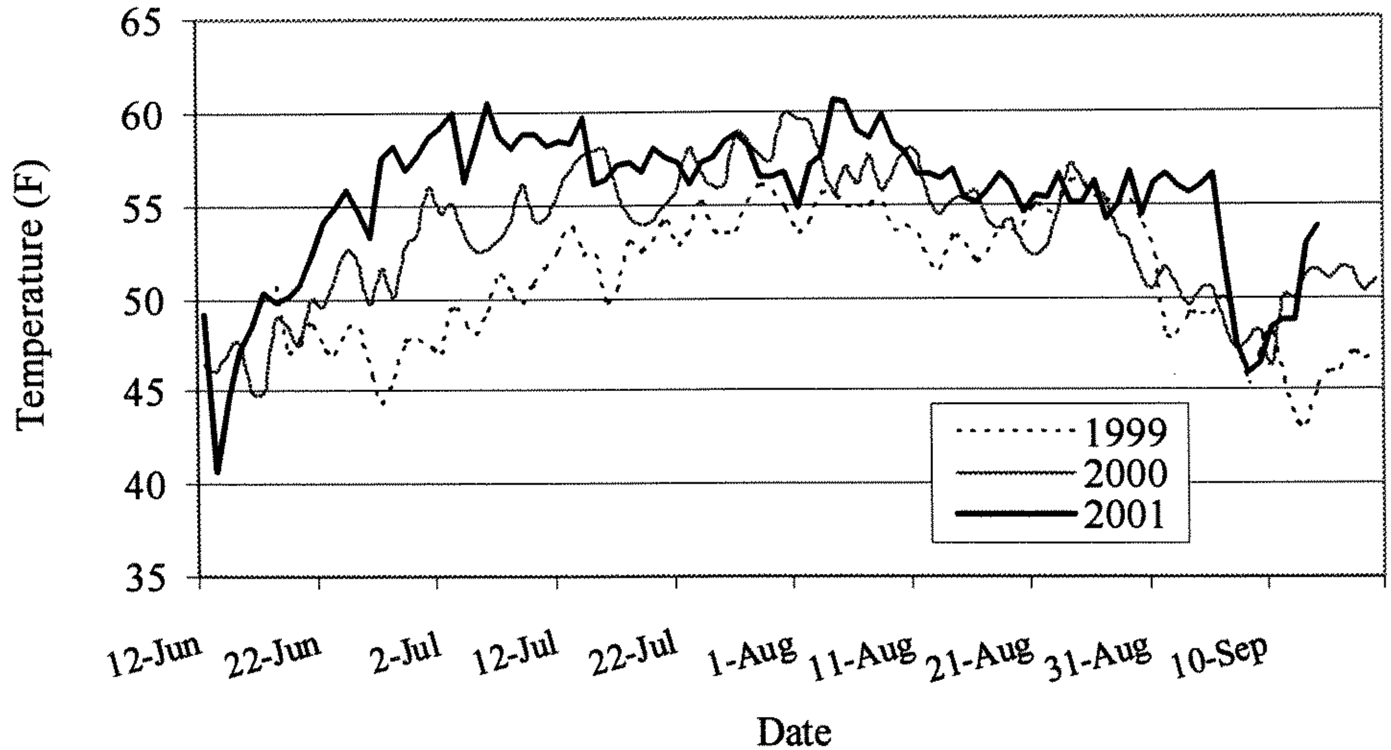


Figure B-8. Comparison of daily mean stream temperatures for Mol Heron Creek, Montana from June through September 1999, 2000, and 2001.

Appendix C:
Photos of the Fry Trap Locations on each of the Four Yellowstone Water Leasing Project Streams for the 2001 Trapping Season.

