MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS
FISHERIES DIVISION

JOB PROGRESS REPORT

State: Montana Title: Southwest Montana Fisheries Investigations

Project No.: F-9-R-34 Title: Inventory and Survey of the Waters of the

Job No.: I-d Jefferson and Madison Drainages

Period Covered: July 1, 1985 through June 30, 1986

Report Period: April 1, 1985 through March 31, 1986

ABSTRACT

Migrant brown trout populations in the Missouri River above Canyon Ferry Reservoir were monitored. Movements start in early August and peak in late October and early November at Toston Dam (22.7 miles upstream). Data suggest that this trophy sized brown trout population is being maintained. Creel census at Toston Dam during the fall of 1985 showed a harvest of 748 brown trout averaging nearly 18 inches (6 week period). Voluntary tag return rates have averaged 6.8% over the past 8 years.

Migrant rainbow populations in the Missouri River were present in spring and fall. Rainbow numbers in the spring were low. The fall "run," once a popular fishery, has declined and the causes are not fully understood.

Populations of brown and rainbow trout in the Jefferson River are discussed. Estimates of brown trout numbers are presented for two sections. Annually estimated numbers of age III and older brown trout average 294 per mile in the lower section and 359 per mile in the upper section. Data on a small rainbow population is presented.

Water temperature and streamflow information is given for the Missouri and Jefferson Rivers.

A summary of stream protection efforts is presented.

Canyon Ferry Reservoir rainbow trout fishery problems are discussed. This resource is maintained through annual stocking. During the 1970's this fishery was very heavily used. Data collected since 1983 verifies that a major decline has occurred. Creel census information for 1983 showed an average catch rate of 0.12 rainbow per hour. Gill net catch rates, which were very low in 1983, indicated improvement by 1985. Growth rate data is included. Recovery of marked reservoir rainbow trout below Canyon Ferry Dam indicates that fish loss is occurring through the radial gate spills. This escapement is felt to be partially responsible for the decline in the reservoir fishery.

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OBJECTIVES AND DEGREE OF ATTAINMENT

Job Objectives

1. To determine trout populations in sections of the Missouri and Jefferson rivers.

2. To monitor daily flow and summer water temperatures at these study sections.

3. To mitigate or enhance habitat alterations due to agricultural, residential, mining and industrial development.

4. To monitor fisheries throughout the drainages.

Degree of Attainment

1. Spring brown trout population estimates were made on the Willow Creek-Three Forks and Hell's Canyon Creek sections of the Jefferson River. Missouri River work was focused on migrating populations of rainbow and brown trout from Canyon Ferry Reservoir. Data is presented.

2. Mean daily discharge and water temperature data of the Missouri and Jefferson rivers were collected. Data is presented.

3. A total of 133 stream alteration projects (Mile High - 14, Broadwater - 25 and Jefferson Valley - 94) were inspected in the Missouri and Jefferson drainages during the past three years. Data is presented.

4. Major effort was focused on Canyon Ferry Reservoir during the project period. Data is presented.

BACKGROUND

The portion of the Missouri River drainage dealt with in this report extends from Canyon Ferry Dam upstream to Three Forks as well as the entire Jefferson River. The fishery resources include a large reservoir, two large rivers and tributary streams.

The Missouri River focused on here lies between Canyon Ferry Reservoir and Toston Dam. This reach of the Missouri is famous for producing trophy trout and was given "Blue Ribbon" status in 1959 by the Montana Department of Fish and Game. Toston Dam is a run-of-the-river irrigation diversion structure that is impassable to upstream migrating fish. At present, a power generation facility is being considered as an addition to the existing dam. Earlier work within this reach was concentrated on resident brown trout populations. Those efforts were curtailed to allow increased attention to migrating trout.

The Jefferson River suffers periodic severe dewatering (in some reaches) and severe temperature problems. Despite these problems, the Jefferson supports a good brown trout population which provided 26,374 days of angling in 1975.

Canyon Ferry Reservoir covers 35,180 acres and has historically been the most heavily fished body of water in the state. This impoundment supports a rainbow and brown trout fishery as well as a substantial yellow perch population. The rainbow population has been maintained by stocking, while the brown trout and yellow perch are self-sustaining. More recently, the rainbow fishery of Canyon Ferry has declined severely, resulting in a marked reduction in angler use.

PROCEDURES

River fish populations were sampled using an 18-foot aluminum boat powered by an outboard jet motor. The electrofishing system used was constructed according to Novotny and Priegel (1971) as modified by Peterman (1978). Fish sampling was accomplished with the exclusive use of straight direct current.

River fish population estimates required multiple sampling runs to achieve adequate sample size. All estimates were calculated according to Vincent (1971 and 1974).

Migrant fish sampling data was based on "catch per unit effort." Standard sections were sampled in a consistent fashion.

The reservoir data was collected with floating and sinking 6' x 125' experimental mesh (3/4" to 2") gill nets.

The creel census design used was very basic. A creel clerk collected angler interview information only. Monthly angler pressure data was supplied by the statewide fishing pressure survey (MDFWP). The desired monthly sampling effort was to include at least 4 days per month from the weekend-holiday strata and at least 5 days per month from the weekday strata. Interviews were conducted using a vehicle and began daily in Townsend. To insure equal sampling coverage of the reservoir, each day of creel census was to begin on alternate sides of the reservoir.

Rainbow trout stocked into the reservoir were given identifying marks. Tetracycline and fin-clip marks were employed.

FINDINGS

River Trout Populations

Missouri River

Brown Trout

The Missouri River between Toston Dam and Canyon Ferry Reservoir is 22.7 miles long. Within this reach of river are four sampling study sections (Table 1 and Figures 1 and 2). The Toston-Deepdale section was utilized to make spring population estimates for resident brown trout from 1979-82 (Rehwinkel, 1980, 1981, 1982 and 1983).

Table 1. Sampling sections located on the Missouri River between Canyon Ferry Reservoir and Toston Dam.

Section Name	Length (miles)
Toston Dam	3.0
Toston-Deepdale	7.3
Deepdale-Townsend	6.0
Townsend-Canyon Ferry	2.2

Tagging

Monitoring of fall brown trout "runs" into the Missouri River was carried out in 1978, 1980, 1982, 1983 and 1985. Sampling in these study sections included tagging all brown trout of 16 inches and longer with individually numbered floy tags in all years except 1983. Sampling intensity varied from year to year.

Table 2 and Table A-1 suggest that the bulk of the brown trout in excess of 16 inches found in this reach of the Missouri River during the fall months are migrants from the reservoir. Overall voluntary tag return rates vary from 4.2 to 8.4 percent (average 6.8%). Tag return information also suggests that all members of the adult brown population are not "running" each year.

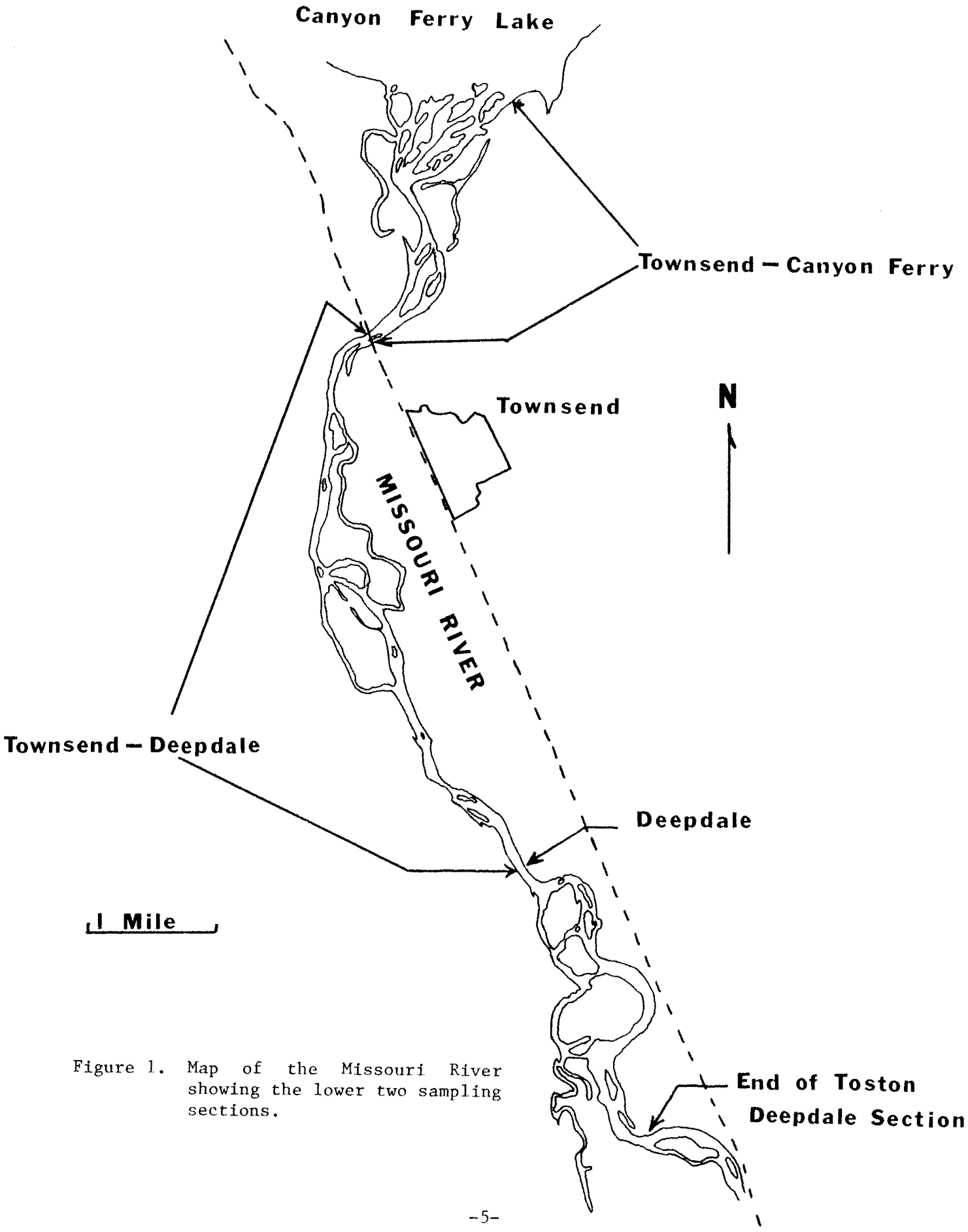


Figure 1. Map of the Missouri River showing the lower two sampling sections.

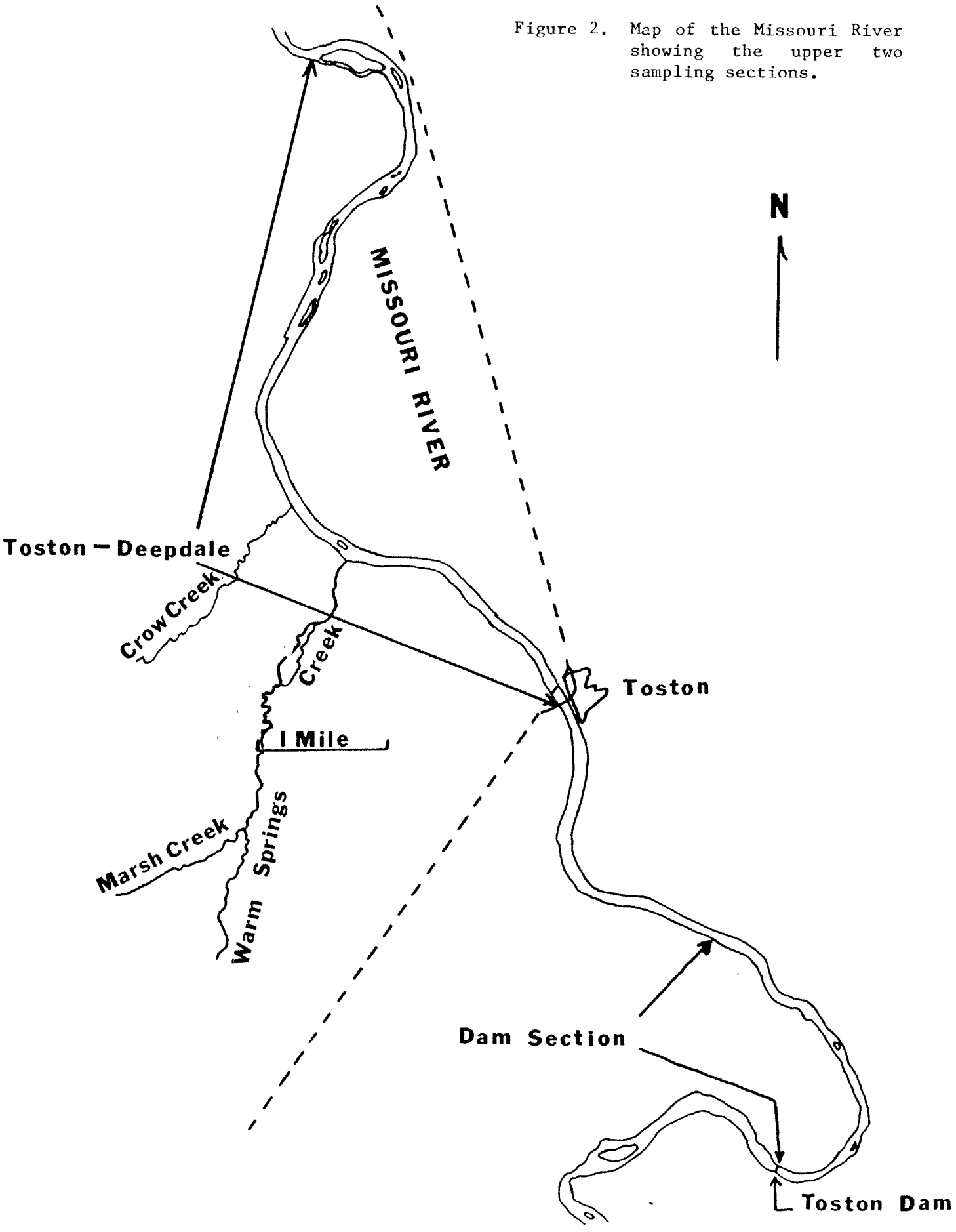


Figure 2. Map of the Missouri River showing the upper two sampling sections.

