IS-65

MISSOURI RIVER FLOW STUDY

Holter Dam to Smith River

by

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Ecological Services and Fisheries Divisions
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PREFACE

The Montana Department of Fish, Wildlife and Parks (DFWP) under provisions of an act passed by the 1969 Montana Legislature filed for instream water rights for purposes of preserving fish and wildlife habitat in a 61.5 mile reach of the Missouri River from Holter Dam to the confluence of the Smith River. To conform with requirements of Senate Bill 76, which provides for statewide adjudication of water rights, the DFWP must refile on all water rights in existence prior to July 1, 1973.

This study was initiated to quantify the rights of the DFWP in the previously described reach of the Missouri River. The principal source of funding was from DJ sponsored Project Number FW-3-R-10. Supplemental funding was provided for this effort by Bureau of Land Management Contract Number MT 950-RFP0-40. This report is intended to satisfy the BLM contract requirements.

The Montana Department of Fish, Wildlife and Parks (DFWP) under provisions of an act passed by the 1969 Montana Legislature filed for instream water rights for purposes of preserving fish and wildlife habitat in the 61.5-mile reach of the Missouri River from Holter Dam to the confluence of the Smith River. The DFWP filed on December 17, 1970 for the amount listed below:

Time Period	Amount (cfs)
January 1 through December 31	3000

This reach of the Missouri River is classified "Blue Ribbon" in recognition of its high recreational, fishery and aesthetic values. This is one of the longest single reaches of blue ribbon trout stream in Montana, and it represents 14 percent of the state's original 452 miles of blue ribbon water. An excellent fishery exists in this area for trophy-sized rainbow and brown trout. Angling pressure was estimated at 1,130 angler days per river mile during the 1975-76 fishing season, making this reach of the Missouri River one of the most heavily utilized recreational river fisheries in Montana.

Recent advances in the development of instream flow methodologies have enabled the DFWP to more accurately define the flows needed to maintain the high quality trout fishery of this reach of river at the existing level. The monthly flow recommendations derived from these methodologies exceed the original filing for all months. For adjudication purposes, the final claim submitted by the DFWP can be less than, but not exceed, the original filing of December 17, 1970. Consequently, the final claim of the DFWP is the same as originally filed. This claim amounts to 2,171,385 acre-feet of water per year or about 55.4 percent of the annual volume of water that is normally available at the USGS gauging site below Holter Dam.

The instream flow methodologies, flow recommendations and other background information are thoroughly discussed in the following section.

1. RIVER

Missouri River (Holter Dam to confluence of Smith River)

2. BACKGROUND AND GENERAL DESCRIPTION

The Missouri is the nation's longest river, 2,475 miles in length from its origin at Three Forks, Montana, to its confluence with the Mississippi River near St. Louis, Missouri. Most of the Missouri River has been impounded by dams and reservoirs. The river segment covered by this claim represents one of the last free-flowing reaches of the entire river. This reach lies in north central Montana and extends from Holter Dam to the confluence of the Smith River, a distance of 61.5 river miles. Stream gradient averages 2.04 ft/mi and varies from 7.84 ft/mi at Halfbreed Rapids to 0.52 ft/mi near Ulm. Stream substrate is predominately sand and gravel.

The principal tributaries entering the Missouri River in this reach are the Dearborn and Smith rivers and Little Prickly Pear, Sheep, Rock, Stickney, Hardy and Wegner creeks. The tributaries add considerable flow to the Missouri during spring runoff, but they contribute very little flow during the remainder of the year.

The river flows in a northeasterly direction through two distinct geologic zones in this reach. From Holter Dam to the confluence of Sheep Creek, a distance of 24.1 miles, the river flows through a mountain canyon having an average width of about 3,000 feet. The Big Belt Mountains lie to the southeast, while the east front of the Rocky Mountains lies to the northwest. A narrow band of riparian vegetation consisting primarily of willow and some cottonwood lies along the river banks. Several brushy islands surrounded by extensive side channels are found in this area. Below the confluence of Sheep Creek, the river abruptly leaves the mountain area and meanders through a wide and generally flat prairie zone. The upper portion of this zone, from Sheep Creek to Cascade, is characterized by well defined pools and riffles with some large brushy islands and side channels. The lower segment of the prairie zone, from Cascade to the confluence of the Smith River, is characterized by a deep meandering channel with very few riffles. Extensive growths of riparian vegetation are found on the floodplain throughout most of the prairie zone.

The drainage area of the Missouri River increases from 17,149 square miles to 20,941 square miles, or by about 22 percent, between Holter Dam and the confluence of the Smith River (USGS 1979). The climate is characterized by moderately low rainfall, a dry atmosphere, hot summers, cold winters and a large proportion of sunny days.

Streamflow is monitored by the USGS at gauges located 0.4 miles downstream from Holter Dam (Holter Dam gauge) and 9.1 miles downstream from the confluence of the Smith River (Ulm gauge). Mean annual discharge for a 33-year period of record at Holter Dam is 4,051,000 acre-feet/year compared to 4,938,000 acre-feet/year for a 21-year period of record at the Ulm gauge (USGS 1978). The maximum flow recorded at Holter Dam was 34,800 cfs on June 8, 1948, while the maximum at Ulm was 27,500 cfs on June 22, 1964. The higher maximum flow at Holter Dam is related to the longer period of flow record.

