POTENTIAL IMPACTS OF ALTERING DISCHARGE

FROM HAUSER DAM, MISSOURI RIVER, ON

FISH POPULATIONS

1984 Completion Report

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EXECUTIVE SUMMARY

From 20 October, 1981 to 14 December, 1983 we collected information on important fish species and their habitat requirements in the Missouri River between Hauser Dam and the impounded water of Holter Reservoir. We also evaluated the importance of Beaver Creek to the Missouri River fishery. This information was used to predict potential impact of altering the flow pattern below Hauser Dam.

Fifteen fish species representing six families were sampled in the Missouri River study area. Brown trout, rainbow trout, and mountain whitefish were the most abundant game fish sampled while longnose suckers and mottled sculpins were the most numerous non-game species.

During 1982 and 1983, 3,478 rainbow trout and 1,435 brown trout were tagged in the Missouri River and Beaver Creek. Anglers reported harvesting 14.5% and 11.7% of the tagged brown and rainbow trout in the Missouri River, respectively. Trout in spawning condition were less frequently recaptured near the original tagging location than were non-spawning trout. After spawning, brown and rainbow trout were most often recaptured downstream from the tagging location or in Holter Reservoir. One brown trout and nine rainbow trout were recovered below Holter Dam.

The trout population in the Missouri River study area ranks among the best in Montana. The brown trout population is primarily adfluvial, spending much of the year in Holter Reservoir, moving up into the river in the fall to spawn and then returning to the reservoir. Although rainbow trout also move in and out of the reservoir, they are more abundant than brown trout in the river during all seasons. The brown trout population is entirely self sustaining while large numbers of Arlee hatchery rainbow are stocked in Hauser and Holter reservoirs.

The abundance of brown trout in the study area during the fall is large (~500/mile) but not exceptional when compared to other large blue ribbon trout streams in Montana. The average size, however, is exceptional. In our study section, 41% of the brown trout sampled in fall were longer than 18.0 inches and these fish weighed an average of 4.2 lb.

The 1982 spring rainbow trout population estimate (2,548/mile) was similar to estimates on the Madison and Gallatin rivers but was larger than for other Montana trout streams for which data were available. Average size during spring was also larger than reported for most large Montana rivers. Over half of the rainbow were longer than 16 inches and weighed an average of 1.8 pounds; nearly one-third were longer than 18 inches, weighing an average of 2.3 pounds. During the study period, brown trout numbers changed little, rainbow trout numbers decreased, and kokanee salmon increased in number.

Spawning and subsequent incubation of eggs and emergence of fry appear to be the trout life history features most likely to be influenced by fluctuating flows in the Missouri River study area. Nearly all observed brown and rainbow trout spawning occurred in four areas. Based upon the large amount of superimposition of redds, the quantity of adequate spawning habitat appears limited for brown trout.

Brown trout spawned from mid-October through mid-December with peak spawning in early to mid-November. Rainbow spawned from mid-March through late May, peaking in late April. Although rainbow of river or reservoir origin used Beaver Creek extensively for spawning, there was no brown trout spawning run up Beaver Creek. Consequently, Beaver Creek does not appear to be a major source of brown trout recruitment to the Missouri River study area, but it does appear to be an important source of recruitment of rainbow trout; 6,693 YOY rainbow trout migrants were captured near the mouth of Beaver Creek in 1983.

From redd observations in 1982 we were unable to account for 82% of the estimated 734 brown trout females in the spawning population. The presence of deep-water redds adjacent to the major spawning areas, and underestimation of the number of redds in areas of concentrated spawning activity account for most of the discrepancy between the number of spawning females and the number of redds observed.

Based upon the measurement of physical and hydraulic characteristics of redds, the minimum depth and velocity selected by brown and rainbow trout spawners in our study area was 0.8 ft and 1.0 fps, respectively; preferred mean velocity was 2.5 fps. Few redds were observed at water velocities exceeding 4.0 fps. Velocity appeared to be more important than depth in spawning site selection.

Brown trout selected larger substrate than rainbow for spawning even though both species spawned in the same general areas. Except for one spawning area, the amount of fine sediment in redds of both species was within the acceptable range for successful egg incubation and fry emergence.

Duration of brown trout redd construction ranged from approximately 1 to 5 days with most redds being completed within 3 days. Early and late in the spawning run, most spawning occurred at night, while during peak spawning, both brown and rainbow trout spawned during both day and night.

Young-of-the-year brown trout were first observed in the Missouri River study area in mid to late April while YOY rainbow trout were first located in mid-June. Young-of-the-year of both species were approximately 1 inch in length when they emerged from the gravel. Mean length of captured YOY brown trout was 0.6 inches to 1.7 inches greater than YOY rainbow trout on comparable sampling dates.

YOY trout occupied near-shore areas in the Missouri River which would be most affected by fluctuating flows. Although brown and rainbow YOY trout were rarely found together, they occupied similar habitats within the study section. Approximately 90% of YOY trout of both species were captured in water depths of less than 2 feet, where mean water velocities were less than or equal to 0.60 fps, and within 8 feet of shore. Young-of-the-year trout were usually associated with substrates dominated by fines or boulders. One or more instream cover components were present at 99% of all YOY trout capture sites. Downstream movement of a few YOY trout was detected in the Missouri River, and nearly all brown and rainbow trout emigrating from Beaver Creek into the river were YOY fish.

Fish, primarily mottled sculpin, made up the bulk of the diet of all but the smallest size group of brown trout. Zooplankton were the most important food item for all size groups of rainbow trout except in August when caddisflies became important. Chironomids were important food for YOY brown trout and were the second most important food item of rainbow.

Three of the four known spawning areas (1, 2, and 3, see Figure 2.0-1) were considerably dewatered during the 1,348 cfs flow test in August 1982. All rainbow trout redd locations observed in the three areas during spring 1982 were dewatered as were 50 to 100% of the observed brown trout spawning locations. The quantity of known suitable spawning habitat remaining at this flow was relatively small. Virtually no YOY trout were dewatered during the August flow test but mottled sculpin were dewatered in relatively large numbers. Large reductions in flow earlier in the year when YOY trout are smaller could be more detrimental.

Means and ranges of water depth, mean water velocity, and distance to shore occupied by YOY trout were similar between normal seasonal and reduced discharges. During experimental low flows YOY distribution changed temporarily, but there was no indication of permanent displacement.

Physical and hydraulic conditions in three spawning areas (1, 2, and 4) were predicted for as many as 36 discharges. The relationships between predicted quantity of suitable spawning habitat and discharge differed between spawning areas. Maximum predicted brown and rainbow trout spawning habitat at area 1 was provided by 3,500 cfs and the maximum at area 2 was 5,178 cfs for brown trout and 5,500 cfs for rainbow. Area 4 predictions were not used in the analysis due to suspected influence of the backwater of Holter Reservoir. Evaluating spawning area 1 and 2 simultaneously, the overall maximum quantity of spawning habitat is predicted to occur at about 2,100 cfs for brown trout and 3,000 cfs for rainbow trout. Spawning activity was concentrated in small areas and did not occur throughout most of the habitat that was predicted and/or appeared available. Therefore, the reliability of spawning habitat modeling results was questioned.

Brown trout redds begin to be dewatered at 60 to 62% of the spawning discharge. Redds constructed when flow was about 5,000 cfs would remain nearly 100% wetted in spawning areas 1 and 2 at discharges greater than 3,000 cfs. Rainbow trout redds built at a discharge of 5,619 cfs would remain wetted at flows greater than 4,500 cfs. At discharges less than 4,000 cfs the percent of spawning habitat wetted would decrease rapidly.

The habitat simulation model predicted that usable YOY trout habitat would increase as discharge decreased from 9,500 cfs to 1,500 cfs. Field observations, however, indicate that YOY trout habitat quality may be reduced at low discharges due to a decline in the number of available cover types.

Potential effects of fluctuating flow on spawning behavior, incubation, YOY trout rearing, and forage fish are discussed.

1.0 INTRODUCTION AND OBJECTIVES

The flowing portion of the Missouri River between Hauser Dam and the impounded water of Holter Reservoir is a high quality fishing and recreation area. This reach has been designated as a Class 1, Blue Ribbon trout stream, which has national importance (Brown et al. 1959). Engineering studies performed for the Montana Power Company indicate that the addition of a new 25MW power house at Hauser Dam, combined with a peaking operation, would produce the highest cost-benefit ratio. Hauser Dam is presently operated as a run-of-the-river plant.

Little information concerning the fish populations in this section of the river and its major tributary, Beaver Creek, has been collected in the past. Due to the importance of the trophy brown trout fishery, the rainbow trout fishery and other recreational activities on this section of the river, information documenting the present status of fish populations and habitat is being gathered to predict potential impacts of altering the flow pattern below Hauser Dam. Although information on several fish species was collected, emphasis was placed on the trout populations. Information presented in this report was collected between 20 October, 1981 and 14 December, 1983.

Specific objectives of this study include:

1. Determine seasonal abundance, distribution and movement of fish species under existing conditions.
2. Monitor spawning migrations, document spawning time, attempt to locate major spawning habitat of brown and rainbow trout, and predict impact of operational changes on spawning success.