Table 2. Voluntary angler tag returns from brown trout tagged in the Missouri River.

Year	Number of Brown Trout Tagged	Number of Tags Returned	Percent from Reservoir
1978	318	22	36
1980	173	8	50
1982	559	47	70
1985	192	8	75
	1242	85	

Timing and Extent of Fall Brown Trout Runs

Electrofishing information collected from 1978-1985 suggests that brown trout enter the Missouri beginning in early August with major concentrations from late September into November. While the exact magnitude of the runs is not known, they appear to number several thousand fish.

Sampling has suggested that numbers of migratory brown trout peak in the Townsend-Canyon Ferry study section in mid-September to early October. Further upstream in the Toston-Deepdale section, numbers of migratory brown trout peak in mid-October. In the section adjacent to the dam, numbers peak in late October.

It appears that the majority of brown trout migrants move upstream as far as the upper two study sections in their attempts to spawn. The greatest concentrations, as indicated by number captured per mile, have occurred in the Toston Dam section. Another lesser used area involves the Warm Springs-Marsh Creek tributary system (3.3 miles upstream from its confluence with the Missouri River).

Concentrations of Gravid Brown Trout

Water clarity in this reach of the Missouri River does not allow observation of fish on redds. However, seven different areas of concentrations of gravid females were noted during 1985 (Figure 3) within the upper 12.5 miles of this reach of the Missouri River. These areas include Marsh Creek and three areas just downstream from Toston Dam in the mainstem river.

Size Composition of Migrant Brown Trout

The vicinity around Toston Dam has long been known to trophy trout fishermen. Fall sampling since 1978 has yielded trout each year which exceed 10 pounds. Data presented in Figures 4 and 5 depict the length frequency of the average daily sample from the upper two sections. These data suggest that numbers of larger brown trout in this run are not declining.

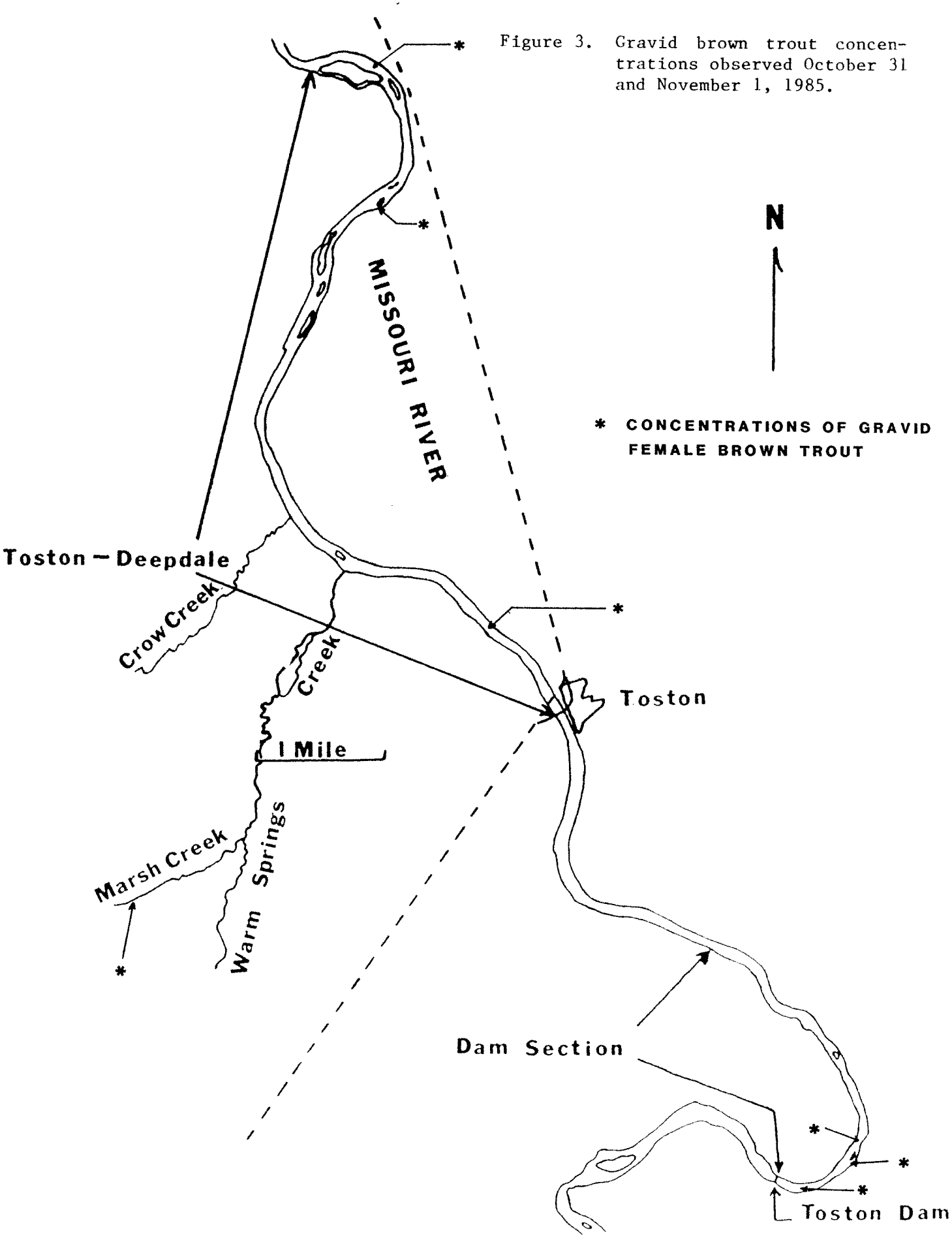


Figure 3. Gravid brown trout concentrations observed October 31 and November 1, 1985.

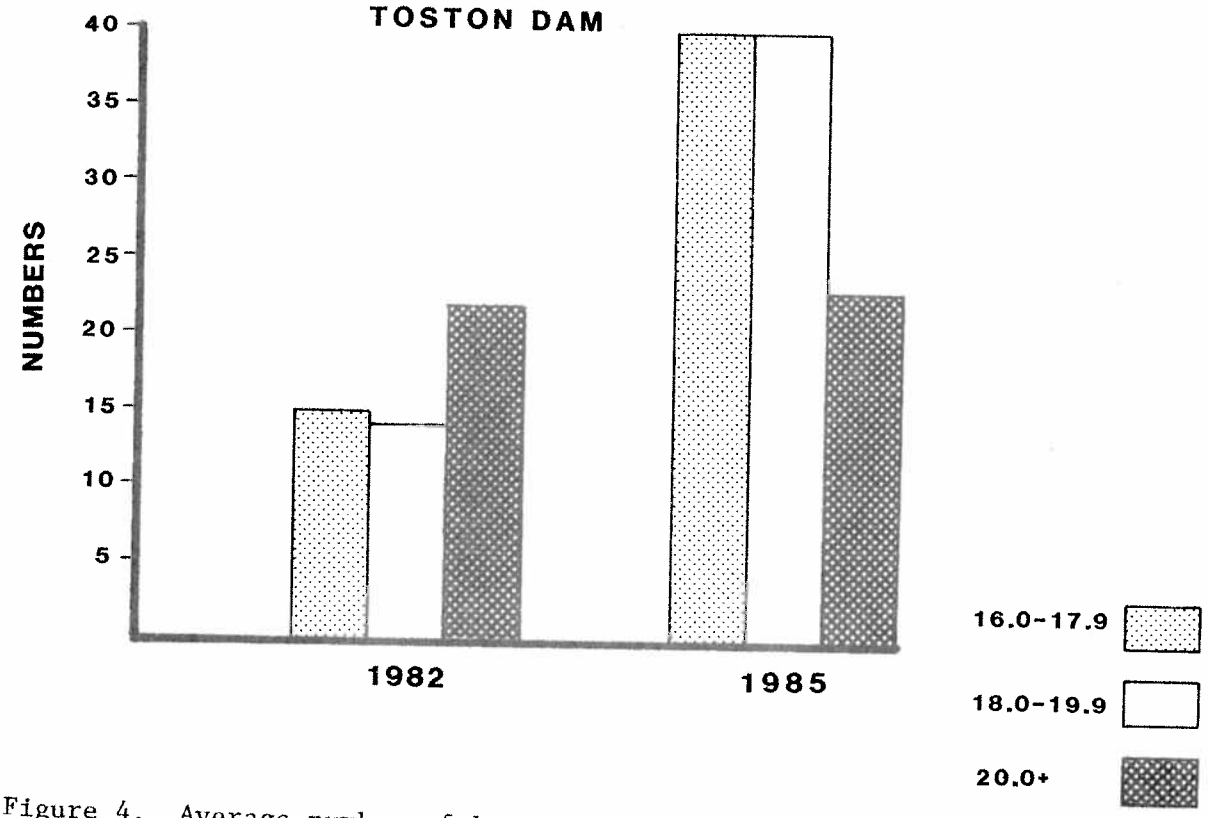


Figure 4. Average number of brown trout sampled per trip by length group for the Toston Dam section (1982 and 1985).

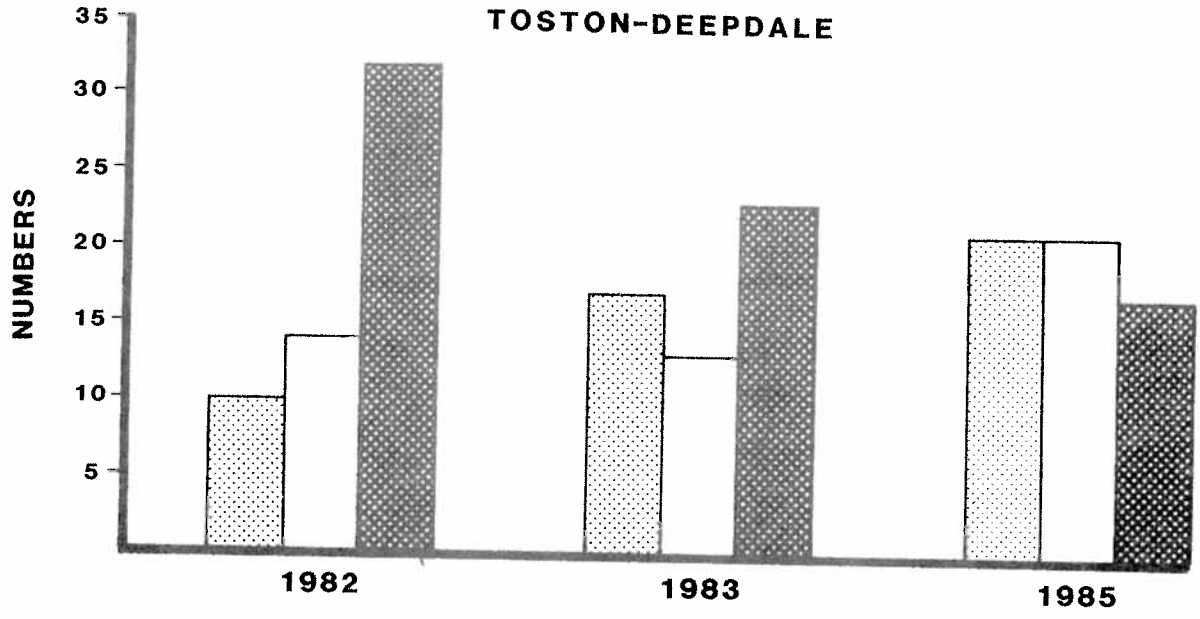


Figure 5. Average number of brown trout sampled per trip by length group for the Toston-Deepdale section (1982, 1983 and 1985).

Creel Census

A cursory creel census was conducted at Toston Dam during the fall in 1982 and 1983. The catch rate was determined to be 0.25 and 0.29 brown trout per hour, respectively. During the fall of 1985 a more thorough creel census was conducted (Table 3). During the 1985 creel period, anglers expended over 3800 hours to harvest 748 brown trout and 393 rainbow trout.

Table 3. Summary of creel census at Toston Dam, fall 1985.

