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INSTREAM FLOW EVALUATION FOR SELECTED WATERWAYS IN WESTERN MONTANA

by

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INTRODUCTION

The purpose of this report is to provide the U.S. Forest Service with instream flow related information for 80 trout streams and rivers in western Montana. These streams are generally of mutual interest to both the Montana Department of Fish, Wildlife and Parks and the U.S. Forest Service due to their high fishery, recreational and other resource values.

Two types of basic instream flow information are provided. They consist of fish population data and a quantification, in terms of cubic feet of water per second, of the instream flows needed for maintaining the existing fishery resource. Other pertinent background and descriptive information for the streams of interest is also provided. In addition, the instream flow contributions of the tributaries to the Smith River are also quantified and discussed in relation to their importance in satisfying the instream water right of the MDFWP for the Smith River.

The 80 contract streams are organized in alphabetical order by river drainage. These drainages are:

Beaverhead and Red Rock
Big Hole
Flathead
Gallatin
Jefferson
Madison
Mainstem Missouri above Canyon Ferry Dam
Ruby
Smith
Yellowstone and Shields

The methodologies used in quantifying the instream flow needs, fish sampling techniques and other related information are thoroughly discussed in the following sections.

INSTREAM FLOW METHODOLOGIES

The best and most accurate method for determining the instream flow needs for fish and wildlife purposes is to derive the actual flow and biological relationships from long-term data collected in drought, normal and above normal water years. While this approach has been tried on a few selected waterways in Montana, it is not a practical means of deriving future recommendations due to the excessive time, cost and manpower required to collect field data. Consequently, flow recommendations for most waterways are derived from instream flow methods that are more compatible with existing budget and time constraints, yet provide acceptable and defendable recommendations.

The method of the MDFWP divides the annual flow cycle for the headwater streams and rivers into two separate periods. They consist of a relatively brief snow runoff or high flow period, when a large percentage of the annual water yield is passed through the system, and a nonrunoff or low flow period which is characterized by relatively stable base flows maintained primarily by groundwater outflow. For headwater rivers and streams, the high flow period generally includes the months of May, June and July while the remaining months (approximately August through April) encompass the low flow period.

Separate instream flow methodologies are applied to each period. Further, it is necessary to classify a waterway as a stream or river and to use a somewhat different approach when deriving low flow recommendations for each. A waterway is considered a stream if the mean annual flow is less than approximately 200 cfs. The vast majority of waterways discussed in later sections have mean annual flows less than 100 cfs.

Methodology for Low Flow Period - Streams

The methodology chosen for deriving low flow recommendations for headwater trout streams is primarily based on the assumption that the food supply is a major factor influencing a stream's carrying capacity (the numbers and pounds of trout that can be maintained indefinitely by the aquatic habitat). The principal food of both the juvenile and adult trout inhabiting the headwater streams of Montana is aquatic invertebrates which are primarily produced in the riffle areas of most streams. The methodology assumes that the trout carrying capacity is proportional to food production which in turn is proportional to the wetted perimeter in riffle areas. This method is a slightly modified version of the Washington Method (Collings, 1972 and 1974) which is based on the premise that the rearing of juvenile salmon is proportional to food production which in turn is proportional to the wetted perimeter in riffle areas. The Idaho Method (White and Cochnauer, 1975 and White, 1976) is also based on a similar premise.

Wetted perimeter is the distance along the bottom and sides of a channel cross-section in contact with water (Figure 1). 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. An example of a relationship between wetted perimeter and flow for a riffle cross-section is illustrated in Figure 2 .

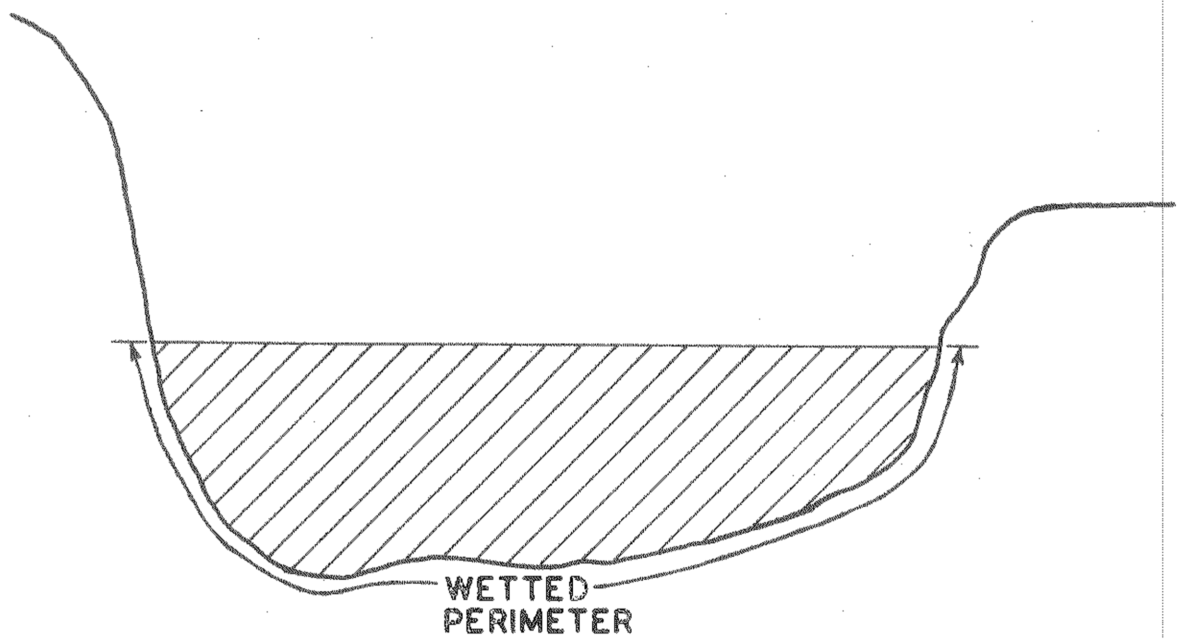


Figure 1. The wetted perimeter in a channel cross-section.

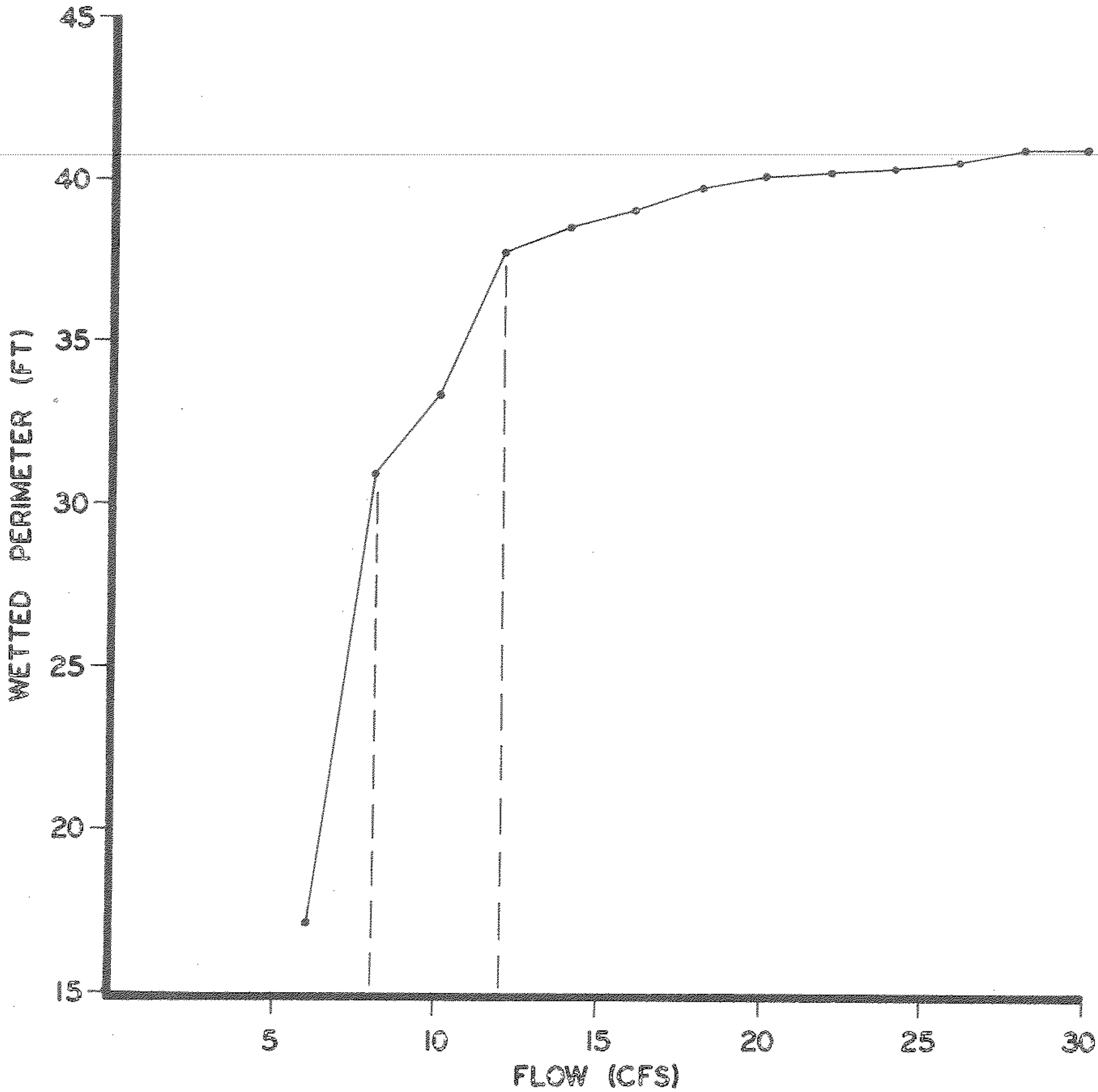


Figure 3. An example of a relationship between wetted perimeter and flow for a riffle cross-section.

There are generally two points, called inflection points, on the plot of wetted perimeter versus flow at which the rate of loss of wetted perimeter is significantly changed. In the example (Figure 2), these inflection points occur at approximate flows of 8 and 12 cfs. Beyond the upper inflection point, large changes in flow cause only very small changes in wetted perimeter. The area available for food production is considered near optimal beyond this inflection point. Below the upper inflection point, the stream begins to pull away from the riffle bottom. At the lower inflection point, the rate of loss of wetted perimeter begins to rapidly accelerate. Once flows are reduced below the lower inflection point, the riffle bottom is being exposed at an accelerated rate and the area available for food production greatly diminishes.

The wetted perimeter-flow relationship may also provide an index of other limiting factors that influence a stream's carrying capacity. One such factor is cover. Cover, or shelter, has long been recognized as one of the basic and essential components of fish habitat. Cover serves as a means for avoiding predators and provides areas of moderate current speed used as resting and holding areas by fish. It is fairly well documented that cover improvements will normally increase the carrying capacity of streams, especially for larger size fish. Cover can be significantly influenced by streamflow.

In the headwater streams of Montana, overhanging and submerged bank vegetation is an important component of trout cover. The wetted perimeter-flow relationship for a stream channel may bear some similarity to the relationship between bank cover and flow. At the upper inflection point, the water begins to pull away from the banks, bank cover is lost and the stream's carrying capacity declines. Flows exceeding the upper inflection point are considered to provide near optimal bank cover. At flows below the lower inflection point, the water is sufficiently removed from the bank cover to severely reduce its value as fish shelter. It is reasonable to assume that this premise would be more acceptable if the wetted perimeter-flow relationships were also derived for pools and runs, areas normally inhabited by adult trout. However, cross-sections through pools and runs may not be necessary. When the wetted perimeter-flow relationship for riffles and the composite of all habitat types (pools, runs and riffles) comprising a study section are compared, as illustrated in Figure 3 , the shape of the curves and, consequently, the flows at which the inflection points occur, are very similar. This similarity is probably explained by the fact that most headwater streams, due to their high gradients, tend to be mainly comprised of riffle areas. Pools are generally few in number and poorly developed. A riffle area, therefore, describes the typical habitat type that normally occurs throughout most headwater streams.

It has been demonstrated that riffles are also critical areas for spawning sites of brown trout and shallow inshore areas are required for the rearing of brown and rainbow trout fry (Sando, 1981). It is, therefore, assumed that, in addition to maximizing bank cover and food production, the flows exceeding the upper inflection point would also provide favorable spawning and rearing conditions.

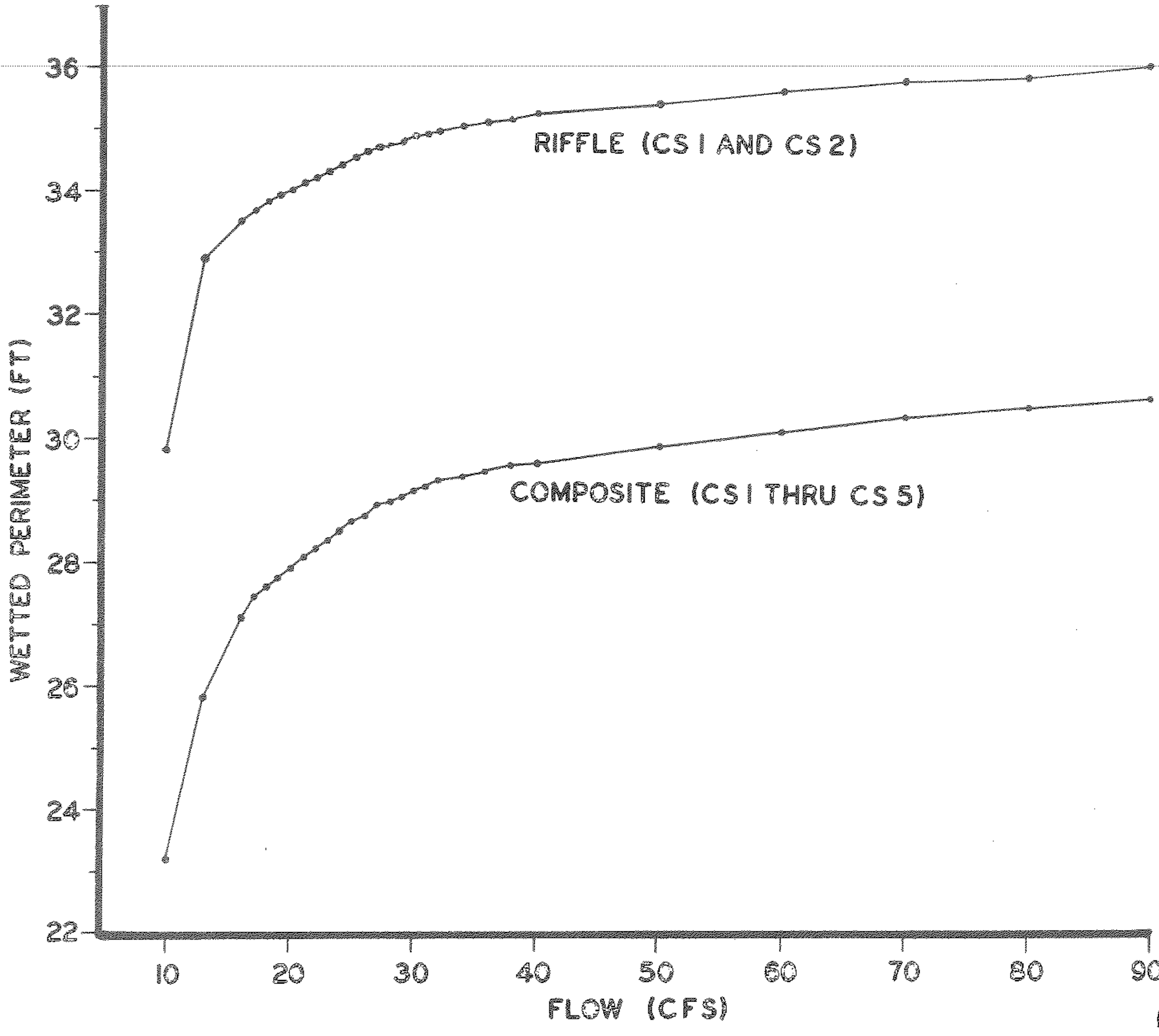


Figure 3. Comparison of the relationships between wetted perimeter and flow for a composite of five cross-sections encompassing various habitat types and a composite of two riffle cross-sections in a subreach of Cherry Creek, Madison River drainage.

Riffles are the area of a stream most affected by flow reductions (Bovee, 1974 and Nelson, 1977). Consequently, the flows that maintain suitable riffle conditions 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 both resident and migratory trout populations, they should receive the highest priority for instream protection.

The wetted perimeter/inflection point method provides a range of flows (between the lower and upper inflection points) from which a single instream flow recommendation can be selected. Flows below the lower inflection point are judged undesirable based on their probable impacts on food production, bank cover and spawning and rearing habitat, while flows exceeding the upper inflection point are considered to provide a near optimal habitat for trout. The flows at the lower and upper inflection points are believed to bracket those flows needed to maintain the low and high levels of aquatic habitat potential. These flow levels are defined as follows:

1. High Level of Aquatic Habitat Potential - That flow regime which will consistently produce abundant, healthy and thriving aquatic populations. In the case of game fish species, these flows would produce abundant game fish populations capable of sustaining a good to excellent sport fishery for the size of stream involved. For rare, threatened or endangered species, flows to accomplish the high level of aquatic habitat maintenance would: 1) provide the high population levels needed to ensure the continued existence of that species, or 2) provide for flow levels above those which would adversely affect the species.

2. Low Level of Aquatic Habitat Potential - Flows to accomplish a low level of aquatic habitat maintenance would provide for only a low population abundance of the species present. In the case of game fish species, a poor sport fishery could still be provided. For rare, threatened or endangered species, their populations would exist at low or marginal levels. In some cases, this flow level would not be sufficient to maintain certain species.

The final flow recommendation is selected from this range of flows by the fishery biologist who collected, summarized and analyzed all relevant field data for the streams of interest. The biologist's rating of the stream resource forms the basis of the flow selection process. Factors considered in the biologist's evaluation include recreational usage, the existing level of environmental degradation, water availability and the magnitude and composition of existing fish populations. The fish population information, which is essential for all streams, is a major consideration. A nonexistent or poor fishery would likely justify a flow recommendation at or near the lower inflection point unless other considerations, such as the presence of species of special concern (arctic grayling and cutthroat trout), warrant a higher flow. In general, only streams with exceptional resident fish populations or those providing crucial spawning and/or rearing habitat for migratory populations would be considered for a recommendation at or near the upper inflection point. An exception are those tributary streams that are an essential source of the water that is needed for maintaining downstream aquatic habitat. In this particular situation, water supply is the overriding consideration. Streams in this category include Cabin and Beaver Creeks of the Madison drainage and the West Fork of the Madison River. These and other exceptions are thoroughly discussed in later sections.

The process of deriving the flow recommendation for the low flow period, thusly, combines a field methodology (wetted perimeter/inflection point method) with a thorough evaluation by a field biologist of the existing stream resource.

The wetted perimeter-flow relationships are derived using a wetted perimeter predictive (WETP) computer program developed in 1980 by the Montana Department of Fish, Wildlife and Parks (Nelson, 1980). This program was designed to eliminate the relatively complex data collecting procedures associated with the hydraulic simulation computer models in current use while providing more accurate wetted perimeter predictions.

Description of the WETP Program and Data Collecting Procedures

The WETP program uses at least two sets of stage (water surface elevation) measurements taken at different know discharges (flows) to establish a least-squares fit of log-stage versus log-discharge. Once the stage-discharge rating curve for each cross-section is determined, the stage at a flow of interest can be predicted. This rating curve, when coupled with the cross-sectional profile, is all that is needed to predict the wetted perimeter at most flows of interest.

The program should be run using three sets of stage-discharge data collected at a high, intermediate and low flow. Additional data sets are desirable, but not necessary. The three measurements are made when runoff is receding (high flow), near the end of runoff (intermediate flow) and during late summer-early fall (low flow). The high flow should be considerably less than the bankful flow while the low flow should approximate the lowest flow that normally occurs during the summer-fall field season. Sufficient spread between the highest and lowest calibration flows is needed in order to compute a linear, sloping rating curve (Figure 4).

The WETP program can be run using only two sets of stage-discharge data. This practice is not recommended since substantial "two-point" error can result. However, when only two data sets are obtainable, the higher discharge should be at least twice as high as the lower discharge.

The WETP model is invalidated if channel changes occur in the study area during the data collecting process. For this reason, the collection of the field data needed for calibrating the program should be completed during the period beginning when runoff is receding and ending with the onset of runoff the following year. The stream channel is expected to be stable during this period.

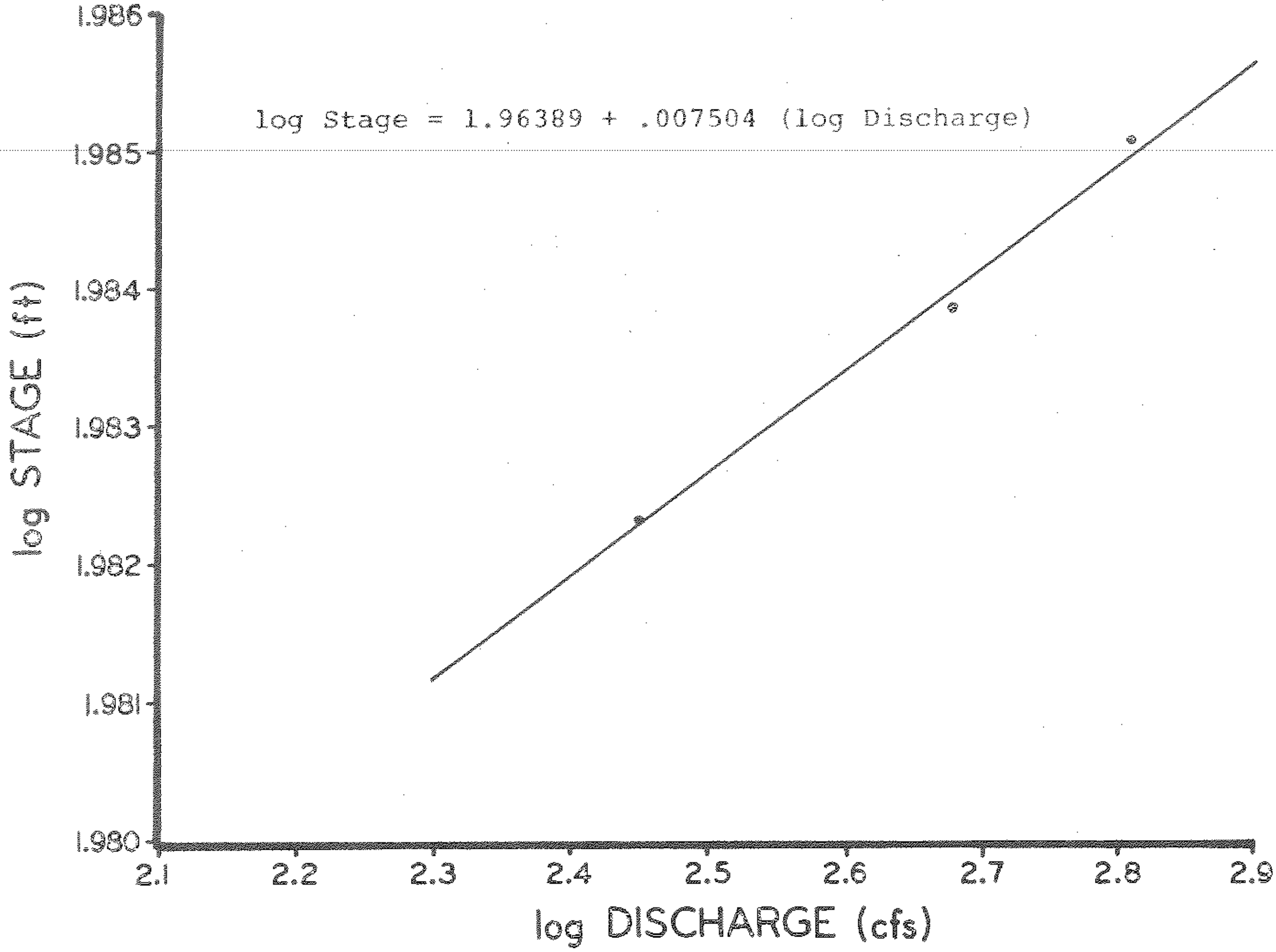


Figure 4. An example of a "three point" stage-discharge rating curve for a riffle cross-section.