3.8.1 Spawning

Three major spawning areas of brown and rainbow trout were examined during the 1,358 cfs (38.5 m^3/s) flow to evaluate substrate size in areas known to be used for spawning, to measure depths and velocities of potential spawning areas with suitable substrate, and to determine bottom profiles of spawning areas as far into the channel as possible. Thirteen permanent transects were established at known spawning sites: six transects at the first gravel bar along the right bank just below the dam, six at the series of gravel bars along the right bank approximately 1 mile (1.6 km) downstream from the dam, and one at the mouth of Beaver Creek. Along each transect, substrates were sampled and photographed, profiles of spawning areas were made, and depths and mean velocities were measured.

3.8.2 YOY Rearing

Stranding of YOY trout and other fish on dewatered substrate and the isolation of fish in pools were evaluated during the period of 1,358 cfs (38.5 m^3/s flow. Sampling was restricted to four areas previously found to contain relatively large concentrations of YOY trout and where they were most likely to be affected by dewatering. Section 1 encompassed the dewatered portion of the first gravel bar along the right bank just below the dam. Section 2 included the series of six exposed gravel bars along the right bank approximately 1 mile (1.6 km) downstream from the dam. Section 3 consisted of the delta areas just above and below the mouth of Beaver Creek and Section 4 was the mid-stream island approximately 1 mile (1.6 km) downstream from the dam (directly across from Section 2).

Twelve, 1.1 yd (1 m) wide transects were established over the four sections to examine stranding on dewatered substrate. Individual surface rocks were removed and aquatic vegetation examined along the transects. Although primary interest focused on the numbers and sizes of YOY trout stranded, the numbers and sizes of other fish species found were also recorded.

The location and size of pools isolated from the main river channel at 1,358 cfs (38.5 m^3/s) were noted and species and size of each fish captured in these pools were recorded.

3.9 Physical Habitat Simulation

Data collected in this and other parts of the study were used to help predict impact of proposed flow modifications in the Missouri River Study area. Predictions were made using the USFWS physical habitat simulation (PHABSIM) system. This system is a collection of computer programs used to relate changes in discharge to changes in the quantity of usable fish habitat. The underlying principles of PHABSIM include: (1) each species exhibits preference within a range of habitat conditions it can tolerate, (2) these ranges can be defined for each species, and (3) the area of stream providing these conditions can be quantified as a function of discharge and channel structure (Bovee 1982). The primary output of the model is a measure of usable microhabitat called weighted usable area.

Hydraulic simulation is the first step in the habitat evaluation process. Because of constraints of a large river environment, as well as time and funds, we utlized the water surface profile option of the PHABSIM system. This model is a multiple transect approach which uses data collected at a minimum of one discharge to predict changes in water surface elevation, depth, velocity, and wetted perimeter along each transect at other specified discharges. Field data required included cross-section survey data (from high water marks), distances between cross-sections, corresponding water surface elevations at all cross sections at the known discharge and, description of substrate, bank and overbank material and vegetation as well as where these change within the cross sections.

During the 3 day period in which transect data were collected, Montana Power Company regulated the river at a constant flow of 5,178 cfs (146.6 m^3/s), as determined from the stage-discharge relationship developed by Montana Power Company in 1982. Survey data were collected along four transects in each of three sections of the river; these sections corresponded to spawning areas 1, 2 and 4, and were also suitable for examining influences of flow on rearing habitat.

We surveyed bank and wadable areas (depth ≤ 3 feet; 0.9 m) using a level and hand-held stadia rod. Channel profiles in unwadable areas were surveyed from a boat equipped with a constant recording fathometer (Raytheon, model DE-719B). A range finder (Lietz, model SD-5F), operated by a person on shore, was used to determine distances along the transect and to keep the boat on course. To provide targets for the boat operator, two large floats were placed off each bank at the outer extent of the measurements taken by wading. For a more detailed description of field techniques, see Graham et al. (1979).

Following completion of field data collection, channel profiles were plotted for each transect using the elevation data. Each transect was then divided into several subsegments based upon depth, substrate and areas known to be important for spawning and YOY trout rearing (the model accepts up to 100 subsegments). The model predicts mean depth and velocity of each subsection at the observed and simulated discharges. These data are then fed into the HABITAT model which, using observed habitat preferences for depths, velocity, and substrate associations at each life stage of interest, calculates a weighted suitability index. This index reflects the relative preference of the species for the combination of structural and hydraulic characteristics found in each stream segment (group of four transects). This index is expressed as the percentage of the gross surface area in the stream segment which contains suitable combinations of habitat variables for each life stage of the species for each simulated discharge. An example of model output is presented in Table 3.9-1. For a detailed explanation of how the PHABSIM system functions, see Bovee, 1982 and Milhous et al., 1981.

3.10 Reduced Flow Test, 1983

On 4 August, 1983 a reduced flow test was conducted to evaluate the accuracy of hydraulic modeling predictions at three major brown and rainbow trout spawning areas (areas 1, 2, and 4), to determine if YOY trout are displaced from utilized habitat and to measure changes in YOY trout habitat.

3.10.1 Spawning

Water surface elevations were measured by surveying techniques at four discharges [2863 cfs (81.1 m^3/s), 2,357 cfs (66.7 m^3/s), 1,956 cfs (55.4 m^3/s), and 5,048 cfs (143.0 m^3/s)] (Table 3.10-1). Water depths and velocities were measured along modeling transects to compare observed with predicted values, and to determine suitability of these areas for spawning and/or incubation at the three lowest discharges.

3.10.2 YOY Rearing

Displacement of YOY trout from utilized habitat as well as changes in available habitat characteristics were evaluated at three flows. Sampling was restricted to four previously established stations where YOY trout were relatively abundant. Station 1 was sampled at 2,863 cfs, Stations 2 and 10 at 2,357 cfs, and Station 4 at 1,956 cfs (Figure 36-1).

Stations were electrofished with a canoe mounted electrofishing unit using a handheld, mobile electrode. The number of YOY trout captured plus number observed but not captured at each station was recorded as was the species and length of each captured trout. Techniques described in Section 3.6.3 were used to evaluate YOY trout habitat selection and to quantify changes in physical habitat.

3.11 Predicted Dewatering of Utilized Spawning Habitat

In 1982, 77 brown trout redd depths were measured at spawning areas 1 and 2. The number of these redds dewatered at a specific discharge was determined by using predicted changes in water surface elevation. Three inputs were required to use this method: 1) the discharge and water surface elevation of the river at the time of spawning; 2) the distribution of redd depths at spawning areas 1 and 2; and 3) predictive modeling to determine water surface elevations at numerous discharges.

The number of redds dewatered at areas 1 and 2 was determined at 100 cfs (2.8 m^3/s) increments between 3,000 cfs (85.0 m^3/s) and 2,500 cfs (70.8 m^3/s). The total number of redds dewatered at a given discharge was divided by the number of redd depth measurements (77) to determine the percent dewatered. Spawning areas 3 and 4 were not included in this analysis because the influence of Beaver Creek (area 3) and the backwaters of Holter Reservoir (area 4) made hydraulic modeling unreliable. Also, redds at area 4 are not dewatered within the range of flows outlined above.

TABLE 3.6-1

SCHEDULE FOR SAMPLING YOY TROUT
IN THE MISSOURI RIVER, 1983

Month	NUMBER OF SAMPLING PERIODS	DATES OF SAMPLING PERIODS
April	2	4/16-17[a] 4/30-5/1[a]
May	2	5/14-15 5/28-29
June	2	6/12-14 6/25-27
July	2	7/9-12[b] 7/23-24
August	2	8/6-7 8/20-21
September	2	9/3-4 9/17-18
October	2	10/1-2 10/15-16
November	1	11/12-13

[a]Stations 7, 14 not sampled (not established)
[b]Stations 1, 4, 8, 11 not sampled (high water)

TABLE 3.6-2

SCHEDULE FOR SAMPLING YOY TROUT
IN THE MISSOURI RIVER, 1982

Month	NUMBER OF SAMPLING PERIODS	DATES OF SAMPLING PERIODS
April	1	4/25
May	2	5/20 - 5/21 5/31
June	2	6/22 - 6/24 6/25 - 7/2
July	3	7/6 - 7/9 7/14 - 7/16 7/23 - 7/24
August	3	7/30 - 8/5 8/11 - 8/12 8/24 - 8/27
September	1	9/18 - 9/20
October	1	10/28 - 10/31

TABLE 3.6-3

CLASSIFICATION OF SUBSTRATES BASED ON A MODIFIED VERSION OF THE WENTWORTH PARTICLE SIZE SCALE

SUBSTRATE TYPE	PARTICLE SIZE (inches)
Fines	< 0.08
Gravel	0.08 - 2.52
Cobble	2.53 - 9.84
Boulder	> 9.84

TABLE 3.6-4

CLASSIFICATION OF COVER COMPONENTS

COVER COMPONENT	DESCRIPTION
Instream	
Submerged Vegetation (SV)	Aquatic, emergent, or terrestrial vegetation partially or wholly submerged
Rock Cover (RC)	River substrate large enough to be used by YOY trout as cover (relative to size of fish)
Woody Organic Debris (OD)	Dead woody vegetation wholly or partially submerged <u>or</u> living or dead woody vegetation extending <u>into</u> the water from the bank
Undercut Bank (UB)	River bank undercut by erosion
Overhanging	
Overhanging Vegetation (OHV)	Living or dead vegetation extending out over the water's surface and within 11.8 inches (30 cm) of the water's surface.