Period	Estimated Pressure (hrs)	Harvest Rate (fish/hr)		Harvest		Average Length	
		Brown	Rainbow	Brown	Rainbow	Brown	Rainbow
Sept. 28-Oct. 11	1290	0.14	0.05	181	65	17.9	16.3
Oct. 12-Oct. 25	1246	0.21	0.11	262	137	17.2	17.5
Oct. 26-Nov. 8	1271	0.24	0.15	305	191	17.9	17.0
	3807			748	393		

Rainbow Trout

The Missouri River between Canyon Ferry Reservoir and Toston Dam supports both spring and fall runs of rainbow trout. The reservoir rainbow population from which these runs originate consists of planted, fall spawning variety of Arlee strain; a small, wild spring spawning segment; and, most recently, spring spawning DeSmet rainbow which were first introduced in 1983. The presence of both spring and fall running rainbow strains in the reservoir has made it impossible to accurately assess the resident rainbow population in the Missouri River downstream from Toston Dam. Monitoring of spring runs of rainbow trout into the Missouri River from Canyon Ferry Reservoir was carried out in 1979 and 1981-85 (Table 4). Sampling of the fall run was focused on the Townsend-Canyon Ferry section and was accomplished in 1978, 1980, and 1982-85 (Table 5). All rainbow trout in excess of 13 inches were affixed with individually numbered floy tags. The sampling effort varied from year to year.

Table 4. Voluntary angler tag returns from rainbow trout tagged during spring sampling in the Missouri River.

Year	Number of Rainbow Trout Tagged	Number Returned	Number Returned from Reservoir	Percent Returned
1979	85	5	0	5.9
1981	301	19	12	6.3
1982	288	18	8	6.3
1983	198	12	9	6.1
1984	104	12	10	11.5
1985	228	12	2	5.3
	1204	78	41	$\bar{x}$ = 6.9

Table 5. Voluntary angler tag returns from rainbow trout tagged during fall sampling in the Missouri River.

Year	Number of Rainbow Trout Tagged	Number Returned	Number Returned from Reservoir	Percent Returned
1978	316	44	19	13.9
1980	114	8	2	7.0
1982	886	57	22	6.4
1984	120	10	6	8.3
1985	161	13	5	8.1
	1597	132	54	$\bar{x}$ = 8.7

These data indicate that most of the rainbow trout originate from Canyon Ferry Reservoir. Overall annual voluntary tag return rates varied from 5.3 to 13.9 percent.

Age Structure of the Fall Run

During 1978, the fall run was at its documented high. Age determinations from scale samples taken at that time are presented in Table 6.

Table 6. Age structure of the fall rainbow trout run into the Missouri River, 1978.

Age	N	Length Range (inches)	Average Length (inches)
0	24	4.4 to 11.4	7.3
I	21	12.3 to 16.7	15.1
II	28	16.0 to 19.2	17.9
III	5	20.1 to 21.5	20.7
IV	1	24.5	24.5

Age I and II rainbow trout dominated the harvest during the 1978 fall run and continue to make up the bulk of the fall run. Rainbow trout age III and older make up only a small portion of the fall run and harvest.

Timing and Extent of Rainbow Runs

Spring

Electrofishing has suggested that rainbow trout move into the Missouri River from mid-March through mid-May. In 1985, peak numbers of migrant rainbow were captured on May 9 in the Toston Dam section.

While it has not been determined which strains of rainbow make up the spring run, it is more than likely a mix of the wild and Arlee strain fish. DeSmet rainbow cannot be expected to enter the run until 1986.

Spring running rainbow trout move all the way up the river to Toston Dam, based on angler tag returns. Rainbow trout also use at least three miles of Warm Springs and Marsh Creeks when irrigation demands allow.

Spawning, as indicated by gravid females extruding eggs, was first detected on April 9, 1984 and appeared to peak in early May, 1985.

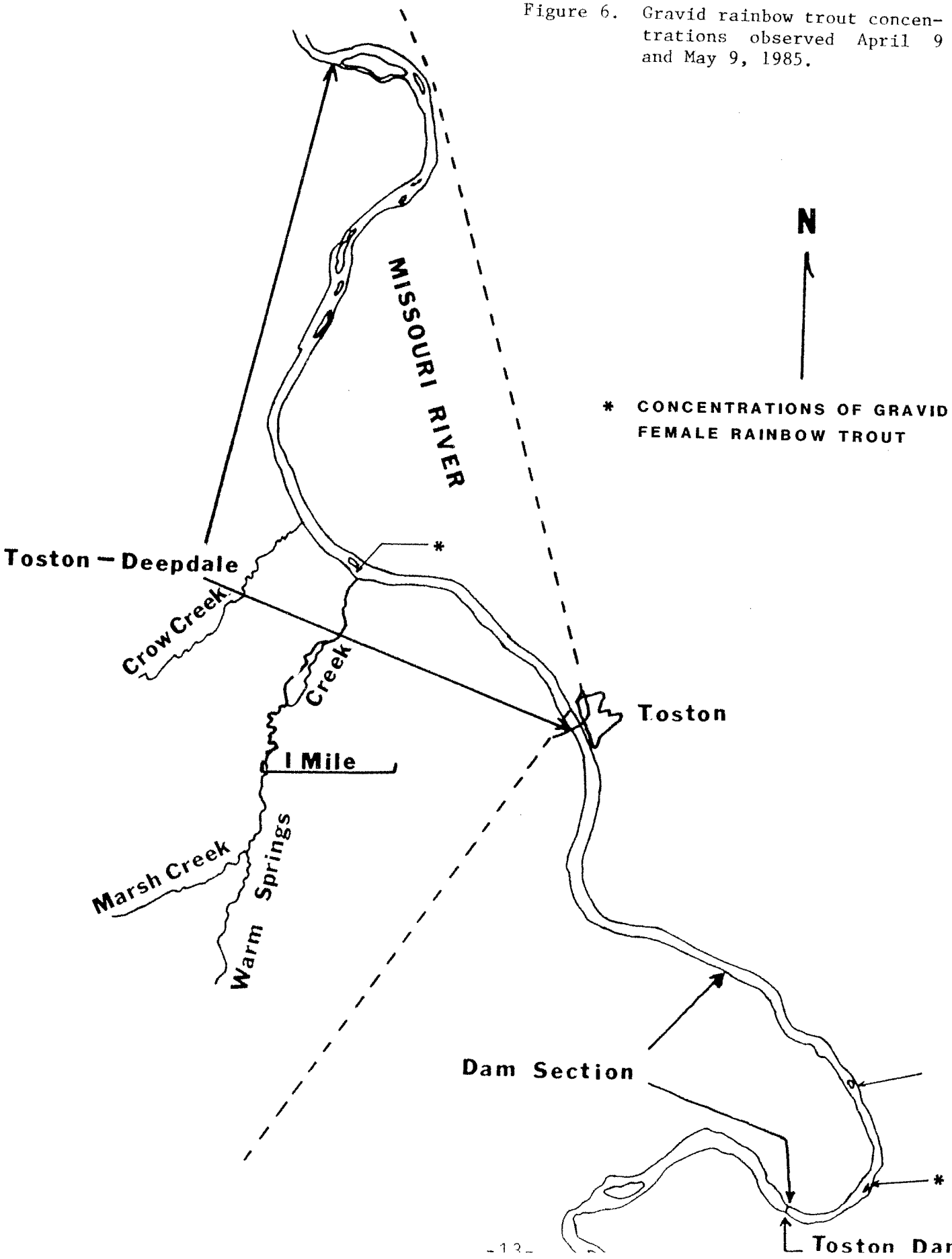
Concentration of Gravid Rainbow Trout

Water clarity does not allow direct observation of spawning activities. Electrofishing revealed three concentrations of gravid female rainbow trout in the spring of 1985 (Figure 6). The two major concentrations are immediately adjacent to spring discharges (Big Spring and Warm Springs Creeks). Cold water tributaries (Crow and Dry Creeks) did not attract migrating rainbow.

Fall

In 1978 and 1979, Fredenberg (1980) documented a substantial fall rainbow trout run and associated fishery. He showed the fall fishery concentrated between Townsend and Canyon Ferry Reservoir to peak between October 20 and November 17. Electrofishing at that time showed large numbers of rainbow trout. In the years that followed, the magnitude of the run declined dramatically and the peak was delayed until mid-November (Figures 7 and 8). Rainbows

Figure 6. Gravid rainbow trout concentrations observed April 9 and May 9, 1985.



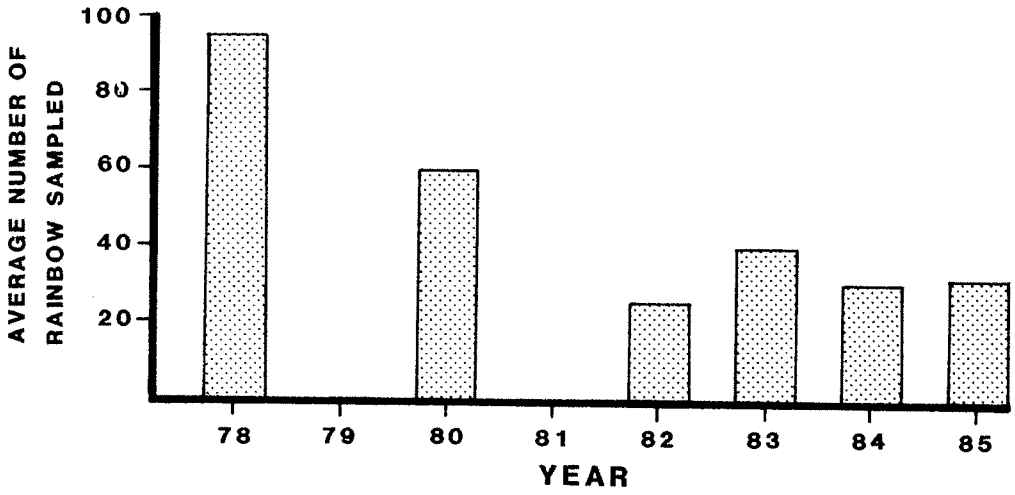


Figure 7. Average number of 13.0 inch and larger rainbow trout sampled in the Townsend-Canyon Ferry section between 1978 and 1985.

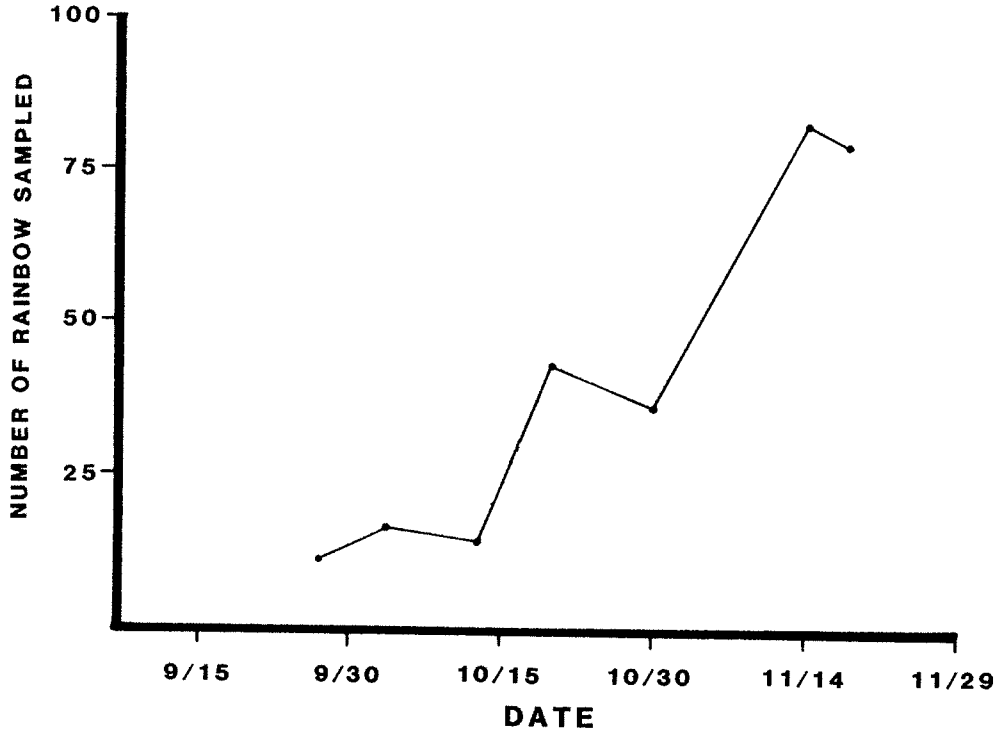


Figure 8. Numbers of 13.0 inch and larger rainbow trout sampled per day during fall 1983 in the Townsend-Canyon Ferry section of the Missouri River.

sampled in 1978 averaged 16.4 inches (1.69 lbs.) and the 1985 fish averaged 17.9 inches (2.12 lbs.).

Creel Census

Fredenberg's study documented 11,673 angler hours with a harvest of 7856 rainbow trout in 1978. The weighted mean catch rate was 0.67 rainbow trout per hour for that year. During the fall of 1985 (September 28 through November 8), another creel census was conducted on the same study area. The total fishing pressure was estimated at 117 hours with a harvest of 5 rainbow trout. The catch rate was 0.043 fish per hour.

Jefferson River

Willow Creek-Three Forks Section

Brown trout. Annual brown trout population estimates were conducted in this section (Figure 9) from 1979 through 1985. Previous work has indicated that spring numbers of age III and older brown trout vary between 248 and 452 per mile (Rehwinkel, 1980, 1981, 1982, 1983). The population estimates for 1983, 1984 and 1985 are shown in Tables 7, 8 and 9 respectively.

Table 7. Brown trout population estimates for the Willow Creek-Three Forks study section (7.0 miles), spring 1983 (80% confidence limits in parentheses).