Present day flow regimens of the Missouri River are not entirely natural because of regulation and storage at several dams in the drainage upstream from the study area. Flow is largely controlled by Canyon Ferry Reservoir, the largest of three consecutive upstream reservoirs. Canyon Ferry was completed in 1953, and it is operated by the U.S. Bureau of Reclamation for irrigation, hydropower, flood control, recreation and supplemental water supply for the city of Helena. Canyon Ferry has a surface area of 35,200 acres and a storage capacity of 2,051,000 acre-feet. Hauser and Holter reservoirs lie downstream of Canyon Ferry Dam and provide head for power generation. Hauser and Holter Dams are owned and operated by Montana Power Company.

A 1969 state law (Chapter 345, Laws of 1969) authorized the Montana Department of Fish, Wildlife and Parks (DFWP) to appropriate water for instream uses on 12 high quality trout streams in the state. For the 61.5-mile reach of the Missouri River from Holter Dam (T14N, R3W, Sec. 8) to the confluence of the Smith River (T19N, R2E, Sec. 9) the DFWP filed a claim for 3,000 cfs from January 1 through December 31.

When the claim was originally filed, this 61.5-mile reach of river was subidvided by county into two separate sections from the mouth of the Smith River to the Cascade County-Lewis and Clark County lines and from the Lewis and Clark County-Cascade County lines to Holter Dam (see attached filings). The claim was recorded in Cascade County on December 17, 1970 and in Lewis and Clark County on December 21, 1970. For purposes of adjudication, the DFWP is combining these two sections and claiming December 17, 1970, the earlier date, as the priority date.

3. THE FISHERY

The 61.5-mile reach of the Missouri River from Holter Dam to the confluence of the Smith River is classified by the Montana Fish and Game Commission as a blue ribbon trout fishery (Brown et al. 1959). This is one of the longest single reaches of blue ribbon trout stream in Montana, and it represents 14 percent of the state's original 452 miles of blue ribbon water. An excellent fishery exists in this area for trophy-sized rainbow and brown trout. Many trout from 5 to 10 pounds are taken by anglers each year as well as a good number of trout larger than 10 pounds. Fish larger than 10 pounds are predominately brown trout. Mountain whitefish are several times more abundant than trout and provide an important winter fishery. A few burbot and walleye are found in the river, however they are not nearly as abundant as trout and whitefish. Longnose and white suckers, carp, longnose dace and mottled sculpin are the prevalent nongame species.

A creel survey conducted from April through October, 1980, on the sport fishery of the Missouri River indicated anglers caught 0.36 rainbow trout per man-hour (trout/hr) and 0.02 brown trout/hr (Berg 1981 b). The catch rate ranged from a low of 0.21 trout/hr during the runoff peak in June to a high of 0.77 trout/hr in August. Boat fishermen caught 0.90 trout/hr while bank fishermen caught 0.31 trout/hr. Other fish species taken in the creel in 1980 included mountain whitefish, brook trout, cutthroat trout, walleye, yellow perch, burbot, longnose and white suckers and carp. About 65 percent of the anglers interviewed in 1980 were from Great Falls, 27 percent were from other parts of Montana, and 8 percent were from out-of-state.

An estimate of statewide fishing pressure was compiled for the 1975-76 fishing season by the Montana Department of Fish and Game (MDFG 1976). Results of the survey indicated about 69,500 angler days were expended on the 61.5-mile reach of the Missouri River from Holter Dam to the confluence of the Smith River. This amounts to an average of 1,130 angler days per river mile. By comparison, fishing pressure on 102 miles of the Madison River averaged 957 angler days per river mile during the same fishing season. The Madison is regarded as one of Montana's premier trout rivers.

Access to the Missouri River between Holter Dam and the Smith River is very good. There are several public access areas along the upper half of the river. Old U.S. Highway 91, now designated as a recreation road, parallels considerable portions of the river and also provides easy access. River flow is always good for floating, and many recreationists take advantage of this sport. The outstanding scenery and fishing add to the enjoyment of this activity.

4. WATERFOWL

Many species of waterfowl are seasonally associated with the river. Mallards, mergansers, Canadian geese and teal nest along the river on islands, backwater

areas and sloughs. Some mallards, goldeneyes and geese spend the winter in ice-free areas along the river. During spring migration, the river is often an important resting area for thousands of pintails, mallards and other waterfowl enroute to northern nesting areas. Several species of shorebirds such as killdeer, snipe, phalarope and gulls are also seasonally associated with the river.

5. WILDLIFE

The extensive riparian vegetation along the lower half of the study section provides excellent habitat for many wildlife species. Large numbers of white-tailed deer, mule deer and ring-necked pheasant are found here year-round. Small patches of riparian vegetation along the river in the mountain canyon area also provide habitat for deer. Mink, muskrat, beaver, racoon and a few river otter are found throughout the reach. Bald eagles are often observed along the river corridor during the winter.