TABLE 3.6-5

SCHEDULE FOR SAMPLING YOY TROUT HABITAT, 1983

DATES OF SAMPLING PERIODS	MEAN DISCHARGE FOR PERIOD (cfs)
6/29-7/4	10,401 ± 665
7/26-30	5,268 ± 224
8/23-26	5,537 ± 293

TABLE 3.8-1

FLOW SCHEDULE FOR THE PERIOD JUST PRIOR TO AND INCLUDING THE REDUCED FLOW TEST ON THE MISSOURI RIVER BELOW HAUSER DAM: 16-17 AUGUST, 1982.[a]

DATE	TIME	FLOW (CFS)	APPROXIMATE ELAPSED TIME (HRS)	
16 August	12:00 AM - 10:30 AM	6,200	10.5	
	10:30 AM - 11:00 AM	6,200 → 9,500	0.5	
	11:00 AM - 5:00 PM	9,500	6.0	24
	5:00 PM - 6:00 PM	9,500 → 8,200	1.0	
	6:00 PM - 12:00 AM	8,200	6.0	
17 August	12:00 AM - 7:00 AM	8,200	7.0	
	7:00 AM - 8:00 AM	8,200 → 6,200	1.0	
	8:00 AM - 10:00 AM	6,200	2.0	
	10:00 AM - 11:00 AM	6,200 → 1,500	1.0	24
	11:00 AM - 7:00 PM	1,500	8.0	
	7:00 PM - 8:00 PM	1,500 → 5,900	1.0	
	8:00 PM - 12:00 AM	5,900	4.0	

[a]Flows provided by Project Operator.

TABLE 3.9-1

EXAMPLE OUTPUT OF THE HABITAT MODEL, TRANSECT SET 2, MISSOURI RIVER, 1982

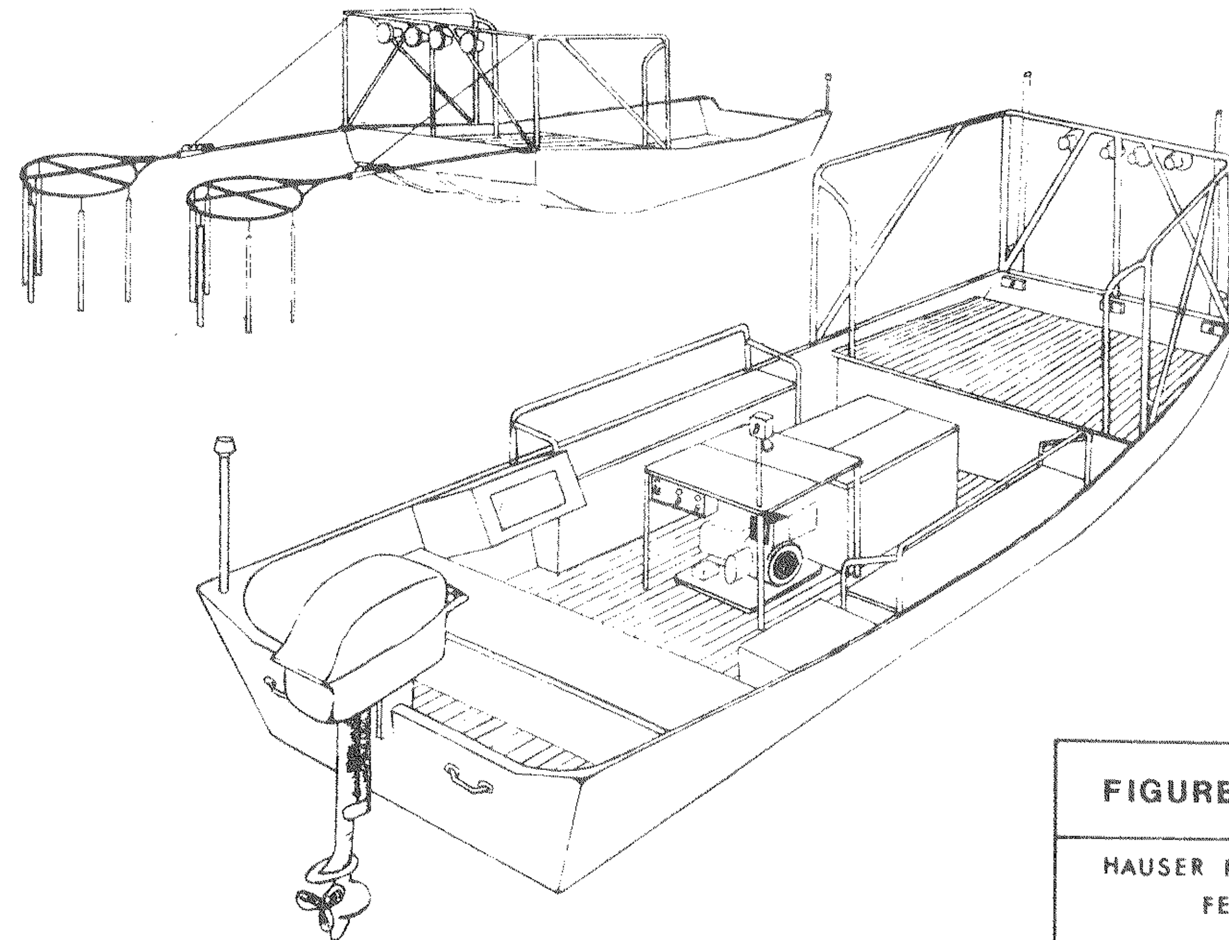
Q vs. Available Habitat Area as a Percentage of the Gross Area for Rainbow Trout

Q	GROSS	SPAWNING	FRY	ADULT	JUVENILE	INCUBATION
2700.	341631.	13.10	.93	30.93	12.26	44.30
2800.	346356.	12.25	.87	30.22	13.59	43.89
2900.	351736.	11.45	.86	29.60	15.05	43.49
3000.	356803.	10.71	.87	28.84	14.75	43.09
3500.	368264.	8.27	.54	26.65	15.08	41.92
4000.	371665.	7.28	.23	26.95	12.93	40.67
4500.	374752.	7.52	.12	26.94	10.69	38.72
5000.	377639.	7.87	.09	25.28	8.82	36.22
5178.	378592.	7.91	.07	24.70	8.32	35.30
5500.	379632.	7.78	.05	23.68	7.05	33.59
6000.	381038.	7.13	.07	21.59	5.20	30.70
6500.	382388.	6.14	.07	19.82	3.95	27.78
7000.	383614.	5.14	.07	17.55	3.14	24.97
7500.	384722.	4.15	.07	15.31	2.66	22.40
8000.	385669.	3.24	.07	13.11	2.14	20.15
8500.	386587.	2.37	.06	11.16	1.76	18.15
9000.	387480.	1.71	.06	9.37	1.44	16.32
9500.	388330.	1.18	.04	7.88	1.20	14.60

TABLE 3.10-1

FLOW SCHEDULE FOR THE FLOW TEST ON THE MISSOURI RIVER
BELOW HAUSER DAM: 4 AUGUST, 1983

Time	Flow (cfs)	Elapsed Time (hrs)
8:00 AM - 9:00 AM	5,814 → 2,863	1.0
8:00 AM - 11:30 AM	2,863	2.5
11:30 AM - 12:00	2,863 → 2,357	.50
12:00 - 1:45 PM	2,357	1.75
1:45 PM - 2:15 PM	2,357 → 1,956	.50
2:15 PM - 4:00 PM	1,956	1.75
4:00 PM	1,956 → 5,048	-

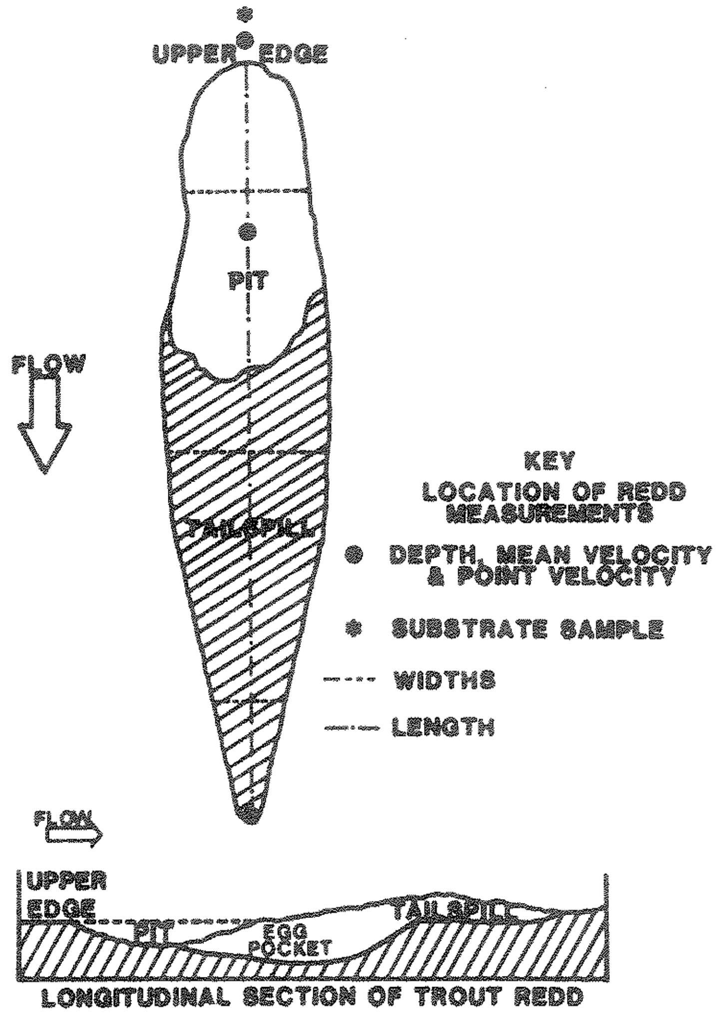


Source: Smith-Root Inc.