Age	Average Length (inches)	Number	Biomass (lbs.)	Number Per Mile
III	12.4	1291 (±310)	841.2	184
IV+	15.8	666 (±112)	893.3	95
Total		1957 (±330)	1734.5	279

Table 8. Brown trout population estimates for the Willow Creek-Three Forks study section (7.0 miles), spring 1984 (80% confidence limits in parentheses).

Age	Average Length (inches)	Number	Biomass (lbs.)	Number Per Mile
III	13.0	1425 (±238)	1042.8	204
IV+	16.2	824 (±185)	1189.8	118
Total		2249 (±302)	2232.7	322

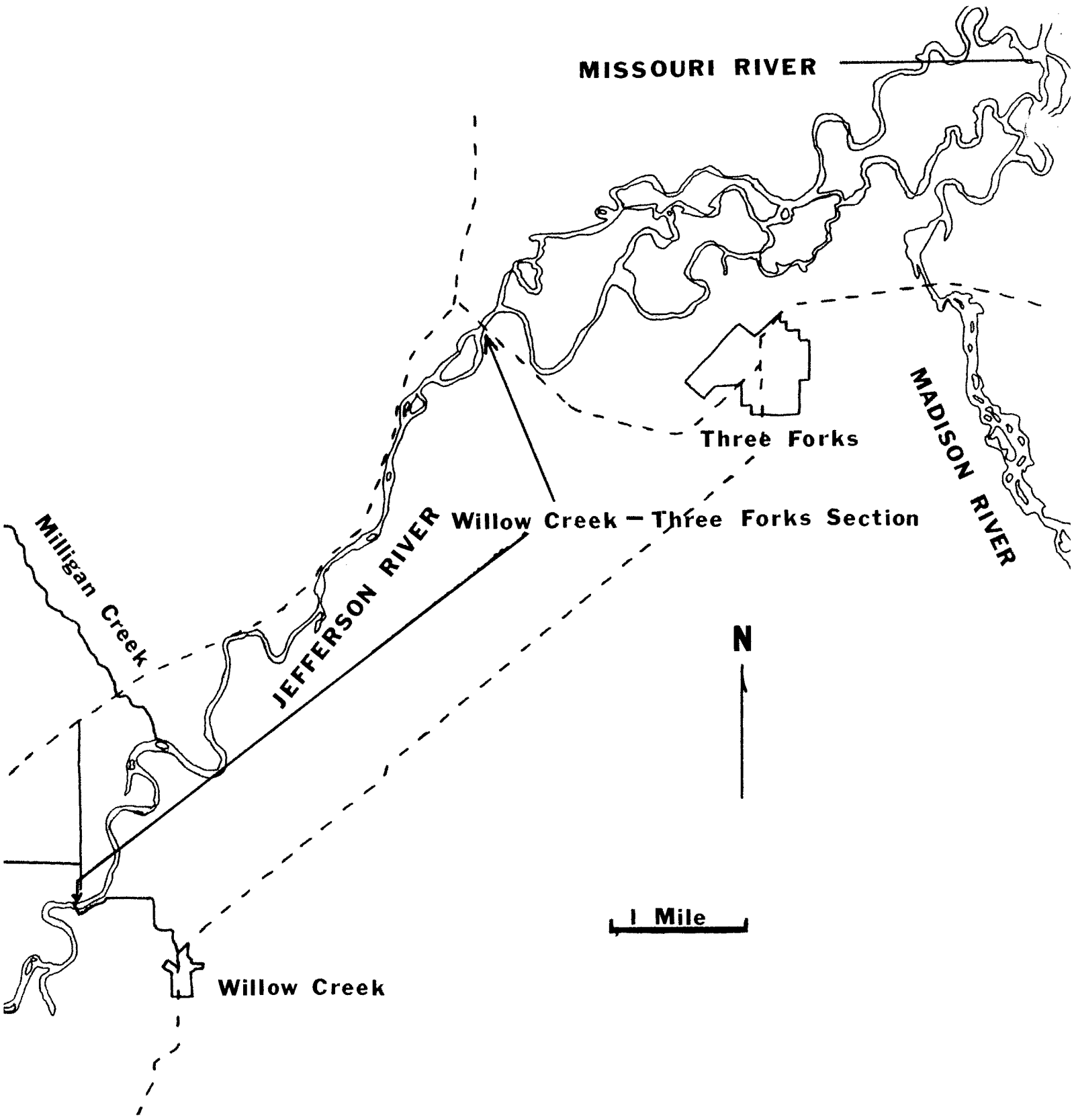


Figure 9. Map of the Willow Creek-Three Forks sampling section on the Jefferson River.

Table 9. Brown trout population estimates for the Willow Creek-Three Forks study section (7.0 miles), spring 1985 (80% confidence limits in parentheses).

Age	Average Length (inches)	Number	Biomass (lbs.)	Number Per Mile
III	12.4	1325 (±214)	838.5	189
IV+	15.9	647 (±143)	859.3	92
Total		1972 (±258)	1697.8	281

Calculation of total annual mortality of adult brown trout have indicated excessively high values in most years (69.5, 88.5 and 56.0 in 1980 through 1982). During the three years dealt with in this report, high annual mortality rates have again been documented (Table 10). While the reasons for this excessive annual mortality are not know, severe winter icing conditions in this reach of river may play a role.

Table 10. Annual mortality rates for adult brown trout in the Willow Creek-Three Forks section of the Jefferson River.

Year	Age Group	Number of III+	Number of IV+	Annual Mortality Rate
1982-1983	III+ to IV+	2732	666	75.6%
1983-1984	III+ to IV+	1957	824	57.9%
1984-1985	III+ to IV+	2249	647	71.2%

Rainbow trout. Rainbow trout numbers in this section are insufficient to estimate accurately. Rainbow trout representation in the marking sample ranged between 1.6 and 8.9% from 1983 through 1985. The largest number were sampled in the spring of 1984. A length frequency is presented in Figure 10.

The length frequency illustrates that the population is dominated by small fish (10.0-10.4"). Table 11 summarizes the age-growth information for the 1984 sample.

Table 11. Average length at age for rainbow trout in the 1984 sample from the Willow Creek-Three Forks section of the Jefferson River.

	Age II	Age III	Age IV
Sample Size	8	52	7
Length Range	5.8-9.2"	8.6-13.7"	10.9-15.5"
Average Length	8.0"	10.2"	12.6"

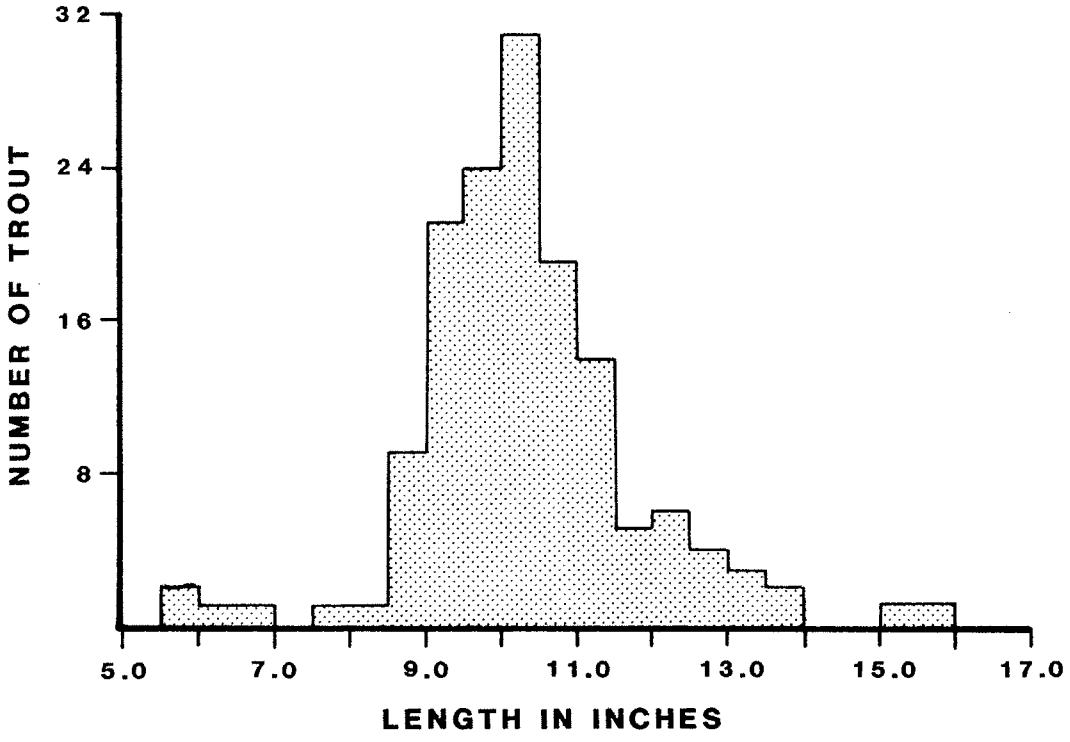


Figure 10. Length frequency distribution of the 1984 rainbow trout sample from the Willow Creek-Three Forks section.

Hell's Canyon Creek Section

Brown trout. Annual brown trout population estimates were conducted in this section (Figure 11) from 1983 through 1985. This section was added since it appeared that the water temperatures were cooler and it was located above all major Jefferson River irrigation diversions. The brown trout estimates for 1983, 1984 and 1985 are shown in Tables 12, 13 and 14, respectively.

Table 12. Brown trout population estimates for the Hell's Canyon Creek section (3.1 miles) of the Jefferson River, spring 1983 (80% confidence limits in parentheses).

Age	Average Length (inches)	Number	Biomass (lbs.)	Number Per Mile
III	13.6	413 (±59)	352.2	114
IV+	16.4	432 (±59)	634.1	139
Total		845 (±83)	986.3	253

Table 13. Brown trout population estimates for the Hell's Canyon Creek section (3.1 miles) of the Jefferson River, spring 1984 (80% confidence limits in parentheses).

Age	Average Length (inches)	Number	Biomass (lbs.)	Number Per Mile
III	13.0	550 (±82)	420.5	177
IV+	16.2	448 (±56)	633.2	145
Total		998 (±99)	1053.7	322

Table 14. Brown trout population estimates for the Hell's Canyon Creek section (3.1 miles) of the Jefferson River, spring 1985 (80% confidence limits in parentheses).

Age	Average Length (inches)	Number	Biomass (lbs.)	Number Per Mile
III	12.3	503 (±95)	322.8	162
IV+	15.4	1057 (±160)	1335.8	341
Total		1560 (±186)	1658.6	503

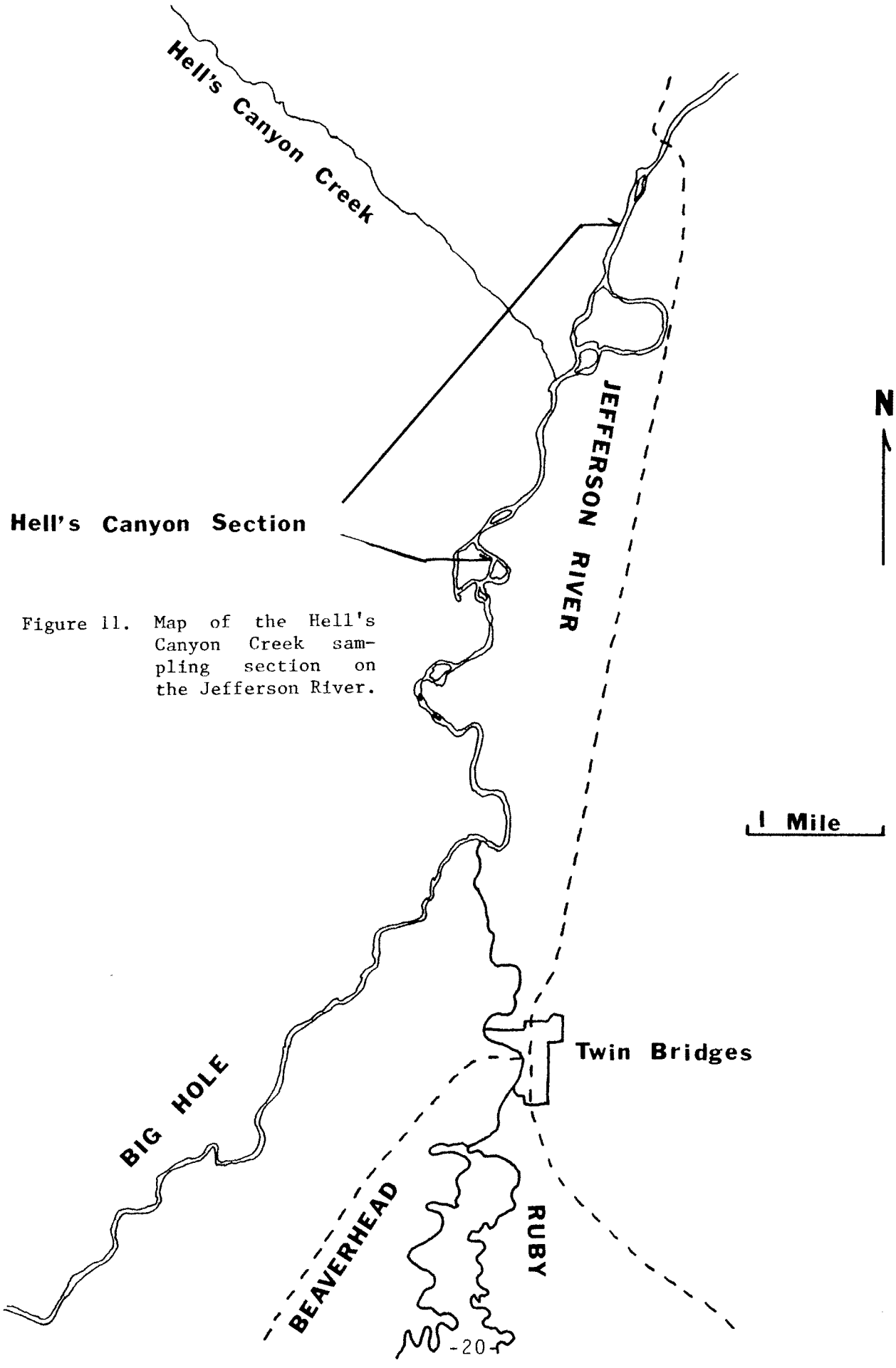


Figure 11. Map of the Hell's Canyon Creek sampling section on the Jefferson River.