Cross-sections were placed in an area that typified the stream reach for which instream flow recommendations were to be derived. For the headwater streams, this would mean a sequence from the head of a riffle to the head of the next riffle. This sequence was described using from 5 to 10 cross-sections. The cross-sections were placed to describe the typical habitat types in the proportion that they occurred within each sequence. The cross-sections were classified as riffles, runs or pools and recorded. The cross-sections through pools and runs were subsequently eliminated from the analyses since, as previously explained, there appears to be little justification or advantage for their use in the flow recommendation process.

The recommendations were selected solely from the wetted perimeter-flow relationships for riffle areas. If two or more riffle cross-sections were available, the computed wetted perimeters for all riffle cross-sections at each flow of interest were averaged and the recommendation selected from the wetted perimeter-flow relationship for the composite of all riffle cross-sections.

The limitations and advantages of the WETP program, as well as field data requirements and surveying techniques, are discussed by Nelson (1980).

Methodology for Low Flow Period - Rivers

The wetted perimeter/inflection point method will, if used correctly, provide defendable flow recommendations for the headwater trout streams. While the underlying assumptions of this method appear valid, it cannot yet be said that the method enables the biologist to accurately predict the effects of flow reductions on the trout standing crops and the carrying capacity of the aquatic habitat. The validation of this method can only be accomplished by comparing the range of possible flow recommendations generated by the method to those recommendations derived from the actual relationships between trout standing crops and flow.

The Montana Department of Fish, Wildlife and Parks completed a study in 1980 that validated the wetted perimeter method as applied to the trout rivers of southwest Montana (Nelson, 1980a, 1980b and 1980c). In this study, the actual trout standing crop and flow relationship were derived from long-term data collected for five reaches of the Madison, Gallatin, Big Hole and Beaverhead Rivers, all nationally acclaimed wild trout fisheries. These relationships provided a range of flow recommendations for each reach. Flows less than the lower limit were judged undesirable since they led to substantial reductions of the standing crops of adult trout or the standing crops of a particular group of adults, such as trophy-size trout. Flows greater than the upper limit supported the highest adult standing crops during the study period. Flows between the lower and upper limits are broadly defined as those flows supporting intermediate standing crops or those standing crops that normally occur within each reach. The final recommendation was selected from this range of flows.

The range of flows derived from the trout-flow relationships for the five river reaches were compared to those derived from the wetted perimeter method as applied to riffle areas. The study results showed that the inflection point flows had a somewhat different impact on the trout standing crops of rivers than previously assumed for streams. For rivers, the flow at the upper inflection point is a fairly reliable estimate of the lower limit of the range of flows derived from the trout-flow relationships or, in other terms, flows less than the upper inflection point are undesirable as recommendations since they lead to substantial reductions of the standing crops of adult trout.

The flow at the upper inflection point is not necessarily the preferred recommendation for all trout rivers. The "Blue Ribbon" rivers would generally require a higher flow in order to maintain the sport fishery resource at the existing level. For those rivers having a lower resource rating, the flow at the upper inflection point may be a satisfactory recommendation. In general, flows less than the upper inflection point are undesirable as flow recommendations regardless of the existing state of the river resource.

For those rivers that support resident salmonid populations and provide crucial spawning and/or rearing habitat for migratory populations as well, the flow recommendations derived from the wetted perimeter/inflection point method would, in addition to maintaining the resident population at the existing level, also serve to:

1) facilitate the movement of adults to upstream spawning areas and their return to downstream residencies,

2) maintain favorable spawning and incubation habitat,

3) maintain favorable habitat for the rearing of fry and juveniles, and

4) facilitate the movement of juveniles to downstream adult residencies.

Methodology for High Flow Period - Streams and Rivers

Several major components of aquatic habitat in river systems are related to the physical features and form of the river channel itself. Over time, aquatic populations have adapted and thrived within the physical contraints of channel configuration and flow. Basic to the maintenance of the existing aquatic populations is the maintenance of the existing habitat that has historically sustained them.

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.

Most unregulated headwater streams and rivers in Montana are characterized by an annual spring high water period which normally occurs during May, June and July and results from snowmelt in the mountainous headwaters. Annual spring flow conditions on unregulated streams are heavily dependent upon snowpack and its rate of thawing. On regulated streams, the occurrence and magnitude of the high water period may vary depending upon reservoir operation and storage capacity.

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 configuration would affect both the abundance and species composition of the present aquatic populations by altering the existing habitat types.

Several workers (Leopold, Wolman and Miller 1964, US Bureau of Reclamation 1973, and Emmett 1975) adhere to the concept that the form and configuration of river channels are shaped by and designed to accommodate a dominant discharge. 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 flood-plain.

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 streams and rivers was estimated by using the 1½ year frequency peak flow. The 1½ year frequency peak flow was determined by interpolation between the 1.25 and 2 year frequency peak flows as supplied by the USGS for the streams and rivers in question.

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 is chosen.

A gradual rising and receding of flows should be associated with the dominant discharge and the shape of the spring hydrograph should resemble that which occurs naturally. USGS flow records were used to determine the time when the high flow period and peak flow normally occur on a given stream. The dominant discharge is requested for that period when it normally occurs. Flows are increased from a base flow level to the dominant discharge in 2-week intervals at the 80th percentile flow level, corresponding to the natural timing of the high flow period.

The 80th percentile is the flow that is exceeded in 8 of 10 years or, in other terms, in 8 years out of 10 there is more water than the 80th percentile flowing in the stream. The 80th percentile was chosen in part because of its compatability with irrigation development. To economically develop efficient, full-service irrigation systems, a good water supply is considered necessary in about 8 years out of 10, on the average (MDNRC, 1976). It is also our belief that the high flow months can withstand substantial withdrawals and not alter the basic functions of channel maintenance. The 80th percentile flows allow for substantial water depletions.

The above instream flow method, which is termed the dominant discharge/channel morphology concept, can only be applied to those streams and rivers having at least 9 years of continuous USGS gauge records. While 10 years is the minimum period of record the USGS considers adequate for deriving reliable estimates of the 80th percentile flows, a minimum period of 9 years is used for this report.

High flow recommendations cannot be derived for the vast majority of streams and rivers considered in this report because most lack long-term flow records.

FISH POPULATIONS

Upper Yellowstone and Missouri River Drainages

The salmonid populations within the contract streams of the upper Yellowstone and upper Missouri River drainages primarily consist of year-round residents. These fish are non-migratory, completing all their life functions and stages in a relatively short stretch of stream. Unlike resident populations, migratory populations reside as adults and/or sub-adults in a river, lake or reservoir and use the tributaries for spawning and the rearing of their young. The South Fork of the Madison River, which is a spawning and rearing stream for adult brown trout residing in Hebgen Reservoir, is the only contract stream within these drainages in which rearing trout of a migratory population are known to comprise a significant portion of the existing stream population.

Flathead River Drainage

Investigations into the status and life history of the westslope cutthroat trout and bull trout fishery in the upper Flathead River Basin and Flathead Lake are presently being conducted by the Montana Department of Fish, Wildlife and Parks (Graham et al. 1980, Fraley et al. 1981, Leathe and Graham 1981). It is necessary to understand their life history to adequately assess habitat requirements necessary to maintain the fishery. Adequate instream flows in the river system are necessary to provide adequate rearing habitat for juvenile cutthroat and bull trout, a downstream migration corridor for juvenile fish to Flathead Lake, an upstream migration corridor for spawning cutthroat trout in the spring and bull trout in the summer and fall, and year-round habitat for resident cutthroat trout and mountain whitefish. A brief life history is presented for the cutthroat and bull trout.

The bull trout population in the Flathead drainage is almost entirely adfluvial, living in a lake as subadults or adults and migrating into tributaries to spawn. The migratory pattern of bull trout is similar in the North and Middle Forks. These fish reside in Flathead Lake, begin moving up the lower Flathead River in early spring, start to arrive in their spawning tributaries in late summer and begin returning to the lake in the fall.

Three basic life history patterns have been identified throughout the range of westslope cutthroat trout. These patterns are migratory between lakes and streams, migratory from small tributaries to main rivers, and nonmigratory stocks (Behnke 1979) which are referred to as adfluvial, fluvial, and resident, respectively.

Adfluvial westslope cutthroat spawners begin moving up the lower Flathead as early as February and probably move into tributaries sometime in April or May. They spend a varying amount of time on the spawning grounds and most return to the main river around the time of peak runoff. Block (1955) found spawners in North Fork streams June 17 and Johnson (1963) felt cutthroat spawning peaked in mid-June. Time spent in the river between the tributaries and Flathead Lake appears quite variable. Studies of cutthroat in three Idaho streams indicated a movement pattern upstream to upper drainages in spring and early summer, no movement during the summer, and movement to the lower drainages in the fall (Johnson and Bjornn 1978, Thurow and Bjornn 1978).

Juvenile cutthroat and bull trout spend from one to four growing seasons in the tributaries before moving into the main river. The majority spend two to three seasons in the tributaries. Adfluvial juvenile trout migrate from streams in late spring and early summer. They may spend several months in the river before entering Flathead Lake.

FISH POPULATION ESTIMATES

As previously discussed, an evaluation of existing fish populations is an essential component of the flow recommendation process. In addition to providing a means for partially justifying the selection of a particular flow recommendation, the fish data also serve to document the state of the existing fishery resource. Personnel of the Montana Department of Fish, Wildlife and Parks expended considerable time and effort in collecting this information and summarizing it for use in the recommendation process and for comparison with the populations of other streams and rivers.

Two techniques, electrofishing and snorkeling, were used in surveying fish populations and estimating standing crops. These techniques are discussed as follows.

Electrofishing

Fish populations in the streams of the upper Missouri and Yellowstone drainages were sampled using a bank electrofishing unit basically consisting of a 110 volt Honda gas generator, a Fisher shocker box, a 500 ft cord, a stationary negative electrode, and a hand-held, mobile positive electrode. For the larger waterways, a boat mounted electrofishing unit was sometimes required to effectively sample the population. A mild electric shock temporarily immobilizes the fish located in the immediate vicinity of the positive electrode, allowing them to be dip netted. The fish capturing efficiency of the units is highly variable since efficiency rates are influenced by stream size, the magnitude of the flow, water clarity, specific conductance, water temperature, cover types and the species and size of fish. For the waterways considered in this report, up to approximately 47 percent of the total population was captured during a single electrofishing run.

The fish population is enumerated using a mark-recapture method which allows for the estimation of the total numbers and pounds (the standing crops) of fish within a stream section. For most streams, standing crop estimates were obtained for 1,000 ft study sections. The larger waterways sometimes required longer sections in order to obtain reliable estimates.

The standing crop estimates require at least two electrofishing runs through each study section. During the first or marking run, all captured fish are anesthetized, marked with a partial caudal fin clip so they can be later identified, then released after individual lengths and weights are recorded. It is desirable to make the second or recapture run at least two weeks after the marking run. This two week period allows the marked fish to randomly redistribute themselves throughout the population. During the recapture run, all captured fish are again anesthetized and released after the lengths and weights of all new (unmarked) fish and the length only of all marked fish are recorded. The population estimate is basically obtained using the formula $P = \frac{MC}{R}$; where P is the estimated number of fish, M is the number initially marked, C is the number of marked and unmarked fish collected during the recapture run, and R is the number of marked fish collected during the recapture run. This formula, although somewhat modified in its final form for statistical reasons, is the basis of the mark-recapture technique.

The numbers of fish are actually estimated by length groups. Those ½ inch length intervals having similar or equal recapture efficiencies comprise a length group. This grouping is necessary because recapture efficiencies are dependent on fish size. Generally, electrofishing is more effective for capturing larger fish due to their greater surface area and their higher visibility when in the electric field. Because recapture efficiencies are length related, the numbers of fish must be estimated by length groups, then added to obtain the total estimate. Generally, at least seven recaptures are needed per length group in order to obtain a statistically valid estimate.

Pounds of fish are obtained by multiplying the average weight of the fish within each length group by the estimated number, then adding to obtain the total pounds. Estimates can also be obtained for different age-groups of fish. This mark-recapture technique, which is thoroughly discussed by Vincent (1971 and 1974), has been adapted for computer analyses by the DFWP.

Only electrofishing survey data, consisting of the species, numbers and length ranges of captured fish, are provided for those streams in which fish populations are too sparse to reliably estimate using the mark-recapture method. These comprise approximately 10 percent of the streams discussed in this report.

Snorkeling

Snorkeling is preferable to electrofishing as a technique for obtaining population estimates in the streams of the Flathead drainage because of the extreme clarity, low conductivity and inaccessibility of many waters in the drainage. In wilderness areas and Glacier National Park where regulations prohibit electrofishing equipment, snorkeling is an effective and practical method for obtaining estimates. This method has been used with success in other drainages of high water clarity as reported in Graham et al. (1980).

Underwater observations of fish have often been used for studying the behavior and density of fish (particularly salmonids) in streams. In streams like those in the upper Flathead drainage, low conductivity and high water clarity limit the effectiveness of electrofishing. Many researchers have thus resorted to taking underwater counts of fish populations using a single observer (Kennleyside 1962, Reed 1967, Pollard and Bjornn 1973, Everest and Chapman 1972).

Good concentration and peripheral vision are essential when fish numbers are large or when the observer's view is obstructed. If the site is deep on one side, the observer positions himself on the shallow side and looks toward the deeper water. Slight modifications of these procedures are necessary when fish are hidden by water turbulence, boulders, log jams, algae mats or undercut banks.

Individual pool, run, riffle, and pocket water habitats were snorkeled on each reach of the North and Middle Fork Flathead Rivers during the summer of 1980. On the North Fork, two observers made underwater fish counts for each feature. Each observer worked up one side and then down the center of each feature. Features snorkeled on the North Fork consisted almost entirely of runs selected at random for each of the two river reaches.

A more extensive fish population census was conducted on the Middle Fork, a smaller river where stream features are more easily defined. During mid-summer, 1980, pool and run habitat units were snorkeled on a 14 mile section of river from the headwaters to Schafer Meadows and a 30 mile section from Schafer Meadows to Bear Creek. Fish counts were made in at least every third pool and fewer randomly selected runs in both sections by a single observer. The observer snorkeled up each side and then down the center of each feature.

In late summer, fish density estimates were made on two 6.2 mile (10 km) sections of the Middle Fork. One section was located upstream from Schafer Meadows (headwaters to Cox Creek) and one was located downstream (2 miles below Schafer Meadows to Granite Creek). In these two sections, observers made fish population estimates in every third pool, run, and pocket water feature and every fifth riffle feature.

Surface areas for each feature snorkeled were calculated and average densities per 100 sq ft were estimated for each species and age class. The total numbers of each feature or habitat unit in each 6.2 mile section were counted and population estimates for each species by age class were made for the 6.2 mile sections.

Cutthroat trout estimates made by snorkeling and electrofishing in 12 North Fork tributary reaches were compared by Fraley et al. (1981). Numbers of age 0 fish estimated by snorkeling were generally higher than numbers estimated by electrofishing. Numbers of age 0 fish are difficult to estimate by any method which makes these results questionable. Graham (1977) reported difficulties in observing age 0 fish because of their size and habitat associations. Snorkeling estimates for age I cutthroat were higher than electrofishing estimates, while estimates of mean numbers of age II and III+ fish were similar for each method. Total estimates of age I and older cutthroat made by snorkeling average 25 percent higher than electrofishing estimates for the 12 sections. The differences between the mean estimates of each method were tested (paired t test) for each age class and for age I and older cutthroat combined. There was no significant difference between the estimates made by the two methods at the 95 percent level (Fraley et al., 1981).

Electrofishing and snorkeling estimates were made for cutthroat trout in one Middle Fork tributary. The electrofishing estimate was made by the mark-recapture method and was 20 percent higher than the snorkeling estimate for age I and older cutthroat.

Estimates of cutthroat trout by the two methods varied between streams, probably due to differences in the physical habitat characteristics of the sections. Snorkeling appears more effective than electrofishing for estimating cutthroat numbers in streams where levels of debris and turbulence are not great. In sections which have large amounts of debris or water turbulence, electrofishing is probably a more effective method.

Graham and Sekulich (in preparation) report that snorkeling estimates of cutthroat numbers are comparable to estimates made by various methods of removal. Northcote and Wilkie (1963) found snorkeling to be an effective method of estimating numbers of several species of fish.

Estimates of bull trout numbers for each age class were made by snorkeling and electrofishing in four 328 foot (100 m) sections of North Fork tributary reaches. Electrofishing estimates for age 0 and age I bull trout were considerably higher than the snorkeling estimates while estimates of age II and age III+ bull trout by both methods were similar. Electrofishing estimates of age I, II, and III+ bull trout combined were 27 percent higher than the snorkeling estimates. Paired t tests indicated no significant difference between the means of the estimates for each age class made by snorkeling and electrofishing, but the sample size was small. We believe the habits of juvenile bull trout make them more difficult to observe while snorkeling than are cutthroat trout. A better evalutation of snorkeling as a method for estimating juvenile bull trout numbers will be made in 1981 after more sections are sampled.

WATER AVAILABILITY

The instream flow recommendations presented in later sections will, if enacted, limit the availability of water for future consumptive users and water development projects. For future planning, it is desirable to define the period in which water in excess of the recommendations is available and to quantify this excess. This information is presented where available in later sections. However, the discussion of water availability is limited for the vast majority of streams since a thorough evaluation requires long-term flow records which are presently lacking for all but a few contract streams.

The discussions of water availability basically consist of comparisons of the monthly flow recommendations to the monthly median and mean flows of record. These statistics provide a measure of the normal or typical flow condition. The median is the flow that is exceeded in 5 of 10 years or in 5 years out of 10 there is more water than the median flowing in the stream. The median is preferred over the mean because it is less readily influenced by unusually high flows which tend to cause the mean to over estimate the norm. The mean rather than the median, however, is more commonly used as an indicator of normal flows because it is an easier statistic to derive.

Although biased by high flows, the monthly means still compare favorably to the medians if derived from long-term gauge records. The similarity of these two values is illustrated in Table 1 which compares the mean and median flows of record on a monthly and annual basis for a typical unregulated stream (Bridger Creek) and river (Big Hole River) of the Upper Missouri drainage of southwest Montana. While monthly means and medians are similar, as indicated in Table 1 , the annual means greatly exceed the annual medians. This is characteristic of unregulated headwater streams and rivers in which a large percentage of the annual water yield is passed during a relatively brief snow runoff period. For these waterways, the median annual flow is vastly superior to the mean annual flow as an indicator of the normal condition. For regulated streams, the annual mean and median values are generally more similar.

Median monthly flows are only available for comparing to the flow recommendations for those streams having at least 9 years of continuous USGS gauge records. While ten years is the minimum period the USGS considers adequate for deriving reliable estimates of monthly medians, a minimum period of 9 years is used for this report. For those streams having one to nine years of continuous flow records or more than 9 years of discontinuous records, the mean monthly flows are substituted. The relatively short period of time for which most of the monthly means were derived detracts somewhat from their reliability as indicators of the norm. These monthly means, while varying in reliability, still provide some insight into water availability and, consequently, are a meaningful addition to the report. For the vast majority of contract streams which are ungauged by the USGS, water availability information is generally limited to a relatively few sporadic flow measurements collected by various state and federal agencies.

Table 1 . Comparison of mean and median flows of record (cfs) derived from USGS gauge records for Bridger Creek and the Big Hole River.

	Bridger Creek[a/]		Big Hole River[d/]	
	Mean[b/]	Median[c/]	Mean[e/]	Median[f/]
Jan	7.2	5.6	349	344
Feb	8.9	6.7	363	328
Mar	15.5	10.5	445	400
Apr	64.7	52.0	1,526	1,290
May	158.0	141.0	3,449	3,150
Jun	104.0	75.5	4,121	3,970
Jul	31.9	28.3	1,347	1,330
Aug	13.6	12.2	482	445
Sep	10.9	9.2	377	305
Oct	10.8	8.9	507	447
Nov	10.3	9.0	508	475
Dec	8.7	6.2	398	348
Annual	36.6	12.0	1,157	480

a/ Bridger Creek near Bozeman, Montana.
b/ Derived for a 24-year period of record (1946-69).
c/ Derived for a 19-year period of record (1950-68).
d/ Big Hole River near Melrose, Montana.
e/ Derived for a 54-year period of record (1924-77).
f/ Derived for a 49-year period of record (1925-73).

The final monthly flow recommendations selected for the streams discussed in later sections of this report generally exceed the normal water availability, as measured by the monthly mean and median flows of record, for the months of November through March. This is the winter period when the natural flows are lowest for the year. These naturally occurring low flows, when coupled with the adverse effects of surface and anchor ice formation and the resulting scouring of the river channel at ice-out, can impact the fishery. Consequently, water depletions during this crucial low flow period have the potential to be extremely harmful to the already stressed trout populations. If trout populations are to be maintained at existing levels, little or no water should be removed during the crucial winter period.

RULES OF THUMB

Various nonfield or office methods that utilize historical flow records as a means of deriving instream flow recommendations are described in the literature. Of these methods, the most often used is the Tennant Method (Tennant, 1975). Recommendations of the Tennant Method are based on a fixed percentage of the mean annual flow of record with the following percentages recommended for both cold and warm water streams:

Narrative Description of Flows[a]	Recommended Base Flow Regimens Oct-Mar	: Apr-Sept	Fisheries Classification
Flushing or Max.	200% of the average flow		-
Optimum Range	60%-100% of the average flow		-
Outstanding	40%	60%	I
Excellent	30%	50%	II
Good	20%	40%	III
Fair or Degrading	10%	30%	IV
Poor or Minimum	10%	10%	-
Severe Degradation	10% of average flow to 0 flow		-

[a] Most appropriate description of the streamflow for fish, wildlife, recreation and related environmental resources (adapted from Tennant, 1975).

Thirty percent of the mean is described as the base flow recommended to sustain good survival habitat for most aquatic species and 60 percent as providing excellent to outstanding habitat for most aquatic species during their primary periods of growth and for the majority of recreational uses. The percentages selected from the table depend on the stream's numerical rating in a fisheries classification system. The higher the rating, the greater the percentage recommended.