FIGURE 3.1-1

HAUSER PROJECT EXPANSION
FERC NO. 2188

ELECTROFISHING BOAT



(FROM REISER AND WESCHE, 1977)

FIGURE 3.5-1

HAUSER PROJECT EXPANSION
FERC NO. 2188

LOCATION OF
REDD MEASUREMENTS

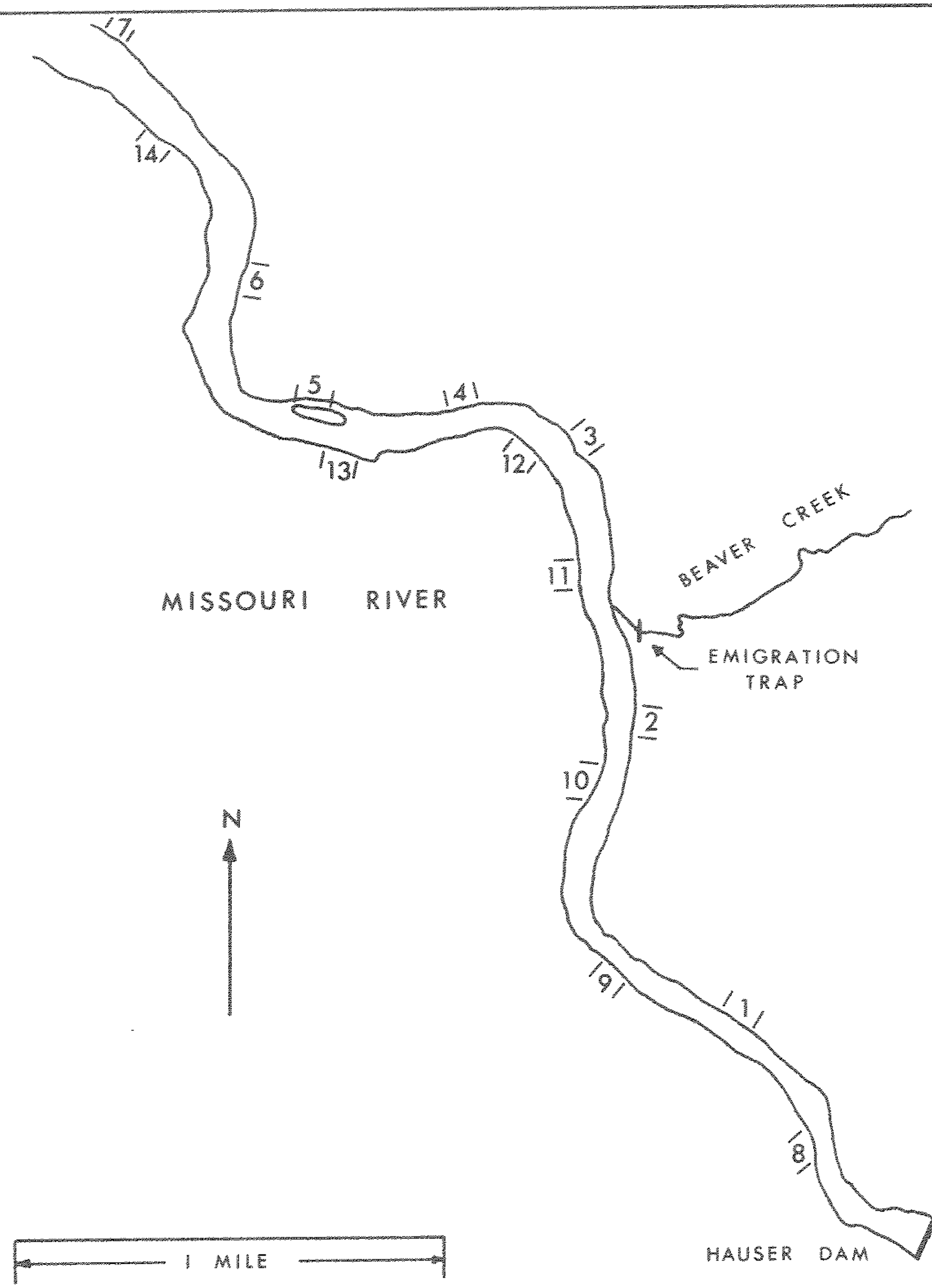


FIGURE 3.6-1

HAUSER PROJECT EXPANSION
FERC NO. 2188

MAP OF STUDY AREA
SHOWING YOY TROUT
ELECTROFISHING SECTIONS

4.0 RESULTS

4.1 Species Composition

Fifteen fish species representing six families were sampled in the Missouri River study area. (Table 4.1-1). Brown trout, rainbow trout, and mountain whitefish were the most abundant game fish sampled while longnose suckers and mottled sculpins were the most numerous non-game species. Walleye were rare in the study area, but some exceeding 10 lbs (4500 gm) were captured. Crappie and fathead minnows were also rare; only one larval crappie and two fathead minnows were sampled.

4.2 Trout Movement and Harvest

Five thousand fish were tagged in the study area during 1982 and 1983. These included 3,478 rainbow trout and 1,435 brown trout. The remaining tags were placed in brook, cutthroat, and rainbow-cutthroat hybrid trout as well as walleye. Recapture of tagged fish by fishermen or by electrofishing provided information on movement. Brown and rainbow trout movement trends were evaluated as non-spawning or general movement, pre-spawning movement, and post-spawning movement. Non-spawning movement was determined from fish not gravid or ripe when tagged, or recaptured. Pre-spawning movement was based on fish that were not ripe or gravid when first captured, but were in spawning condition when recaptured. Post-spawning movement was determined from fish captured in spawning condition, but were not ripe or gravid when later recaptured.

Tagged fish recovered by anglers were assumed to be non-ripe or non-gravid when caught outside of the spawning season, but were not assumed to be ripe or gravid when caught during the spawning season.

Anglers reported catching 11.7% of the rainbow trout tagged in the Missouri River study area and 4.0% of the rainbows tagged in Beaver Creek (Table 4.2-1). The brown trout harvest rate in the river was higher than for rainbows with a reported harvest of 14.5%; only 3.0% of the brown trout tagged in Beaver Creek were reported caught. Two of the five brook trout tagged in the river were harvested by anglers. Of 31 cutthroat trout tagged in the river, 9.7% (3) were reported creeled. A total of 22 brown and 4 rainbow trout with tags were reported caught and released in the Missouri River.

4.2.1 Brown Trout Movement

During 1982 and 1983, 489 recapture locations were obtained from 1,435 brown trout tagged in the Missouri River and Beaver Creek. Spawning movement trends were determined from 104 recapture locations, and 385 tag returns were related to non-spawning movement.

For non-spawning brown trout (general movement), an average of 69.6% of the recaptures (range = 80.9 to 16.7%) were recovered in the initial tagging subsection (Table 4.2-2). Eight brown trout which were not in spawning condition when tagged were recovered by anglers in Holter Lake; four of these trout were tagged during early October. Secondary sexual characteristics were less prominent during early October and may have been overlooked. Thus these movements were possibly spawning related. No resident brown trout from Beaver Creek were recovered in the Missouri River (Table 4.2-2).

Brown trout pre-spawning movements revealed no obvious trends (Figure 4.2-1). Compared to non-spawning fish, however, spawning brown trout were less frequently recaptured in the subsection from which they were tagged.

For spawning brown trout, an average of 53.1% of the recaptures occurred at the initial tagging location.

Post-spawning relocations were most often downstream from the tagging location (Figure 4.2-2). Fifty percent of the recaptures were from anglers at Holter Lake, and most tagged fish were creeled prior to 1 July of the following year. One tagged brown trout was recovered by an angler below Holter Dam.

Twenty-one brown trout (19 females and 2 males) were observed in spawning condition during consecutive years. We recaptured 10 (47.6%) repeat spawners within the same subsection each of the 2 years (Figure 4.2-3).

4.2.2 Rainbow Trout Movement

During 1982 and 1983, 2,830 rainbow trout were tagged in the Missouri River and 648 were tagged in Beaver Creek. Non-spawning movement was based on 556 recapture locations, and spawning movement was determined from 218 recapture locations.