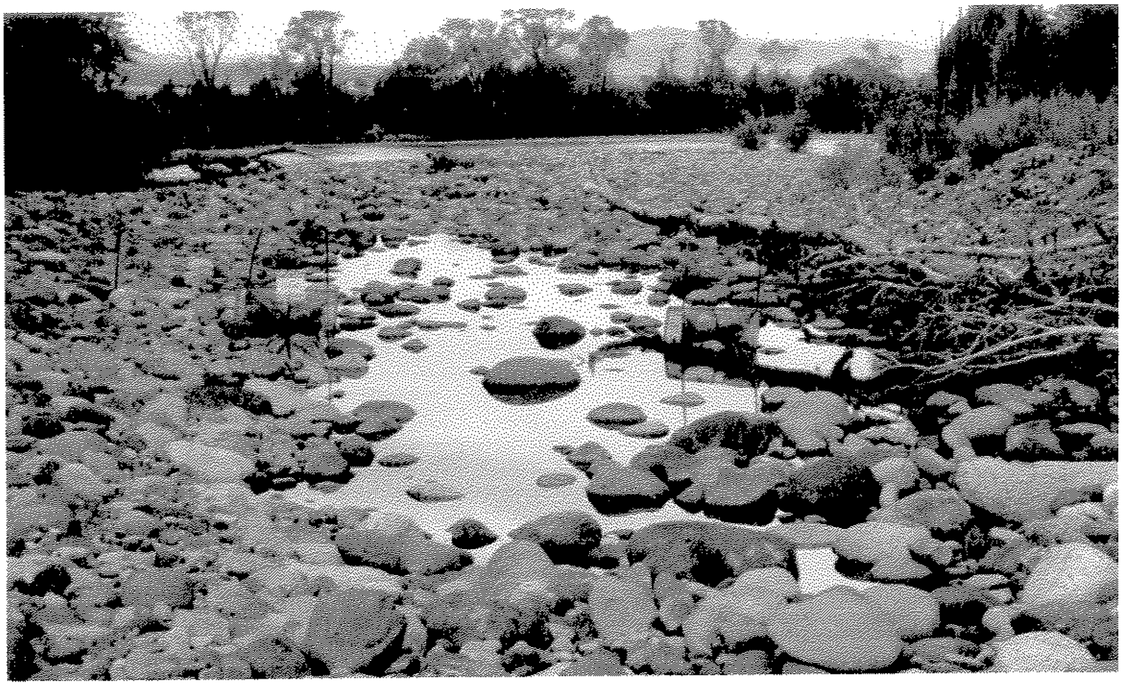


Figure C1. Photo of the 2001 trap sites on Mill Creek, Montana. The Yellowstone River is visible in the background. Photo was taken on July 31, 2001 at a gauge level of 0.46 (1.85 cfs). These trap sites have been used since 1997.

Figure C2. Photo of the 2001 trap site on Big Creek, Montana. The Yellowstone River is visible in the background. Photo was taken on July 26, 2001 at a gauge level of 0.80 (12.91 cfs). This is the same site that was used in 2000.

Figure C4. Photo of the 2001 trap site on Mol Heron Creek, Montana. The Yellowstone River is approximately 110 yards (100 m) downstream from the trap site. Photo was taken on August 4, 2001 at a gauge level of 0.96 (9.16 cfs). This is the same site used in 1999 and 2000. The rock berm and plywood baffling used to reduce flow velocities near the trap tail are visible.