Data presented by Nelson (1980c) suggest that recommendations derived from a fixed percentage method may be valid for the "Blue Ribbon" trout rivers of southwest Montana. His data suggested that the percentage of the mean annual flow selected as a recommendation depends on the channel morphology with the wider, shallower rivers requiring a higher percentage of the mean. The more typical rivers of the study area required instream flows approximately equal to at least 33% of the mean in order to maintain the high quality, wild trout fishery at an acceptable, but far from the most desirable, level.

The purpose of this section is to determine if a fixed percentage method is applicable to the headwater trout streams of Montana. Any rules of thumb that should emerge from this evaluation would provide guidelines for deriving flow recommendations for those streams in which time, budget and/or manpower constraints limit the use of an accepted field methodology.

For this evaluation, the flows at the lower and upper inflection points, as derived from the wetted perimeter method applied to 38 streams of the upper Missouri River drainage of southwest Montana, are expressed as a percentage of the mean annual flow (Table 2). The mean annual flow is the summary flow statistic most readily obtainable for gauged streams. For ungauged streams, the mean can be estimated using various simulation models. While the mean is not necessarily an indicator of the normal flow condition, it does provide a measure of the amount of water that is passed by the stream channel. The mean flows listed in Table 2 reflect the means at the cross-sectional sites from which the wetted perimeter data were collected.

Table 2. Inflection point flows expressed as percentages of the mean annual flow for selected streams of the upper Missouri River drainage of southwest Montana.

	Mean Annual Flow in cfs	Percentage of Mean Flow	
		Lower Inflection	Upper Inflection
Beaverhead and Red Rock River Tribs.			
Big Sheep Cr.	65.0(26) a/	31	77
Blacktail Deer Cr.	54.0(18)	67	93
Bloody Dick Cr.	70.2 b/	26	37
Grasshopper Cr.	51.6(23)	43	54
Horse Prairie Cr.	109.0(7)	22	35
Medicine Lodge Cr.	35.5 b/	28	34
Big Hole River Tribs.			
Birch Cr.	29.4(28)	41	82
Canyon Cr.	31.8 c/	6	16
Johnson Cr.	39.2 c/	13	22
Miner Cr.	39.1(1)	8	26
Pattengail Cr.	48.5 c/	41	49
S. Fork Big Hole R.	52.1(3)	23	46
Trail Cr.	85.3(8)	16	29
Willow Cr.	20.6(4)	39	63
Wise R.	187.0(7)	24	32
Gallatin River Tribs.			
Big Bear Cr.	14.3(2)	28	63
Bozeman Cr.	35.9 d/	17	39
Bridger Cr.	36.6(24)	55	82
Hyalite Cr. (upper reach)	67.2(47)	22	60
Hyalite Cr. (at mouth)	69.5 d/	29	36
Porcupine Cr.	24.3 d/	53	66
Reece Cr.	14.1(2)	43	128
Rocky Cr.	35.8(2)	22	67
Spanish Cr.	73.6 d/	61	109

Table 2. Continued.

	Mean Annual Flow in cfs		Percentage of Mean Flow Lower Inflection	Percentage of Mean Flow Upper Inflection
Jefferson River Tribs.				
Boulder R.	67.5	b/	27	33
Little Boulder R.	17.5	b/	46	109
S. Boulder R.	51.1	b/	29	78
Whitetail Cr.	19.3(1)		21	36
Madison River Tribs.				
Beaver Cr.	74.6	e/	32	64
Cabin Cr.	74.2	e/	15	27
Cherry Cr.	35.2	e/	37	85
Grayling Cr.	80.0	f/	39	75
Hot Springs Cr.	8.8	e/	51	80
Indian Cr.	77.9	e/	26	62
Jack Cr.	46.1(6)		65	134
W. Fork Madison R.	91.9(2)		49	74
Mainstem Missouri R. Tribs.				
Crow Cr.	47.7(15)		23	52
Sixteenmile Cr.	16.7(4)		30	90

a/ Derived from USGS gauge records. Years of record are in parentheses.

b/ Estimate from Farnes and Schafer, 1975.

c/ Estimate from the Dept. of Natural Resources and Conservation, 1981.

d/ Estimate from Farnes and Schafer, 1972.

e/ Estimate from the Soil Conservation Service, 1976.

f/ Estimate from Horpestad, 1976.

The lower and upper inflection point flows for the 38 streams average 33 and 62%, respectively (Table 3). The percentages derived for an individual stream vary greatly as indicated by the wide ranges and relatively large standard deviations in Table 3. Consequently, the averages derived from this analysis (33and 62% of the mean) are only useful in deriving preliminary or reconnaissance level flow recommendations and should not be used in place of an accepted field methodology.

Other investigators have also examined the fixed percentage technique. Swank and Phillips (1976) indicated that an optimum instream flow for streams within the area of the Blue, Wallowa and Cascade Mountains of Oregon ranged from about 60-100% of the mean annual flow. Wesche (1974) found that the rate of loss of the available trout cover in Wyoming's smaller streams (mean annual flows less than 100 cfs) is reduced at its greatest rate at flows less than 25-27% of the mean.

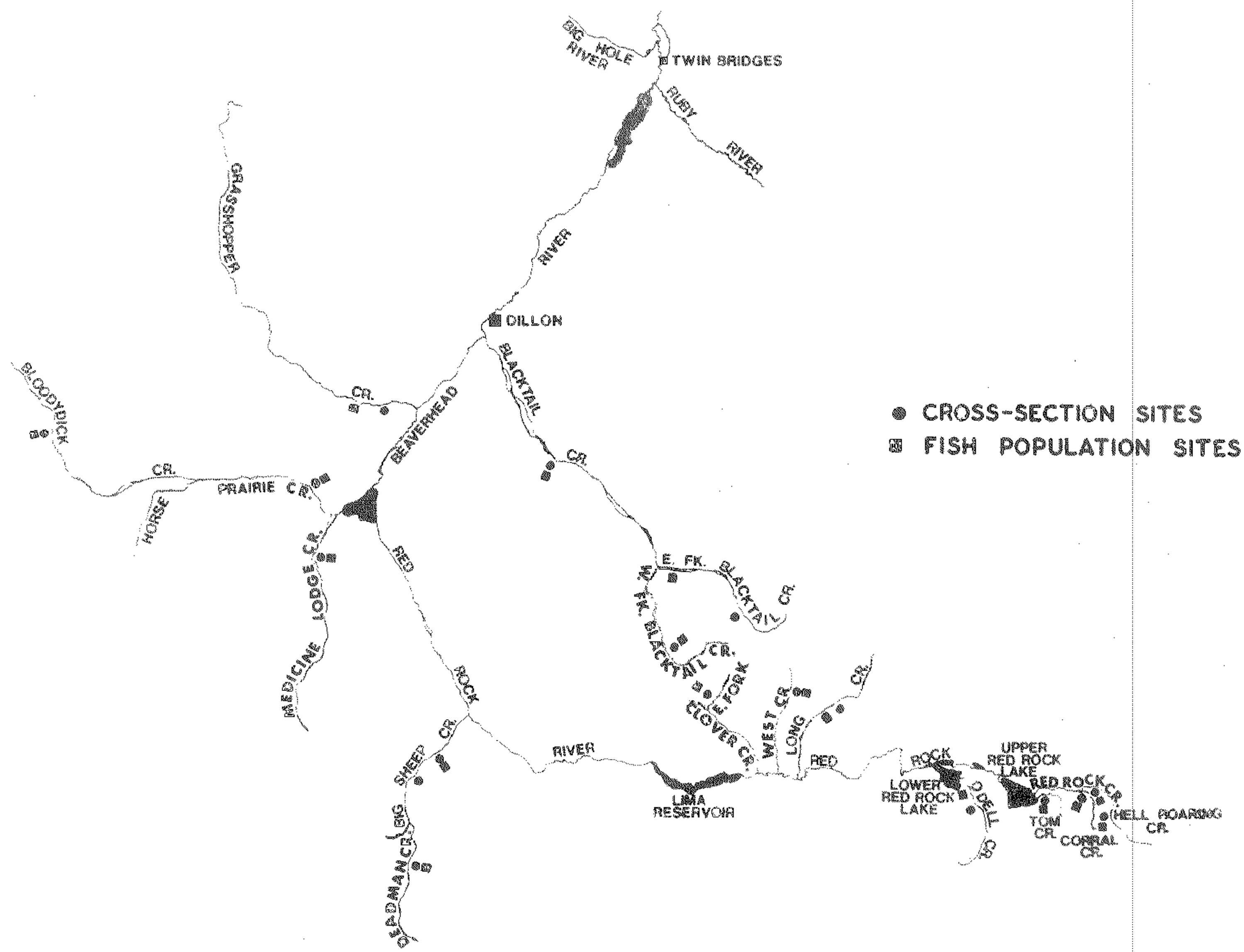
Table 3. Summary of inflection point flows expressed as percentages of the mean annual flow for selected streams of the upper Missouri River drainage of southwest Montana.

	Number of Observations	Percentage of Mean Annual Flow		
		Range(%)	Average(%)	Std. Deviation(%)
Lower Inflection Flow	38	6- 67	33	15.3
Upper Inflection Flow	38	16-134	62	29.3

The analysis presented in this section will be expanded and refined as data become available for additional streams and drainages in Montana. Better defined trends may be found in the future if the streams are subdivided by drainage, morphological types or other yet undefined categories. At present, it appears that the fixed percentage technique is of limited value for deriving flow recommendations for the trout streams of southwest Montana.

BEAVERHEAD AND RED ROCK

RIVER TRIBUTARIES



The study areas of the Beaverhead and Red Rock River Drainages.

1. STREAM

Bloody Dick Creek

2. DESCRIPTION

Bloody Dick Creek originates in the Bitterroot Mountains of Southwest Montana and flows in a southeasterly direction for approximately 24 miles before joining Horse Prairie Creek, a tributary of Clark Canyon Reservoir. The stream meanders through a riparian zone consisting of dense willows, grasses and forbs. The gradient of the 30 ft wide channel averages 11 ft/1000 ft. Land ownership of this 135.5 square mile drainage is shared by the USFS (70%), private individuals (21%), BLM (6%), and the State of Montana (3%). Major tributaries of Bloody Dick Creek include Selway, Park, Lake, Eunice and U-Turn Creeks. Major lakes within the drainage are Selway, Swift and Reservoir.

Lands within the Bloody Dick drainage are used for hay production, livestock grazing, timber harvesting, mining and recreational activities such as fishing, hunting and camping. Access to the drainage is provided by an unimproved gravel road paralleling the stream. A campground on Reservoir Lake is heavily used during the summer months and big game season. Fishing pressure on Bloody Dick Creek during May, 1975 through April, 1976 was estimated by mail survey at 2,380 person-days (MDFG, 1976). This amounts to about 99 person-days/stream mile/year. Data collected from angler logs show that the catch is entirely comprised of brook trout which average 7.1 inches in length (MDFWP, 1980b). Hunting pressure during 1979 for the district encompassing the Bloody Creek drainage amounted to 3,433 man-days for elk and 2,130 for mule deer (MDFWP, 1980a).

Historically, mining for gold and silver has occurred in the lower reaches of the Bloody Dick valley (Geach, 1972). Productivity of the mining operations is unknown.

Environmental problems within the Bloody Dick drainage are mainly related to livestock grazing. Grazing within the riparian zone along portions of the stream has caused loss of vegetative cover, widening of the channel and minor erosion and mass wasting on outside meanders. The lower reaches of Bloody Dick Creek are dewatered during the summer irrigation season. Logging on private land in 1978 caused considerable erosion on a mile of the west slope bordering the stream. Stream channel stability was evaluated by the BLM as good in 1977 (BLM, unpublished data). Excessive peak flows are believed to be impacting the lower watershed.

The SCS (Farnes and Schafer, 1975) estimates the mean annual water yield for the Bloody Dick drainage at 50,800 acre-feet (70.2 cfs). The 25 and 50 year instantaneous peak flows are estimated at 1,600 and 1,840 cfs, respectively.

Sporadic water chemistry measurements have been collected by the USFS during 1976-1980 (USFS, unpublished data). Bloody Dick Creek has excellent water quality characterized by a low specific conductance, a neutral pH, and low concentrations of suspended sediment.

3. FISH POPULATIONS

A 3,540 ft section of Bloody Dick Creek was electrofished on July 24 and August 7, 1974 (Peterson, 1975). Game fish captured in descending order of abundance were brook trout, rainbow trout and mountain whitefish. The mottled sculpin was the only nongame species present. The electrofishing survey data are summarized in Table 4 .

Table 4 . Summary of electrofishing survey data collected for a 3,540 ft section of Bloody Dick Creek (T9S, R15W, Sec. 26A-36B) on July 24 and August 7, 1974.

Species	No. Captured	Length Range (inches)
Brook Trout	568	3.5-12.5
Rainbow Trout	168	2.9-14.9
Mountain Whitefish	80	9.1-18.3
Mottled Sculpin	-	-

The total salmonid standing crop was estimated for the section using a mark-recaptured method (Table 5). Estimates were obtained for all three species of gamefish. The stream supports about 618 game fish, weighing 102 pounds, per 1,000 ft. Brook trout, the dominant game species, comprise about 78% of the total numbers and 53% of the total biomass. Rainbow trout accounted for 16% of the total numbers and 11% of the total biomass. Although trout were abundant in Bloody Dick Creek, their condition (length to weight ratio) was below average for streams surveyed. The mountain whitefish accounted for 6% of the total game fish numbers, but 36% of the total biomass. Of the streams surveyed in the Beaverhead National Forest, Bloody Dick Creek supports one of the highest populations of gamefish.

Table 5 . Estimated standing crops of gamefish in a 3,540 ft section of Bloody Dick Creek (T9S, R15W, Sec. 26A-36B) on July 24, 1974. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Brook Trout	4.0- 5.9	254	
	6.0- 9.9	218	
	10.0-12.5	9	
		481 (±99)	54 (±8)
Rainbow Trout	4.0- 5.9	69	
	6.0- 9.9	25	
	10.0-14.9	6	
		100 (±33)	12 (±2)

Table 5 continued. Estimated standing crops of gamefish in a 3,540 ft section of Bloody Dick Creek (T9S, R15W, Sec. 26A-36B) on July 24, 1974. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Mountain Whitefish	9.1-14.9	30	
	15.0-18.3	7	
		37 (±10)	36 (±9)
Total Gamefish		618 (±105)	102 (±11)

An electrofishing survey was completed on a 300 ft section of Bloody Dick Creek in 1953 (Nelson, 1954b). The brook trout was the only game species present. Two hundred and fifty-four brook trout, weighing a total of 12.7 pounds and averaging 4.8 inches in length, were captured.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 66 ft subreach of Bloody Dick Creek (T9S, R15W, Sec. 14C). Five cross-sections defining the riffle-pool habitat were placed within the subreach. The WETP program was calibrated to field data collected at flows of 20.0, 123.3, and 209.3 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is shown in Figure 5. Lower and upper inflection points occur at 18 and 26 cfs, respectively. Based on an evaluation of existing fishery and recreational use information, a flow of 24 cfs is recommended for the low flow period (July 16 - May 15). Due to lack of long term flow records for Bloody Dick Creek, recommendation for the high flow period (May 16 - July 15) cannot be derived.

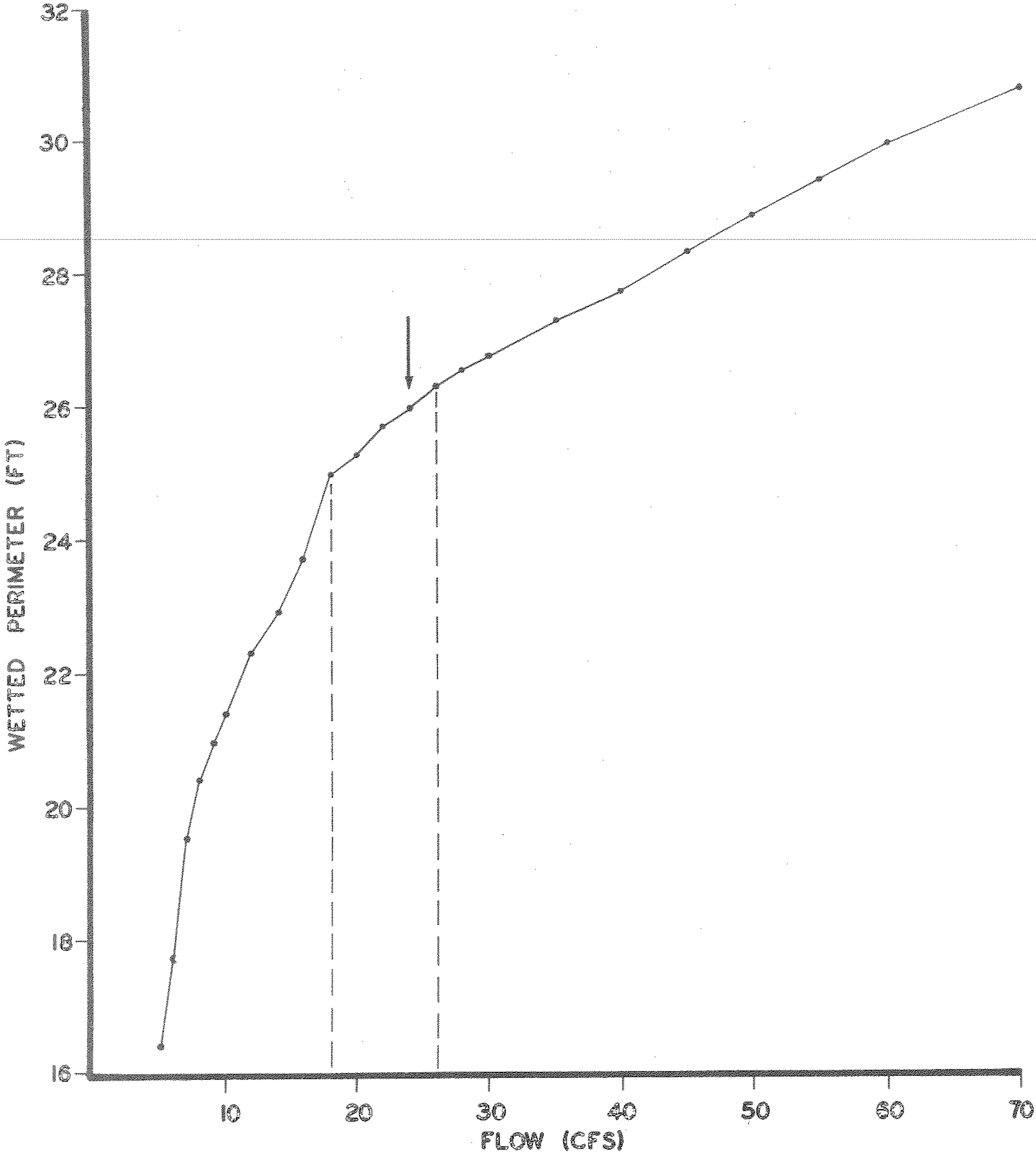


Figure 5. The relationship between wetted perimeter and flow for a single riffle cross-section in Bloody Dick Creek.

1. STREAM

Deadman Creek

2. DESCRIPTION

Deadman Creek originates in the Bitterroot Mountains of southwest Montana and flows in a northerly direction for 17 miles before converging with Big Sheep Creek, a tributary of the Red Rock River. The 25.5 square mile drainage is controlled by the USFS (88%), BLM (10%) and private landowners (2%). Deadman Creek is approximately 10 feet wide and flows through a grassland/sagebrush landscape. The gradient averages 28 ft per 1,000 ft. The riparian zone in the upper portion of the drainage is generally composed of grasses and forbs with sparse woody species. In the lower reaches, clumps of willow become more frequent. Major tributaries include Pine and Little Deadman Creeks. The bottom substrate consists primarily of rubble and coarse gravel.

Lands within the Deadman Creek drainage are mainly used for livestock grazing, timber harvesting and recreation in the form of hunting and fishing. Angler log data compiled by the MDFWP (1980B) show cutthroat trout, averaging 7.1 inches in length, to be the only species caught. The Big Sheep drainage is one of the more popular sage grouse hunting areas in Montana. Elk, mule deer and antelope are also hunted. Access to the middle reaches of Deadman Creek is provided by an unimproved road. The remainder of the stream is accessible only by foot or horseback.

Existing environmental concerns in the drainage are the loss of bank vegetation, streambank erosion and sedimentation of the channel caused by the overuse of the riparian zone by cattle and naturally occurring high-flows. Mass wasting, minor erosion and loss of undercut banks through trampling have all been identified as problems on stretches of Deadman Creek (BLM, unpublished data). A road crossing the stream in its middle reaches has caused a widening of the channel and a possible increase in stream sedimentation.

The SCS (Farnes and Shafer, 1975) estimates the 25 and 50 year instantaneous peak flows for Deadman Creek at 300 and 345 cfs, respectively.

3. FISH POPULATIONS

A 1,000 ft section of Deadman Creek was electrofished on July 25 and August 19, 1980. Game fish present were cutthroat trout, rainbow trout and cutthroat x rainbow hybrids. The mottled sculpin was the only nongame species captured. The electrofishing survey data are summarized in Table 6 .

Table 6 . Summary of electrofishing survey data collected for a 1,000 ft section of Deadman Creek (T15S, R10W, Sec. 22C) on July 25 and August 9, 1980.

Species	No. Captured	Length Range (inches)
Rainbow, Cutthroat and Rainbow x Cutthroat Hybrid Trout	143	4.0-12.7
Mottled Sculpin	-	-

The standing crop of trout was estimated for the section using a mark-recapture method (Table 7). Due to the varying degrees of hybridization between the two trout species present, a total trout estimate was calculated. This 1,000 ft section supports about 202 trout, weighing 23 pounds. This is a relatively productive stream considering its size and high elevation. The condition of the trout (length to weight ratio) was above average for streams surveyed.

Table 7 . Estimated standing crop of trout in a 1,000 ft section of Deadman Creek (T15S, R10W, Sec. 22C) on July 25, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Cutthroat, Rainbow and Cutthroat x Rainbow Hybrid Trout	4.0- 5.9	116	
	6.0- 9.9	83	
	10.0-12.7	3	
		202 (±34)	23 (±3)

The BLM (unpublished data) collected seven trout from Deadman Creek for meristic analyses to determine the degree of hybridization within the population. A moderately high degree of hybridization was found between the native west slope cutthroat trout and the introduced Yellowstone cutthroat and rainbow trout.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected for a 98 ft riffle-run sequence located in T15S, R10W, Sec. 22C. Five cross-sections were placed in the sequence. The WETP program was calibrated to field data collected at flows of 7.4, 10.3 and 14.8 cfs.

Figure 6 illustrates the relationship between wetted perimeter and flow for a composite of two riffle cross-sections. Lower and upper inflection points occur at 4.5 and 8.0 cfs, respectively. Based on an evaluation of existing fishery, recreational use and other resource information, a flow of 7.0 cfs is recommended for the low flow period (July 16 - May 15). A recommendation for the high flow period (May 16 - July 15) cannot be derived for Deadman Creek due to the lack of long-term flow data.