In the Missouri River, an average of 56.6% of the non-spawning recaptures (range = 67.8 to 13.2%) were from the initial tagging subsection (Table 4.2-1). During pre-spawning movement, rainbow trout were less frequently recaptured within the initial tagging subsection; only 25% of the recaptures were from the initial capture location (Figure 4.2-4). No non-spawning rainbow trout in Beaver Creek were recovered in the Missouri River.

A relatively large number of non-spawning rainbow trout were recovered by anglers in Holter Lake. Of the 42 angler returns from Holter Lake, 32 non-spawning rainbows were tagged during the fall and 10 were tagged in the spring. It is likely that some of the non-spawners tagged in the spring were associated with the spawning migration but were not in spawning condition at the time of capture. There also appeared to be a fall migration of rainbow trout from Holter Lake to our study section, and a similar proportion of fall and spring migrating fish were harvested in Holter Lake during the spring and early summer. The number of fall migrating fish that ripen during the winter to spawn in the spring is not known. Two non-spawning rainbows were recovered by anglers below Holter Dam.

Rainbow trout post-spawning movement was similar to the brown trout post-spawning movement pattern (Figure 4.2-5). Sixty-seven percent of the relocations were downstream from the initial tagging location, and 52% of the relocations were from anglers downstream from the lower boundary of the 2.8 mile (4.5 km) study section. Of the 22 angler returns below the study section, 13 were creeled in Holter Lake, 7 were caught below Holter Dam, and 2 were recovered in tributaries of Holter Reservoir; one each in Willow Creek [11.6 river miles (18.6 rkm) below Hauser Dam] and in Cottonwood Creek [17.0 river miles (27.4 rkm) below Hauser Dam].

Fifty rainbow trout spawning movements from the Missouri River to Beaver Creek were observed in 1982 and 1983. In 1982, 90% of the spawners recovered in Beaver Creek were tagged at or below the mouth of Beaver Creek (sections 3, 4 and 5) earlier during the spring (Figure 4.2-6). In 1983, most (74%) relocations in Beaver Creek were from spawners tagged during the fall of 1982 because few tags were distributed during 1983. Of the rainbow trout spawners marked in 1982 and recovered in Beaver Creek in 1983, 45%, 26%, and 29% were tagged above, at, or below the mouth of Beaver Creek, respectively.

After spawning in Beaver Creek, most rainbow trout were recovered downstream from the mouth of Beaver Creek

(Figure 4.2-7). Twenty-four recapture locations (35%) were from sections 4 and 5, 22 (32%) were from Holter Lake, and two (2.9%) were from below Holter Dam.

We observed 20 rainbow trout (11 males and 9 females) in spawning condition during 2 consecutive years. Considering that recapture locations at section 3 (at the mouth of Beaver Creek) were combined with Beaver Creek relocations, 15 (75%) were observed in the same spawning area each of the 2 years (Figure 4.2-8).

4.3 Population Estimates

4.3.1 Missouri River

Brown and rainbow trout population and biomass estimates in the Missouri River study area were calculated during spring and fall 1982 and 1983 (Tables 4.3-1, 4.3-2, 4.3-3, and 4.3-4). The estimated number of brown trout in the study area was 249 (± 47) for age II and older fish during spring 1982 while the estimate in the fall was 1,387 (± 181) for brown trout age I and older. This represents a 457% increase between the fall and the spring estimate in 1982; all age groups of brown trout displayed an increase in population levels in the fall over spring 1982. The largest percentage increases occurred in the IV and V and older age groups, while the largest numerical increase occurred in age II brown trout. The spring 1983 population estimate of brown trout was 426 (±33) for ages II to V and older, substantially lower than the fall 1982 estimate but 71% greater than that obtained in spring 1982. The fall 1983 brown trout estimate was 1,346 (±212) for age I to IV and older, which was almost identical to the point estimate for brown trout in fall 1982.

The rainbow trout estimate was greater by 56% in spring 1982 than in fall 1982, even though the fall estimate included an additional age group, age I. The spring 1982 population estimate was 7,912 (± 2,062) for age groups II to IV and older while the fall 1982 estimate, which included age I to IV and older fish, was 5,061 (± 864). The spring 1983 rainbow trout population estimate was 3,726 (± 795), only 47% of the spring 1982 rainbow estimate. The fall 1983 rainbow estimate was once again much higher; it was 6,044 (± 1,422). Although the estimate was the highest since spring 1982, the population levels of older aged rainbows was lower than from any other estimate. Age I rainbows comprised the major portion of this estimate.

Brown trout biomass estimates in the study area remained seasonably stable in 1982 and 1983. Spring biomass estimates of brown trout in the study area were 465 lbs (211 kg) in 1982 and 571 lbs (259 kg) in 1983. During the fall, brown trout biomass estimates were 3,119 lbs (1,415 kg) in 1982 and 3,326 lbs (1,509 kg) in 1983. The estimated biomass of rainbow trout was at its highest during spring 1982 at 11,529 lbs (5,230 kg). The biomass of age III rainbows in spring 1982 comprised most of the estimate and was larger than the total biomass from all age groups in the three other estimates. The total biomass decreased to 5,266 lbs (2,389 kg) during fall 1982 and remained stable during spring 1983 (5,636 lbs; 2,556 kg) and fall 1983 (5,512 lbs; 2,500 kg).

Kokanee population and biomass estimates were obtained during fall 1982 and spring 1983 (Table 4.3-5). The population and biomass estimates in fall 1982 were 440 (± 189) and 185 lbs (84 kg), respectively, for kokanee 9.0-11.4 inches (229-290 mm) in length. During spring 1983, the population and biomass estimates were 140 (± 37) and 93 lbs (42 kg) for kokanee in the 9.5-12.9 inch (241-328 mm) size group.

The weights of brown and rainbow trout captured during the spring population estimate in 1982 ranged from 0.07-7.5 lbs (30-3,420 gm) and from 0.07-7.8 lbs (30-3,535 gm), respectively. The range of brown trout weights during the fall population estimate in 1982 was 0.02-13.2 lbs (20-6,000 gm) while the range of rainbow trout weights was 0.01-5.8 lbs (5-2,620 gm).

Back-calculation of fish lengths from the Missouri River study area showed extremely high growth rates (Table 4.3-6). Brown trout grew faster and weighed more than comparably aged rainbows. Both brown and rainbow trout grew most rapidly between the first and second year of life when the incremental growth was 8.0 and 7.2 inches (203 and 183 mm), respectively. Growth tended to decline for both species after age 3. The growth rate of both trout species in the study area was greater than that found on a section of the Missouri River between Holter Dam and Cascade during 1948 and 1949 (Kathrein, 1950) and in a 2.2 mile (3.5 km) stretch of the river immediately upstream from Canyon Ferry Reservoir (Fredenberg, 1980) in 1978 and 1979. Equations used to back-calculate lengths and weights are given in Table 4.3-7.

Four age groups corresponding roughly to the back-calculated lengths for ages 1-4 rainbow trout are shown in length frequency distributions from spring and fall 1982 (Figure 4.3-1). The largest mode displayed in the spring 1982 rainbow length frequency probably represents at least 2 age-groups, both age 4 and 5. Three modes are exhibited by the fall 1982 brown trout length frequency (Figure 4.3-2). The first mode corresponds with the back-calculated length of age 2, the second with age 3, and the fourth mode appears to include age 4 and older fish. A very small number of fish near 5.5 inches (140 mm) represents YOY brown trout that correspond to age 1. Eighteen kokanee were aged using scales and their length back-calculated for each age (Table 4.3-6). Although the sample was small, kokanee exhibited a faster growth rate their first year than either trout species and had a larger back-calculated length at age 2 than rainbows.

Population estimates calculated with Chapman's modification of the Petersen estimate are valid only if several assumptions are met; one of the most important assumptions is that there is no recruitment to the population. These assumptions were of particular concern with the estimates made in the river, since several included both resident and adfluvial fish.

The spring population estimates of brown trout did not appear to be affected by immigration or emigration and represents the resident population in the river on 23 May, 1982, and 14 May, 1983. However, the spring rainbow trout estimate was influenced by emigration of fish that had finished spawning and returned to Holter Reservoir. The mean number of rainbow trout caught each night during the recapture runs declined 57% and 22% in 1982 and 1983, respectively, from the number caught during the marking runs, which suggests a lower density of fish in the river. A comparison of discharge records and catch rates of rainbow trout implies that the reduction in electrofishing efficiency during the recapture runs was not a result of discharge alteration. Since it appears that a portion of the rainbow spawners left the study area, the spring population estimate would be an underestimate if it is assumed that an equal proportion of marked and unmarked fish emigrated to the reservoir.