6. INSTREAM FLOW METHODOLOGIES

Recent advances in the development of instream flow methodologies have enabled the DFWP to more accurately define instream flow needs for rivers of the state. The purpose of the following section is to discuss instream flow methods the DFWP has applied to the reach of the Missouri River between Holter Dam and the confluence of the Smith River.

Instream flow methodologies for the Missouri River can be divided into two separate time periods. They consist of a relatively brief runoff or high flow period, when a large percentage of the annual water yield is passed by the river, and a low flow period which is characterized by relatively stable base flows. Separate flow recommendations are derived for each period.

Methods for High Flow Period

A. Dominant Discharge/Channel Morphology Concept

It is generally accepted that the major force in the establishment and maintenance of a particular channel form in view of its bed and bank material is the annual high flow characteristics of the river. It is the high spring flows that determine the shape of the channel rather than the average or low flows.

The major functions of the high spring flows in the maintenance of channel form are bedload movement and sediment transport. It is the movement of the bed and bank material and subsequent deposition which forms the mid-channel bars and, subsequently, the islands. High flows are capable of covering already established bars with finer material which leads successively to vegetated islands. Increased discharge associated with spring runoff also results in a flushing action which removes deposited sediments and maintains suitable gravel conditions for aquatic insect production, fish spawning and egg incubation.

Reducing the high spring flows beyond the point where the major amount of bedload and sediment is transported would interrupt the ongoing channel processes

and change the existing channel form and bottom substrates. A significantly altered channel would affect both the abundance and species composition of the present aquatic populations by altering the existing habitat types.

Several workers adhere to the concept that the form and configuration of river channels are shaped by and designed to accommodate a dominant discharge (Leopold, Wolman and Miller 1964, U.S. Bureau of Reclamation 1973, Emmett 1975). The discharge which is most commonly referred to as a dominant discharge is the bankful discharge (Leopold, Wolman and Miller 1964, Emmett 1975). Bankful discharge is defined as that flow when water just begins to overflow onto the active floodplain.

Bankful discharge tends to have a constant frequency of occurrence among rivers (Emmett 1975). The recurrence interval for bankful discharge was determined by Emmett (1975) to be 1.5 years and is in close agreement with the frequency of bankful discharge reported by other studies (Leopold, Wolman and Miller 1964, Emmett 1972). The bankful discharge for the Missouri River from Holter Dam to the confluence of the Smith River was approximated from flow records gathered at USGS gauge stations. This calculation indicated dominant discharge of the Missouri River from Holter Dam to the confluence of the Smith River is approximately 11,822 cfs.

It is not presently known how long the bankful flow must be maintained to accomplish the necessary channel formation processes. Until studies further clarify the necessary duration of the bankful discharge, a duration period of 24 hours was chosen.

B. Wild and Scenic Missouri River Paddlefish Migration Requirement

The reach of the Missouri River between Holter Dam and the confluence of the Smith River is located only 76 miles upstream from the Upper Missouri Wild and Scenic River which begins at Fort Benton, Montana, and it is the source of much of its water. As such, it is vital to secure and maintain flow in the Missouri River from Holter Dam to the Smith River to sustain fish populations in the Wild and Scenic segment.

Research studies indicate that paddlefish in the Wild and Scenic portion of the Missouri River require a flow of 14,000 cfs to initiate their annual spring migration to spawning sites (Berg 1981 a, Gardner and Berg 1981). Furthermore, flow should remain at or above 14,000 cfs for 48 consecutive days from May 19 through July 5 at the USGS gauge station located at Virgelle, Montana. This time period was selected because it satisfies the biological requirements of paddlefish. It also conforms to the time period when median flow historically reaches or exceeds 14,000 cfs at the Virgelle gauge. Median flow at the Virgelle gauge was computed by the USGS, Helena, for a 39-year period of record between water years 1940 and 1978.

The paddlefish is officially listed as a "Species of Special Concern-Class A" in Montana (Holton 1980), and only six major self-sustaining populations remain in the United States. For this reason, every effort should be made to preserve a flow of 14,000 cfs in the Wild and Scenic portion of the Missouri River so the paddlefish migration can continue to occur, and the species can survive.

Based on calculations made from USGS data gathered at the Virgelle and Holter Dam gauge stations, it was determined that the Missouri River at Holter Dam contributes 45.7 percent of the median flow of the Missouri River at Virgelle. Therefore, to maintain the annual spring paddlefish migration in the Wild and Scenic portion of the Missouri River it is recommended that flow of the Missouri River at the Holter Dam gauge be maintained at 45.7 percent of 14,000 cfs, or 6,398 cfs, for 48 consecutive days from May 19 through July 5.

Methods for Low Flow Period

A. Wetted Perimeter/Inflection Point Method

Flow recommendations during this time period are based, in part, on the wetted perimeter/inflection point method. Wetted perimeter is the distance along the bottom and sides of a channel cross-section in contact with water. As the flow in the stream channel decreases, the wetted perimeter also decreases, but the rate of loss of wetted perimeter is not constant throughout the entire range of flows. There is a point, called an inflection point, on the plot of wetted perimeter versus flow at which the rate of loss of wetted perimeter is significantly changed. Above the inflection point, large changes in flow cause only very small changes in wetted perimeter. Below the inflection point, the river begins to pull away from the riffle bottom, exposing the bottom at an accelerated rate. The flow recommendation is selected at or beyond this inflection point.