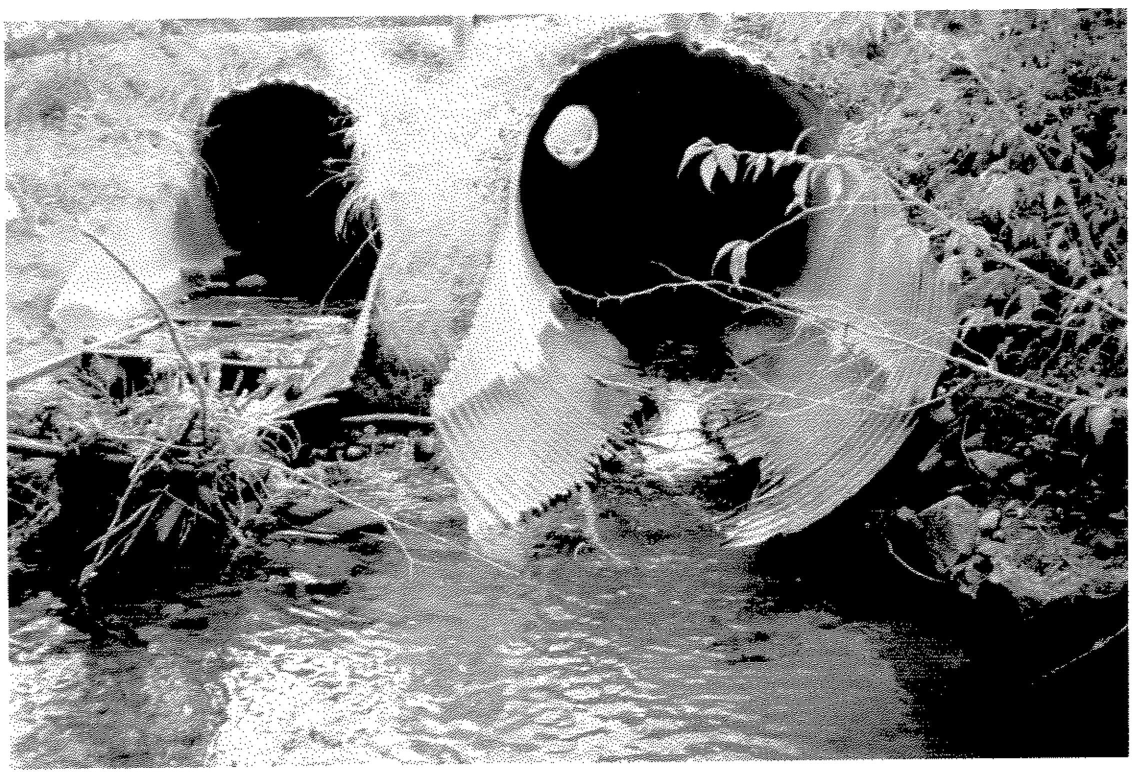
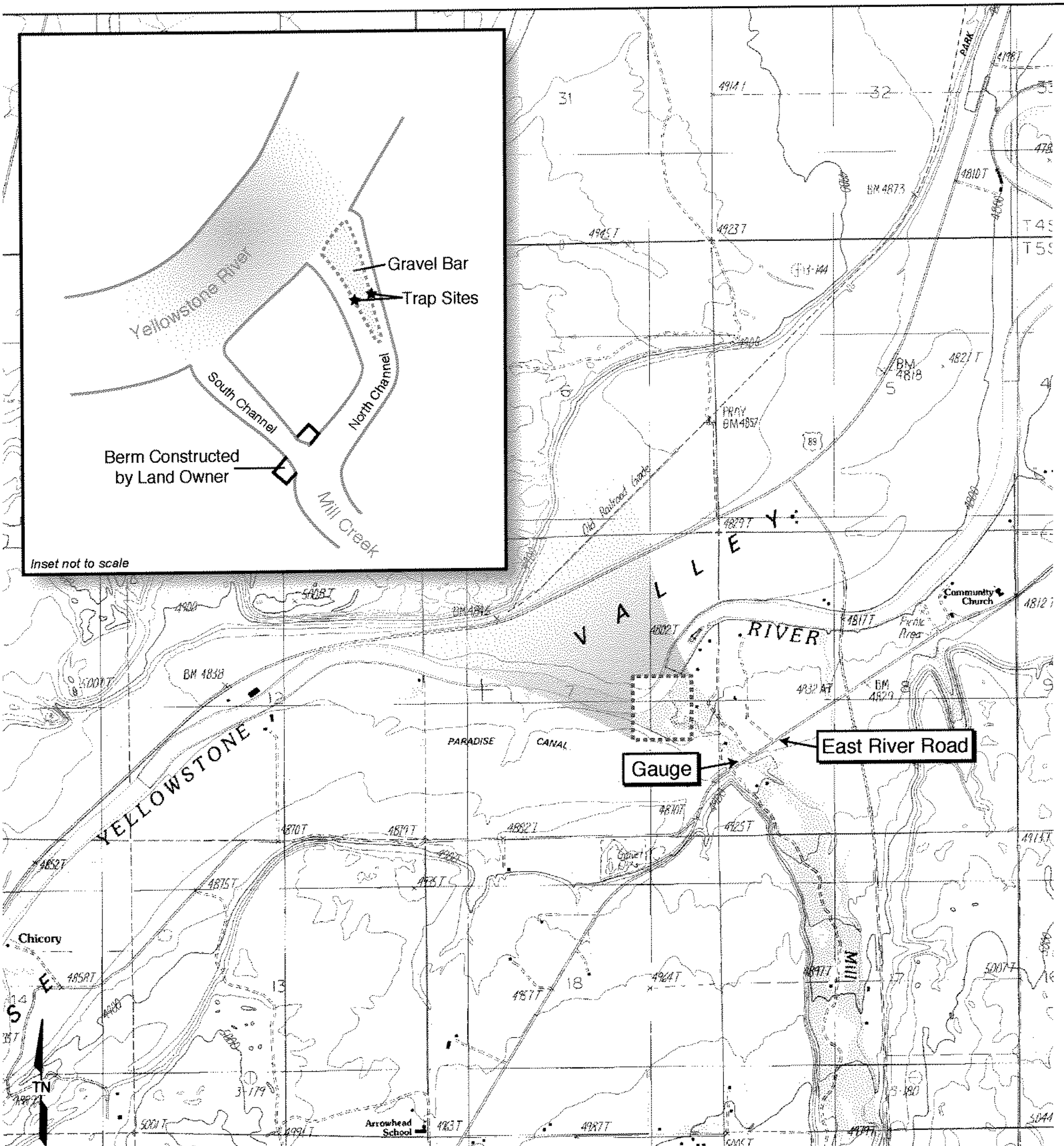