Total annual mortality rates were calculated for the brown trout in this section (Table 15). During the three years covered by this report, the Jefferson River experienced unusually high minimum summer flows (see data in following section).

Table 15. Total annual mortality rates for brown trout in the Hell's Canyon Creek section of the Jefferson River.

Year	Age Group	Number of III+	Number of IV+	Annual Mortality Rate
1983-1984	III+ to IV+	845	448	47.0%
1984-1985	III+ to IV+	998	1057	≅ 0

Annual mortality rates for older brown trout were less than 50 percent from 1983 to 1984 and not detectable from 1984 to 1985 within the limits of the confidence intervals.

Rainbow trout. Spring sampling in the Hell's Canyon Creek section revealed unusually high numbers of rainbow trout (many were in gravid condition) at the mouth of Hell's Canyon Creek. Further investigation showed this to be the only tributary of the Jefferson River which was not either dewatered or choked with sediment. Sampling indicated that rainbow trout did migrate up this very small tributary for one-half mile. Spawning was observed.

These rainbow trout ranged in length from 6.4 to 21.8 inches in length. Tagging was initiated to ascertain this population's origin. A summary of the numbers tagged and numbers returned is given in Table 16. Based on the information from subsequent tag returns, these rainbow trout apparently reside in the Jefferson River from Mayflower Bridge (27 miles downstream) to near Twin Bridges (8 miles upstream).

Table 16. Rainbow trout tagging summary for the Hell's Canyon Creek section of the Jefferson River, 1983-1985.

Year	Number Tagged	Number Returned	Percent of Tags Returned
1983	18	1	5.6
1984	180	9	5.0
1985	187	13	7.0

Considering the uniqueness of this lower river, wild rainbow population, the very limited spawning area and the relatively high rate of voluntary tag returns, special regulations to protect rainbow trout were initiated. These regulations (catch and release on all rainbow trout in the entire Jefferson River with no gear restriction) were implemented in 1986.

River Temperature and Flow

Missouri River

Summer discharges of the Missouri River at Toston during 1983 and 1984 were all above monthly means, while flows during the summer of 1985 were below monthly means and recommended instream fishery levels (Table 17). Minimum discharges were 3000 cfs (August 5), 4620 cfs (August 22) and 1300 cfs (July 12) for 1983, 1984 and 1985, respectively. Daily records are provided in Appendix Tables A2-A4.

Table 17. Missouri River mean monthly discharge (cfs) for 1983, 1984 and 1985 (U.S.G.S., Toston).

Month	1983	1984	1985	Mean
June	12730	19690	4545	11700
July	9470	9419	1469	4500
August	4124	5333	2197	2460
September	5080	5813	3390	3430

Water temperatures in this reach of the Missouri River are commonly above those recommended for salmonid growth (Elliot, 1975 and 1976; Vincent, 1979). The maximum mean daily water temperatures were recorded on August 6 and 7, 1983 (74.3°F), July 26, 1984 (71.6°F) and July 10, 1985 (75.0°F). Daily temperature records are provided in Appendix Tables A5-A7.

Jefferson River

Summer discharges of the Jefferson River at Three Forks during 1983 and 1984 were exceptionally high, while flows in 1985 were the lowest since 1978. Mean monthly flows are presented in Table 18. Minimum discharges recorded for each year were 1310 cfs (August 8, 1983), 2680 cfs (August 30, 1984), and 254 cfs (July 30, 1985). Daily records are provided in Appendix Tables A8-A10.

Table 18. Jefferson River mean monthly discharge (cfs) for 1983, 1984 and 1985 (U.S.G.S., Three Forks).

Month	1983	1984	1985	Mean*	Mean**
June	6139	9867	2050	5500	7700
July	4471	4930	377	2100	2440
August	2120	3030	621	690	962
September	2262	3303	1216	1000	1100

* 50% Exceedence Flows, calculations based on 29 year period of record (1941-1969) at Sappington, MT (U.S.G.S., 1975).

** 50% Exceedence Flows, calculations based on 9 year period of record (1964-1972) near Twin Bridges, MT (U.S.G.S., 1975).

Based on these limited and dated U.S.G.S. hydrographs, there appears to be a minimum of difference in the discharge between the upper and lower fish sampling sections of approximately 300 cfs. Therefore, during the summer months, the Jefferson River has 300 cfs less flow in the lower reach than it has above the major irrigation diversion points.

Summer water temperatures usually exceed desirable levels for maintenance of a coldwater fishery. Monthly maximum water temperatures are listed in Table 19 for both the Three Forks and Twin Bridges sites on the Jefferson River.

Table 19. Jefferson River monthly maximum water temperatures for Three Forks and near Twin Bridges sites (1983 through 1985).

	Maximum Monthly Temperatures °F					
	Three Forks			Near Twin Bridges		
Year	June	July	August	June	July	August
1983	66.5	73.0	78.0	--	75.0	77.0
1984	68.5	72.5	71.5	71.5	74.5	73.0
1985	72.5	79.0	76.0	72.0	74.5	71.5

During 1984 and 1985 a nearly complete temperature record allowed summary of hours spent at or above 70.0°F (Table 20). The monthly average air temperature data is also included (U.S. Weather Service). During the high river discharges of 1984, both the near Twin Bridges and Three Forks sites had approximately the same number of hours at or above 70.0°F (despite the slightly warmer air temperatures at Three Forks). Conversely, under the severely restricted flow situation of 1985, the Three Forks water temperature site had more than twice the number of hours spent at or over 70°F. Monthly average air temperatures appear to be approximately 2°F cooler at the Twin Bridges location. All available daily water temperature records are provided in Appendix Tables A11-A16.

Stream Protection

This objective falls under the responsibilities of the Natural Streambed and Land Preservation Act of 1975. Duties implementing this law are shared with local Soil Conservation Districts. In the area adjacent to the Missouri and Jefferson Rivers there are three Conservation Districts: Broadwater, Jefferson Valley, and Mile High. From 1983 through 1985 a total of 133 alteration projects were mitigated in the three conservation districts (Table 21).

Stream projects associated with mining appear to be increasing in number annually. During this three-year period, 57 projects were mine related (43%).

Other Fisheries

Canyon Ferry Reservoir

Canyon Ferry Reservoir has been managed as a rainbow trout fishery since its construction in 1953. Initially (1953-1955), rainbow plants into the reservoir consisted of fingerlings (average length 2 inches). After the short-lived "boom" years, plants were changed to use mainly catchable size rainbow (7 inches and larger). In the 1960's the costs and benefits of the catchable management were questioned. Upon completion of an evaluation of planting success and costs (Holton, 1966), the stocking program was changed to use sub-catchable size rainbow trout (4 to 6 inches). These plants were to number 300,000 annually and be planted in early summer. From the mid-1960's to the present, Canyon Ferry not only received the basic recommended plant but also received nearly all the surplus rainbows from the entire state hatchery system (Table 22).

Table 20. Jefferson River water temperature summary for total hours spent at or over 70.0°F during 1984 and 1985 (Three Forks and near Twin Bridges) - monthly average air temperatures included.

	1984				1985			
	Water Three Forks Hours 70°+	Air °F Cardwell	Water Twin Bridges Hours 70°+	Air °F Twin Bridges	Water Three Forks Hours 70°+	Air °F Cardwell	Water Twin Bridges Hours 70°+	Air °F Twin Bridges
June	-0-	58.1	6.5	57.1	21.5	61.8	21.5	60.8
July	103.0	67.1	110.0	66.3	469.5	70.8	250.5	68.4
August	60.5	67.7	69.5	64.9	153.5	62.7	7.0	60.0
Total	163.5		186.0		644.5		279.0	

Table 21. Summary of habitat alteration projects by Conservation District and year.

District		Agriculture	Residential	Mining	Industrial*	Roads	Total
Mile High	1983	1	0	0	0	0	1
Jefferson	1983	9	2	8	10	1	30
Broadwater	1983	2	1	2	1	1	7
Mile High	1984	3	0	3	3	1	10
Jefferson	1984	1	1	13	3	2	20
Broadwater	1984	5	0	4	0	1	10
Mile High	1985	0	1	1	1	0	3
Jefferson	1985	14	2	24	0	4	44
Broadwater	1985	3	1	2	1	1	8

* Included logging.

Table 22. Summary of Canyon Ferry Reservoir stocking between 1970 and 1979.

Year	Range of Stocking Dates	Number of Sub-Catchable Rainbow	Number of Catchable Rainbow	Total	Number of Misc. Fish Planted
1970	3-31 to 10-21	235,665	69,996	305,661	1,000,652 Kokanee
1971	4-6 to 11-30	256,285	157,784	414,069	--
1972	3-22 to 9-5	416,395	161,760	578,155	--
1973	5-31 to 12-21	351,328	181,671	532,999	--
1974	3-14 to 12-10	654,326	95,177	749,503	540 Cutthroat
1975	4-28 to 12-9	626,055	63,787	689,842	--
1976	4-7 to 12-17	528,788	30,189	558,977	--
1977	5-23 to 9-14	693,209	8,795	702,004	76,497 0-3" Rainbow
1978	4-25 to 10-5	680,775	53,036	733,811	--
1979	4-25 to 9-12	506,183	27,037	533,220	99,580 0-3" Rainbow
Total		4,949,009	849,232	5,798,241	
Average		494,901	84,923	579,824	

Fishery investigations have periodically been focused on Canyon Ferry Reservoir. Initially, a post-impoundment study was done (Graham, 1956), later survey work concentrating on rough fish (Heaton, 1959 and 1961), and finally a rainbow stocking evaluation was conducted (Holton, 1966).

Angling success was extremely high for the first 2 or 3 years of reservoir life. This was followed by a period of up and down years (Table 23). During the 1970's, angling, as indicated by the "Fisherman Log Program," was good. The standard annual pattern was one of excellent fishing from ice-off through June (0.50 rainbow per hour). This was followed by very slow fishing in mid-summer (0.10 rainbow per hour or less). Fall angling would usually be quite good, especially on the upper end of the reservoir.

Table 23. History of angling success on Canyon Ferry Reservoir, 1954 through 1982.

Years	Rainbow Trout Catch Rate (Fish/hour)	Source
1954	0.90	University and Regional files
1955-1958	0.10-0.25	Heaton
1959-1962	0.28-0.51	University and Regional files
1963-1965	0.04-0.29	Headquarters files
1966-1969	0.43-0.58	Fisherman Logs*
1970-1979	0.37-0.62	Fisherman Logs*
1980-1982	0.30-0.66	Fisherman Logs*

*Fisherman log catch rates appear to reflect higher success than those generated from actual creel census.

In the early 1980's, angler complaints began to increase. Fishery investigations were again directed to Canyon Ferry Reservoir in 1983. The initial work suggested that a major reduction of the rainbow population had occurred despite continued stocking. Concurrent to the crash in the rainbow population was a dramatic decline in angler use (Table 24).

Table 24. Fishing pressure estimates for Canyon Ferry Reservoir, 1962 to 1985.

Year	Estimated Angler Days	Source of Estimate
1962	35,000	Bureau of Sport Fisheries
1971-1972	80,000	MDFWP
1975-1976	133,300	MDFWP
1982-1983	118,000	MDFWP
1984-1985	65,771	MDFWP

The project initiated in 1983 had four components. First, a year-long creel census would be conducted in 1983 to identify the existing situation. Second, reservoir sampling of the fishery would be re-instituted. Third, a longer-lived wild rainbow strain (Lake DeSmet strain) (Wyoming Fishery Research Report, 1980) would be added to the plant. Finally, all planted rainbow would be marked with tetracycline for future identification and 10% of both wild (DeSmet) and domestic (Arlee) rainbows would be given identifying fin-clips for later identification.

Creel Census

Data from the 1983 creel census consisted of catch rates for each month of the year. This information was combined with monthly pressure estimates from the statewide fishing pressure survey to generate harvest information.

A summary of angler contacts and catch rates is presented in Table 25. Fishing pressure estimates for Canyon Ferry are shown in Table 26, and Table 27 presents monthly harvest estimates for rainbow trout and yellow perch utilizing an average fishing day of 3.5 hours.

Table 25. Summary of angler contacts made on Canyon Ferry Reservoir during 1983.