The maintenance of suitable flows in riffles is essential for the well-being of trout populations since the production of aquatic invertebrates, the principal food of trout, primarily occurs in riffle areas (Hynes 1970). Aquatic insects comprise the bulk of the diet of rainbow trout in the Missouri River from Holter Dam to the confluence of the Smith River (Berg 1981 b). If flows in the Missouri River were reduced below the inflection point, the riffle bottom would be exposed at an accelerated rate, and the area available for trout food production would be greatly diminshed.

Riffles are also the area of a stream most affected by flow reductions (Bovee 1974, Nelson 1977). Consequently, the maintenance of suitable riffle conditions for food production will also maintain suitable conditions in pools and runs, areas normally inhabited by adult trout. Because riffles are the habitat most affected by flow reductions and are essential for the well-being of trout populations, they should receive a high priority for instream flow protection.

The wetted perimeter/inflection point method was applied to 22 riffle transects located in six typical riffles of the Missouri River between Holter Dam and the confluence of the Smith River in 1980. Wetted perimeter-flow relationships for the riffle areas were derived using a wetted perimeter predictive (WETP) computer program developed in 1980 by the Montana Department of Fish, Wildlife and Parks (Nelson 1980). The WETP program was calibrated to field data collected at flows of 7,110, 5,500, 3,100 and 2,700 cfs. The inflection point on the wetted perimeter-discharge relationship occurs at 2,900 cfs for 17 of the 22 riffles (Figures 1-3). Therefore, 2,900 cfs is the flow recommended to maintain wetted perimeter of the riffles at the inflection point.

B.. Missouri River Trout Spawning and Rearing Requirement

The best method of determining instream flow needs for fish is to derive flow recommendations based on field study of the biological requirements of key fish species. Rainbow and brown trout are the most important game fish in the Missouri River between Holter Dam and the confluence of the Smith River, and they comprise the bulk of the sport fishery.

Research studies conducted in 1980 and 1981 indicated that side channels of the Missouri River are vital for rearing of young-of-the-year (YOY) rainbow and brown trout from early July through mid-October (Berg 1981 b). For comparable habitats YOY trout were substantially more abundant in side channels than in the main channel. In riffle-run brush borders, the most common trout rearing habitat type in the Missouri River, a composite average of 1.59 YOY trout per electrofishing minute* (trout/min) were sampled in side channels compared to only 0.61 YOY trout/min in the main channel. In rock borders, another common trout rearing habitat type, a composite average of 2.04 YOY trout/min were sampled in side channels, while only 1.37 YOY trout/min were found in the main channel.

Rearing studies were continued in side channels of the Missouri River until early November 1980. The average catch rate in the side channels declined from 2.29 YOY trout/min in August to 2.12 YOY trout/min in early October, a reduction of only 0.17 YOY trout/min during this time period. In early November the catch rate in the side channels declined significantly to an average of only 0.38 YOY trout/min, indicating that a large number of YOY trout had moved from the side channels to the main channel. In summary, field data indicates that side channels are vital for trout rearing from early July until about mid-October.

Research studies also indicate that side channels of the Missouri River are vital for brown trout spawning and incubation from mid-October through early May (Berg 1981 b). The Missouri River was searched extensively in the fall of 1980 for brown trout spawning activity, and a total of 38 brown trout redds were located. Although equal effort was spent searching main channel and side channel areas of the river, 84 percent of the redds were found in side channels. The preference of side channels for brown trout spawning is apparently related to more suitable depth, velocity, substrate and adjacent cover characteristics in the side channels.

Brown trout initiated spawning in side channels of the Missouri River in about mid-October 1980. Spawning peaked in early November, and the incubation period for brown trout eggs extended through late April and early May. Rainbow trout spawned in side channels in late March and early April and some eggs incubated until mid-May. Based on these considerations, adequate flow must be maintained in side channels for trout spawning and incubation from mid-October through mid-May.

Eleven side channels of the Missouri River between Holter Dam and the confluence of the Smith River were intensively studied in 1980 and 1981 to evaluate the amount of flow required to maintain suitable conditions in the side channels for rainbow and brown trout spawning, incubation and rearing. Habitat

*An electrofishing minute is a standard scientific unit of measurement used in fish population surveys.

conditions (mean channel depth, water velocity and flow) were very good, and trout utilization of side channels for spawning and rearing remained consistently high when flows were 4,000 cfs or higher in the Missouri River. However, habitat conditions and utilization of the side channels for spawning and rearing declined precipitously when flows receded below 4,000 cfs. At a flow of 4,100 cfs, 64 percent of the side channels contained adequate flow for trout spawning, incubation and rearing, while at 3,600 cfs only 9 percent of the side channels contained adequate flow.

Thus, based on research information gathered from the Missouri River, in 1980 and 1981, a flow of 4,000 cfs is recommended to maintain suitable conditions in side channels for trout spawning, incubation and rearing. Flow must remain at 4,000 cfs or higher from the inception of trout rearing in early July through the end of the rainbow trout incubation period in mid-May.