Figure C5. Photo of the double culvert on Cedar Creek, Montana at the Highway 89 crossing. The culvert on the left in the photo has a fish ladder that was installed in the late 1980's. Photo was taken on August 4, 2001 at a gauge level of 0.50 (1.71 cfs).

Appendix D:
Map of the Mill Creek Monitoring Area



Map of the Mill Creek Monitoring Area.

Scale = 1:19,200

Base Map: USGS 7.5 Minute-series
Pray, Montana, quadrangle (1965, revised 1994)

0 1/2
miles

GANDA

Prepared by Garcia and Associates

Appendix E:
Stream Discharge Readings for the Three Gauges on Cedar Creek, Montana from June to September 2001.

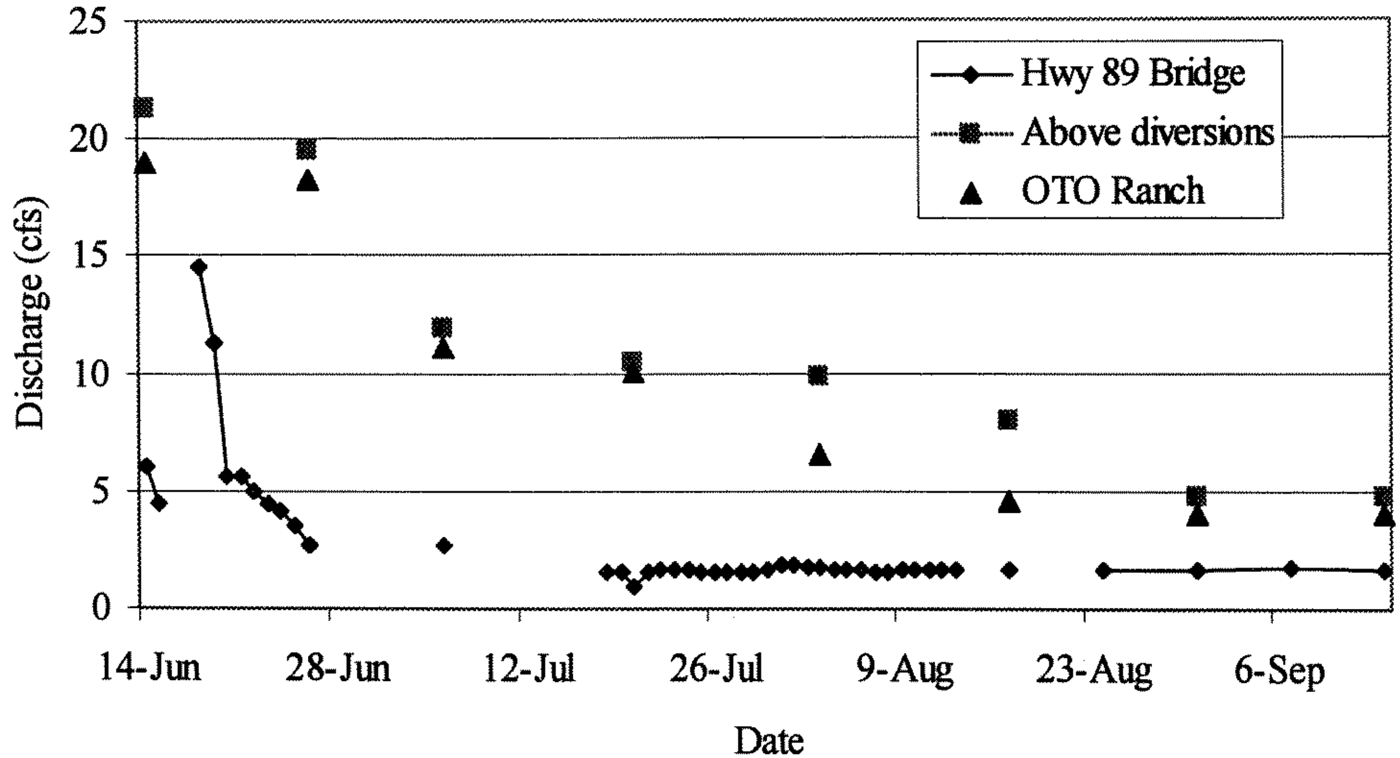


Figure E1. Discharge readings for the three gauges on Cedar Creek, Montana from June to September 2001. Discharge was measured bi-weekly at the two upper gauges.

Appendix F:
Graphs of Daily Discharge and Temperature Readings for the Four Yellowstone Water Leasing Project Streams in Park County, Montana from June to September 2001.