Month	Number of Days Sampled	Number of Interviews Taken	Total Number of Hours Sampled	Yellow Perch Catch Rate (Fish/hr.)	Rainbow Trout Catch Rate (Fish/hr.)
January	11	454	1602.0	0.900	0.128
February	17	469	1449.5	1.062	0.143
March	14	583	2350.0	0.060	0.099
April	8	235	803.5	0.260	0.073
May	9	281	910.0	0.024	0.102
June	10	366	1165.0	0.071	0.102
July	11	354	1008.75	0.137	0.070
August	11	277	873.5	0.619	0.039
September	11	293	1006.0	0.548	0.042
October	12	405	1507.5	0.153	0.131
November	10	335	1215.5	0.046	0.263
December	10	340	1061.0	1.879	0.195
Total	134	4392	14,952.25	$\bar{x}$ = 0.4799	$\bar{x}$ = 0.1196

Table 26. Summary of estimated monthly fishing pressure (trips) on Canyon Ferry Reservoir, 1983 (MDFWP).

Month	Estimated Total Trips
January	4,703 (±1381)
February	2,588 (±952)
March	6,468 (±1824)
April	8,355 (±2838)
May) June)	19,813 (±3783)
July	7,231 (±2387)
August	8,650 (±2183)
September	5,636 (±2399)
October	5,969 (±2469)
November	2,150 (±975)
December	2,091 (±1155)
Two Day Non-Res.	5,799 (±1442)
Total	79,453

Table 27. Estimated monthly harvest of rainbow trout and yellow perch, Canyon Ferry Reservoir, 1983.

Month	Estimated Hours Fished	Estimated Number of Yellow Perch Harvested	Estimated Number of Rainbow Trout Harvested
January	16,460	14,814	2,107
February	9,058	9,620	1,295
March	22,638	1,358	2,241
April	29,243	7,603	2,135
May)			
June)	69,346	3,537	7,073
July	25,309	3,467	1,772
August	30,275	18,740	1,181
September	19,726	10,810	828
October	20,892	3,196	2,737
November	7,525	346	1,979
December	7,319	13,751	1,427
Two Day Non-Res.	20,297	9,229	2,427
Total	278,088	96,471	27,202

In addition, spot creel census checks were conducted in the spring of 1984 and 1985. This information is shown in Table 28.

Table 28. Summary of creel census information for Canyon Ferry Reservoir, 1984 and 1985.

Month	Year	Number of Days Sampled	Number of Interviews Taken	Total Number of Hours Sampled	Rainbow Trout Catch Rate (Fish/hr.)
April	1984	1	96	305.0	0.118
May	1984	6	210	710.5	0.287
June	1984	3	199	725.0	0.320
April	1985	10	402	1295.5	0.209
May	1985	8	360	1066.75	0.147
June	1985	3	160	516.0	0.169

Table 29. Total number and percent composition of fish sampled in 33 duplicate bottom gill net sets (1955-1984) from Canyon Ferry Reservoir.

	Rainbow Trout	Brown Trout	Yellow Perch	White Sucker	Longnose Sucker	Carp	Whitefish	Other Species	Total
1955									
Number	63	103	250	6341	1328	450	121	35	8691
% of Total	0.72	1.19	2.88	73.0	15.3	5.18	1.39	0.40	
1958									
Number	16	73	1422	4258	105	210	11	53	6148
% of Total	0.26	1.19	23.1	69.3	1.71	3.42	0.18	0.86	
1960									
Number	22	51	796	3444	106	168	11	19	4617
% of Total	0.48	1.10	17.2	74.6	2.30	3.64	0.24	0.41	
1964									
Number	22	65	2613	1875	98	198	8	6	4885
% of Total	0.45	1.33	53.5	38.4	2.01	4.05	0.16	0.12	
1967									
Number	24	78	1016	1286	166	200	38	17	2825
% of Total	0.85	2.76	36.0	45.5	5.88	7.08	1.35	0.60	
1968									
Number	86	91	2105	945	246	138	31	9	3651
% of Total	2.36	2.49	57.7	25.9	6.74	3.78	0.85	0.25	
1983									
Number	29	60	2353	1600	74	49	54	19	4238
% of Total	0.68	1.42	55.52	37.75	1.75	1.16	1.27	0.45	
1984									
Number	13	77	2055	1736	203	40	160	63	4347
% of Total	0.30	1.77	47.27	39.94	4.67	0.92	3.68	1.45	

Survey of Fishery

Previous fishery investigations exclusively employed bottom-set (6' x 125') experimental mesh (3/4" to 2") gill nets to sample Canyon Ferry Reservoir. A series of 17 sets were made in June and 16 in August. These 33 sets were duplicated in 1955, 1958, 1960, 1964, 1967 and 1968. Although use of surface nets has been shown to be a more effective sampling technique for rainbow trout (Posewitz, 1961), the 33 bottom set series were duplicated in 1983 and 1984 for purposes of comparison. A summary of all bottom-set gill nets is presented in Table 29 (previous page).

Additionally, 11 surface sets were made in June and August of 1983 and 1984. Fall mid-reservoir surface gillnetting has been demonstrated to be very effective for rainbow trout in other Missouri River reservoirs (Hill and Wipperman, 1983). Therefore, sampling in 1985 was changed to 10 surface sets made in October. The surface gill net data, although not comparable because of sampling season changes, is shown in Table 30.

Table 30. Summary of surface gill net samples for 1983, 1984 and 1985 on Canyon Ferry Reservoir.

Date	Number of Sets	Number of Rainbow Sampled	Average Length of Rainbow	Length Range of Rainbow	Average Number of Rainbow Per Net
June 1983	11	13	15.0"	10.1-22.4"	1.18
August 1983	11	33	15.3"	5.9-19.3"	3.00
June 1984	11	54	15.4"	11.8-19.0"	4.91
August 1984	11	25	15.7"	5.5-19.6"	2.27
October 1985	10	152	12.5"	8.8-19.5"	15.2

Rainbow Trout Age-Growth

Scale samples used for age analysis were limited to collections taken during the winter and early spring 1983 (creel census, Table 31) and the fall 1985 (Table 32). The later sample contained known age individuals (fin-clipped). Age determinations from scales has been confused by two factors: 1) the samples are dominated by fish of hatchery origin which have spent widely varying time periods within that system prior to reservoir life, and 2) most rainbow appear to lay down a "stocking check." The average length at age shown in Table 31 is substantially greater than that noted by Fredenberg (1980) even after a one year error is corrected. This may be a reflection of the reduced density of rainbow in Canyon Ferry Reservoir in 1983.

Table 31. Summary of rainbow trout ages sampled during the January through March period, 1983 (creel census).

Age	Sample Size	Average Length (inches)	Length Range (inches)
I	16	11.4	8.4 to 14.5
II	35	16.9	15.3 to 18.1
III	33	18.5	17.3 to 20.5
IV	1	18.3	--

Table 32. Summary of rainbow trout ages sampled in Canyon Ferry Reservoir during fall gillnetting (October 1985).

Age	Sample Size	Average Length (inches)	Length Range (inches)
0+	116	11.2	8.8 to 12.8
I+	18	15.5	13.1 to 16.8
II+	18	17.8	17.0 to 19.5

The fall 1985 netting effort captured mostly rainbow planted during the summer of 1985. The data suggests excellent survival of the 1985 plant and poor survival of the 1984 plant.

Rainbow Trout Escapement

Evidence of rainbow trout downstream escapement from Canyon Ferry Reservoir has existed since 1965. Canyon Ferry Dam spills water surplus to power production through top-mounted radial gates which draw from a 25 to 30 foot depth. These gates are not screened to prevent fish escapement. A summary of Canyon Ferry Dam radial gate spills is shown in Table 33. These records (U.S. Bureau of Reclamation) reveal that Canyon Ferry spilled water through the radial gates during 23 of the 30 years of operation. The average duration of the radial gate spills has been more than 50 days with a mean discharge of 7282 cfs.

While the magnitude of escapement from Canyon Ferry has not been established, fish planting into Holter Reservoir (downstream from Canyon Ferry) has been delayed until after reservoir spills because of documented fish loss from Holter Reservoir (Hill, 1973).

Table 33. Summary of Canyon Ferry Dam radial gate spills (May through September), 1956-1985.

Year	Days of Duration	Mean Discharge (cfs)
1956	78	5771
1957	43	8235
1958	68	4580
1959	58	9789
1960	58	5313
1961	0	0
1962	40	6502
1963	61	11097
1964	67	11461
1965	74	9662
1966	0	0
1967	30	7759
1968	0	0
1969	54	6073
1970	65	5278
1971	9	8112
1972	18	3574
1973	0	0
1974	20	8965
1975	46	8967
1976	68	3195
1977	0	0
1978	23	3139
1979	0	0
1980	40	8916
1981	40	12381
1982	57	6951
1983	37	5301
1984	99	6456
1985	0	0
	$\bar{x}$ = 50.13	$\bar{x}$ = 7282

In an attempt to document the magnitude of escapement, all rainbow trout planted in Canyon Ferry since 1982 have received tetracycline marks for later identification. In addition to Arlee rainbow from a hatchery system, a wild, spring spawning rainbow, the DeSmet rainbow, has been introduced to the reservoir. Fin clips were used to differentiate the different strains. Ten percent of each strain were fin clipped in each year through 1985. Arlee rainbow received left pelvic clips in 1983 and 1985 and right pelvic clips in 1984. DeSmet rainbow have received adipose clips.

Arlee rainbow were planted as 5 inch fish from May through early August in 1983 and 1985 and after August 7 in 1984 to avoid the radial gate spill. DeSmet rainbow were planted in September and October from 1983-85 as young of the year. An additional plant of over 63,000 yearling DeSmet was made in May of 1985. Stocking records for 1983-85 are presented in Table 34.

Table 34. Canyon Ferry rainbow trout stocking records for 1983 through 1985.

Year	Strain	Date Planted	Number Planted	Total Number	Average Size of Plants
1983	Arlee	4-19-83 to 8-16-83	418,498		5.5"
	DeSmet	9-27-83 to 10-4-83	240,558	659,056	4.0"
1984	Arlee	8-7-84 to 9-12-84	312,198		5.5"
	DeSmet	9-12-84 to 10-30-84	702,926	1,015,124	3.5"
1985	Arlee	5-21-85 to 8-8-85	434,237		5.0"
	DeSmet "I"	6-6-85 to 6-11-85	63,618	691,966	4.0"
	DeSmet "O"	8-26-85 to 9-12-85	194,111		3.0"

Sampling was initiated in 1983 in an attempt to document escapement from Canyon Ferry. Rainbow trout were sampled below Canyon Ferry Dam, below Houser Dam and below Holter Dam during 1983 and 1984. Of 377 rainbow collected in 1983, two (2) were from Canyon Ferry. Summer collections in 1984 found six

(6) of 285 to be from Canyon Ferry. Fall 1984 sampling in the Canyon Ferry tailrace found 31 of 201 sampled rainbow or 15 percent to be from Canyon Ferry Reservoir.

MANAGEMENT RECOMMENDATIONS

Missouri River

1) Initiate larval fish trapping in the spring to document spawning success or failure and potential recruitment.

Jefferson River

1) Curtail annual population surveys on the Willow Creek-Three Forks section and possibly substitute a section in the mid-river area.

2) Identify possible tributary habitat improvement projects to increase rainbow trout recruitment.

Canyon Ferry Reservoir

1) Continue marking rainbow trout plants and increase efforts to document survival, harvest and escapement.

2) Attempt to follow brown trout year classes more closely.

3) Curtail fall rainbow trout plants due to poor survival.

4) Begin investigations into fish food habits and reservoir plankton populations.

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Waters Referred To:

Missouri River	3-17-4944-01
Jefferson River	3-10-3840-01
Hell's Canyon Creek	3-10-3280-01
Canyon Ferry Reservoir	3-17-8832-05

Key Words:

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Rainbow trout
Escapement

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APPENDIX

Table A1. Chronological listing of brown trout tag returns for fish tagged in the fall of 1982.

Return Date	Return Location
Oct. 17, 1982	Missouri River, Toston-Deepdale
Nov. 4, 1982	Missouri River, Toston-Deepdale
Dec. 5, 1982	Missouri River, Toston-Deepdale
Dec. 18, 1982	Missouri River, Toston-Deepdale
Jan., 1983	Missouri River, Mouth of Dry Creek
Jan. 31, 1983	Reservoir, Silos
Feb. 10, 1983	Missouri River, Toston-Deepdale
Feb. 10, 1983	Missouri River, Toston-Deepdale
Feb. 10, 1983	Missouri River, Toston-Deepdale
Feb. 13, 1983	Missouri River, "FLUME"
Feb. 24, 1983	Reservoir, Confederate
March 3, 1983	Reservoir, Whitehorse
March 4, 1983	Reservoir, Beaver Creek Bay
March 6, 1983	Reservoir, Whitehorse
March 12, 1983	Reservoir, White Earth
March 13, 1983	Missouri River, Deepdale
March 13, 1983	Reservoir, White Earth
March 13, 1983	Reservoir, Goose Bay
March 19, 1983	Reservoir, White's Bay
March 26, 1983	Reservoir, Confederate
April 1, 1986	Reservoir, Confederate
April 17, 1983	Reservoir, White Earth
April 17, 1983	Reservoir, Hellgate
April 23, 1983	Reservoir, Duck Creek Bay
April 23, 1983	Reservoir, Near Canyon Ferry Dam
April 23, 1983	Reservoir
May 1, 1983	Reservoir, Beer Can Bay
May 11, 1983	Reservoir, Confederate
May 26, 1983	Reservoir
May 29, 1983	Reservoir, Ski Bay
June, 1983	Reservoir, Silos
June 4, 1983	Reservoir, Hellgate
June 8, 1983	Reservoir, Goose Bay
June 15, 1983	Reservoir, Snaggy Bay
June 15, 1983	Reservoir, Snaggy Bay
June 24, 1983	Reservoir, Scuda Bay
July 4, 1983	Reservoir, Silos
August 31, 1983	Missouri River, "FLUME"
March 25, 1984	Reservoir, Silos
May 10, 1984	Reservoir, Goose Bay
June 9, 1984	Reservoir, Goose Bay
June 28, 1984	Reservoir, Magpie Bay
Dec. 13, 1984	Reservoir, Silos
Feb. 28, 1985	Reservoir, Silos
August 16, 1985	Missouri River, Toston
Sept. 29, 1985	Missouri River, Toston Dam
Oct. 31, 1985	Missouri River, Toston Dam

Table A2. Missouri River mean daily discharge (cfs), April through October 1983 (U.S.G.S. gauge at Toston).