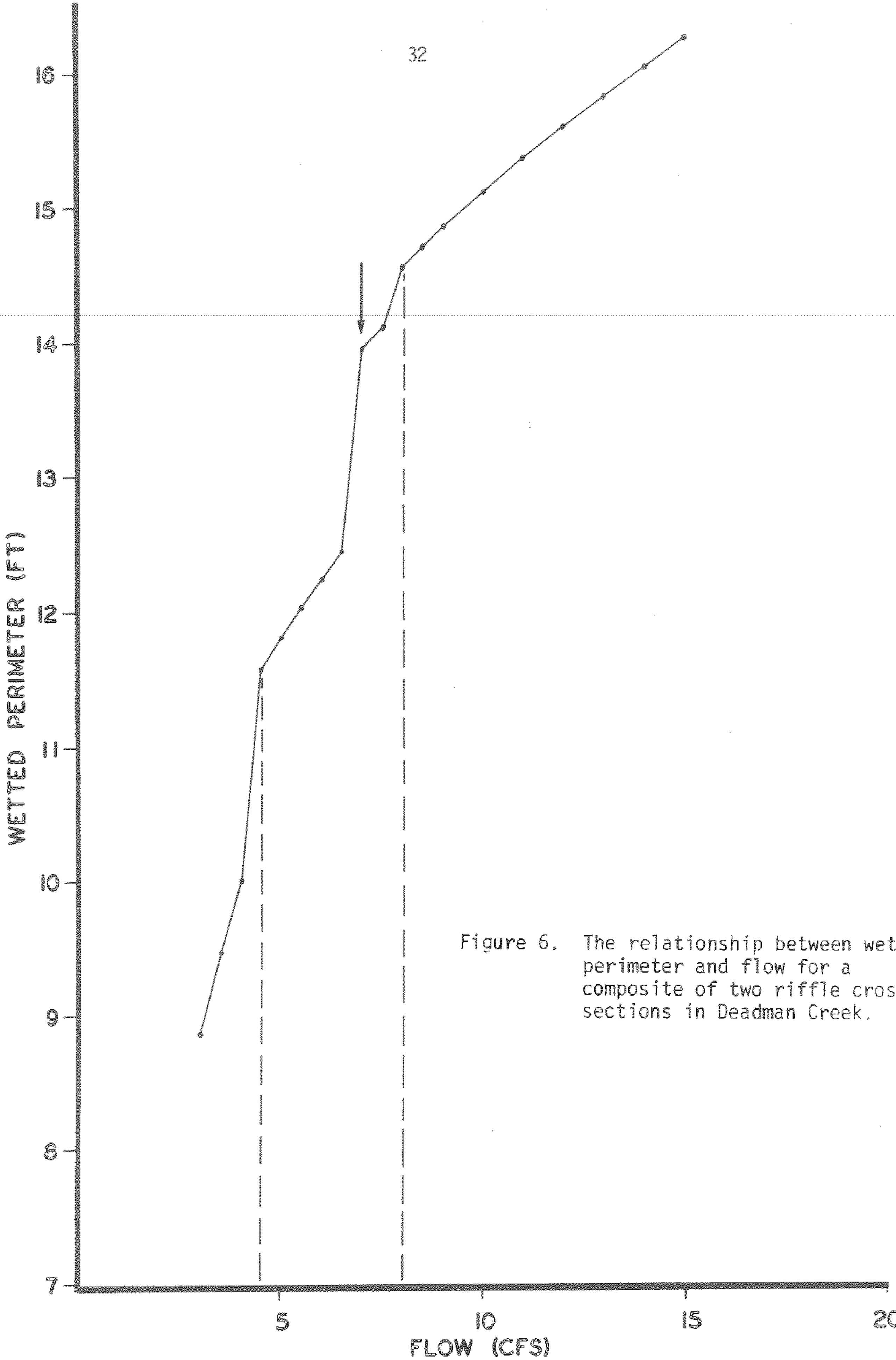


Figure 6. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Deadman Creek.

1. STREAM

East Fork Blacktail Deer Creek

2. DESCRIPTION

The East Fork Blacktail Deer Creek originates in the Snowcrest Range in southwest Montana, approximately 35 miles south of Dillon, Montana. It flows for 15.5 miles in a northeasterly direction before joining the West Fork to form Blacktail Deer Creek, a tributary of the Beaverhead River. Land ownership of the 56 square mile drainage is shared by the USFS (43%), Montana Department of Fish, Wildlife and Parks (36%) and BLM (14%). The East Fork flows in a 15-25 ft wide channel having an average gradient of 19 ft per 1,000 ft. The riparian zone is vegetated with conifers, willow, birch, grasses and sedges. Extensive beaver dam development within the middle reach causes the stream to lose much of its fluvial nature. Major tributaries include Alkali, Indian, Rough, Meadow and Lawrence creeks. The drainage is characterized by sagebrush/grassland slopes and conifer covered headwater ridges.

Lands within the drainage are primarily used for wildlife winter range, recreational activities, including hunting, fishing and camping, and livestock grazing. Access is provided by an unimproved road paralleling the stream for its lower 12 miles and a trail system along the upper three miles. In 1974, the MDFWP acquired 20,000 acres within the drainage for the protection of critical elk winter range. Antelope, moose, mule deer, game birds, waterfowl and many nongame species are also found within the game range. Hunting District 324, which includes the East Fork Blacktail Deer drainage, is one of the most heavily used hunting areas in the state. In 1979, elk hunting pressure in the district was estimated at 13,083 hunter-days (MDFWP, 1980a).

Field checks of anglers over a period of approximately 20 years have shown this stream to be a highly popular sport fishery for pan-sized gamefish. Brook, rainbow and cutthroat trout, rainbow x cutthroat hybrids and mountain whitefish comprise the game fish creeled by anglers. A creel census in 1974 showed a catch rate of 1.5 fish/hour for the East Fork Blacktail Deer Creek during the summer months (MDFWP, unpublished data). Brook trout, which averaged 10.2 inches in length, comprise 97% of the catch reported in angler logs (MDFWP, 1980b).

All lands within the East Fork drainage are publicly owned. Only USFS and BLM lands within the upper drainage are currently being grazed by livestock. Streambank stability and riparian zones are in fair to good condition throughout the drainage (MDFWP, unpublished data and Foggin et al., 1978).

Flow information was collected for the East Fork Blacktail Deer Creek 2.5 miles below the USFS boundary from May - November of 1977 and 1978 (Foggin et al., 1979). Mean, minimum, and maximum recorded flows in 1977 were 16.7, 13.0 and 149 cfs, respectively. The mean flow for the seven-month period in 1978 was 60.6 cfs. The minimum and maximum recorded flows were 13 cfs in November and 266 cfs in June, respectively.

Suspended sediment yields during 1977 and 1978 were measured 2.5 miles below the USFS boundary and 4.5 miles above the convergence with the Middle and West Forks (Foggin et al., 1978). Average sediment yields in pounds/acre were 306 and 352 for the upper and lower stations, respectively. Water quality at these two stations was characterized by a moderate specific conductance, a slightly alkaline pH and low levels of sulfate and major nutrients. All measured parameters were slightly higher at the lower station.

Macroinvertebrate sampling at the upper station reveal an insect community typical of high elevations and velocities (Foggin et al., 1978). The lower station supported taxa more tolerant to high turbidity and warmer water. The biomass and diversity were greater at the lower station.

Elser and Marcoux (1972) found average turbidity readings for stations located on the lower reaches of the East Fork to be among the lowest of 39 stations sampled in the Beaverhead drainage.

3. FISH POPULATIONS

Because extensive fisheries information was collected in 1974 and 1975 on two sections of the East Fork Blacktail Deer Creek, no further electrofishing was conducted (Peterson, 1976). One of the sections was established to measure changes in fish populations over a long period (10-20 years) in a portion of stream that was previously heavily grazed by livestock. Grazing was discontinued in 1974 when the property was purchased by the DFWP. A relatively undisturbed section located 2.2 miles upstream served as a control.

Game fish species present in both sections in descending order of abundance were brook trout, rainbow trout and mountain whitefish. Cutthroat trout are also present in small numbers. The mottled sculpin was the only nongame species present. The electrofishing survey data for 1975 only are summarized for both sections in Table 8 .

Table 8 . Summary of electrofishing survey data collected in a 3,650 ft control section (T11S, R5W, Sec. 3) and a 4,860 ft disturbed section (T11S, R5W, Sec. 8) of East Fork Blacktail Creek in August, 1975.

Fish Species	No. Captured		Length Range (inches)	
	Control	Disturbed	Control	Disturbed
Brook Trout	599	208	4.0-14.9	4.0-13.7
Rainbow Trout	34	24	6.4-16.1	6.9-16.1
Mountain Whitefish	46	160	9.4-18.1	6.6-16.4
Mottled Sculpin	-	-	-	-

The standing crops of trout in both sections in 1974 and 1975 were estimated using a mark-recapture method. The brook trout, the predominant trout species, comprised over 87% of the total trout numbers and biomass in both sections during both years. In 1975, the control (undisturbed) section supported about 164 brook and rainbow trout, weighing 52 pounds, per 1,000 ft of stream. The trout population in the control section was about two times greater than in the disturbed section (Table 9). The control section is characterized by the presence of a greater number of larger trout.

Standing crops of trout in a 2,650 ft section near the mouth of East Fork Blacktail Deer Creek were estimated in 1970 (Elser and Marcoux, 1972). The brook trout, the predominant trout species, accounted for 88% of the total trout numbers. The rainbow trout was the other game fish species captured. This section supports an estimated population of 114 trout, weighing 34 pounds, per 1,000 ft.

Table 9 . Estimated standing crops of trout in a 3,650 ft control section (T11S, R5W, Sec. 3) and a 4,860 ft disturbed section (T11S, R5W, Sec. 8) of East Fork Blacktail Deer Creek in August, 1975. Eighty percent confidence intervals are in parentheses.

Species	Length Range (inches)	Control Per 1,000 Ft Numbers	Control Per 1,000 Ft Pounds	Disturbed Per 1,000 Ft Numbers	Disturbed Per 1,000 Ft Pounds
Brook Trout	4.0- 5.9	43		49	
	6.0- 9.9	67		35	
	10.0-14.9	46		18	
		156(±11)	48(±2)	102(±12)	23(±2)
Rainbow Trout	6.4- 9.9	5		5	
	10.0-16.1	3		2	
		8(±1)	4(±1)	7(±3)	3(±1)
Total Trout		164(±11)	52(±2)	109(±12)	26(±2)

4. FLOW RECOMMENDATIONS

Cross sectional data were collected for an 81 ft riffle-pool sequence located near stream mile 14.0 (T11S, R5W, Sec. 34A). Five cross sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 19.9, 35.6 and 49.6 cfs.

The relationship between wetted perimeter and flow for the composite of five cross-sections is illustrated in Figure 7. Lower and upper inflection points occur at 16 and 26 cfs, respectively. Based on an evaluation of existing fishery, recreational use and other resource information, a flow of 20 cfs is recommended for the low flow period (July 16 - May 15). A recommendation for the high flow period (May 16 - July 15) cannot be derived due to the lack of long-term data for the East Fork Blacktail Deer Creek.

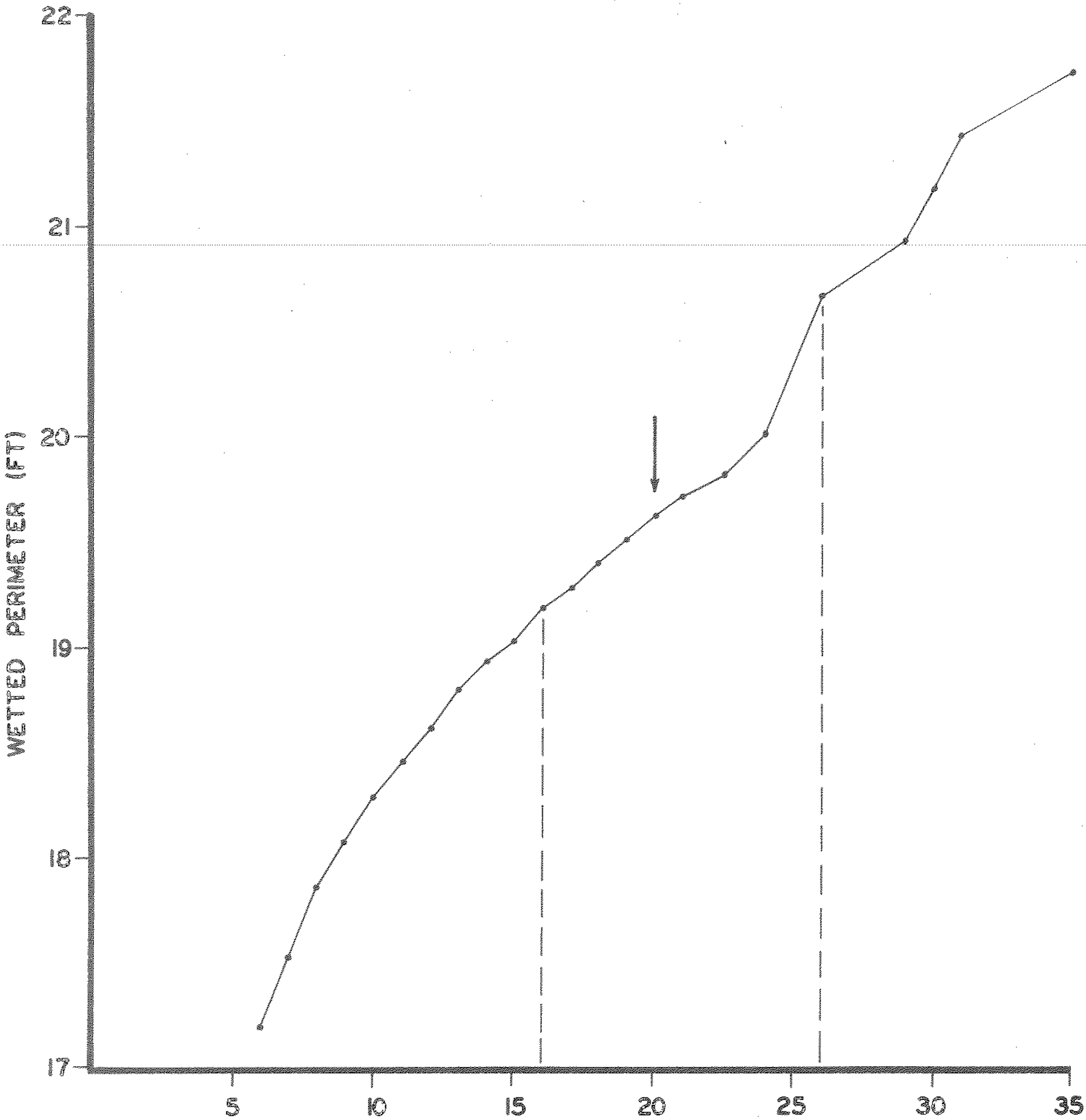


Figure 7. The relationship between wetted perimeter and flow for a composite of five cross-sections in the East Fork Blacktail Deer Creek.

1. STREAM

East Fork Clover Creek

2. DESCRIPTION

East Fork Clover Creek originates in the Snowcrest Mountains of southwest Montana and flows in a southeasterly direction for approximately five miles before entering Clover Creek. Clover Creek continues for 7.5 miles before joining Wolverine Creek, a tributary of the Red Rock River. Land ownership within the 7.5 square mile drainage is shared by the USFS (50%), State of Montana (35%), private individuals (21%), and BLM (4%). The 9 ft wide channel has an average gradient of 72 ft per 1,000 ft. The stream cascades through a riparian zone vegetated with willow, grasses and forbs. There are no major tributaries to East Fork Clover Creek. The drainage consists of grassland/sagebrush hillsides in the lower reaches and forested slopes in the upper drainage.

Lands within the East Fork Clover Creek drainage are used for livestock grazing, which occurs on private and public lands, and recreation in the form of hunting, fishing and hiking. An unimproved road parallels the lower 1.5 miles of stream. Access to the upper reaches is provided by a trail system. Information gathered from angler logs show that 86% of the catch consists of brook trout and the remaining 14% cutthroat trout (MDFWP, 1980b). Both species average 9.8 inches in length. This drainage is part of hunting district 324, one of the most popular elk hunting areas in Montana. During the 1979 big game season, 13,083 hunter-days were recorded (MDFWP, 1980a).

Potential and existing environmental problems within the East Fork Clover Creek drainage are related to cattle grazing and other agricultural activities. The physical removal of willows and the over-grazing and trampling of the riparian zone by livestock on portions of the stream have contributed to the widening of the stream channel, destruction of undercut banks and loss of streambank vegetation.

In May - June, 1970, the East Fork of Clover Creek had the lowest turbidity readings of 39 stations sampled in the Beaverhead River drainage (Elser and Marcoux, 1972). Suspended sediment levels do not appear to be excessive even during runoff.

3. FISH POPULATIONS

A 1,000 ft section of East Fork Clover Creek was electrofished on July 21 and August 12, 1980. Game fish captured were brook and cutthroat trout. The only nongame species present was the mottled sculpin (Table 10).

Table 10 . Summary of electrofishing survey data collected for a 1,000 ft section of the East Fork Clover Creek (T13S, R5W, Sec. 8B) on July 21 and August 12, 1980.

Species	No. Captured	Length Range (inches)
Brook Trout	90	2.0-9.9
Cutthroat Trout	13	4.2-9.6
Mottled Sculpin	-	-

The standing crop of brook trout in the section was estimated using a mark-recapture method (Table 11). This 1,000 ft section supports about 270 brook trout, weighing 35 pounds. When compared to other streams of this size in the Beaverhead National Forest, the population and condition of the trout are above average.

Table 11 . Estimated standing crop of brook trout in a 1,000 ft section of East Fork Clover Creek (T13S, R5W, Sec. 8B) on July 21, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Pounds
Brook Trout	4.0-5.9	111	
	6.0-9.9	159	
		270 ($\pm$101)	35 ($\pm$13)

The BLM (unpublished data) collected cutthroat trout from East Fork Clover Creek for meristic analyses to determine the degree of hybridization within the population. Although more fish were needed for positive conclusions, it appears that the trout of the East Fork are Yellowstone and westslope cutthroat hybrids.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 78 ft riffle-pool sequence located in T13S, R5W, Sec. 8B. Five cross-section were placed within this sequence. The WETP program was calibrated to field data collected at flows of 4.2, 6.9 and 10.4 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 8 . The lower and upper inflection points occur at 2 and 4.5 cfs, respectively. Based on an evaluation of existing fisheries, recreational use and other resource information, a flow of 4.0 cfs is recommended for the low flow period (July 16 - May 15). Flow recommendations for the high flow period (May 16 - July 15) cannot be derived for the East Fork Clover Creek due to the lack of long-term flow data.

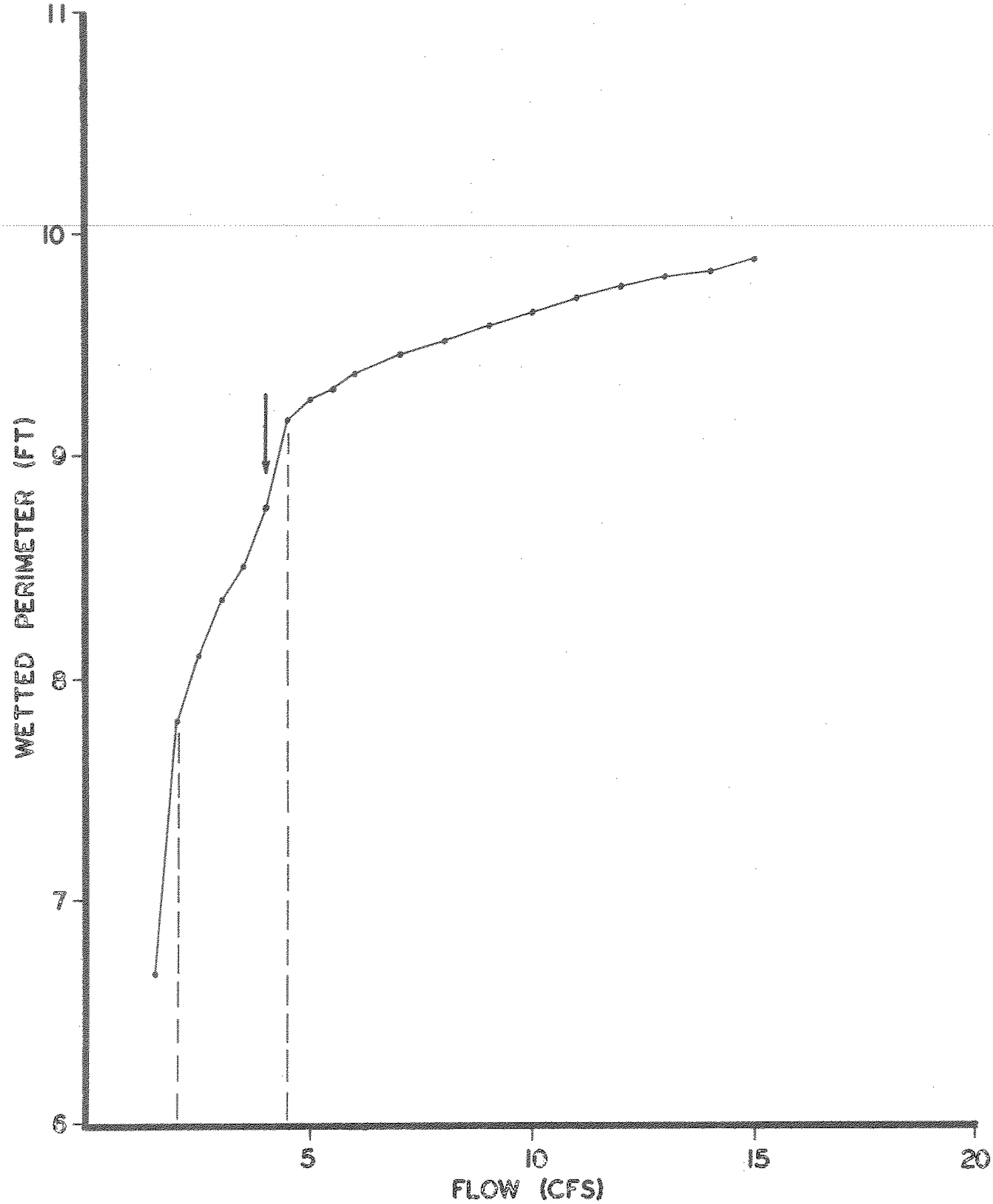


Figure 8. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in East Fork Clover Creek.

1. STREAM

West Creek

2. DESCRIPTION

West Creek flows in a southerly direction for 10 miles before entering the Red Rock River above Lima Reservoir. It originates on the west slope of the Snowcrest Range and drains a 15 square mile area. The drainage is controlled by private individuals (46%), the USFS (43%), and the BLM (10%). The majority of the stream (83%) flows through private land, which is primarily used for grazing. The drainage is characterized by grassland/sagebrush covered hilsides. Only the headwater area contains timbered slopes. West Creek flows with a fairly steep gradient of 52 ft per 1,000 ft. The riparian zone is composed of willow, aspen, sage, grasses and sedges. The upper portion of the channel is characterized by extensive beaver dam construction, causing the stream to lose its fluvial nature. Major tributaries of this 6 ft wide stream are Middle and Anton Creeks.

Lands within the West Creek drainage are used for livestock grazing, hay production and recreation mainly in the form of hunting. The hunting district encompassing the West Creek drainage is one of the more heavily used areas during the big game season. Hunting pressure for elk was estimated at 13,083 hunter-days during the 1979 season (MDFWP, 1980a).