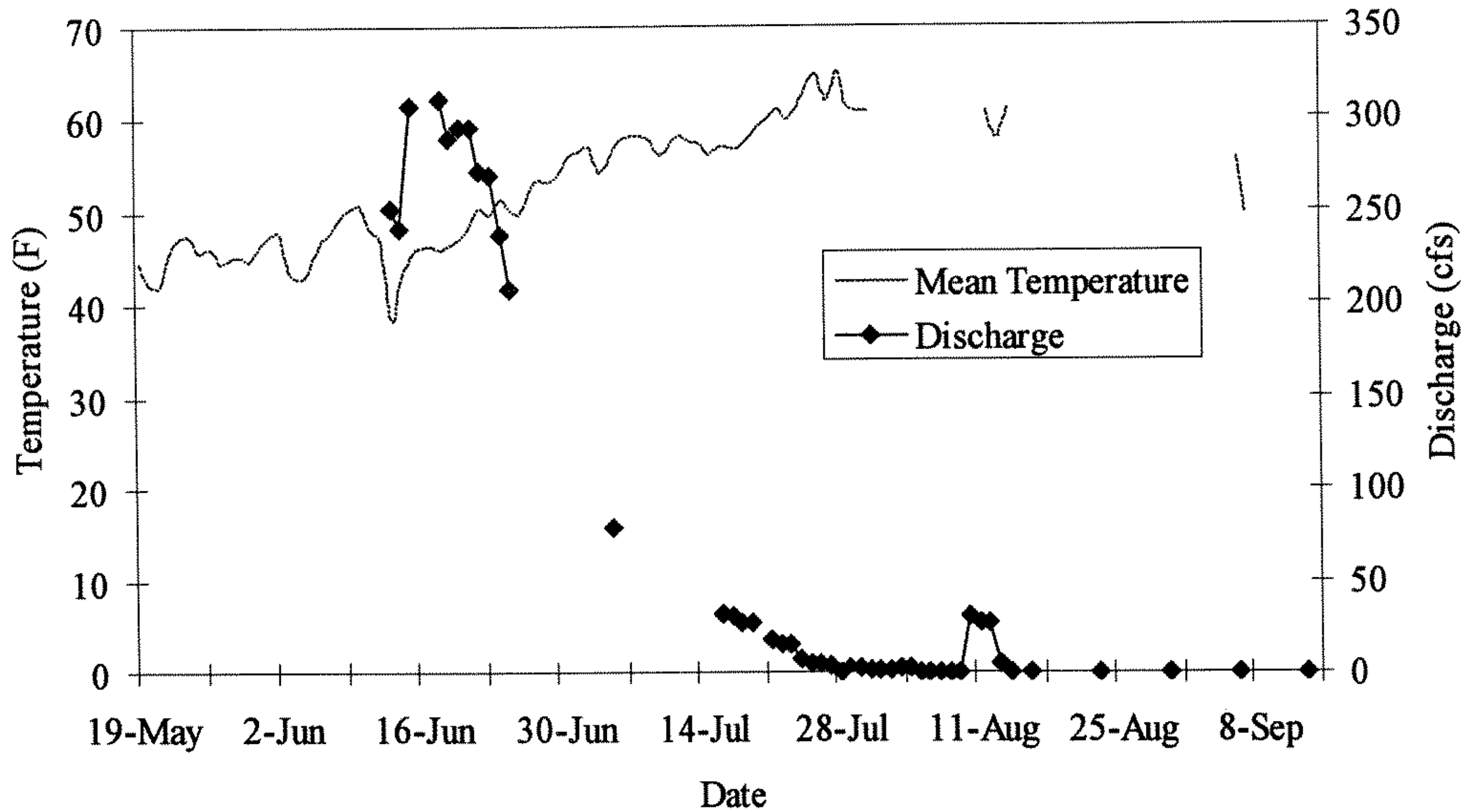


Figure F1. Daily discharge and mean daily stream temperature for Mill Creek, Montana from June to September 2001. Temperature data were edited to remove points