C. Summary of Methods for the Low Flow Period

As described above, a flow of 2,900 cfs is required to maintain wetted perimeter of riffles in the Missouri River at the inflection point. However, a flow of 4,000 cfs is required to maintain suitable conditions for trout spawning, incubation and rearing in side channels. Since the flow required to maintain side channels supercedes the flow requirement to maintain wetted perimeter of riffle areas, a flow of 4,000 cfs is recommended for the low flow period from early July through mid-May. This flow maintains adequate wetted perimeter of riffle areas for trout food production as well as suitable conditions in side channels for trout spawning, incubation and rearing.

7. FLOW RECOMMENDATIONS

Flow recommendations derived from the methodologies described above are shown in Table 1. These are the flow levels that are needed to maintain the blue ribbon trout fishery of the Missouri River from Holter Dam to the confluence of the Smith River at its existing level. For adjudication purposes, these recommendations must be adjusted to the constraints imposed by the original instream filing of December 17, 1970. This adjustment is necessary because the final claim can be less than, but not exceed, the original filing. The recommended flows exceed the original claim for all months. Consequently, the final instream flow claim of the DFWP is the same as originally filed.

The final claim is compared to the median monthly flows of record, as derived from USGS flow records for the gauge below Holter Dam, in Table 2. The median provides a measure of water availability during a normal or typical water year. The median is the flow that is exceeded in 5 of 10 years or, in other terms, in 5 years out of 10 there is more water than the median flowing in the river. Table 2 shows that the final claim is less than the median flow for all months.

The final claim amounts to 2,171,385 acre-feet of water per year or about 55.4 percent of the annual volume of water that is normally available at the USGS gauging site below Holter Dam (Table 2).

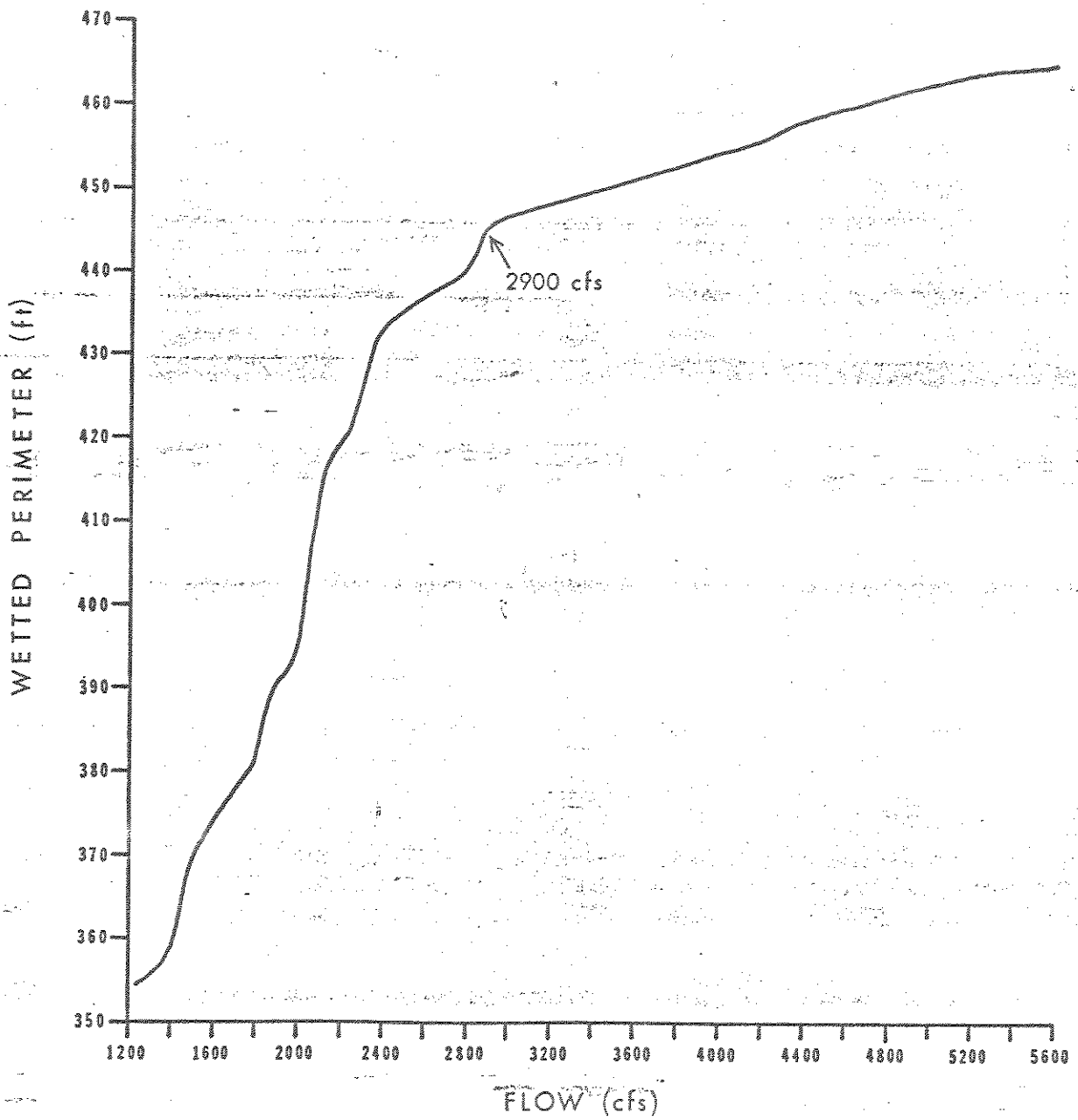

Figure 1. Wetted perimeter-discharge relationship for a composite of nine riffle transects located on the Missouri River near Craig.