Day	April	May	June	July	August	September	October
1	4640	6660	17800	12200	3660	4960	6250
2	4690	6960	16800	12300	3570	4830	6650
3	4890	7120	14900	12900	3420	4910	6290
4	4780	6910	14400	13100	3310	4870	6160
5	4730	6730	13800	12400	*3000	4890	6000
6	4670	6880	13200	11400	3280	4810	5890
7	4630	7250	12600	10500	3220	4670	5780
8	4670	7090	12200	10800	3190	4660	5730
9	4730	6990	12200	10900	3210	4820	5690
10	4750	6860	12300	12500	3450	4800	5730
11	4750	6730	13200	14700	3720	4930	5830
12	4560	6560	17000	15200	3840	5350	5980
13	4400	6380	18200	14400	3720	5590	5550
14	4360	6020	15900	13600	3810	5070	5800
15	4400	6000	13900	12000	3780	4770	6360
16	4630	5980	13200	11400	3770	4570	6430
17	4750	5950	13400	10500	3760	4450	6450
18	4800	5990	13000	9770	3650	4500	6920
19	4840	6280	12600	8740	3600	4930	6850
20	5060	6250	12000	7730	3740	5100	6770
21	5360	5950	10900	7020	4070	5310	6500
22	5950	6060	10000	6670	4800	5500	6400
23	6660	6380	9510	5710	5330	5580	6480
24	7440	7000	9160	5720	5480	5510	7130
25	8210	8040	9750	5390	5470	5380	7000
26	8640	9600	9570	4990	5400	5270	6800
27	8410	11200	9370	4740	5490	5290	6750
28	7600	13400	9620	4350	5460	5570	6670
29	7040	15200	10400	4170	5320	5640	6560
30	6560	16700	10900	4000	5220	5870	6520
31		17800		3780	5090		6540
Mean	5520	8030	12726	9470	4124	5080	6337

*Lowest recorded summer discharge.

Table A3. Missouri River mean daily discharge (cfs), April through September 1984 (U.S.G.S. gauge at Toston).

Day	April	May	June	July	August	September
1	4920	6700	19300	20500	6420	5540
2	4930	6550	20100	18600	6360	5830
3	4930	6860	19200	16200	6300	6100
4	4930	6960	18400	15000	6150	6110
5	5010	6630	16900	13600	6250	5940
6	5230	6740	16700	12900	6260	5730
7	5580	6680	16700	12600	6150	5780
8	5800	6470	16200	12800	6020	5700
9	5830	6390	15100	12400	5810	5650
10	5810	6580	14400	11800	5490	5630
11	5740	7050	14700	10300	5190	5540
12	5600	7430	15400	9230	5070	5550
13	5430	8280	15700	8670	5020	5480
14	5250	9750	16000	8510	4970	5370
15	5150	13600	16500	7920	4930	5450
16	5390	17600	17700	7730	4890	5440
17	6030	20100	20100	7070	4930	5420
18	7130	20500	21300	6660	4870	5360
19	8460	20500	21600	6310	4820	5260
20	9410	20700	21600	6110	4840	5300
21	9590	20300	22900	6090	4670	5650
22	8880	19700	24400	6280	*4620	6080
23	8380	18800	25000	6280	4770	5950
24	8560	18300	25500	6160	4640	5990
25	8430	17500	26000	6060	4800	6150
26	8020	16000	25300	5840	5870	6290
27	7420	15400	23500	5670	5470	6510
28	6980	14400	22000	5720	5150	6590
29	6770	13800	21300	6090	4880	6530
30	6780	13800	21200	6410	4780	6460
31		15900		6480	4920	
Mean	6546	12770	19690	9419	5333	5813

*Lowest recorded summer discharge.

Table A4. Missouri River mean daily discharge (cfs), April through October 1985 (U.S.G.S. gauge at Toston-provisional).

Day	April	May	June	July	August	September	October
1	4540	7350	7830	1520	1520	1640	4210
2	5600	7750	8160	1490	1600	1750	4210
3	6420	8540	8580	1390	1860	1810	4090
4	5920	10100	8980	1530	2000	1800	4200
5	5540	10900	8330	1730	2130	1710	4730
6	5400	10500	8140	1790	2450	1750	4880
7	5280	9770	8350	1790	2470	2220	5030
8	5260	9250	8180	1710	2240	2460	5150
9	5390	9100	7890	1610	2020	2770	5260
10	5720	9210	7330	1520	1910	3000	5250
11	6220	9500	6240	1380	1950	3220	5270
12	7040	9240	5420	*1300	2120	3430	5580
13	8080	8420	4450	1350	2360	4020	5720
14	9290	7670	4020	1390	2660	4130	5750
15	9280	6360	3160	1370	2790	4020	5620
16	10000	5390	3200	1360	2780	3970	5590
17	10700	5080	3080	1340	2740	3920	5570
18	10800	4850	2660	1350	2690	4040	5550
19	10600	4720	2470	1430	2590	4370	5520
20	10100	4720	2350	1550	2500	4140	5440
21	9310	4620	2140	1530	2370	4080	5350
22	8470	4590	1980	1530	2230	4090	5380
23	7810	4640	1830	1450	2150	4220	5600
24	7480	4780	1700	1430	2050	4270	5760
25	7090	5050	1690	1450	2010	4240	5550
26	6720	5910	1670	1390	1990	4040	5330
27	6510	7230	1690	1340	1960	4070	5290
28	6390	7460	1640	*1300	1890	4160	5270
29	6280	7780	1610	1340	2170	4190	4980
30	6920	7780	1590	1400	2080	4160	4980
31		7870		1470	1830		4840
Mean	7339	7295	4545	1469	2197	3390	5192

*Lowest recorded summer discharge.

Table A5. Missouri River mean daily water temperature (°F), April through October 1983 (U.S.G.S. gauge at Toston).

Day	April	May	June	July	August	September	October
1	45.5	51.8	57.2	61.7	71.6	68.0	47.3
2	45.5	52.7	57.2	59.9	71.6	67.1	50.0
3	41.0	52.7	57.2	56.3	72.5	65.3	49.1
4	41.9	52.7	58.1	57.2	72.5	63.5	49.1
5	41.9	54.5	57.2	61.7	72.5	61.7	50.9
6	41.0	51.8	59.0	64.4	74.3	59.9	50.9
7	42.8	50.0	60.8	65.3	74.3	61.7	50.0
8	46.4	51.8	61.7	65.3	73.4	62.6	50.0
9	46.4	48.2	61.7	64.4	69.8	61.7	50.0
10	46.4	44.6	61.7	59.9	71.6	59.0	50.0
11	45.5	43.7	59.0	58.1	73.4	58.1	48.2
12	43.7	41.9	53.6	61.7	70.7	59.0	48.2
13	42.8	43.7	53.6	64.4	70.7	59.9	49.1
14	42.8	48.2	56.3	66.2	71.6	59.9	49.1
15	45.5	50.9	59.0	63.5	69.8	59.0	48.2
16	46.4	51.8	58.1	61.7	68.0	59.0	47.3
17	48.2	50.9	58.1	62.6	69.8	57.2	46.4
18	50.9	53.6	60.8	64.4	69.8	52.7	46.4
19	51.8	51.8	58.1	67.1	68.0	47.3	44.6
20	52.7	53.6	56.3	68.0	66.2	46.4	45.5
21	53.6	56.3	57.2	66.2	67.1	47.3	46.4
22	54.5	57.2	55.4	68.0	68.0	49.1	46.4
23	54.5	59.0	59.9	68.0	68.0	51.8	48.2
24	54.5	59.9	60.8	67.1	67.1	53.6	45.5
25	50.9	60.8	60.8	68.9	66.2	55.4	45.5
26	48.2	60.8	62.6	68.0	66.2	56.3	45.5
27	49.1	60.8	63.5	67.1	66.2	56.3	46.4
28	48.2	60.8	60.8	68.0	66.2	53.6	46.4
29	49.1	61.7	61.7	69.8	66.2	50.9	46.4
30	51.8	59.9	61.7	70.7	65.3	48.2	46.4
31		57.2		71.6	66.2		47.3

Table A6. Missouri River mean daily water temperature (°F), April through October 1984 (U.S.G.S. gauge at Toston).

Day	April	May	June	July	August	September	October
1	43.7	47.3	55.4	62.6	69.8	61.7	48.4
2	42.8	50.0	54.5	63.5	69.8	61.7	49.6
3	43.7	50.0	55.4	64.4	70.7	61.7	50.7
4	46.4	49.1	55.4	65.3	69.8	62.6	51.6
5	48.2	50.0	53.6	66.2	68.9	63.5	52.3
6	48.2	46.4	53.6	66.2	68.0	60.8	52.3
7	46.4	47.3	53.6	64.4	68.0	55.4	52.9
8	46.4	50.0	53.6	64.4	68.9	53.6	53.6
9	46.4	52.7	53.6	65.3	69.8	55.4	53.6
10	45.5	52.7	54.5	65.3	70.7	57.2	53.4
11	43.7	52.7	51.8	66.2	68.9	58.1	53.4
12	42.8	54.5	52.7	68.0	66.2	57.2	52.7
13	43.7	57.2	55.4	68.0	68.9	56.3	50.0
14	46.4	59.0	56.3	68.0	67.1	55.4	46.4
15	50.0	58.1	59.9	68.9	68.9	55.4	44.6
16	52.7	54.5	59.9	69.8	69.8	57.2	42.8
17	53.6	50.9	59.9	70.7	69.8	59.0	41.5
18	52.7	52.7	60.8	70.7	70.7	59.9	40.3
19	50.9	55.4	60.8	69.8	70.7	60.8	39.2
20	48.2	56.3	59.9	69.8	68.9	60.8	38.5
21	46.4	52.7	59.0	68.0	67.1	58.1	38.1
22	50.9	51.8	56.3	66.2	67.1	54.5	38.1
23	51.8	53.6	56.3	64.4	68.0	50.9	38.5
24	49.1	51.8	60.8	64.4	66.2	47.3	39.6
25	45.5	50.9	63.5	68.9	64.4	46.4	39.7
26	41.0	52.7	64.4	71.6	62.6	46.4	41.0
27	39.2	52.7	64.4	70.7	64.4	44.6	38.8
28	41.0	54.5	65.3	69.8	64.4	45.5	37.8
29	42.8	58.1	65.3	69.8	63.5	45.5	37.6
30	43.7	60.8	63.5	68.0	63.5	46.4	36.9
31		59.0		68.9	63.5		36.0

Table A7. Missouri River mean water temperature (°F), April through September 1985 (U.S.G.S. gauge at Toston).

Day	April	May	June	July	August	September
1	44.1	58.5	57.2	70.2	69.1	62.8
2	44.6	58.3	56.5	70.7	68.4	61.2
3	44.2	56.3	57.2	71.6	65.8	61.5
4	43.0	54.0	58.3	72.0	66.0	63.0
5	43.7	52.7	59.2	72.3	68.2	63.9
6	45.0	53.8	60.4	72.7	68.4	62.2
7	46.6	55.9	62.4	72.9	69.6	57.2
8	47.5	57.2	62.4	72.7	68.0	54.5
9	49.1	57.2	62.1	73.8	65.1	56.7
10	51.3	56.7	62.8	75.0	63.7	57.9
11	51.1	53.2	63.1	74.3	60.8	59.0
12	49.5	50.5	63.9	72.1	59.4	59.0
13	50.2	52.2	63.9	71.1	59.7	56.1
14	51.1	54.7	64.4	70.3	60.8	57.7
15	50.9	55.9	67.5	71.6	63.9	58.6
16	51.1	57.4	66.7	72.0	63.3	58.1
17	51.6	58.3	67.1	70.9	61.3	56.1
18	52.5	58.6	67.1	70.5	64.0	54.5
19	50.7	61.0	68.7	71.1	66.9	53.2
20	45.9	62.6	68.9	72.7	67.1	53.1
21	45.1	63.1	67.1	73.6	65.8	54.9
22	45.1	64.2	67.3	73.8	64.9	53.1
23	44.8	65.5	68.0	72.9	64.6	51.4
24	43.0	65.3	64.8	72.1	65.3	51.6
25	43.5	64.0	59.9	72.3	66.7	52.5
26	46.4	61.3	59.2	72.5	67.8	53.4
27	50.5	59.9	62.4	73.2	68.2	50.0
28	54.0	61.5	66.4	72.1	68.5	44.8
29	56.1	60.3	68.9	70.3	68.5	43.9
30	57.2	56.8	69.6	67.8	68.2	44.6
31		54.5		67.1	65.3	

Table A8. Jefferson River mean daily discharge (cfs), April through October 1983 (U.S.G.S. gauge near Three Forks).