when the thermograph was out of the water.

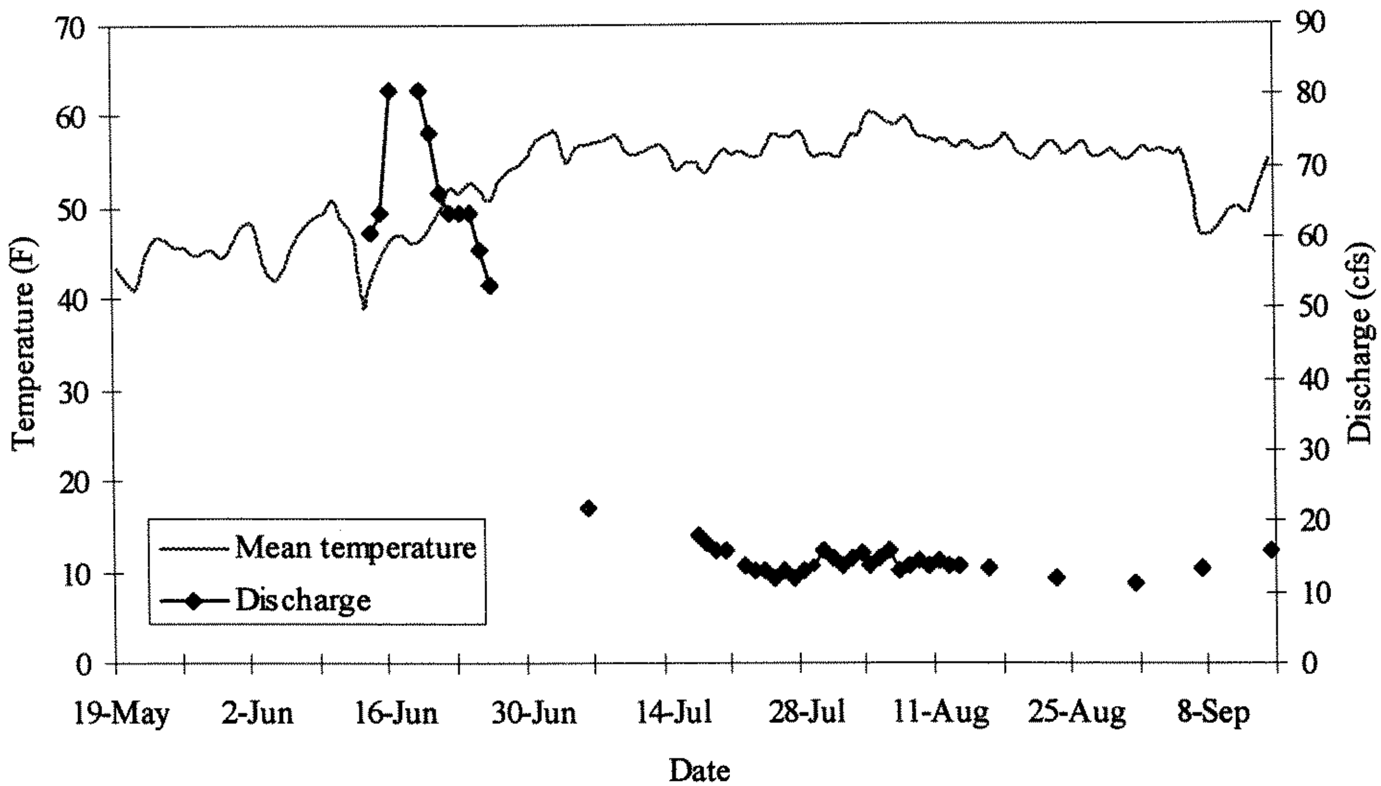


Figure F2. Daily discharge and mean daily stream temperature for Big Creek, Montana from May to September 2001.