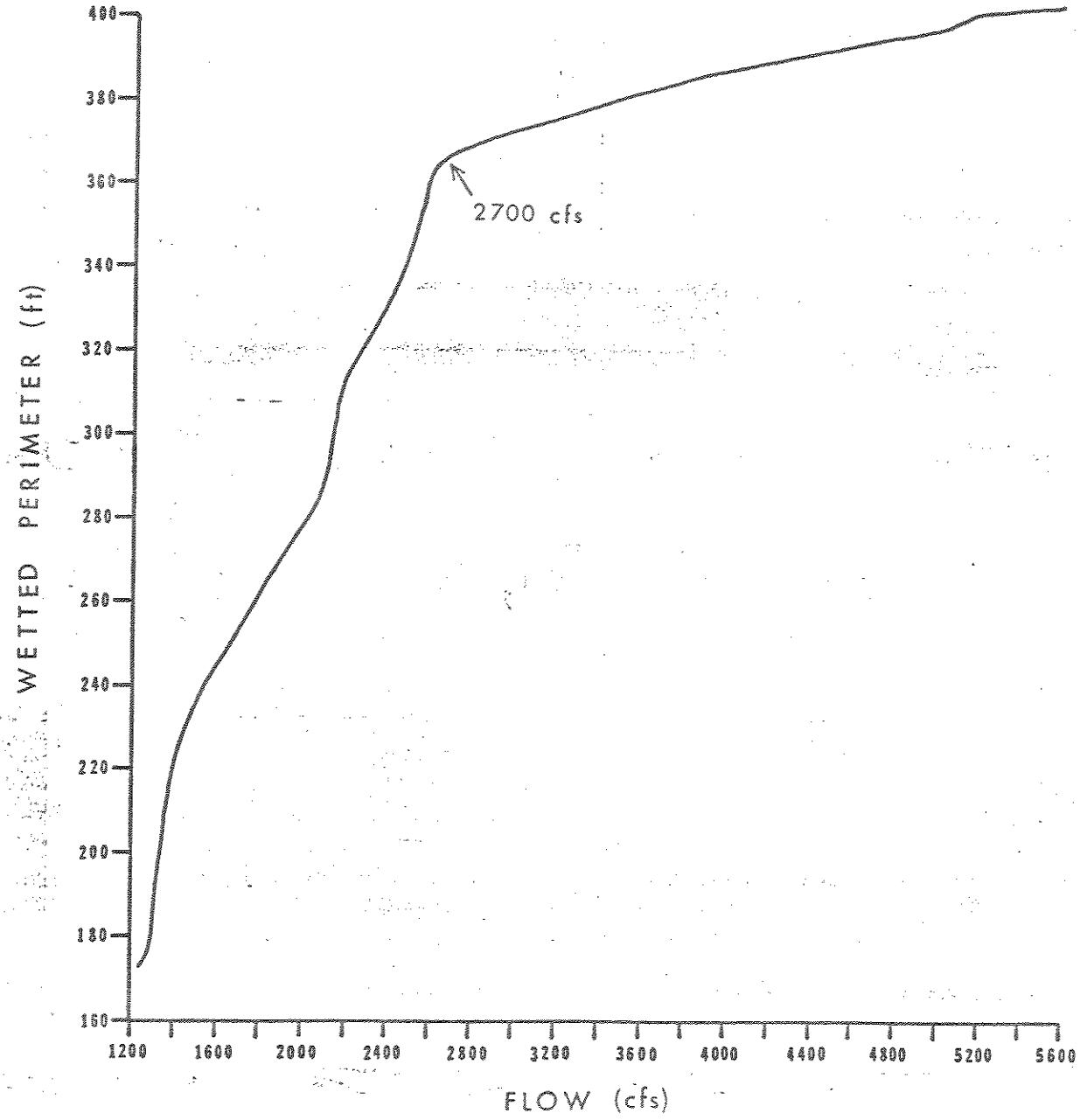

Figure 2. Wetted perimeter-discharge relationship for a composite of five riffle transects located on the Missouri River near Hardy.