In general, the habitat and overall condition of West Creek is poor (BLM, unpublished data). The substrate is compacted with fine sediment, virtually eliminating all spawning gravels. Bank erosion is high, primarily due to bank slumping and channel scouring. This is primarily caused by livestock trampling and overgrazing of the banks. Stream crossings by vehicles are also contributing to the problem. Numerous beaver dams and debris jams are found throughout the channel creating barriers to fish movement. Although the riparian vegetation is fairly dense on many sections of stream, in areas where cattle graze only 37% of the stream is shaded and the depth has decreased due to the widening of the channel.

3. FISH POPULATIONS

During 1980, five stream habitats varying from beaver ponds to riffle-run sections were electrofished on West Creek. Section lengths varied from 100-1,000 ft. All were located in T13S, R4W, Sec. 6D. No fish were captured or observed in these sections. Major factors limiting the fishery include the complete lack of spawning areas as a result of compaction by sediments and numerous beaver ponds and debris jams which hinder upstream movement (BLM, unpublished data).

In 1952-53, Nelson (1954a) surveyed various tributaries of the Red Rock River to assess the status of arctic grayling populations. Two young-of-the-year grayling were collected near the mouth of the West Creek, indicating that this stream was used in the past by grayling for spawning and the rearing of young.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were collected in a 45.6 ft riffle-run sequence located in T13S, R4W, Sec. 6D. Five cross-sections were placed within the sequence. The WETP program was calibrated to field data collected at flows of 2.6, 4.1 and 12.0 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 9 . The lower and upper inflection points occur at 2 and 4 cfs, respectively. Based on an evaluation of existing fishery and other resource information, a flow of 2.0 cfs is recommended for the low flow period (July 16 - May 15). Because long-term flow records are unavailable for West Creek, recommendations for the high flow period (May 16 - July 15) cannot be derived.

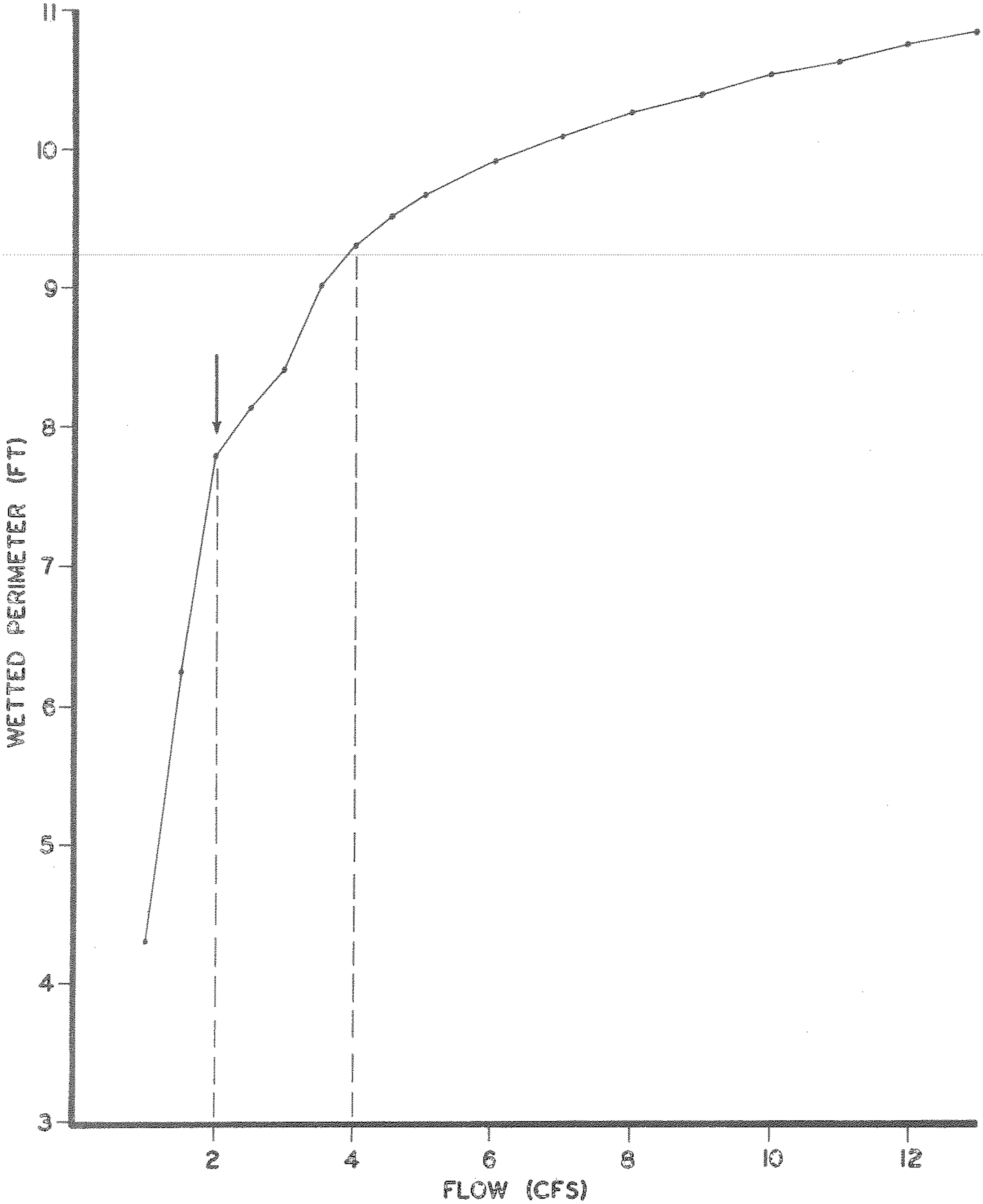
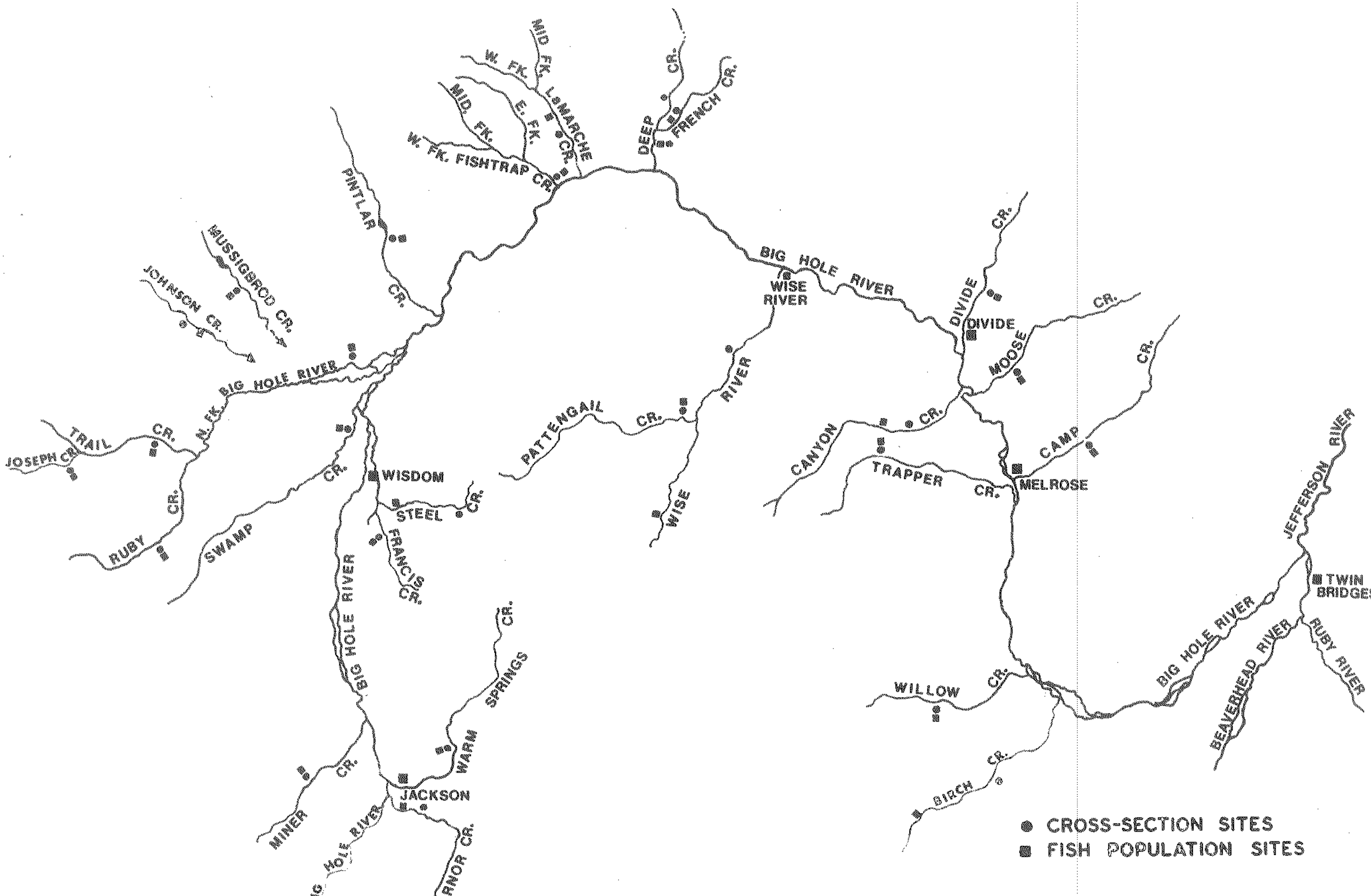


Figure 9. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in West Creek.

BIG HOLE RIVER TRIBUTARIES



The study areas of the Big Hole River Drainage.

1. STREAM

Birch Creek

2. DESCRIPTION

Birch Creek originates in the West Pioneer Mountain Range of southwest Montana and flows in an easterly direction for 18.5 miles before entering the Big Hole River, 4.5 miles south of Glen, Montana. The 48 square mile drainage is controlled by the USFS (73%), private individuals (18%), BLM (7%), and the State of Montana (2%). The average gradient of the 20 ft wide channel is approximately 43 ft/1,000 ft. The portion of the drainage on USFS lands is characterized by steeply timbered slopes and a narrow floodplain. After leaving USFS lands, the vegetative cover consists of sagebrush and grassland communities with much of the land converted to irrigated hay pastures. The riparian zone is composed primarily of willow, birch, aspen, alder, grasses and forbs. Major tributaries include Thief, Sheep, and Mule Creeks. Alpine lakes, such as Tub, Pear, Boot, and Lilly Lakes, dot the headwater area.

Lands within the Birch Creek drainage are used for mining, cattle grazing, hay and grain production and recreation in the form of fishing, hunting, camping and hiking. A gravel road parallels the creek, becoming a jeep trail along the upper reaches of the stream. There are two USFS campgrounds, a picnic area and the opportunity for extensive hiking within the scenic drainage.

Fishing pressure on Birch Creek from May, 1975 to April, 1976 was estimated at 84 person-days (MDFG, 1976). This amounts to about 5 person-days/stream mile/year. Angler log data compiled by the MDFWP (1980b) show that 90% of the catch from Birch Creek consists of brook trout averaging 8.3 inches in length. Cutthroat trout, averaging 12.5 inches in length, comprise the remaining 10% of the catch. Hunting for mule deer is popular in the drainage.

Present mining activity within the drainage is limited to scattered patented claims and small operations. In the past, the Birch Creek drainage was a major producer of metals. The town of Farlin was established on the banks of Birch Creek in the late 1800's as a result of the influx of miners. A smelter was constructed in the drainage to keep up with production (Geach, 1972). Approximately 23,136 tons of ore, which yielded 1,000,000 pounds of copper, 5,000 pounds of lead, 43,000 oz. of silver and 308 oz. of gold, were mined in the area. The majority of the production occurred between 1902-1920.

The major use of the water in the Birch Creek drainage after leaving USFS lands is for the irrigation of hay and grain crops. Privately owned irrigation companies have constructed dams on the outlets of Deerhead, Pear, Anchor, Tub, Boot and May Lakes. Birch Creek is essentially used as a means for conveying water 10-15 miles from these alpine lakes into a series of irrigation ditches and pipes. Considerable damage to the Birch Creek channel has occurred as a result of dam failures on these numerous lakes. This has produced a scoured channel, a reduction in instream cover due to extensive bedload movement and loss of bank vegetation. Fish habitat in the form of pools and other resting and holding areas is lacking. Because of the extensive irrigation network below the USFS boundary, the natural channel is severely dewatered for the lower 8 miles during the summer irrigation season.

A USGS gauge station was operated at stream mile 11.0 of Birch Creek from 1946-76. The average annual discharge for the 28-year period of record was 29.4 cfs. A minimum of 0.8 cfs in November, 1958 and a maximum of 427 cfs in July, 1975 were recorded during the period of operation.

Water chemistry data have been collected for Birch Creek by the USFS from 1974-1980 (USFS, unpublished data). In general, Birch Creek follows the typical pattern for streams in the Big Hole River drainage with low specific conductance, alkalinity and hardness levels and a neutral pH. During two sampling periods, dissolved zinc concentrations were slightly elevated and were above recommended standards for fish and other aquatic life (Wentz, 1974). These concentrations may be a result of metals leaching into the stream from old tailings.

3. FISH POPULATIONS

Considerable time and effort was devoted to locating a 1,000 ft section of Birch Creek with good cover and riffle-pool development. Two electrofishing passes through the section were completed on August 1, 1980. Cover and other likely fish habitat were thoroughly worked. The brook trout and mottled sculpin were the only species present (Table 12). Based on this survey, the trout population of Birch Creek appears to be extremely sparse. This may be a result of a number of factors including the elevated metal concentrations, the excessive flow fluctuations that occur throughout the year, and inadequate resting habitat and cover.

Table 12 . Summary of electrofishing survey data collected for a 1,000 ft section of Birch Creek (T5S, R11W, Sec. 1A) on August 1, 1980.

Species	No. Captured	Length Range (inches)
Brook Trout	12	3.6-6.4
Mottled Sculpin	-	-

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 98 ft riffle-run sequence located in T5S, R10W, Sec. 23B. Five cross-sections were placed within this sequence. The WETP program was calibrated to field data collected at flows of 17.6, 85.4 and 161.2 cfs.

The relationship between wetted perimeter and flow for composite of two riffle cross sections is shown in Figure 10 . Lower and upper inflection points occur at 12 and 24 cfs, respectively. Based on an

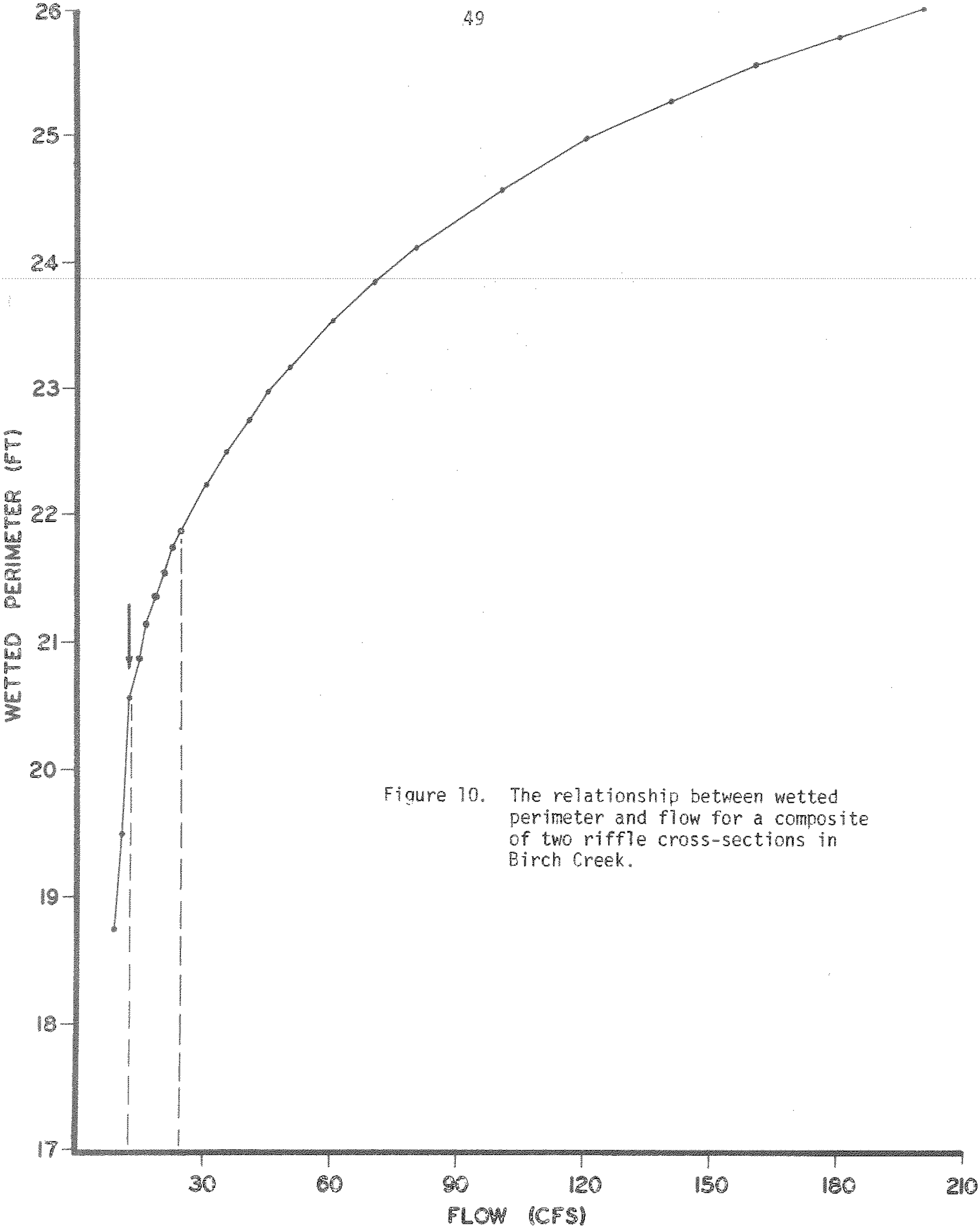


Figure 10. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Birch Creek.

evaluation of existing fishery, recreational use and water availability information, a flow of 12 cfs is recommended for the low flow period (July 16 - May 15).

Monthly flow recommendations for the low and high flow periods are listed in Table 13. The median monthly flows of record for the USGS gauge at stream mile 11.0 are also listed for comparison. These median flows reflect the headwater storage that occurs during the year and water releases from these reservoirs during the summer irrigation season. No irrigation diversions are located upstream of the gauge. The recommendations for the months of November through April exceed the median flows.

The monthly flow recommendations, when adjusted to fall within the constraints of water availability during a median water year, amount to approximately 12,109 acre-feet of water per year or about 61% of the annual flow that is normally available at the USGS gauge on Birch Creek.

Table 13. Instream flow recommendations derived for Birch Creek using the wetted perimeter/inflection point method (low flow period) and the dominant discharge/channel morphology concept (high flow period) compared to the median flows of record.

Month	Recommended Flows	Approximate Median Flows[a]	
	CFS	CFS	AF
January	12	7.2	443
February	12	6.9	383
March	12	7.5	461
April	12	10.0	595
May 1-15	12	19.8	589
May 16-31	32.8	57.1	1,812
June 1-15[b]	73.7	114.1	3,394
June 16-30	60.9	130.0	3,867
July 1-15	40.7	74.0	2,201
July 16-31	12	50.7	1,609
August	12	30.5	1,875
September	12	12.1	720
October	12	15.9	977
November	12	10.0	595
December	12	7.3	449
			19,970

Table 13 continued. Instream flow recommendations derived for Birch Creek using the wetted perimeter/inflection point method (low flow period) and the dominant discharge/channel morphology concept (high flow period) compared to the median flows of record.

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a/ Derived for a 19-year period of record (1958-76 water years) for the USGS gauge at stream mile 11.0 (T5S, R10W, Sec. 23).

b/ The bankful flow, which is presently undefined, should be maintained for 24-hours during this period.

1. STREAM

Canyon Creek

2. DESCRIPTION

Canyon Creek originates in the Pioneer Mountains, southeast of the town of Divide, Montana. The stream flows in a northeasterly direction for 16 miles before joining the Big Hole River. For the majority of its length, Canyon Creek cascades through a forested canyon containing numerous limestone caves. It flows through cottonwood and willow bottoms in its lower few miles. The stream gradient averages 36 ft/1,000 ft. Ownership of the 51 square mile drainage is shared by the USFS (97%), BLM (2%) and private landowners (1%). The only named perennial tributaries are Lion and Vipond Creeks. Numerous high mountain lakes and intermittent streams drain the headwater area. The substrate within the 12 ft wide channel is composed primarily of gravel and rubble.

Lands within the Canyon Creek drainage are used for cattle grazing, mining, and recreational activities including fishing, hunting and camping. An improved gravel road,which parallels the lower 12 miles of stream, ends at a USFS campground. A guest ranch is located along the stream.

Fishing pressure on Canyon Creek in 1975-76 was estimated at 432 person-days per year (MDFG, 1976). This amounts to about 27 person-days/stream mile/year. Angler log data compiled by the DFWP shows that the catch consists entirely of cutthroat trout, averaging 7.5 inches in length (MDFWP, 1980b). The drainage is a popular area for hunting mule deer and elk and provides important mule deer winter range as well. Presently, the Canyon Creek drainage is being managed under the USFS rest rotation grazing allotment system (USFS, unpublished data).

Beginning in the late 1800's, the mining boom swept through the Canyon Creek drainage and the Trapper Creek drainage, the adjacent drainage to the south. A large smelter was built at the town of Glendale along Trapper Creek, for processing the ore mined in the area. Charcoal and coke were used to operate the smelter. Thirty-eight charcoal kilns, producing 1,000,000 bushels of charcoal per year, were built in the Canyon Creek drainage.

The Vipond Park and Quartz Hill Mining Districts are located in the drainage. From 1902-1965, total recorded production from this district was 57,261 tons of ore containing silver, lead, copper, gold and zinc (Geach, 1972). Presently, an exploration group is studying the feasibility of reopening the area for silver and copper production (USFS, unpublished data).

The 1977 Montana Legislature requested the Department of Natural Resources and Conservation to study the feasibility of constructing an off-stream storage reservoir on a tributary to the Big Hole River. The reservoir is to be used for augmenting instream flows in the Big Hole and Jefferson Rivers, irrigation and flood control (DNRC, 1979). A site on Canyon Creek was selected for further study. The Canyon Creek site was later eliminated due to potential seepage problems (DNRC, 1981).

The water of Canyon Creek has a low specific conductance, a low hardness and alkalinity, a neutral pH and low suspended sediments. This is typical for the tributaries of the Big Hole River (USFS, unpublished data).

The aquatic resource is relatively unaffected by mans' activities. Minor losses of riparian habitat and undercut banks have occurred on several isolated sections of the stream. Although the headwater area was extensively mined and left unreclaimed and toxic metals may be leaching into the stream, their effect on the aquatic resource appears negligible.

3. FISH POPULATIONS

A 1,000 ft section of Canyon Creek was electrofished on July 9 and 31, 1979. Game fish captured were rainbow trout, rainbow x cutthroat hybrids and brook trout. The mottled sculpin was the only nongame species captured. Table 14 summarizes the electrofishing survey data for Canyon Creek.

Table 14 . Summary of electrofishing survey data collected for a 1,000 ft section of Canyon Creek (T2S, R10W, Sec. 15A) on July 9 and 31, 1979.