Day	April	May	June	July	August	September	October
1	1860	3880	9460	5700	1450	2650	2380
2	1870	4120	9060	5730	1400	2590	2450
3	1920	4210	8320	5940	1360	2520	2490
4	1940	4160	7460	6130	1330	2490	2500
5	1860	3960	6930	5970	1330	2490	2440
6	1730	3940	6590	5390	1350	2430	2430
7	1700	3940	6180	4780	1330	2330	2410
8	1710	3880	5790	4370	*1310	2210	2350
9	1750	3690	5680	4050	1360	2160	2350
10	1840	3630	5730	4880	1570	2170	2330
11	1920	3470	6160	6770	1990	2220	2360
12	1940	3360	7070	8370	2130	2220	2390
13	1930	3210	7790	9160	2260	2180	2380
14	1920	3050	7770	7760	2210	2070	2450
15	1890	2950	7340	6040	2100	2010	2490
16	1890	2880	6670	5400	2080	1940	2610
17	1900	2730	6470	4950	2040	1890	2710
18	1940	2980	6050	4610	1930	1870	2650
19	2020	2930	5790	4160	1870	2000	2540
20	2130	2740	5580	3620	1880	2170	2540
21	2580	2560	5130	3220	2120	2360	2520
22	3180	2670	4930	2930	2580	2490	2540
23	3650	2820	4650	2650	2840	2510	2600
24	4330	3140	4290	2520	3150	2470	2620
25	4990	3550	4130	2340	3160	2370	2670
26	5480	4260	4000	2180	3110	2270	2660
27	4870	5070	3890	2080	3070	2190	2680
28	4250	6160	4360	1950	2990	2170	2590
29	3820	7140	5220	1790	2880	2180	2530
30	3720	8170	5690	1630	2810	2240	2500
31		9220		1520	2740		2540
Mean	2618	4015	6139	4471	2120	2262	2506

*Lowest recorded summer discharge.

Table A9. Jefferson River mean daily discharge (cfs), April through September 1984 (U.S.G.S. gauge near Three Forks).

Day	April	May	June	July	August	September
1	2270	3380	8160	9590	3560	3390
2	2310	3260	9120	8870	3500	3610
3	2340	3360	9280	8000	3490	3590
4	2350	3540	8930	7310	3530	3520
5	2370	3380	8330	6810	3620	3430
6	2470	3430	8310	6470	3530	3360
7	2710	3300	8370	6340	3480	3440
8	2850	3140	8280	6320	3350	3410
9	2780	2890	7880	6270	3220	3400
10	2770	2960	7270	6060	3080	3400
11	2720	3320	7340	5690	2960	3340
12	2620	3610	8050	5220	2930	3330
13	2430	3770	8620	4890	2880	3250
14	2300	4360	8670	4520	2890	3180
15	2260	5650	8760	4300	2850	3150
16	2430	7410	8950	4130	2830	3140
17	2940	9520	9450	3960	2800	3140
18	3950	11100	9850	3810	2750	3100
19	4860	11900	10000	3700	2760	3030
20	5430	11200	10000	3610	2840	2950
21	5410	10000	10500	3550	2830	2960
22	4770	9950	11900	3540	2780	2950
23	4490	9830	13400	3430	2740	2990
24	4800	9540	14800	3340	2760	3100
25	4700	9010	14900	3280	2880	3250
26	4260	8410	13300	3190	2980	3420
27	3820	7910	11800	3080	2950	3550
28	3450	7350	11100	3080	2870	3580
29	3420	6920	10600	3350	2770	3580
30	3450	6620	10100	3510	*2680	3560
31		7030		3600	2840	
Mean	3324	6356	9867	4930	3030	3303

*Lowest recorded summer discharge.

Table A10. Jefferson River mean daily discharge (cfs), April through October 1985 (U.S.G.S. gauge near Three Forks-provisional).

Day	April	May	June	July	August	September	October
1	1750	2980	4100	445	269	325	1580
2	1820	3140	4190	449	278	330	1600
3	1980	3380	4940	471	308	330	1600
4	2090	4030	5030	544	371	369	1590
5	2160	4780	4300	675	555	387	1600
6	2040	4810	3880	664	651	377	1610
7	1970	4410	3780	580	716	431	1650
8	2010	3990	3640	443	680	553	1680
9	2150	3790	3420	360	624	728	1760
10	2270	3820	3100	325	578	957	1660
11	2720	3920	2680	277	615	1200	1750
12	3560	3780	2240	271	673	1360	1890
13	4720	3430	1970	272	815	1580	1920
14	5670	3040	1710	278	955	1630	1920
15	5270	2640	1530	303	985	1530	1900
16	5440	2270	1370	324	971	1490	1880
17	5430	2040	1230	332	959	1450	1890
18	5430	1920	1110	337	907	1590	1890
19	5220	1860	1020	404	878	1770	1860
20	4950	1850	927	445	828	1790	1800
21	4420	1860	822	431	740	1740	1770
22	3860	1850	710	400	665	1710	1790
23	3440	1890	569	354	593	1700	1820
24	3240	1910	515	336	537	1680	1800
25	3040	1990	450	310	534	1640	1780
26	2840	2340	425	302	518	1600	1780
27	2740	3040	454	292	491	1560	1780
28	2660	3480	463	279	452	1560	1770
29	2710	3530	476	264	416	1560	1740
30	2870	3780	454	*254	375	1560	1710
31		4010		261	324		1670
Mean	3349	3083	2050	377	621	1216	1756

*Lowest recorded summer discharge.

Table A11. Jefferson River median daily water temperature (°F), June through August, 1983 (Three Forks).

Day	June	July	August
1	59.0	-	70.8
2	59.3	-	70.5
3	59.0	-	71.0
4	-	-	70.8
5	-	59.8	72.0
6	-	-	74.0
7	61.0	-	74.8
8	61.3	69.8	73.0
9	61.8	67.5	71.3
10	61.5	61.5	72.5
11	-	61.0	73.3
12	-	-	71.5
13	-	-	-
14	56.3	-	-
15	59.5	-	-
16	59.3	-	-
17	59.8	-	-
18	61.8	-	-
19	59.5	-	-
20	57.8	-	-
21	57.5	-	-
22	57.0	-	-
23	61.0	-	-
24	63.5	-	-
25	63.5	66.3	65.5
26	-	66.3	64.8
27	-	65.8	65.8
28	-	67.0	66.5
29	-	68.5	65.5
30	-	70.0	61.0
31	-	70.3	67.0

Table A12. Jefferson River median daily water temperature (°F), June through August, 1984 (Three Forks).

Day	June	July	August
1	56.8	62.5	67.5
2	54.3	63.3	67.0
3	55.0	63.8	67.3
4	55.3	64.5	66.3
5	53.8	65.8	66.0
6	52.8	66.0	65.5
7	52.5	63.3	65.0
8	52.3	63.0	65.8
9	52.5	62.8	67.5
10	53.3	63.5	67.3
11	51.8	65.5	66.0
12	50.5	66.5	64.0
13	54.3	67.5	65.5
14	55.5	67.0	65.5
15	60.0	67.8	66.5
16	60.0	68.3	67.8
17	57.8	68.8	67.5
18	61.3	68.3	68.3
19	61.3	67.3	68.5
20	61.0	66.8	66.5
21	58.3	66.0	65.3
22	54.8	63.8	65.0
23	56.5	61.8	66.0
24	61.0	63.0	63.8
25	64.3	67.8	62.5
26	64.5	69.3	62.0
27	64.3	69.3	62.8
28	65.3	68.5	62.8
29	66.0	67.3	62.3
30	63.3	65.3	62.3
31		66.3	62.5

Table A13. Jefferson River median daily water temperature (°F), June through August, 1985 (Three Forks).

Day	June	July	August
1	-	67.5	-
2	-	68.3	-
3	-	69.0	-
4	-	71.0	-
5	-	71.5	-
6	-	71.0	-
7	-	71.0	71.0
8	-	71.3	67.8
9	-	72.5	68.3
10	-	72.5	66.3
11	-	69.3	61.8
12	-	71.0	60.0
13	-	67.8	59.8
14	63.3	71.3	61.5
15	64.0	71.0	66.8
16	64.8	71.0	64.3
17	64.8	69.0	64.0
18	64.5	70.5	66.8
19	65.3	70.5	67.8
20	66.8	72.3	68.5
21	63.5	73.8	67.3
22	65.5	74.5	66.3
23	65.3	73.0	66.0
24	62.8	70.3	67.3
25	57.0	71.5	68.5
26	56.8	72.5	69.3
27	61.5	73.8	70.0
28	64.8	72.0	70.0
29	67.3	68.0	70.8
30	68.0	67.0	69.8
31		67.0	68.8

Table A14. Jefferson River median daily water temperature (°F), June through August, 1983 (near Twin Bridges).

Day	June	July	August
1	-	-	69.0
2	-	-	68.0
3	-	-	68.5
4	-	-	67.3
5	-	-	68.3
6	-	-	70.5
7	-	-	70.5
8	-	-	68.8
9	-	63.8	69.3
10	-	57.3	69.0
11	-	56.0	70.3
12	-	60.5	66.5
13	-	64.8	66.8
14	-	65.5	67.5
15	-	59.5	65.0
16	-	59.3	63.0
17	-	59.3	66.0
18	-	62.5	66.0
19	-	64.5	64.3
20	-	63.5	63.8
21	-	64.0	65.0
22	-	65.8	64.0
23	-	65.0	62.5
24	-	64.5	62.5
25	-	65.5	62.5
26	-	65.3	62.0
27	-	64.8	63.5
28	-	65.5	63.3
29	-	67.0	63.0
30	-	68.8	62.8
31		68.0	63.8

Table A15. Jefferson River median daily water temperature (°F), June through August, 1984 (near Twin Bridges).

Day	June	July	August
1	53.0	63.0	66.5
2	51.8	64.0	66.8
3	52.8	64.8	67.0
4	52.5	66.0	66.8
5	51.3	66.8	65.8
6	51.0	66.3	64.5
7	49.8	63.5	65.0
8	50.8	62.8	66.8
9	51.5	63.5	68.0
10	50.0	64.5	67.8
11	49.3	66.3	64.0
12	52.8	67.5	64.3
13	55.3	67.5	66.3
14	57.3	67.8	64.5
15	60.5	68.5	66.8
16	60.3	69.0	68.0
17	60.8	69.5	67.0
18	61.0	69.5	68.3
19	61.3	67.3	67.8
20	59.0	66.0	66.0
21	56.5	64.8	64.5
22	56.0	61.8	64.3
23	59.0	60.8	65.3
24	63.0	65.3	62.3
25	65.5	68.5	61.5
26	65.0	69.8	64.0
27	65.5	69.3	63.3
28	66.5	67.8	62.5
29	66.3	66.3	62.3
30	63.5	65.0	61.8
31		67.0	61.5

Table A16. Jefferson River median daily water temperature (°F), June through August, 1985 (near Twin Bridges).

Day	June	July	August
1	55.3	64.5	64.3
2	54.8	66.5	63.3
3	54.5	68.5	61.5
4	55.8	69.0	63.0
5	58.0	69.0	63.8
6	57.5	68.5	65.8
7	59.3	68.8	65.0
8	60.5	68.8	63.5
9	59.5	-	61.5
10	59.3	-	61.3
11	60.5	-	57.3
12	61.5	-	55.5
13	60.8	66.5	57.5
14	58.8	-	59.5
15	63.3	-	63.5
16	63.8	-	61.3
17	62.5	-	60.8
18	63.0	-	63.5
19	65.8	-	63.8
20	66.5	-	63.8
21	63.8	68.3	63.3
22	65.0	69.3	62.0
23	65.0	67.5	61.3
24	62.5	66.5	62.5
25	56.8	66.5	63.3
26	57.0	66.3	63.3
27	61.3	68.5	64.8
28	64.0	65.8	64.5
29	64.3	63.3	64.8
30	64.3	60.0	63.3
31		61.3	61.5

Table 1. Comparison of the 1984 and 1985 average maximum, minimum and mean water temperatures for the March through September period at the Varney and Norris thermograph stations (F^{o}).

Month	Varney			Norris		
	Maximum	Minimum	Mean	Maximum	Minimum	Mean
			1984			
April	44.7	38.7	41.7	48.2	38.9	43.6
May	49.5	42.4	46.0	55.7	49.3	52.5
June	52.9	47.0	50.0	58.6	54.7	56.7
July	61.4	54.7	58.1	69.0	63.7	66.4
Aug.	63.0	57.1	60.1	71.6	64.0	67.8
Sept.	54.6	49.3	52.0	57.2	50.4	53.8
			1985			
April	1/	1/	1/	46.8	41.3	44.1
May	1/	1/	1/	59.7	53.2	56.5
June	61.8 2/	53.5 2/	57.7 2/	66.7	56.6	61.7
July	66.1	57.5	61.8	74.2	62.9	68.6
Aug.	62.2	53.7	58.0	62.9	59.5	61.2
Sept.	52.7	47.1	49.9	1/		

1/ No data available.

2/ Temperature for June 18-30, 1985 period only.