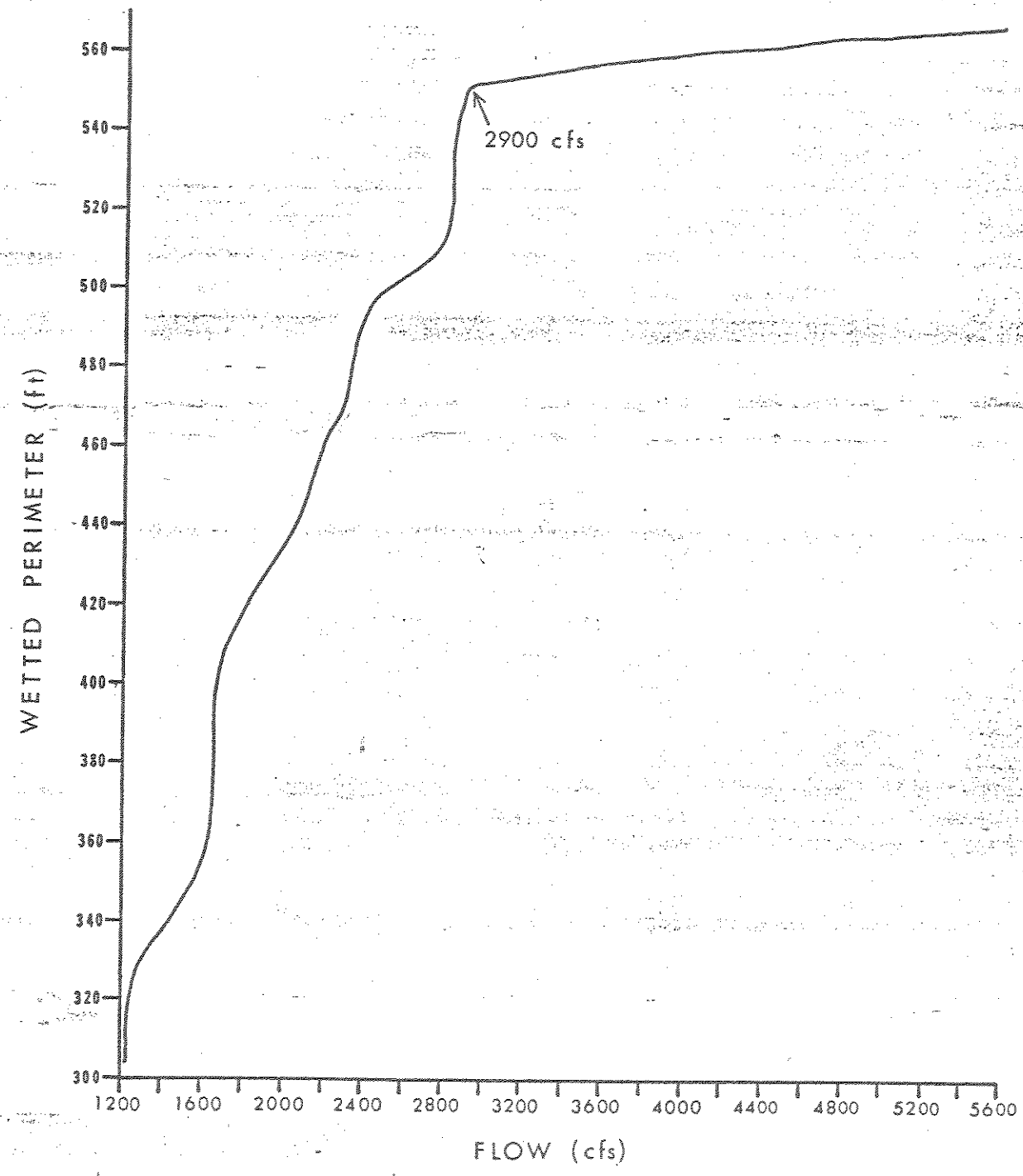

Figure 3. Wetted perimeter-discharge relationship for a composite of eight riffle transects located on the Missouri River near Cascade.

Table 1. Monthly flow recommendations for the Missouri River (from Holter Dam to the confluence of the Smith River) compared to the original filing of December 17, 1970 and the final claim.

Time Period	Flow Recommendations (cfs)[a/]	Original Filing (cfs)[b/]	Final Claim (cfs)[c/]
January	4,000	3,000	3,000
February	4,000	3,000	3,000
March	4,000	3,000	3,000
April	4,000	3,000	3,000
May 1-18	4,000	3,000	3,000
May 19-31	6,398	3,000	3,000
June 1-30	6,398[d/]	3,000	3,000
July 1-5	6,398	3,000	3,000
July 6-31	4,000	3,000	3,000
August	4,000	3,000	3,000
September	4,000	3,000	3,000
October	4,000	3,000	3,000
November	4,000	3,000	3,000
December	4,000	3,000	3,000

a/ Derived from the dominant discharge/channel morphology concept, the Wild and Scenic Missouri River paddlefish migration requirement, the wetted perimeter/inflection point method, and the Missouri River trout spawning and rearing requirement.

b/ Flows as originally filed on December 17, 1970.

c/ Derived by adjusting the flow recommendations to the constraints imposed by the original instream filing of December 17, 1970.

d/ Includes a flow of 11,822 cfs (the approximate bankful discharge) for 24 hours.

Table 2. Comparison of the final instream flow claim for the Missouri River (from Holter Dam to the confluence of the Smith River) to the approximate median flows of record.