Species	No. Captured	Length Range (inches)
Rainbow Trout and Rainbow x Cutthroat Hybrids	92	2.6-12.7
Brook Trout	64	4.0-11.7
Mottled Sculpin	-	-

The standing crop of trout in the section was estimated using a mark-recapture method (Table 15). This 1,000 ft section supports about 211 trout, weighing 27 pounds. Rainbow trout and rainbow x cutthroat hybrids were the predominant game fish. They comprised about 54% of the total trout numbers and 59% of the total biomass. Brook trout accounted for 46% of the trout numbers and 41% of the biomass.

Table 15. Estimated standing crop of trout in a 1,000 ft section of Canyon Creek (T2S, R10W, Sec. 15A) on July 9, 1979. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Rainbow Trout and Rainbow x Cutthroat Hybrids	4.0- 5.9	43	
	6.0- 9.9	64	
	10.0-12.7	6	
		113(±29)	16(±4)

Table 15 continued. Estimated standing crop of trout in a 1,000 ft section of Canyon Creek (T2S, R10W, Sec. 15A) on July 9, 1979. Eighty percent confidence intervals are in parentheses.

Brook Trout	4.0- 5.9	59	
	6.0- 9.9	36	
	10.0-11.7	3	
		98(±28)	11(±2)
Total Trout		211(±40)	27(±5)

Wipperman and Needham (1965) electrofished a 340 ft section of Canyon Creek located 2.5 miles upstream from the present section. The brook trout was the dominant trout species with 95 individuals captured. Twenty-one cutthroat x rainbow hybrids, three rainbow trout and two cutthroat trout were also captured. Of the 121 trout captured, only 14% were longer than 7 inches.

Gill netting data show that rainbow and cutthroat trout and rainbow x cutthroat hybrids are present in Canyon, Cresent, Grayling and Vera Lakes, mountain lakes within the headwaters of the Canyon Creek drainage. (Wipperman and Elser, 1968).

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were collected in a 96 ft riffle-pool sequence in T2S, R10W, Sec. 12A. Five cross-sections were placed within the sequence. The WETP program was calibrated to field data collected at flows of 4.2, 15.3 and 48.2 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is illustrated in Figure 11 . Lower and upper inflection points occur at flows of 2 and 5 cfs, respectively. Based on an evaluation of existing fishery, recreational use and other resource information, a flow of 4 cfs is recommended for the low flow period (July 16 - May 15). Due to the lack of long-term flow data for Canyon Creek, recommendations for the high flow period (May 16 - July 15) cannot be derived.

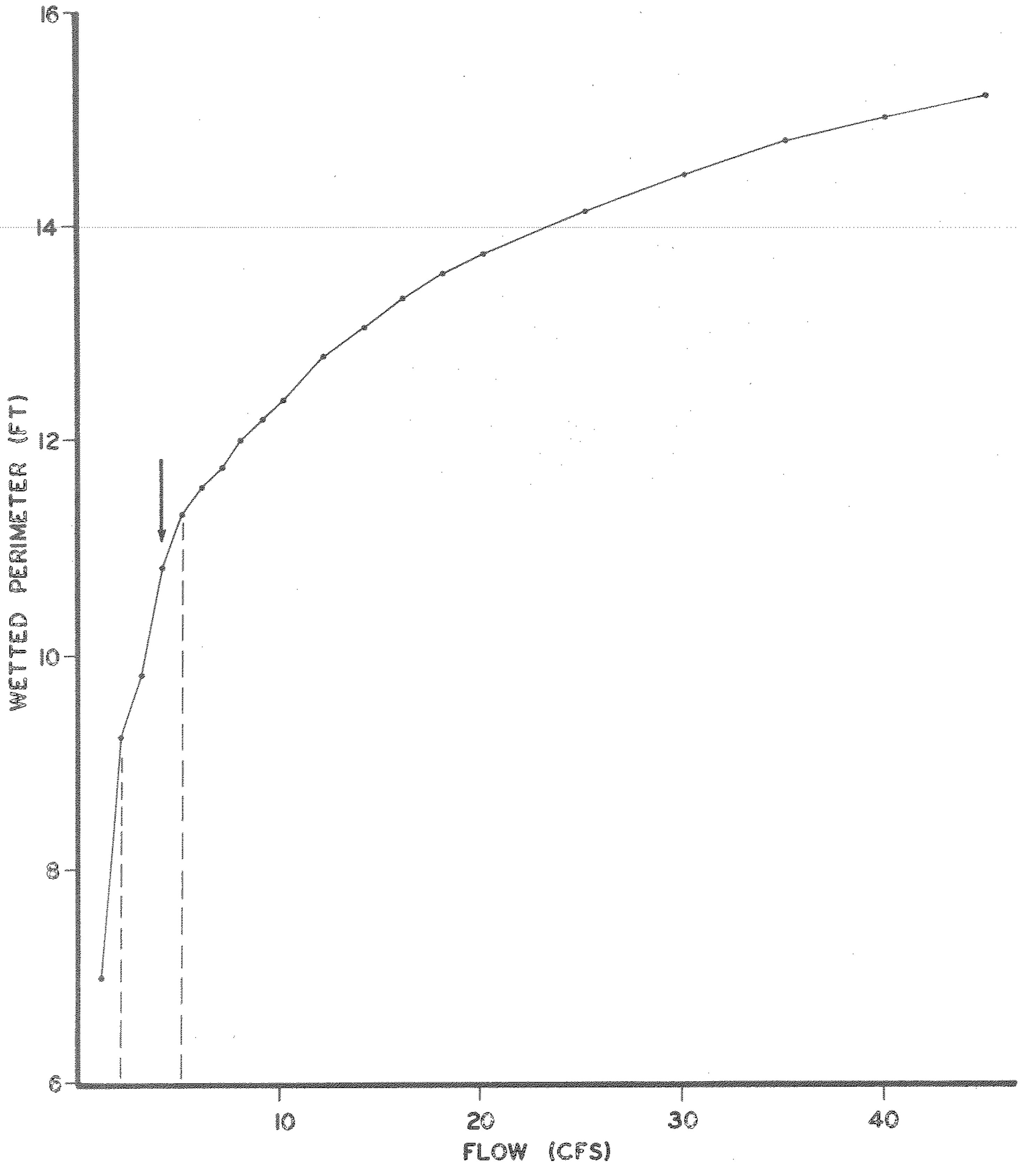

Figure 11. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Canyon Creek.

1. STREAM

Deep Creek

2. DESCRIPTION

Deep Creek arises on the southern slope of the Anaconda-Pintlar Range of southwest Montana, 12 miles west of Wise River, Montana. Deep Creek is formed at the confluence of Ten Mile and Seven Mile Creeks, then meanders through dense willow and alder bottoms in a southerly direction for 9 miles before entering the Big Hole River. Other tributaries of Deep Creek include French, Sullivan, Slaughterhouse and Twelve Mile Creeks. Vegetative cover in the 100 square mile drainage consists of conifer forests in the upper portion, changing to sagebrush/grasslands at the lower elevations. The majority of the drainage (63%) was acquired by the Montana Department of Fish, Wildlife and Parks in 1976 as a wildlife management area, which protects an important deer and elk migration route and winter habitat for moose. The remainder of the drainage is divided between the USFS (30%), private landowners (5%) and the BLM (2%). Average gradient of the 30 ft wide channel is 8.4 ft/1,000 ft.

Lands within Deep Creek drainage are primarily used for wildlife management, recreation in the form of hunting, fishing and skiing, timber harvesting, cattle grazing and hay production along the lower reaches. The Mt. Haggin Wildlife Management Area is presently one of the more popular elk and mule deer hunting districts in the state. Hunting pressure in 1979 was estimated at 33,644 hunter-days (MDFWP, 1980a). There is presently a grazing contract with the Mt. Haggin Livestock Company and a logging contract with Louisiana Pacific on the Mt. Haggin WMA. Prior to the acquisition of the Mt. Haggin property by the DFWP, willows within the riparian zone were physically and chemically removed to increase the grazing area (Wipperman, 1967). A small ski area primarily used by local residents is also located in the drainage.

During the irrigation season, the lower reaches of Deep Creek are diverted causing severe dewatering. Damage to the stream caused by the trampling of banks and grazing in the riparian zone is evident on the lower reaches. A subdivision presently being developed on Deep Creek could contaminate ground water through improper use or placement of septic tanks, affect the stream recharge rate through well production and alter the floodplain through the drainage of marshy areas.

The water chemistry of Deep Creek above the confluence of French Creek was analyzed during the summer of 1980 at three different flows (Oswald, 1981). In general, Deep Creek exhibits the typical chemical pattern for streams of the Big Hole drainage of a low specific conductance, low hardness and alkalinity levels, a neutral pH and low suspended sediments.

3. FISH POPULATIONS

A 1,000 ft section of Deep Creek above the mouth of French Creek was electrofished on August 26 and September 9, 1980. A 1,000 ft section below the mouth was electrofished on July 11 and August 2, 1979. Game fish present in both sections were brook trout, rainbow trout, mountain whitefish and burbot. Longnose sucker, longnose dace, and mottled sculpin were the nongame species captured. Table 16 summarizes the electrofishing survey data for the two sections.

Table 16. Summary of electrofishing survey data collected for two 1,000 ft sections of Deep Creek above (T2N, R12W, Sec. 9A) and below (T2N, R12W, Sec. 20D) the mouth of French Creek on August 26 and September 9, 1980 and July 11 and August 2, 1979, respectively.

	No. Captured		Length Range (inches)	
Species	Above French	Below French	Above French	Below French
Brook Trout	131	16	2.2- 9.9	1.6- 9.9
Rainbow Trout	12	18	2.5-11.0	5.2-10.2
Mountain Whitefish	6	19	8.4-13.1	10.2-12.5
Burbot	13	10	7.2-13.0	7.6-10.7
Longnose Sucker	25	66	4.5-12.4	4.6-10.1
Longnose Dace	-	-	-	-
Mottled Sculpin	-	-	-	-

In comparing the two sections, approximately eight times more brook trout were captured above the mouth of French Creek than were captured below.

Due to the low numbers of fish captured in the lower section, the standing crop of brook trout could only be estimated in the section above the mouth of French Creek (Table 17). This section supports about 167 brook trout, weighing 18 pounds. The condition factors for brook trout (length to weight ratio) were below average for streams sampled in the present study.

Table 17. Estimated standing crop of brook trout in a 1,000 ft section of Deep Creek located above the mouth of French Creek (T2N, R12W, Sec. 9A) on August 26, 1980. Eighty percent confidence intervals are in parentheses.

		Per 1,000 Ft	
Species	Length Group (inches)	Numbers	Pounds
Brook Trout	4.0-5.9	63	
	6.0-9.9	104	
		167 (±35)	18 (±3)

Electrofishing surveys conducted in 1964 (Wipperman and Needham, 1965) and 1966 (Wipperman, 1967a) show similar results. In both years, numbers of brook trout captured above the French Creek confluence were considerably greater than those below.

Within the 2.5 miles between the upper and lower sections, some factor or combination of factors are depressing the trout population. French Creek, whose fishery is also depressed, is the only major tributary entering Deep Creek between these sections.

Although not captured during the 1979 or 1980 electrofishing surveys, low numbers of arctic grayling have been found in the lower reaches of Deep Creek (Wipperman and Needham, 1965 and Wipperman, 1967a). The fluvial arctic grayling is classified as a species of special concern (Deacon et al., 1979). Once widely distributed throughout the upper Missouri River drainage, remnant populations of fluvial arctic grayling are now only found in the upper Big Hole drainage. Vincent (1962) cites agricultural practices that reduce natural streamflows, increase siltation and restrict grayling movement as possible causes for the apparent decline of this species in recent years. It is imperative that instream flow protection is secured for those streams still supporting arctic grayling populations.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were collected in a 158 ft subreach located near stream mile 2.0 (T2N, R12W, Sec. 20D). Five cross-sections describing the riffle-pool habitat were placed within the subreach. The WETP program was calibrated to field data collected at flows of 33.8 and 187.5 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is shown in Figure 12. Lower and upper inflection points occur at 20 and 40 cfs, respectively. Based on an evaluation of existing fishery and other resource information, a flow of 30 cfs is recommended for the low flow period (July 16 - May 15). Recommendations for the high flow period (May 16 - July 15) cannot be derived for Deep Creek due to lack of long-term flow data.

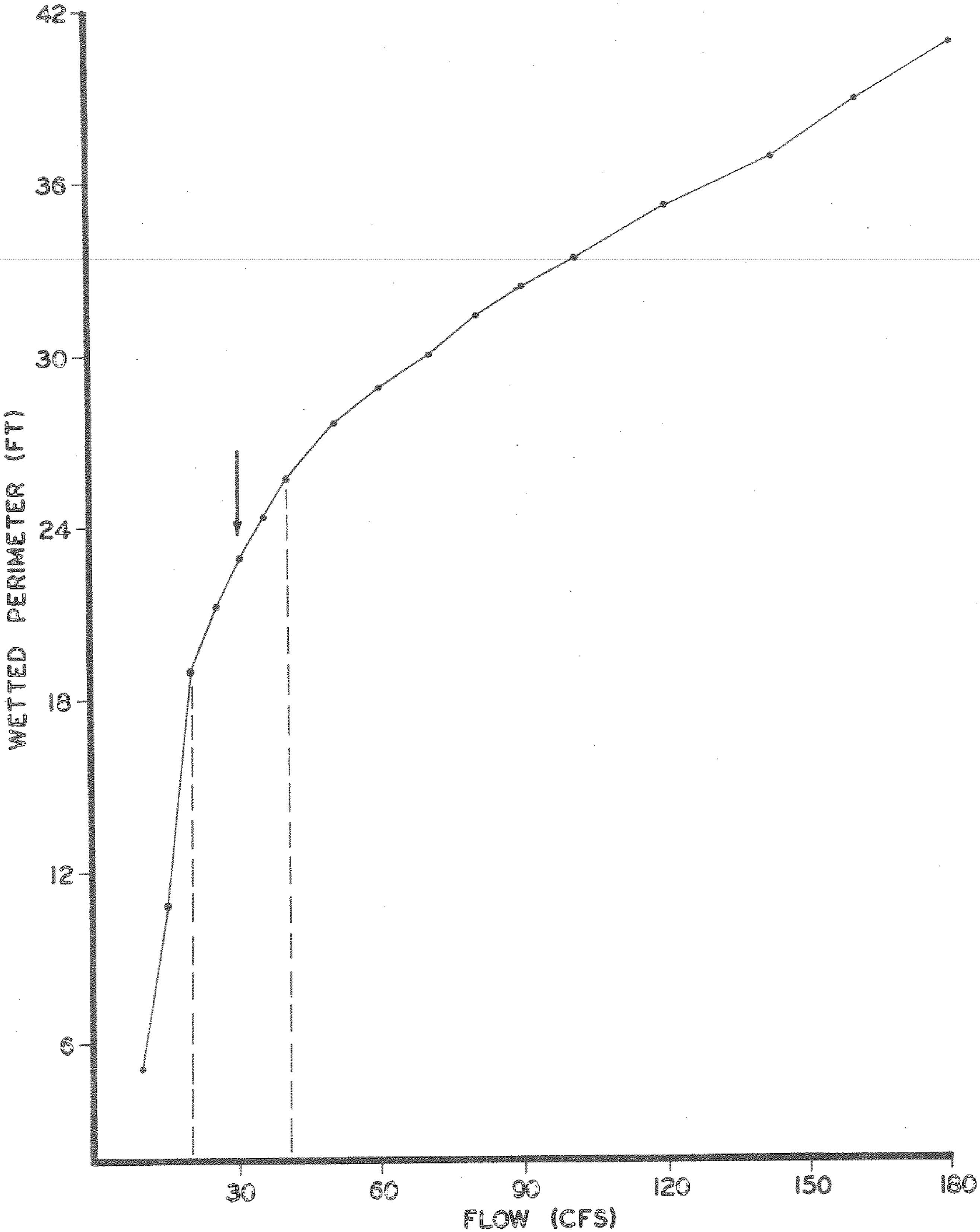

Figure 12. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Deep Creek.

1. STREAM

Fishtrap Creek

2. DESCRIPTION

Fishtrap Creek originates on the southeast slope of the Anaconda-Pintlar Range of southwest Montana at the convergence of its East, West and Middle Forks and flows five miles before entering the Big Hole River. Swamp and Pallisade Creeks and the East, West and Middle Forks are the major tributaries. General topography of the upper drainage consists of steeply timbered, roadless canyons. In its lower reaches, gentle grassland and sagebrush benches surround the narrow floodplain. Fishtrap Creek drains an area of 48.5 square miles. The drainage is controlled by the USFS (78%), private individuals (9%) and the State of Montana (3%). Sixty percent of the USFS land is within the Anaconda-Pintlar Wilderness Area. The gradient of the 31 ft wide channel averages 17 ft per 1,000 ft. Average gradient of the three forks ranges from 43 - 84 ft/1,000 ft.

Lands within the Fishtrap drainage are used for recreation, hay production, livestock grazing and timber harvesting in the upper reaches. Recreational activities include fishing, hunting and hiking. Fishing pressure on Fishtrap Creek during May, 1975 through April, 1976 was estimated from a mail survey at 84 person-days (MDFG, 1976). This amounts to about 17 person-days/stream mile/year. Angler log data compiled by the DFWP show that catches consist entirely of brook trout, which average 8.0 inches in length (MDFWP, 1980b).

Although only 9% of Fishtrap drainage is owned by private individuals, 80% of the stream channel is on private lands. The stream is extensively used for irrigation and may become severely dewatered during the irrigation season. The over-grazing of the riparian zone along portions of the channel by livestock has produced trampled banks, a reduction of streambank willows and an increase in sediment accumulations.

Although only limited water chemistry information is available for Fishtrap Creek, it appears this water follows the typical pattern for streams of the Big Hole drainage. The water is characterized by a low specific conductance and a neutral pH (USFS, unpublished data).

3. FISH POPULATIONS

A 1,000 ft section near the mouth of Fishtrap Creek was electrofished on July 17 and August 2, 1979. Game fish captured in descending order of abundance were brook trout, burbot and rainbow trout. Longnose sucker and mottled sculpin were the only nongame species present. Table 18 summarizes the electrofishing survey data for Fishtrap Creek.

Table 18. Summary of electrofishing survey data collected for a 1,000 ft section of Fishtrap Creek (T1N, R13W, Sec. 4B) on July 17 and August 2, 1979.

Species	No. Captured	Length Range (inches)
Brook Trout	224	1.6-14.0
Burbot	29	5.2- 9.4
Rainbow Trout	9	5.0- 7.8
Longnose Sucker	-	-
Mottled Sculpin	-	-

The standing crop of brook trout in the section was estimated using a mark-recapture method (Table 19). The 1,000 ft section supports about 310 brook trout, weighing 27 pounds. Of the 25 Big Hole tributaries electrofished during 1979-80, Fishtrap Creek supports one of the highest standing crops of brook trout.

Table 19. Estimated standing crop of brook trout in a 1,000 ft section of Fishtrap Creek (T1N, R13W, Sec. 4B) on July 17, 1979. Eighty percent confidence intervals are in parentheses.

		Per 1,000 Ft	
Species	Length Group (inches)	Number	Pounds
Brook Trout	4.0- 5.9	241	
	6.0- 9.9	65	
	10.0-14.0	4	
		310 (±76)	27 (±5)

A section of Fishtrap Creek located approximately 2.5 miles from the mouth was electrofished in 1964 (Wipperman and Neeham, 1965) and 1966 (Wipperman, 1967a). The brook trout was the predominant game fish captured in both years. The rainbow trout was also present in small numbers.

Anglers report catching arctic grayling in Fishtrap Creek, although their presence has not been documented during electrofishing surveys. The arctic grayling is considered a species of special concern in the state of Montana (Deacon et al., 1979). A once abundant species throughout the upper Missouri River Drainage above the Great Falls, it now exists in only remnant populations in the Big Hole drainage. Low numbers of grayling are found in selected tributaries and the upper main river (Liknes, 1981). The fluvial arctic grayling has specific habitat requirements, which usually restrict its distribution to lower reaches in small streams (Vincent, 1962). Vincent cites agricultural and logging practices, which cause a loss in flows, an increase in sedimentation and a restriction of fish movement by irrigation dams as the probable reasons for the decline of the arctic grayling in recent history. It is imperative that instream flow protection is secured for those streams still supporting arctic grayling populations.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected for a 68 ft riffle-run sequence located in T1N, R13W, Sec. 4B. Five cross-sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 8.2 and 86.5 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is shown in Figure 13 . Lower and upper inflection points occur at 5 and 10 cfs, respectively. Based on fishery and other resource information, a flow of 10 cfs is recommended for the low flow period (July 16 - May 15). Due to the lack of long-term flow data, recommendations for the high flow period (May 16 - July 15) cannot be derived for Fishtrap Creek.

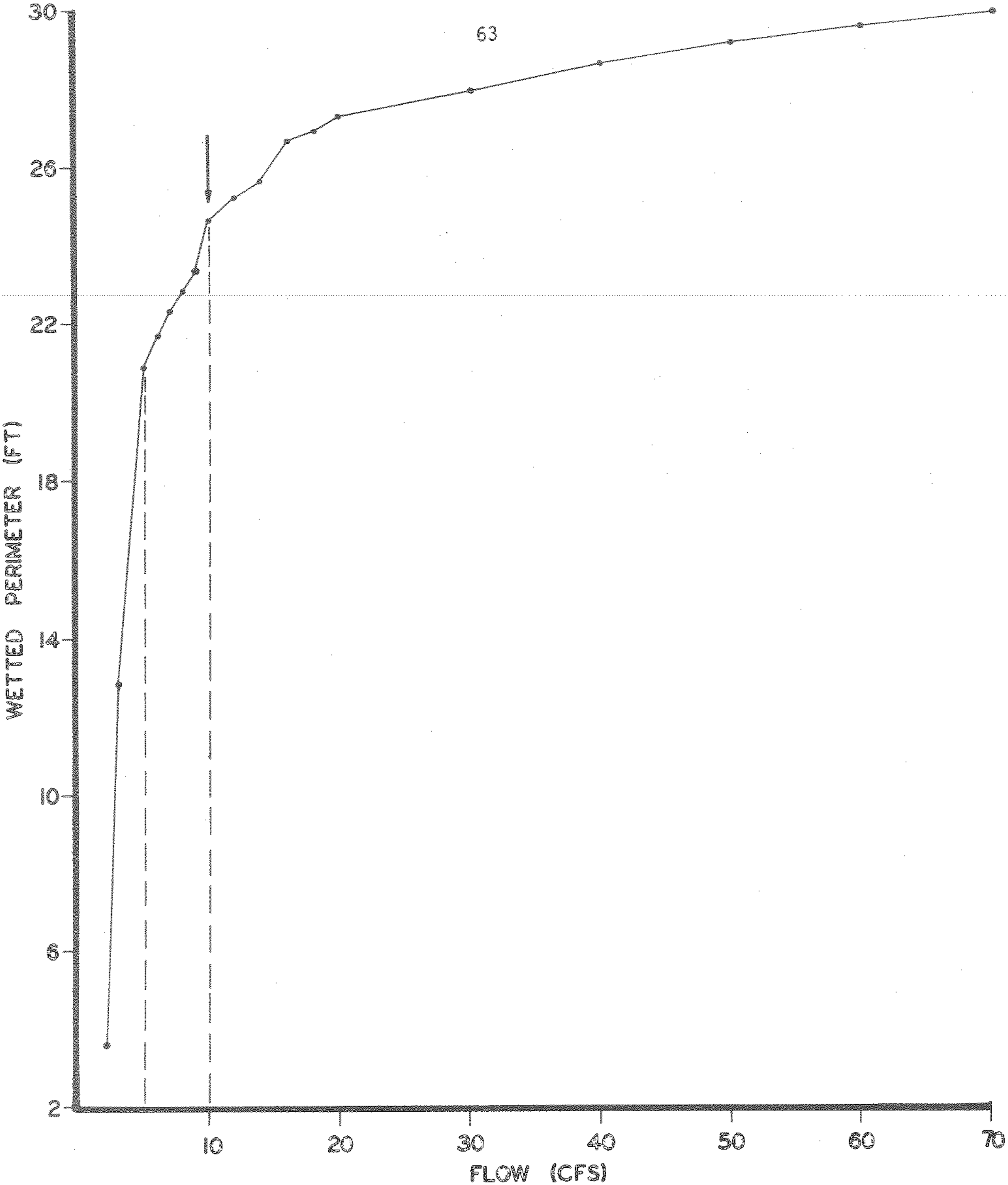

Figure 13. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Fishtrap Creek.