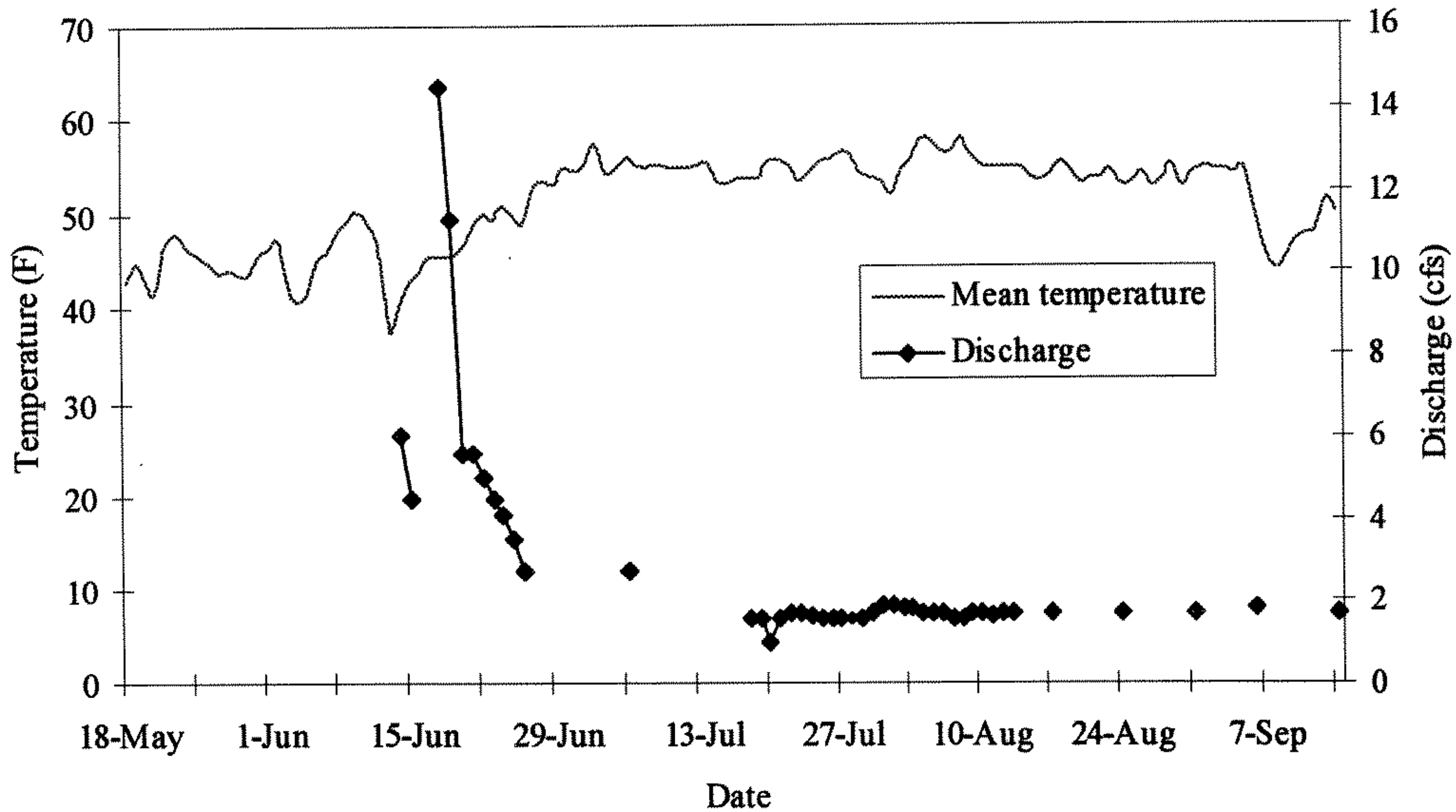


Figure F3. Daily discharge and mean daily stream temperature for Cedar Creek, Montana from May to September 2001.