The fall population estimates of brown trout in 1982 and 1983 were apparently influenced by immigration of fish from Holter Reservoir. As in spring 1982, changes in electrofishing efficiencies due to water discharge from Hauser Dam did not appear to be a factor. However, electrofishing efficiences during fall 1983 were low due to equipment problems. The efficiency rate for brown trout was 19% during fall 1983, down from 30% in fall 1982. This decrease in efficiency did not affect the population estimate. The average number of brown trout caught per electrofishing run increased from August or September through November in 1982 and 1983. This recruitment to the population caused the fall population estimates to be inflated. However, since the estimates were made on 9

October, 1982, and 10 October, 1983, and more fish entered the river after the estimates were completed, the estimates should be used as an index for the minimum number of brown trout in the river during fall 1982 and 1983. The fall brown trout estimates appear reliable since estimates in both years were nearly identical, even though efficiency rates were substantially different. Fall rainbow trout estimates did not appear to be influenced greatly by fish immigration or emigration. The addition of age I fish to the estimates in the fall was the most significant factor affecting the estimates. Age I rainbow trout estimates, which were not calculated in spring, were a major component in the fall. No major changes were seen in the average number of kokanee captured each electrofishing run in October and November of both years.

The number of trout and salmon captured per hour on each electrofishing trip on the Missouri River during the fall of 1982 and the spring and fall of 1983 was calculated (Table 4.3-8). Highest mean capture rate for brown and rainbow trout was along the left bank during fall 1982, and for kokanee along the right bank during fall 1983. Right and left streambanks were designated as though you are looking downstream. The highest capture rate of brown trout, rainbow trout, and kokanee during the fall of 1982 was along the left bank on 3 December, 9 November and 5 October, respectively. Catch per hour for both trout species along both banks was highest on or later than 19 October. The only significant difference (F-test; $P=0.05$) between catch rates of the same species on the two banks was with rainbow trout. The mean number of rainbow trout caught per hour was 61% greater on the left bank than on the right bank.

Capture rates during spring 1983 were highest for brown trout and kokanee on the left bank on 8 May and 11 May, respectively. The number of brown trout captured per hour on the left bank was significantly greater than on the right bank (F-test; P=0.05). The highest catch rate for rainbow trout occurred 10 April on the right bank; rainbow catch rates steadily decreased after the 10 April peak. The highest catch of rainbow trout on the left bank was on 24 March.

Catch per unit effort during September and October 1983 for both brown and rainbow trout was low but then increased dramatically in November. The large change in the C.P.U.E. is due to changes in the efficiency of the electrofishing equipment and does not reflect changes in seasonal abundance caused by movement of trout. The capture rates for trout from the fall of 1983 should be used cautiously; they are not comparable to any of the previous fall or spring catch rates and should only be used to assess trends in fish abundance during the fall of 1983.

Excluding data from November, the highest catch per hour for brown trout and kokanee was on the right bank on 19 and 6 October, respectively, and on the left bank for rainbow trout on 9 October. Although electrofishing efficiency was lower during the fall of 1983, the mean capture rate of kokanee, even if November sampling was excluded, was approximately equal to or greater than any other kokanee capture rate during the study. This indicates a strong kokanee year class in 1983 and may suggest that the kokanee population of the Missouri River-Holter Reservoir complex is increasing. No significant differences (F-test; P=0.05) were found between catch rates of the same species on the two banks over the entire fall. However, if catch data from November are excluded, the number of rainbow trout and kokanee caught on the left and right bank, respectively, was significantly greater than the capture rate on the other respective bank.

4.3.2 Beaver Creek

Brown and rainbow trout population and biomass estimates in Beaver Creek Sections 2 and 3 were calculated during the spring and fall in 1982 and 1983 to assess the size of resident trout populations (Tables 4.3-9 and 4.3-10). The estimated rainbow trout numbers in Section 2 increased dramatically between March and September of 1982; this increase was entirely due to the addition of the 0 age group in September. Rainbow trout numbers in Section 2 decreased in 1983 but remained much higher than the initial estimate in spring 1982. Also, the biomass estimate continually increased to a high of 11.3 lbs (5.1 kg) during fall 1983. Brown trout population levels in Section 2 remained much more stable than rainbow levels and comprised most of the biomass except during September 1983. The highest rainbow trout population estimate from Section 3 was during spring 1983. The rainbow trout populations of Section 3 were greater than in Section 2 during both spring estimates. Brown trout population estimates in Section 3 also remained stable and were consistently higher than estimates from Section 2. The largest biomass estimates from Section 3 was from fall 1983 and 1982 for rainbow and brown trout, respectively. During 1982, brown trout biomass in Section 3 was at least two times greater than rainbow biomass but in 1983, biomass of the two species were nearly equal. Population and biomass estimates of cutthroat trout in Section 3 were also obtained during the fall of 1983 (Table 4.3-10). It appears that cutthroat trout in Section 3 may be increasing in numbers.

Population estimates for rainbow, cutthroat, and rainbow-cutthroat hybrids were combined in Section 4 due to problems in identifying separate species because of hybridization and the large number of small fish (Table 4.3-11).

Both the combined and brook trout population estimates were greatest during fall 1983. The lumped biomass estimate was also greatest in fall 1983 while the highest brook trout biomass estimate was from fall 1982. The trend in increasing number and biomass estimates may indicate recovery of the populations after flooding in 1981.

Mottled sculpin and brook trout were the only other resident fish sampled. Although large numbers of mountain whitefish and suckers are present in the river, no resident adults of these species were captured or observed in Beaver Creek. However, there is a large spawning run of suckers into Beaver Creek during the spring, and several yearling catostomids were found in an isolated pool at Section 2 on 13 March, 1982.

As would be expected, the back-calculated lengths of resident trout in Beaver Creek showed a much slower growth rate than in the Missouri River (Table 4.3-12). The aged fish in Sections 2 and 3 were combined because of the close proximity of the sections and to obtain average growth rates representative of the lower 5.0 miles (8.0 km) of the stream. As in the river, brown trout exhibited higher growth rates than rainbows at each age. Both brown and rainbow trout in the lower sections grew most in their first year of life. Aged rainbow, cutthroat, and rainbow-cutthroat hybrid trout were combined in Section 4 for back-calculation purposes as they were for population estimates. The combined group showed a higher rate of growth than brown trout during the first year of life. However, after the first year, brown trout growth rates were higher. Although both groups from Section 4 appear to grow faster than those in Sections 2 and 3, very small sample sizes were used to calculate the regression equations and therefore their predictive value is questionable. Only age I in the combined group contained a substantial sample size; it showed a lower incremental growth rate than the lower sections, which would be expected since Section 4 is near the headwaters of Beaver Creek. Equations used to back-calculate lengths and weights for trout in Beaver Creek electrofishing sections are presented in Table 4.3-13.

4.4 Spawning

4.4.1 Redd Counts

Brown Trout - Missouri River

During the 3 years brown trout spawning was monitored, spawning began between 11 and 22 October and was completed by mid to late December. Water temperature at initiation of spawning was between 49 and 52°F (9.4 and 11.1° C) (Figure 4.4-1). Spawning activity peaked in early to mid November during 1981 and 1982 (Figure 4.4-2).

During our study, most redds (87 to 100%) were observed in four general spawning areas: 1. the large gravel bar immediately below the dam, 2. the series of riffles about 1 mile (1.6 km) below the dam, 3. the delta at the mouth of Beaver Creek, and 4. the shallow run above Cochran Gulch (Figure 2.0-1).

Fifty-five and 130 brown trout redds were observed in 1981 and 1982, respectively. These redd counts were known to be underestimates. Factors contributing to the low redd counts were: 1. the high incidence of multiple redds and superimposed redds; 2. the presence of redds in relatively deep water that were not visible to the observer; and 3. kokanee salmon spawning activity that progressively increased during the three fall spawning periods. Redds of unknown origin, brown trout or kokanee, were omitted from the counts.

In 1982 considerably more redds were counted than in 1981. This was due to more frequent observations which allowed us to better enumerate multiple and superimposed redds. During 1982, an estimated 29% of the redds observed were single spawning sites (Table 4.4-1). All other redds were aggregates with additional construction in front of, adjacent to, or directly over the original spawning site (superimposed). The 55 redds counted in 1981 actually represent 55 redd aggregates; the number of individual spawning sites was probably much larger. The discovery of spawning area 4 also supplemented the 1982 redd count.

In 1983, an estimated 487 brown trout redds were counted on 14 December. This higher estimate was primarily a result of observing deep-water redds adjacent to known spawning areas, especially at area 3, during the low flow test. The redd count was also increased by more accurately esti- using aerial photographs and planimetric methods. The estimated number of redds at area 4 was greatly increased by using this method. We also observed 49 redds in relatively deep water that were not associated with the four major spawning areas.

In 1983, kokanee spawning was extensive at areas 1 and 3, while none were observed spawning at areas 2 and 4 during the 3 years of investigation. Electrofishing also failed to find spawning kokanee concentrated at areas 2 and 4. Deep water redds observed during 1983 were designated as brown trout redds because brown trout spawners were predominantly electrofished in these areas.

The delta at the mouth of Beaver Creek (area 3) was heavily used by brown trout in 1981 and 1982. In 1983, kokanee appeared to displace brown trout spawners from the shallow, observable portion of the delta. Because of heavy use by kokanee, redds in this area were all designated as kokanee redds although some brown trout spawning probably occurred. Deep water redds in the vicinity of the delta (approximately 175 redds) were counted as brown trout redds, although some kokanee spawning may have occurred there. During electrofishing, kokanee were primarily concentrated in the shallow portion of the delta, while brown trout were captured in the deeper waters above and below the delta.