1. STREAM

Francis Creek

2. DESCRIPTION

Francis Creek, which is located two miles southeast of Wisdom, Montana, drains the western benches and steeper, upper slopes of the West Pioneer Mountains. It flows in a westerly direction for 8 miles before entering Steel Creek, a tributary of the Big Hole River. The drainage is comprised of grassland/sagebrush benches in the lower reaches and steep timbered slopes in the headwater area. Except for two small improved roads, the drainage is roadless. Sand and Sheep Creeks are the only perennial tributaries to Francis Creek. Francis Creek drains an area of 25 square miles. Ownership of the drainage is shared by the USFS (60%), private individuals (20%) and the State of Montana (20%). Average gradient for this 22 ft wide stream is 32 ft per 1,000 ft.

The major land uses of the Francis Creek drainage are cattle grazing and hay production in the lower drainage and grazing and recreation on the USFS lands. Recreational activities include hunting, fishing and hiking. The drainage provides winter range for mule deer and elk. A small herd of antelope is increasing within the area (DNRC, 1979). Presently, the entire USFS portion of the drainage is under consideration for inclusion into the National Wilderness System.

The 1977 Montana Legislature requested the Department of Natural Resources and Conservation to determine the feasibility of constructing an offstream reservoir on a tributary to the Big Hole River. Water from the reservoir is to be used for the augmentation of instream flows to the Big Hole and Jefferson Rivers, flood control and irrigation (DNRC, 1979). A reservoir site was identified on lower Francis Creek for further study. This site was later eliminated due to potential seepage problems, an inadequate supply of water to fill the reservoir and Wisdom being in the floodpath (DNRC, 1981).

The long-term use of the riparian zone of Francis Creek by cattle has affected stretches of the stream. The effects are manifested in minor erosion of the stream banks, the widening of the channel due to trampling and the reduction of bank cover due to the over browsing of willow cover. Sediment is deposited in the slower pool areas and deeper runs.

3. FISH POPULATIONS

A 1,000 ft section of Francis Creek was electrofished on July 18 and August 7, 1979. Game fish captured in descending order of abundance were brook trout, burbot, mountain whitefish and arctic grayling. Nongame species present include longnose and white sucker and mottled sculpin (Table 20).

Table 20. Summary of electrofishing survey data collected for a 1,000 ft section of Francis Creek (T3S, R15W, Sec. 3B) on July 18 and August 7, 1979.

Species	No. Captured	Length Range (inches)
Brook Trout	413	1.6-14.0
Burbot	32	4.8- 9.0
Mountain Whitefish	7	2.9- 6.4
Arctic Grayling	1	8.3
Longnose Sucker	197	2.6-11.1
White Sucker	2	11.6-12.4
Mottled Sculpin	-	-

The standing crop of brook trout in the section was estimated using a mark-recapture method (Table 21). This section supports about 758 brook trout, weighing 111 pounds. Francis Creek contains the second highest brook trout population of the streams sampled in the Beaverhead National Forest. Although the population is high, the fish are not stunted and have a good length to weight ratio.

Table 21. Estimated standing crop of brook trout in a 1,000 ft section of Francis Creek (T3S, R15W, Sec. 3B) on July 18, 1979. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Brook Trout	4.0- 5.9	259	
	6.0- 9.9	462	
	10.0-14.0	37	
		758 (±171)	111 (±20)

The arctic grayling, which is present in Francis Creek, is considered a species of special concern in the State of Montana (Deacon et al., 1979). A once abundant species throughout the upper Missouri River Drainage above the Great Falls, it now exists in only remnant populations in the Big Hole drainage. Small numbers of grayling are found in selected tributaries and the upper main river (Liknes, 1981). The fluvial arctic grayling has specific habitat requirements, which usually restrict its distribution to the lower reaches of small streams (Vincent, 1962). Vincent cites agricultural and logging practices, which cause a loss in flows, an increase in sedimentation and the restriction of fish movement by irrigation dams as the probable reasons for the decline of the arctic grayling in recent history. It is imperative that instream flow protection is secured for those streams still supporting arctic grayling populations.

4. FLOW RECOMMENDATIONS

Cross-sectional data for Francis Creek were collected for a 67 ft riffle-pool sequence in T3S, R15W, Sec. 3B . Five cross-sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 3.7 and 63.1 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is shown in Figure 14 . Lower and upper inflection points occur at 2 and 5 cfs, respectively. Based on an evaluation of existing fishery and other resource information, a flow of 5 cfs is recommended for the low flow period (July 1 - April 30). Due to the lack of long-term flow data, recommendations for the high flow period (May 1 - June 30) cannot be derived for Francis Creek.

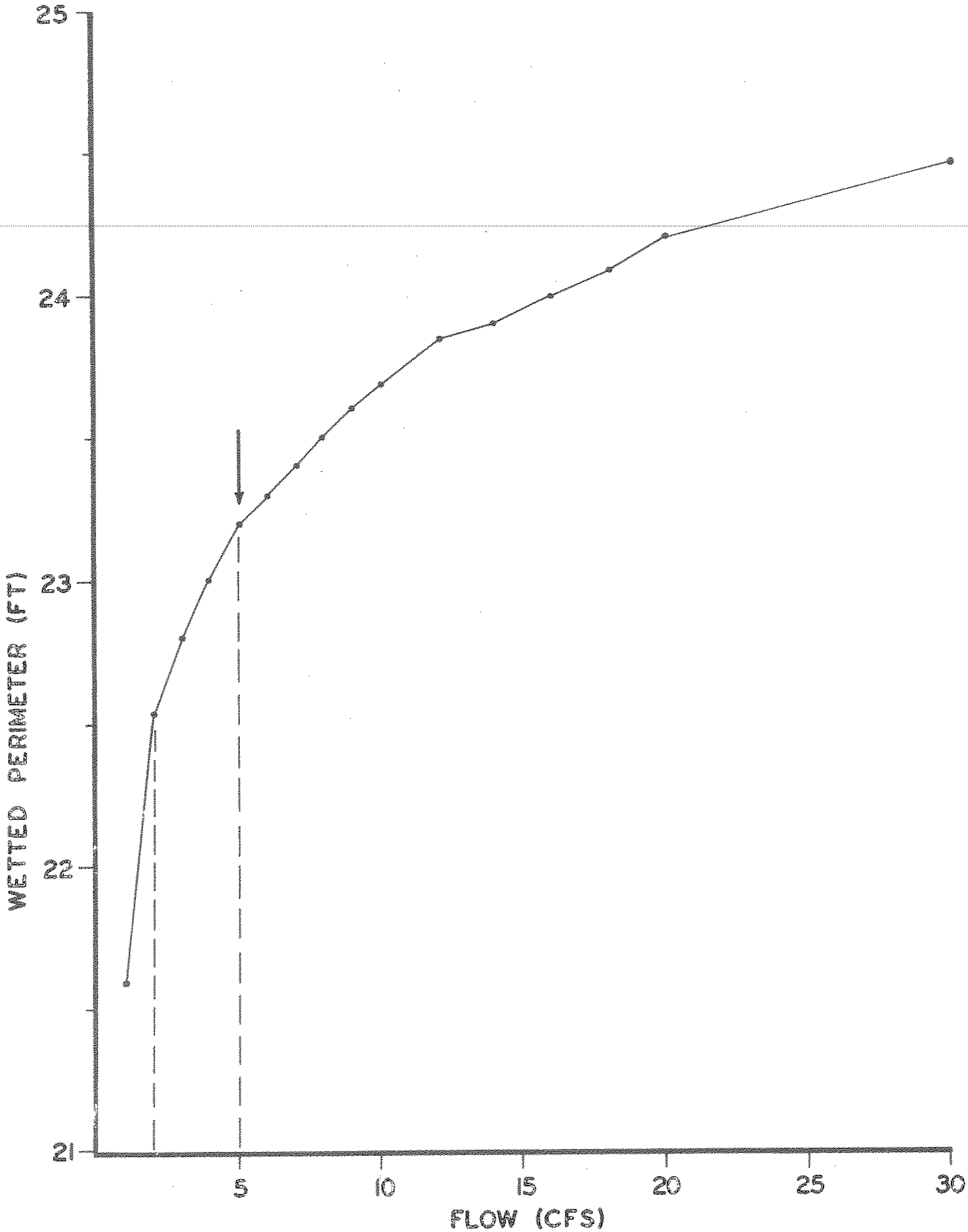

Figure 14. The relationship between wetted perimeter and flow for a single riffle cross-section in Francis Creek.

1. STREAM

French Creek

2. DESCRIPTION

French Creek originates on the eastern slope of the Anaconda-Pintlar Range. It flows in a southerly direction for approximately 8 miles before entering Deep Creek, a tributary of the Big Hole River. French Creek meanders through a narrow floodplain vegetated with willows, grasses and sedges. The stream drains high south facing meadows and timbered hillsides. Ownership of the 46 square mile drainage is shared by the Montana Department of Fish, Wildlife and Parks (78%), the USFS (17%) and private individuals (1%). Much of the flow of French Creek originates in the California Creek drainage. Other smaller tributaries include Moose Creek and Julius and First Chance Gulches. Average gradient of the 20 ft wide channel is 33 ft per 1,000 ft.

Lands within French Creek drainage are used for recreation in the form of hunting and fishing, grazing of livestock, timber harvesting and, historically, mining. The Montana Department of Fish, Wildlife and Parks acquired the Mt. Haggin Wildlife Management Area in 1976 as mule deer and elk habitat. This is currently one of the more popular areas in the state for hunting mule deer (11,700 hunter-days in 1979) and elk (21,944 hunter-days in 1979) (MDFWP, 1980a). Fishing pressure on French Creek from May, 1975 to April, 1976 was estimated by mail survey at 269 person-days (MDFG, 1976). This amounts to about 34 person-days/stream mile/year.

The Mt. Haggin Livestock Company continues to hold a cattle grazing lease on the game management area. A logging contract is held by Louisiana Pacific for the harvesting of timber. Access to the stream is provided by Highway 274 and undeveloped roads throughout the Mt. Haggin area.

In the late 1860's a gold boom swept the French Creek drainage. Placer gold valued at an estimated $5 million was recovered from 1864-69 (Lyden, 1948). Although further dredging has occurred since the late 1800's, little gold has been recovered. Evidence of the washing of bench and creek placers by hydraulic methods still exists along many of the streams in the drainage (Lyden, 1948).

The 1977 Montana Legislature requested the Department of Natural Resources and Conservation to investigate the feasibility of constructing an offstream storage reservoir on a tributary to the Big Hole River. A site on French Creek was initially selected but later eliminated due to the high costs of construction caused by wildlife mitigation and the relocation of Highway 274 (DNRC, 1981).

Water chemistry samples were collected by the Department of Fish, Wildlife and Parks during the summer of 1980 on French Creek and its tributaries (Oswald, 1981). The elevated levels of suspended sediment, arsenic and total iron found in French Creek during certain flow periods may be affecting the aquatic resource. The arsenic is believed to originate from past placer mining in the drainage and from a precipitate emitted by the Anaconda Smelter (Oswald, 1981). Total iron concentrations were positively correlated with an increase in suspended sediment.

3. FISH POPULATIONS

A 1,000 ft section of French Creek was electrofished on July 11 and August 1, 1979. Game fish present in descending order of abundance were rainbow trout, brook trout, mountain whitefish and burbot. Longnose sucker, longnose dace and mottled sculpin were the nongame species captured (Table 22).

Table 22. Summary of electrofishing survey data collected for a 1,000 ft section of French Creek (T2N, R12W, Sec. 10C) on July 11 and August 1, 1979.

Species	No. Captured	Length Range (inches)
Rainbow Trout	17	4.1-10.2
Brook Trout	13	5.5-10.4
Mountain Whitefish	9	8.3-11.5
Burbot	4	7.8- 9.3
Longnose Sucker	48	4.1-11.0
Longnose Dace	-	-
Mottled Sculpin	-	-

The standing crop of gamefish in the section could not be estimated due to the low numbers of fish captured. The condition (length to weight ratio) was below average for streams surveyed in the Beaverhead National Forest.

A 380 ft section of French Creek was electrofished in 1966 (Wipperman, 1967a). Twelve rainbow trout, six brook trout, and one mountain whitefish were captured. In 1976, a 600 ft section was electrofished (MDFWP, unpublished data). Six brook trout, two rainbow trout, three mountain whitefish, three burbot and six longnose suckers were captured. All fish captured in 1976 were 7 inches and longer, suggesting poor reproduction.

Wipperman (1967a) postulated that the low productivity of French Creek may be related to the destruction of riparian vegetation by air pollution from the Anaconda Smelter, the chemical removal of riparian willows along much of the creek in 1965 and the effects of past mining within the drainage.

Trout populations in California and Oregon Creeks, streams within the French Creek drainage, were estimated by the DFWP at 127 and 254 brook trout per 1,000 ft, respectively (Oswald, 1981). When compared to French Creek, these trout populations are substantial. Like French Creek, both these streams are subject to air pollution from the Anaconda Smelter, were placer mined in the past and have elevated arsenic levels. It appears that the environmental problems affecting French Creek are more severe than those of other streams within the drainage.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 174 ft subreach located at stream mile 2.0 (R12W, T2N, Sec. 10C). Five cross-sections describing the riffle-pool habitat were placed within the subreach. The WETP program was calibrated to field data collected at flows of 10.6 and 56.3 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is illustrated in Figure 15 . Lower and upper inflection points occur at 8 and 14 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 10 cfs is recommended for the low flow period (July 1 - April 30). Recommendations for the high flow period (May 1 - June 30) cannot be derived for French Creek due to the lack of long-term flow data.

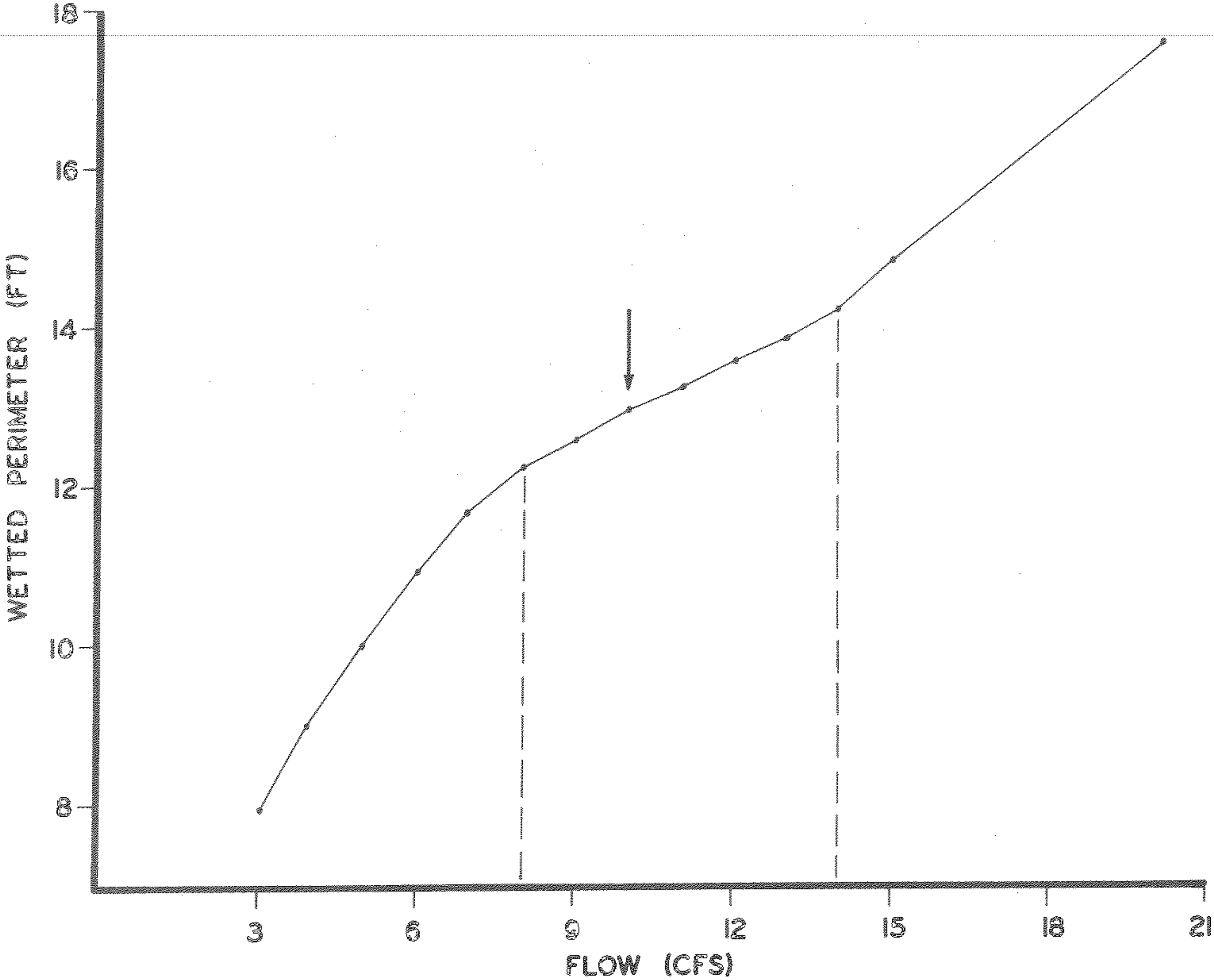

Figure 15. The relationship between wetted perimeter and flow for a single riffle cross-section in French Creek.

1. STREAM

Governor Creek

2. DESCRIPTION

Governor Creek originates along the Big Hole Divide, a small chain of mountains stemming from the Bitterroot Mountains of southwest Montana. It flows in a northerly direction for about 17 miles before joining the South Fork Big Hole River to form the Big Hole River. The average gradient of the 32 ft wide channel is 17 ft/1,000 ft. The drainage primarily consists of open grassland/sagebrush hillsides. Much of this land has been converted into irrigated hay pasture. The riparian zone is vegetated with willow, grasses and forbs. The 122 square mile drainage is controlled by private individuals (56%), the USFS (42%) and the State of Montana (7%). Fifteen of the 17 miles of stream channel are on private lands. Access to the majority of the drainage is provided by gravel country roads. Major tributaries include Andrus, Fox and Pine Creeks.

Land within the Governor Creek drainage is used primarily for hay production and cattle grazing. The stream is diverted into numerous irrigation ditches along its course and can be severely dewatered in its lower 12 miles during the irrigation season. Along the lower sections of Governor Creek, the trampling and grazing of the banks by cattle have caused a loss of stream vegetative cover and undercut banks, have increased erosion and widened the channel. This abuse, coupled with flow decreases during the irrigation season, has increased sedimentation in important riffle and pool habitats. Willows along portions of the lower stream have been removed physically or chemically to increase grazing area.

3. FISH POPULATIONS

A 1,000 ft section of Governor Creek located up and downstream from the Bridge on Miner Creek Road was electrofished on July 24 and August 8, 1979. Game fish captured in descending order of abundance were brook trout, mountain whitefish, burbot, rainbow trout and arctic grayling. Longnose sucker, longnose dace and mottled sculpin were the nongame species present (Table 23).

Table 23 . Summary of electrofishing survey data collected for a 1,000 ft section of Governor Creek (T5S, R15W, Sec. 26C and 35B) on July 24 and August 8, 1979.

Species	No. Captured	Length Range (inches)
Brook Trout	54	2.9-12.8
Mountain Whitefish	28	3.0-10.8
Burbot	10	7.2-11.3
Rainbow Trout	3	5.0- 6.2
Arctic Grayling	2	7.7- 8.7
Longnose Sucker	-	-
Longnose Dace	-	-
Mottled Sculpin	-	-

The standing crop of brook trout in the section was estimated using a mark-recapture method (Table 24). This 1,000 ft section supports about 130 brook trout, weighing 29 pounds. The populations of other game fish were too sparse to reliably estimate using the mark-recapture method.

Table 24 . Estimated standing crop of brook trout in a 1,000 ft section of Governor Creek (T5S, R15W, Sec. 26C and 35B) on July 24, 1979. Eighty percent confidence intervals are in parentheses.

		Per 1,000 Ft	
Species	Length Group (inches)	Number	Pounds
Brook Trout	5.0- 5.9	18	
	6.0- 9.9	99	
	10.0-12.8	13	
		130 (±61)	29 (±13)

A 300 ft section of Governor Creek was electrofished during 1964 (Wipperman and Needham, 1965) and 1966 (Wipperman, 1967a). Numbers of game fish captured were almost identical for the two years. The brook trout was the dominant species in both years. Forty-three and forty-seven brook trout, ranging from 2.6-12.7 inches, were captured in 1964 and 1966, respectively. One arctic grayling was collected during the 1964 survey.