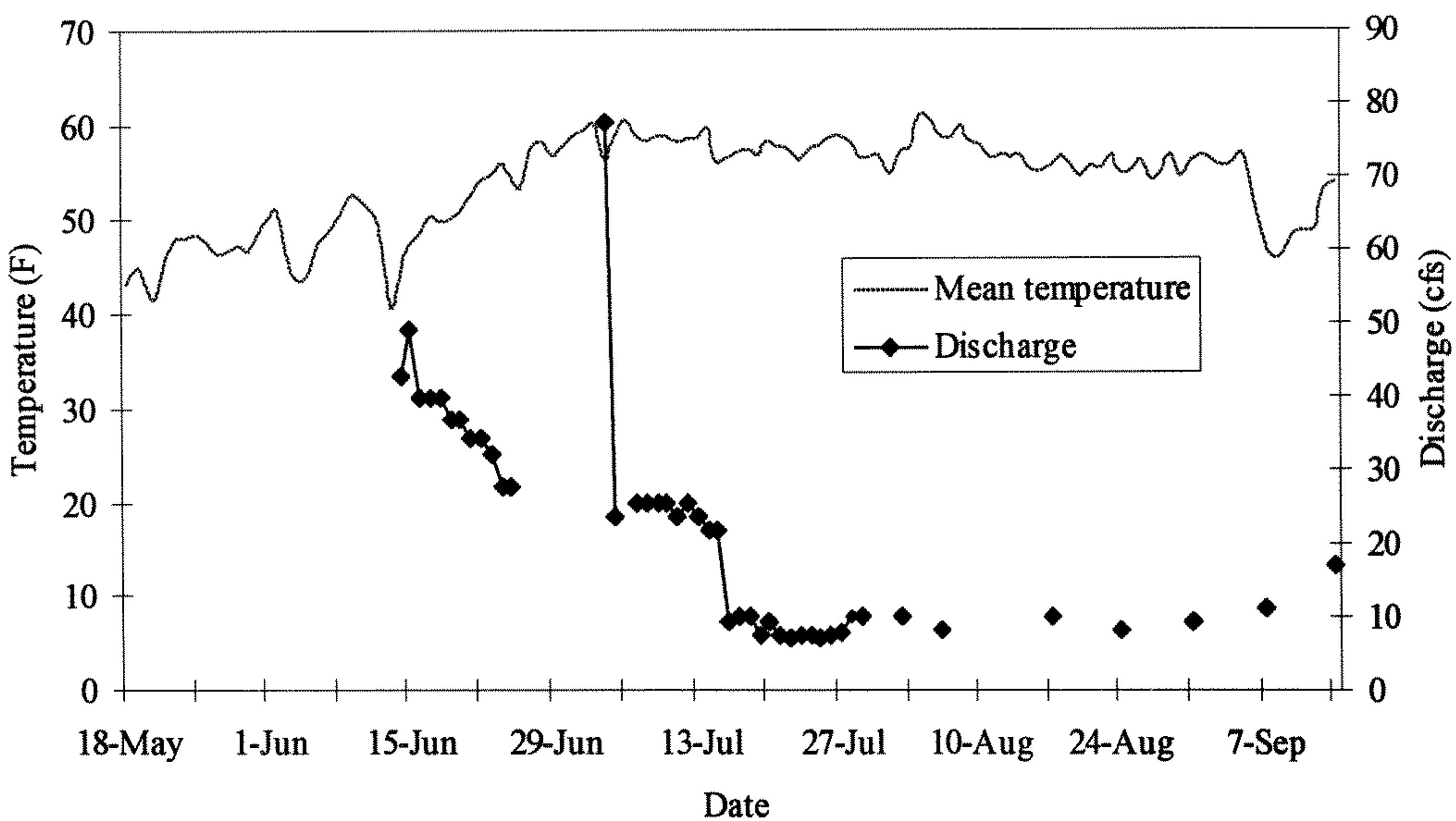


Figure F4. Daily discharge and mean daily stream temperature for Mol Heron Creek, Montana from May to September 2001.