By comparing ground and aerial counts of brown trout redds during the 14 December, 1983 flow reduction, an estimate of the number of brown trout redds that were not visible to ground observers during higher flows was made for areas 1, 2, and 3 (Table 4.4-2). At area 1, 6 of the 20 observed brown trout redds (30%) were found in areas that would not normally be visible to the redd observer. At area 2, 19 of 64 redds (30%) were found in areas not visible at normal flow. In 1983 no ground count of brown trout redds was made at area 3 because of extensive kokanee spawning activity. In 1981 and 1982, however, 21 and 25 brown trout redds, respectively, were observed at this site. This would represent less than 20% of the total number of redds at this area if a similar amount of deep water spawning occurred during the 3 years.

In 1982, an estimated 30 redds were counted at area 4. Redds in this area were aggregated, away from shore, and were at water depths of about 4 ft. (121.9 cm). Therefore, it was difficult to estimate the number of redds present. During 1983, this large group of redds comprised an area of 3,183 ft^2 (295.7 m^2). Dividing this surface area measurement by the average size of individual brown trout redds gave an estimate of 170 redds - a much higher and probably more accurate estimate than could have been made from the ground.

The relative importance of spawning areas changed between years because of differences in discharge. In 1981 when discharge was 3,951 cfs (111.9 m^3/s) during peak spawning (November), the largest number of redds (44%) was observed in area 1. In 1982 when November discharge averaged 5,045 cfs (142.9 m^3/s), area 2 was the most used spawning site with 41% of the redds (Table 4.4-3). During 1983, the average discharge in November was 6,882 cfs (194.9 m^3/s). The number of redds at spawning area 2 was similar during

TABLE 4.4-2

COMPARISON OF REDD COUNTS FROM THE GROUND AND FROM A HELICOPTER DURING THE 14 DECEMBER, 1983 FLOW REDUCTION, MISSOURI RIVER

SPAWNING AREA	NUMBER OF REDDS VISIBLE DURING GROUND SURVEY	TOTAL NUMBER OF REDDS ESTIMATED FROM GROUND AND HELICOPTER	NUMBER OF REDDS NOT VISIBLE DURING GROUND SURVEYS
1	14	20	6 (30%)
2	45	64	19 (30%)
3	21 to 25[a]	175	~ 150 (> 80%)

[a]From 1981 and 1982 redd counts (no count available during 1983)

TABLE 4.4-3

NUMBER AND PERCENT OF TOTAL REDDS IN MAJOR SPAWNING AREAS FOR BROWN TROUT AND RAINBOW TROUT IN THE MISSOURI RIVER BELOW HAUSER DAM

BROWN TROUT

AREA	LOCATION	1981 NUMBER OF REDDS	1981 PERCENT OF TOTAL	1982 NUMBER OF REDDS	1982 PERCENT OF TOTAL	1983 NUMBER OF REDDS	1983 PERCENT OF TOTAL
1	Gravel Bar	24	44	26	16	~ 20	4
2	Series of Riffles	17	31	66	41	~ 64	13
3	Mouth of Beaver Creek	14	25	34	21	~ 175	36
4	Cochran Gulch	--	--	~30	19	~ 164	34
-	Miscellaneous	--	--	4	3	~ 64	13
	Total	55		~160		~ 487	

RAINBOW TROUT

AREA	LOCATION	1982 NUMBER OF REDDS	1982 PERCENT OF TOTAL	1983 NUMBER OF REDDS	1983 PERCENT OF TOTAL
1	Gravel Bar	34	25	78	15
2	Series of Riffles	61	45	198	38
3	Mouth of Beaver Creek	26	19	37	7
4	Cochran Gulch	9	7	125	24
-	Miscellaneous	7	5	90	17
		137		528	

TABLE 4.4-4

NUMBER, LENGTH, AND SEX RATIO OF SEXUALLY MATURE TROUT CAPTURED IN THE MISSOURI RIVER BELOW HAUSER DAM AND IN BEAVER CREEK, 1982-83

LOCATION	DATE	SEX	LENGTH (INCHES) MEAN	LENGTH (INCHES) RANGE	NUMBER OBSERVED	M/F SEX RATIO
BROWN TROUT						
Missouri River	1982	Male	21.7	(13.3-29.8)	110	1:2.3
		Female	20.0	(10.7-26.6)	257	
Missouri River	1983	Male	20.6	(10.9-27.7)	127	1:1.9
		Female	19.6	(12.6-28.4)	249	
Beaver Creek	1982	Male	11.7	(8.5-15.7)	35	1.2:1
		Female	11.3	(8.5-14.7)	30	
RAINBOW TROUT						
Missouri River	1982	Male	16.0	(9.2-24.8)	220	1.1:1
		Female	17.2	(11.7-20.3)	193	
Missouri River	1983	Male	16.4	(9.7-21.6)	471	1.1:1
		Female	17.2	(13.2-21.4)	429	
Beaver Creek[a]	1982	Male	14.4	(6.6-23.3)	214	2.5:1
		Female	17.4	(9.7-23.1)	84	
Beaver Creek[b]	1982	Male	15.5	(9.8-23.3)	163	2.0:1
		Female	17.4	(9.8-23.1)	82	
Beaver Creek[b]	1983	Male	15.9	(9.8-20.7)	318	1:1
		Female	17.0	(10.0-19.8)	313	

[a]Residents and river migrants

[b]River migrants only

TABLE 4.4-5

MEAN AND RANGE OF REDD DEPTHS AND VELOCITIES
SELECTED BY BROWN (N=170) AND RAINBOW (N=249) TROUT, MISSOURI RIVER

BROWN TROUT (1981-1983)

	DEPTH	MEAN VELOCITY	POINT VELOCITY
Mean	2.10 ft (64.0 cm)	2.49 ft (0.76 mps)	0.95 fps (0.29 mps)
Range	0.80 to 3.90 ft (24.4 to 118.9 cm)	1.07 to 4.60 fps (0.33 to 1.40 mps)	0.00 to 2.20 fps (0.00 to 0.67 mps)

RAINBOW TROUT (1982 & 1983)

	DEPTH	MEAN VELOCITY	POINT VELOCITY
Mean	2.19 ft (66.8 cm)	2.31 fps (0.70 mps)	0.84 fps (0.26 mps)
Range	0.80 to 4.70 ft (24.4 to 143.3 cm)	0.30 to 4.50 fps (0.09 to 1.37 mps)	0.00 to 2.30 fps (0.00 to 0.70 mps)

TABLE 4.4-6

PHYSICAL AND HYDRAULIC PARAMETERS OF BROWN TROUT REDDS IN THE MISSOURI RIVER BELOW HAUSER DAM, 1981-83.

		1981		1982		1983	
AREA		MEAN	NUMBER	MEAN	NUMBER	MEAN	NUMBER
1	Depth (ft)	1.66	24	2.10	26	2.34	6
	Mean Velocity (fps)	3.07	24	3.26	26	2.75	6
	Point Velocity (fps)	1.21	24	1.20	26	0.84	6
	Redd Area (ft^2)	33.12	21	27.65	9	10.17	1
	Distance to Shore (ft)	25.60	24	27.03	26	14.82	3
2	Depth (ft)	1.73	17	2.36	51	2.34	7
	Mean Velocity (fps)	1.75	17	2.23	51	2.23	7
	Point Velocity (fps)	0.64	17	0.81	51	0.68	7
	Redd Area (ft^2)	21.10	16	16.53	22	7.27	2
	Distance to Shore (ft)	28.90	15	25.50	46	22.00	5
3	Depth (ft)	1.71	14	2.20	19	2.80	2
	Mean Velocity (fps)	2.13	14	2.45	19	2.75	2
	Point Velocity (fps)	0.83	14	1.19	19	0.58	2
	Redd Area (ft^2)	25.06	7	23.39	5	--	-
	Distance to Shore (ft)	19.70	14	19.70	14	26.90	2
Total[a]	Depth (ft)	1.70	55	2.27	98	2.40	17
	Mean Velocity (fps)	2.42	55	2.54	98	2.46	17
	Point Velocity (fps)	0.94	55	0.99	98	0.73	17
	Redd Area (ft^2)	27.44	44	20.23	36	7.98	5
	Distance to Shore (ft)	25.00	53	25.00	88	20.73	12

[a]Includes miscellaneous redds not in the three areas.