Time Period	Final Claim		Approximate Median Flows[a/]	
	cfs	Acre-Feet	cfs	Acre-Feet
January	3,000	184,419	5,400	331,954
February	3,000	166,572	5,230	290,391
March	3,000	184,419	4,990	306,750
April	3,000	178,470	5,700	339,093
May 1-8	3,000	107,082	6,313	225,336
May 19-31	3,000	77,337	6,740	173,750
June 1-30	3,000	178,470	8,920	530,651
July 1-5	3,000	29,745	8,546	84,734
July 6-31	3,000	154,674	4,799	247,427
August	3,000	184,419	4,090	251,425
September	3,000	178,470	4,230	251,643
October	3,000	184,419	4,550	279,702
November	3,000	178,470	4,810	286,147
December	3,000	184,419	5,260	323,348
		2,171,385		3,922,351

a/ Derived for a 29-year period of record (between water years 1952 and 1980) for the USGS gauge station below Holter Dam.

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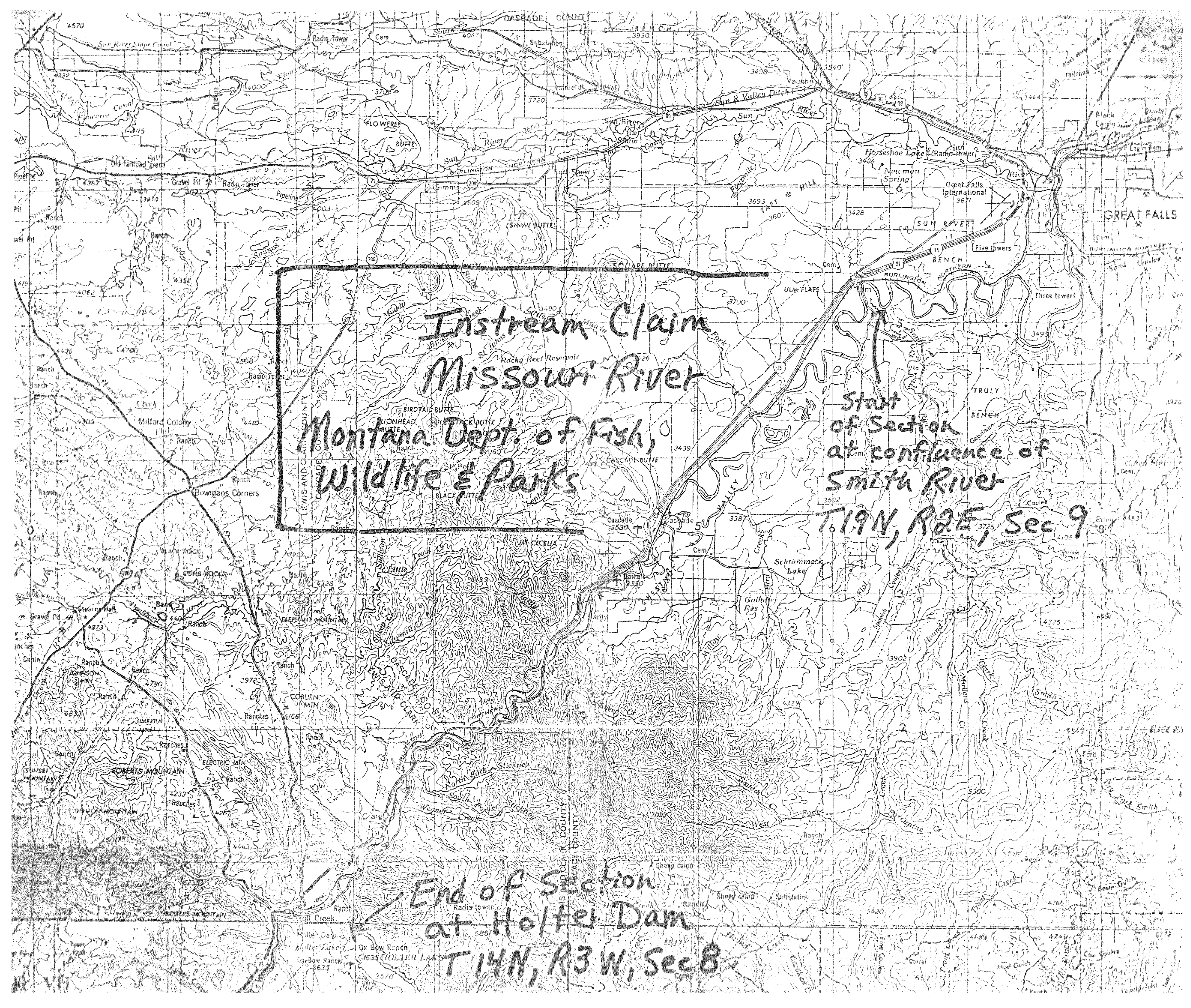

Instream Claim
Missouri River
Montana Dept. of Fish, Wildlife & Parks
Start of Section at confluence of Smith River
T19N, R2E, Sec 9
End of Section at Holter Dam
T14N, R3W, Sec 8
GREAT FALLS
CASCADE COUNTY
LEWIS AND CLARK COUNTY

End of Section at Holter Dam
T 14N, R 3 W, Sec 8