TABLE 4.4-7

MEAN AND RANGE OF REDD DEPTHS AND VELOCITIES
SELECTED BY BROWN (N=240) AND RAINBOW (N=169) TROUT IN BEAVER CREEK

BROWN TROUT (1981-82)

	DEPTH	MEAN VELOCITY	POINT VELOCITY
Mean	0.55 ft (16.8 cm)	1.61 fps (0.49 mps)	0.96 fps (0.29 mps)
Range	0.15 to 2.00 ft (4.60 to 61.0 cm)	0.20 to 3.40 fps (0.06 to 1.04 mps)	0.00 to 2.20 fps (0.00 to 0.67 mps)

RAINBOW TROUT (1982-83)

	DEPTH	MEAN VELOCITY	POINT VELOCITY
Mean	0.74 ft (22.6 cm)	2.38 fps (0.72 cm)	1.38 fps (0.42 mps)
Range	0.35 to 1.35 ft (10.7 to 41.1 cm)	0.65 to 3.98 fps (0.20 to 1.19 mps)	0.10 to 2.75 fps (0.03 to 0.84 fps)

TABLE 4.4-8

PHYSICAL AND HYDRAULIC PARAMETERS OF RAINBOW TROUT REDDS IN THE MISSOURI RIVER BELOW HAUSER DAM, 1982-1983

AREA		1982 MEAN	1982 NUMBER	1983 MEAN	1983 NUMBER
1	Depth (ft)	1.93	32	1.66	17
	Mean Velocity (fps)	2.80	32	2.37	17
	Point Velocity (fps)	1.03	32	1.00	17
	Redd Area (ft^2)	16.35	20	--	--
	Distance to Shore (ft)	23.82	30	24.97	17
2	Depth (ft)	2.43	61	24.3	63
	Mean Velocity (fps)	1.97	61	1.92	63
	Point Velocity (fps)	0.67	61	0.65	63
	Redd Area (ft^2)	14.63	51	10.01	18
	Distance to Shore (ft)	17.55	59	21.36	63
3	Depth (ft)	2.11	26	1.84	9
	Mean Velocity (fps)	3.14	26	2.87	9
	Point Velocity (fps)	1.04	25	1.36	9
	Redd Area (ft^2)	16.25	20	15.36	2
	Distance to Shore (ft)	23.06	12	17.39	9
Total[a]					
	Depth (ft)	2.16	135	2.21	115
	Mean Velocity (fps)	2.42	135	2.17	115
	Point Velocity (fps)	0.86	134	0.82	115
	Redd Area (ft^2)	15.71	107	10.49	23
	Distance to Shore (ft)	20.10	116	22.3	116

[a] Includes miscellaneous redds not in the 3 areas.

TABLE 4.4-9

ESTIMATED DATES OF HATCHING FOR BROWN AND RAINBOW TROUT IN THE MISSOURI RIVER BELOW HAUSER DAM.

DATE OF SPAWNING	# TEMP. UNITS (TU) OR DAYS	HATCHING DATE	PREDICTED SOURCE
	BROWN TROUT (1981-82)		
27 October	800 TU	26 January	Leitritz & Lewis (1976)
	95 days	30 January	Carlander (1969)
	100 days	4 February	Leitritz & Lewis (1976)
22 December	120 days	21 April	Carlander (1969)
	600 TU	23 April	Leitritz & Lewis (1976)
	122 days	23 April	Leitritz & Lewis (1976)
	RAINBOW TROUT (1982)		
30 March	67 days	4 June	Leitritz & Lewis (1976)
	634 TU	31 May	Leitritz & Lewis (1976)
	65 days	2 June	Carlander (1969)
1 June	27 days	27 June	Carlander (1969)
	555 TU	28 June	Leitritz & Lewis (1976)
	28 days	28 June	Leitritz & Lewis (1976)

TABLE 4.5-1

MEAN LENGTH AND LENGTH RANGE OF YOY BROWN AND RAINBOW TROUT CAPTURED IN THE MISSOURI RIVER BELOW HAUSER DAM; 1982 and 1983.

SPECIES	YEAR	N	LENGTH (inches)	RANGE (inches)
Brown Trout	1982	389	2.6	1.0-6.2
	1983	993	2.4	1.0-6.1
Rainbow Trout	1982	1,472	2.1	0.9-6.1
	1983	2,636	2.3	0.9-5.4

TABLE 4.5-2

MOVEMENT OF MARKED YOY BROWN AND RAINBOW TROUT IN THE MISSOURI RIVER BELOW HAUSER DAM: JUNE TO NOVEMBER, 1983.

Species	Upper Section[a]			Middle Section[b]			Lower Section[c]		
	Number Marked	Recaptures From: Upper Section	Recaptures From: Middle Section	Number Marked	Recaptures From: Upper Section	Recaptures From: Middle Section	Number Marked	Recaptures From: Upper Section	Recaptures From: Middle Section
Brown Trout	243	49	2	193	2	31	194	3	1
Rainbow Trout	932	195	0	294	0	61	381	0	1

[a] Sampling Stations 1, 2, 8, 9, 10, 11

[b] Sampling Stations 3, 4, 12, 13

[c] Sampling Stations 5, 6, 7, 14

TABLE 4.5-3

CATCH STATISTICS FOR TROUT EMIGRATING FROM BEAVER CREEK INTO THE MISSOURI RIVER: 19 JUNE TO 27 AUGUST, 1983.

	NUMBER CAPTURED	
SPECIES	YOY	AGE I AND OLDER
Rainbow Trout	6,254	439
Brown Trout	14	1
Cutthroat Trout	0	33
Brook Trout	0	1

Rehwinkel, B. J. 1981. Inventory and survey of the waters of the Jefferson and Missouri River Drainages. Fed. Aid Proj. F-9-R-28, Job no. I-d. Montana Dept. of Fish, Wildlife, and Parks, Helena. 16 pp.

__________. 1982. Inventory and survey of the waters of the Jefferson and Missouri River Drainages. Fed. Aid Proj. F-9-R-29, Job no. I-d. Montana Dept. of Fish, Wildlife, and Parks, Helena. 19 pp.

Rehwinkel, B. J. and E. R. Vincent. 1981. Inventory and survey of the waters of the Gallatin and Madison Drainages. Fed. Aid Proj. F-9-R-28, Job. no. I-a. Montana Dept. of Fish, Wildlife, and Parks, Helena. 13 pp.

Reiser, D. W. 1981. Effects of streamflow reduction, flow fluctuation, and flow cessation on salmonid egg incubation and fry quality. Ph. D. Thesis, Univ. of Idaho, Moscow. 236 pp.

Reiser, D. W. and T. A. Wesche. 1977. Determination if physical and hydraulic preferences of brown and brook trout in the selection of spawning locations. Water Resources Series No. 64. Water Resources Research Institute, Univ. of Wyoming, Larmamie. 112 pp.

Reiser, D. W. and R. G. White. 1981a. Effects of flow fluctuation and redd dewatering on salmonid embryo development and fry quality. Research Technical Completion Report, Idaho Water and Energy Resources Institute, Moscow, Idaho. 88 pp.

__________. 1981b. Influence of streamflow reductions on salmonid embryo development and fry quality. Research Technical Report, Idaho Water and Energy Resources Institute, Moscwo, Idaho. 154 pp.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. 191, Dept. of the Environment, Fisheries and Marine Service. Ottawa, Canada. 382 pp.

Robins, C. R. et al. 1980. A list of common and scientific names of fishes from the United States and Canada, 4 ed. Special Publication No. 12, American Fisheries Society. Bethesda, Maryland. 174 pp.

Sando, S. K. 1981. The spawning and rearing habitats of rainbow trout and brown trout in two rivers in Montana. Master's Thesis. Montana State University, Bozeman, Montana. 66 pp.

Scott, W. B. and E. J. Crossman. 1973. Freshwater fishes of Canada. Bulletin 184, Fish. Res. Bd. Can., Ottawa, Canada. 966 pp.

Stober, Q. J., S. C. Crumley, D. E. Fast, E. S. Killibrew, R. Woodin, G. Engman and G. Tutmark. 1982. Effects of hydroelectric discharge fluctuation on salmon and steelhead in the Skagit River, Washington. Final Report, Fisheries Research Institute, University of Washington, to Seattle Department of Lighting. FRI-UW-8218. 202 p.

Stuart, T. A. 1953. Spawning migration, reproduction and young stages of the loch trout (S. trutta). Fresh. and Sal. Fish. Res. Home Dept., Scotland. Rept. no. 5. 39 pp.

Vincent, E. R. 1971. River electrofishing and fish population estimates. Prog. Fish. Cult. 33(3):163-167.

__________. 1974. Addendum to river electrofishing and fish population estimates. Prog. Fish. Cult. 36(3):182.

Vincent, E. R. and C. G. Clancey. 1980. Fishing regulation evaluation on major trout waters. Fed. Aid Proj. F-9-R-28, Job no. II-c. Montana Dept. of Fish, Wildlife, and Parks, Helena. 13 pp.

Welch, P. S. 1948. Limnological methods. McGraw-Hill Book Co., New York. 382 pp.

Wells, J. D. and J. Decker-Hess. 1981. Inventory and survey of the waters of the Big Hole and Beaverhead Drainages. Fed. Aid Proj. F-9-R-28, Job no. I-b. Montana Dept. of Fish, Wildlife, and Parks, Helena. 35 pp.

Wickett, W. P. 1954. The oxygen supply to salmon eggs in spawning beds. Jour. Fish. Res. Bd. Can. 11(6):933-953.

Williams, T. and B. C. Bedford. 1973. The use of otoliths for age determination. Pages 114-123 in T. B. Bagenal, editor. International symposium on the aging of fish. Univ. of Reading, England.

Witty, K. and K. Thompson. 1974. Fish stranding surveys. Pages 113-120 in K. Bayha and C. Koski, editors. Anatomy of a river. Pacific Northwest River Basins Commission, Vancouver, Washington.

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