During 1978 and 1979, Liknes (1981) captured arctic grayling fry in Governor Creek north of the Miner Creek Road and larger arctic grayling at three locations in the lower five miles. The fluvial arctic grayling is classified as a species of special concern (Deacon et al., 1979). Once widely distributed throughout the upper Missouri River drainage, remnant populations of the fluvial form are now found only in the upper Big Hole River drainage. Governor Creek was one of four streams discovered by Liknes to contain fry as well as older arctic grayling. The arctic grayling has very specific habitat requirements, which usually restrict its distribution in smaller streams to the lower reaches (Vincent, 1962). Much of this habitat drains land prime for agricultural development. Vincent cites the restriction of fish movement by irrigation dams and agricultural practices that decrease flows and increase sediment loads as probable causes for the apparent decline of the fluvial arctic grayling. It is imperative that instream flow protection is secured for those streams still supporting arctic grayling populations.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected for a 72 ft riffle-pool sequence near the mouth of Governor Creek (T5S, R15W, Sec. 36C). Five cross-sections were placed within this sequence. The WETP program was calibrated to field data collected at flows of 8.0 and 35.8 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is shown in Figure 16 . Lower and upper

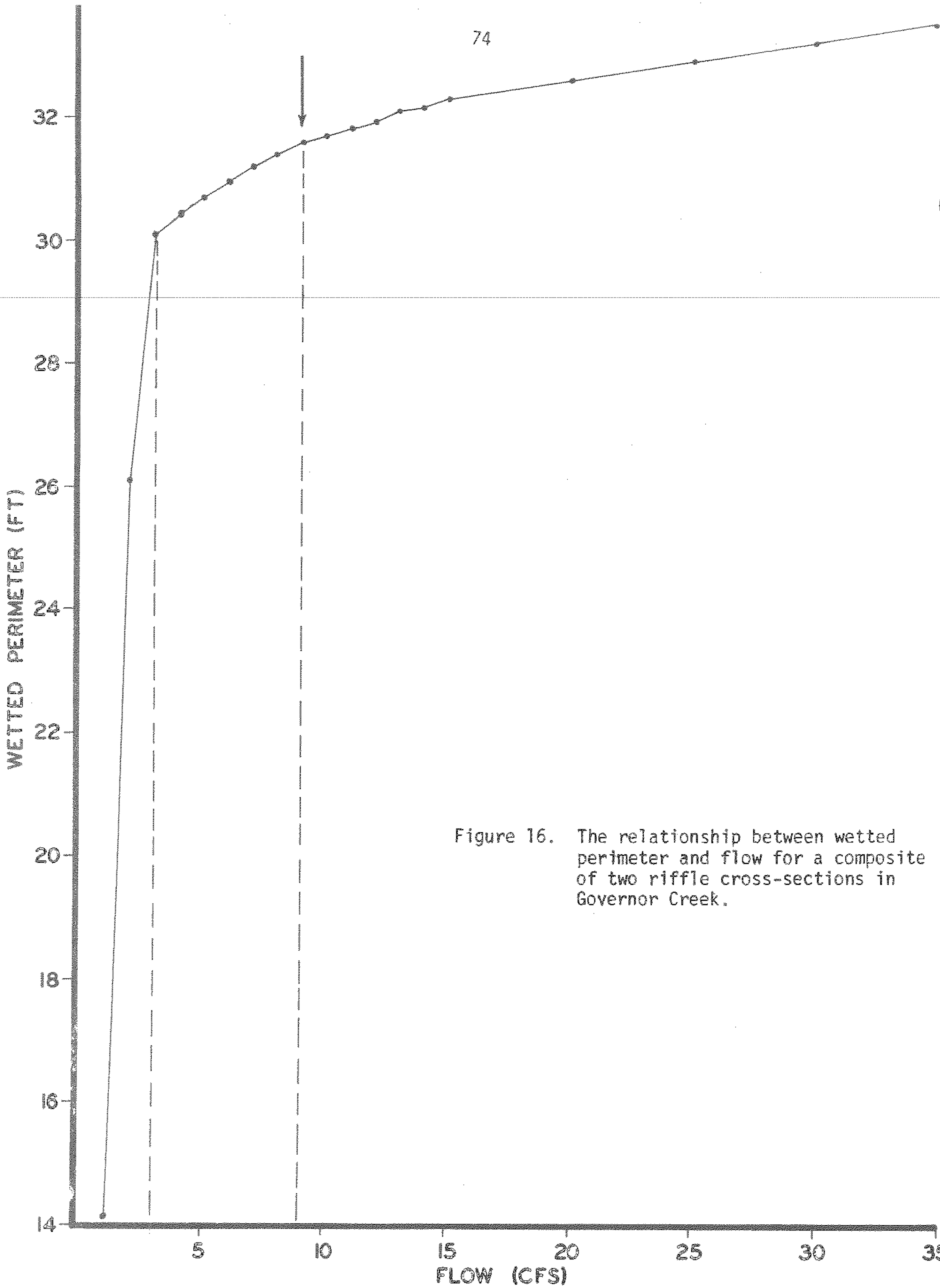

Figure 16. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Governor Creek.

inflection points occur at 3 and 9 cfs, respectively. Based on an evaluation of existing fishery and recreational use information, a flow of 9 cfs is recommended for the low flow period (July 1 - April 30). Due to the lack of long-term flow data, recommendations for the high flow period (May 1 - June 30) cannot be derived for Governor Creek.

1. STREAM

Johnson Creek

2. DESCRIPTION

Johnson Creek originates in the Anaconda-Pintlar Range of southwest Montana and flows in a southeasterly direction for 13.5 miles before entering the North Fork of the Big Hole River. The drainage is characterized by steep timbered slopes in the upper reaches and grassland/sagebrush benches in the lower reaches. The 41.5 square mile drainage is controlled by the USFS (82%), private individuals (18%) and the BLM (1%). Average gradient of the 15 ft wide channel is 30 ft/1,000 ft. The riparian zone is vegetated with alder, birch and grasses in the upper drainage and dense willow stands in the lower drainage. Major tributaries to Johnson Creek include Schultz, Addition and Bender Creeks.

Logging and road construction has been extensive in the upper portion of the Johnson Creek drainage. Lands within the lower drainage are used for cattle grazing and hay production. Recreational activities, including fishing and hunting, occur throughout the area. Fishing pressure on Johnson Creek in 1975-76 was estimated at 174 person-days per year (MDFG, 1976). This amounts to about 13 person-days/stream mile/year. During the hunting season, the drainage is moderately hunted for mule deer and elk.

Logging activity in the upper drainage has resulted in the loss of riparian habitat, an increased sediment load and channel alterations. Downstream of the USFS boundary, Johnson Creek is entirely diverted into a series of irrigation ditches.

The 1977 Montana Legislature requested the Department of Natural Resources and Conservation to study the feasibility of constructing an offstream storage reservoir on a tributary to the Big Hole River. The reservoir is to be used to augment instream flows in the Big Hole and Jefferson Rivers, for irrigation and flood control (DNRC, 1979). After an initial survey, Johnson Creek was one of seven sites selected for further study. The site was later eliminated due to prohibitive construction costs (DNRC, 1981).

Water chemistry samples have been collected sporadically on Johnson Creek (USFS, unpublished data). Water quality is excellent. The water exhibits the typical pattern of low specific conductance, neutral pH and low hardness of the majority of tributaries to the Big Hole River.

3. FISH POPULATIONS

A 1,000 ft section of Johnson Creek was electrofished on July 26, 1979. Due to access problems, only one electrofishing pass was completed. Game fish present in descending order of abundance were brook trout, burbot and mountain whitefish. Mottled sculpin, longnose sucker and longnose dace were the nongame species captured. Table 25 summarizes the electrofishing survey data.

Table 25. Summary of electrofishing survey data collected for a 1,000 ft section of Johnson Creek (T1S, R16W, Sec. 30B) on July 26, 1979.

Species	No. Captured	Length Range (inches)
Brook Trout	125	2.2-10.4
Burbot	12	6.3-11.0
Mountain Whitefish	2	11.1-11.2
Longnose Sucker	7	5.0-10.7
Mottled Sculpin	-	-
Longnose Dace	-	-

Forty-four (35%) of the 125 brook trout captured were seven inches and longer. The total weight of the brook trout was 15.3 pounds. Based on the electrofishing survey data, Johnson Creek supports a substantial brook trout fishery.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected for a 90 ft riffle-run sequence located approximately 0.5 miles above the USFS boundary (T1S, R17W, Sec. 24C). Five cross-sections were placed within the sequence. The WETP program was calibrated to field data collected at flows of 5.4 and 56.4 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is illustrated in Figure 17 . Lower and upper inflection points occur at 5.0 and 8.5 cfs, respectively. Based on an evaluation of existing fishery, recreational use and other resource information, a flow of 7 cfs is recommended for the low flow period (July 16 - May 15). Recommendations for the high flow period (May 16 - July 15) cannot be derived due to the lack of long-term flow data for Johnson Creek.

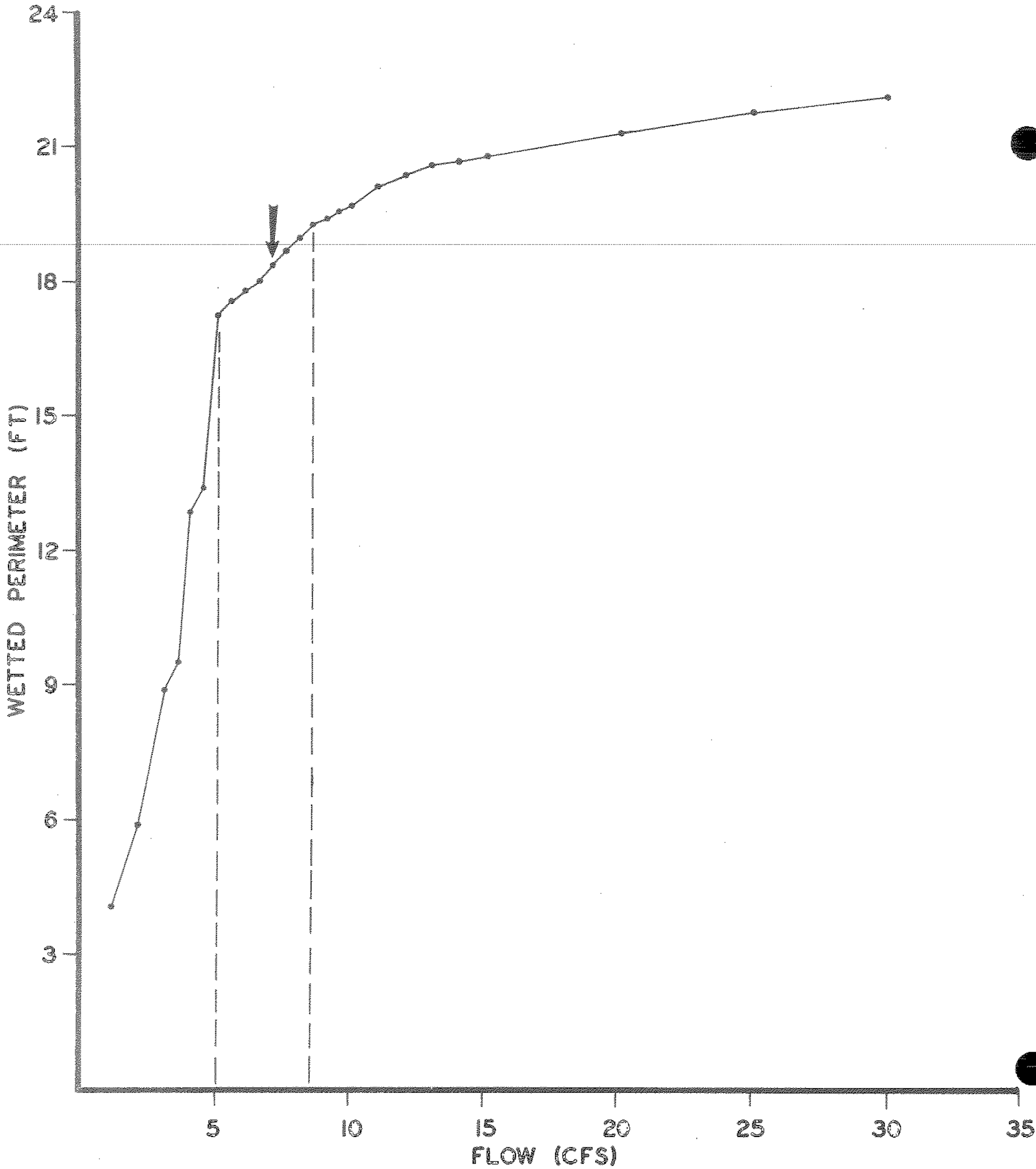

Figure 17. The relationship between wetted perimeter and flow for a single riffle cross-section in Johnson Creek.

1. STREAM

Joseph Creek

2. DESCRIPTION

Joseph Creek flows in an easterly direction for approximately 6 miles before joining Trail Creek, a tributary of the Big Hole River. The stream originates on the east slope of the Bitterroot Mountains of southwest Montana. The USFS controls 99% of the 13.5 square miles of the steep, timbered drainage with the remainder belonging to private individuals. The 18 ft wide channel is lined with dense willow cover in the lower reaches. Beaver ponds are also prevalent. Average gradient of Joseph Creek is 26 ft/1,000 ft. The bottom substrate is composed of sand, gravel, and cobble. Major perennial tributaries include Anderson, Richardson and Cabinet Creeks.

Lands within the Joseph Creek drainage are used for cattle grazing and recreation in the form of hunting and fishing. Fishing pressure during the period of May, 1975 through April, 1976 was estimated from mail surveys at 328 person-days (MDFG, 1976). This amounts to about 24 person-days/stream mile/year. Catches reported in angler logs consist entirely of brook trout, averaging 9.6 inches in length (MDFWP, 1980b). Hunting pressure for moose and elk is moderate within the drainage.

Highway 43 parallels the stream throughout most of its length, crossing the channel at four locations. Habitat losses have occurred above and below these bridges with impacts on stream cover and sinuosity.

3. FISH POPULATIONS

A 1,000 ft section of Joseph Creek at stream mile 1.0 was electrofished on July 19 and August 10, 1979. Brook trout and burbot were the only game species present. The only nongame species captured was the mottled sculpin (Table 26).

Table 26. Summary of electrofishing survey data collected for a 1,000 ft section of Joseph Creek (T2S, R18W, Sec. 16A) on July 19 and August 10, 1979.

Species	No. Captured	Length Range (inches)
Brook Trout	102	2.0-11.1
Burbot	13	4.8- 9.1
Mottled Sculpin	-	-

The standing crop of brook trout in the section was estimated using a mark-recapture method (Table 27). This 1,000 ft section of Joseph Creek supports about 137 brook trout, weighing 14 pounds. A good fishery exists in Joseph Creek as a result of excellent instream and overhanging bank cover and a good riffle-pool ratio.

Table 27 . Estimated standing crop of brook trout in a 1,000 ft section of Joseph Creek (T2S, R18W, Sec. 16A) on July 19, 1979. Eighty percent confidence intervals are in parentheses.

		Per 1,000 Ft	
Species	Length Group (inches)	Number	Pounds
Brook Trout	4.0- 5.9	89	
	6.0- 9.9	47	
	10.0-11.1	1	
		137 (±25)	14 (±3)

Heaton (1960) electrofished a 300 ft section of Joseph Creek in 1959. He captured 93 brook trout, ranging from 2.2-7.1 inches in length.

4. FLOW RECOMMENDATIONS

A 105 ft subreach located near stream mile 0.7 (T2S, R18W, Sec. 16A) was selected for the collection of cross-sectional data. Five cross-sections describing the riffle-pool habitat were placed within the subreach. The WETP program was calibrated to field data collected at flows of 3.5 cfs, 14.6 and 35.5 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is shown in Figure 18 . Lower and upper inflection points occur at 3 and 5.5 cfs, respectively. Based on an evaluation of existing fishery, recreational use, and other resource information, a flow of 4 cfs is recommended for the low flow period of July 16 - May 15. Recommendations for the high flow period (May 16 - July 15) cannot be derived due to the lack of long-term flow data for Joseph Creek.

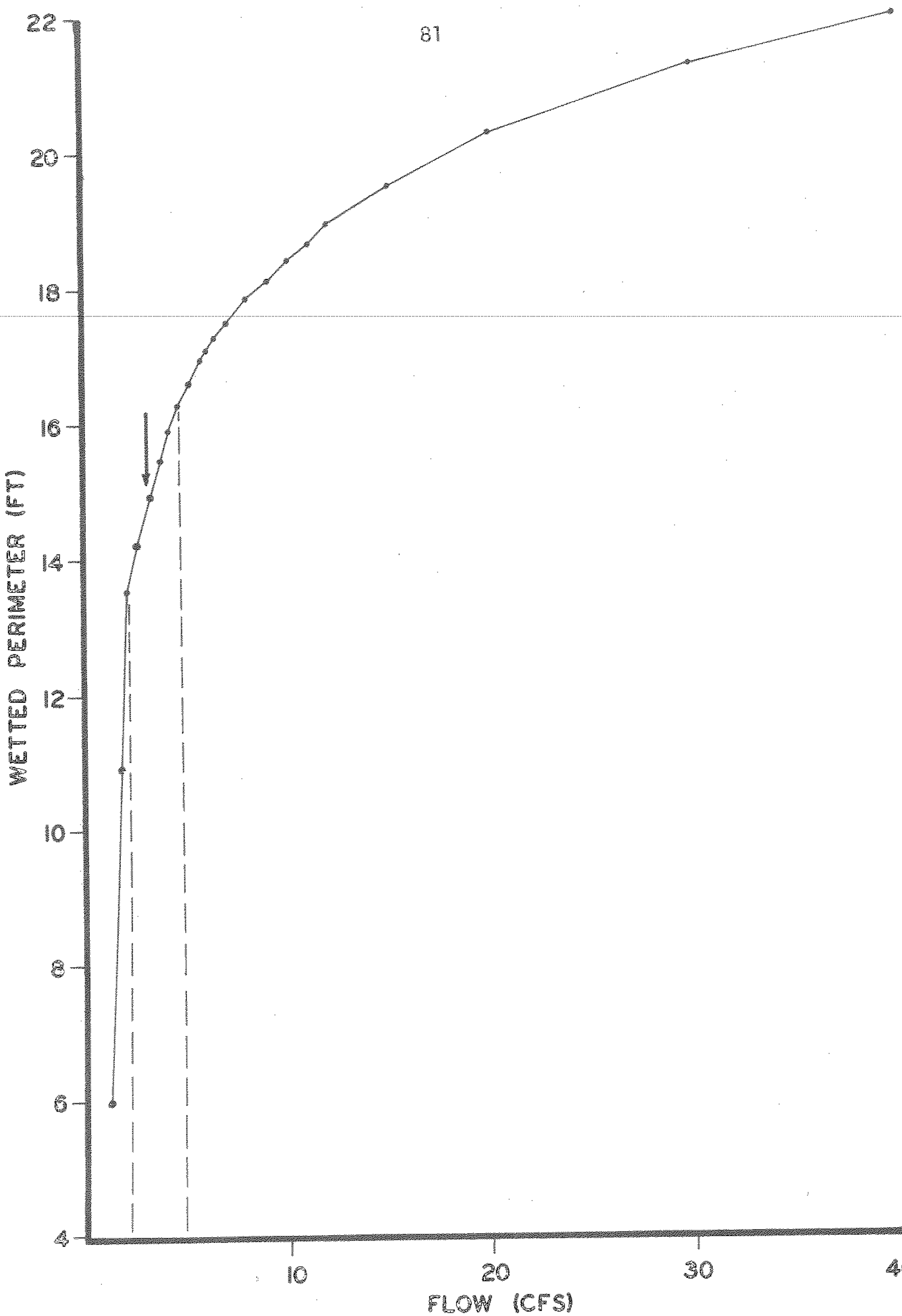

Figure 18. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Joseph Creek.

1. STREAM

LaMarche Creek

2. DESCRIPTION

LaMarche Creek originates in the Anaconda-Pintlar Range of southwest Montana at the confluence of its West and Middle Forks. The stream flows in a narrow floodplain in a southeasterly direction for 8.0 miles before converging with the Big Hole River. The LaMarche Creek drainage is characterized by steep, timbered headwater canyons which form a fan shaped basin. Ninety-four percent of the 52 square mile drainage is controlled by the USFS with 64% of this land in the Anaconda-Pintlar Wilderness Area. The remaining 6% of the drainage is divided equally between private owners and the BLM. The 32 ft wide main channel has an average gradient of 11 ft/1,000 ft. The gradients of the three forks of LaMarche Creek average between 41-46 ft/1,000 ft.

Land uses in the LaMarche Creek drainage are divided between ranching, timber harvesting and recreation. Fishing, hunting, camping and hiking are popular recreational activities. A gravel road parallels the stream for its lower 4 miles, ending at the LaMarche Creek Guest Ranch. Catches reported in angler logs consist entirely of brook trout, averaging 6.3 inches in length (MDFWP, 1980b).

Hay production and cattle grazing primarily occur along the lower reaches of the stream although grazing allotments also exist on USFS lands. Water from LaMarche Creek is diverted from its lower reaches for irrigation, causing the stream to be severely dewatered during the summer irrigation season. Bank erosion and loss of streambank vegetative cover and undercut banks have occurred along portions of the lower stream as a result of overgrazing in the riparian zone. These abuses, coupled with a reduction in natural flows, have caused sediments to accumulate in riffle and pool areas of the stream.

Water quality samples from LaMarche Creek exhibit the typical chemical pattern of the streams of the Big Hole River drainage (USFS, unpublished data). Water chemistry is characterized by a low specific conductance, neutral pH and high dissolved oxygen concentrations.

3. FISH POPULATIONS

A 1,000 ft section located above the USFS boundary was electrofished on July 12 and August 2 and 9, 1979. Game fish present were brook trout, rainbow trout and burbot. Mottled sculpin and longnose sucker were the only nongame species captured (Table 28).

Table 28 . Summary of electrofishing survey data collected for a 1,000 ft section of LaMarche Creek (T2N, R13W, Sec. 16C) on July 12 and August 2 and 9, 1979.

Species	No. Captured	Length Range (inches)
Brook Trout	253	2.4-12.4

Table 28 continued. Summary of electrofishing survey data collected for a 1,000 ft section of LaMarche Creek (T2N, R13W, Sec. 16C) on July 12 and August 2 and 9, 1979.

Species	No. Captured	Length Range (inches)
Rainbow Trout	5	4.0- 8.3
Burbot	-	-
Longnose Sucker	-	-
Mottled Sculpin	-	-

The standing crop of brook trout in the section was estimated using a mark-recapture method (Table 29). This 1,000 ft section supports about 505 brook trout, weighing a total of 54 pounds. Of the tributaries of the Big Hole River electrofished, LaMarche Creek supports one of the highest standing crops of brook trout. The population of rainbow trout could not be estimated due to the low numbers captured.

Table 29 . Estimated standing crop of brook trout in a 1,000 ft section of LaMarche Creek (T2N, R13W, Sec. 16C) on July 12, 1979. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Pounds
Brook Trout	4.0- 5.9	289	
	6.0- 9.9	198	
	10.0-12.4	18	
		505 ($\pm$100)	54 ($\pm$11)

Heaton (1960) electrofished a 300 ft section of LaMarche Creek near the USFS boundary in 1959. Twenty-three brook trout, ranging in length from 3.5-12.1 inches, and 11 rainbow trout, 3.4-7.8 inches in length, were captured.

Although not captured during the 1959 and 1979 electrofishing surveys, Liknes (1981) found age I+ and older arctic grayling in the lower stretches of LaMarche Creek. The fluvial arctic grayling is classified as a species of special concern (Deacon et al., 1979). Once distributed throughout the upper Missouri River drainage, remnant populations of the fluvial form are now found only in the upper Big Hole River and selected tributaries. Because of its habitat requirements, arctic grayling residing in smaller streams are usually restricted to the lower reaches (Vincent, 1962). The land surrounding these streams is usually prime for agricultural development. Vincent cites agricultural practices that decrease fish movement, decrease stream flows and increase water temperatures, sedimentation and turbidity as possible causes for the decline of the fluvial arctic grayling. It is imperative that instream flow protection is secured for those streams still supporting arctic grayling populations.

4. FLOW RECOMMENDATIONS

Cross sectional data were collected in a 94 ft riffle-pool sequence located 2.5 miles upstream of the USFS boundary (T2N, R13W, Sec. 21A). Five cross-sections were placed within the sequence. The WETP program was calibrated to field data collected at flows of 9.1, 25.0 and 158.2 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is illustrated in Figure 19. Lower and upper inflection points occur at 12 and 20 cfs, respectively. Based on an evaluation of existing fishery, recreational use and other resource information, a flow of 15 cfs is recommended for the low flow period of July 16 - May 15. Due to the lack of long-term flow data, recommendations for the high flow period (May 16 - July 15) cannot be derived for LaMarche Creek.

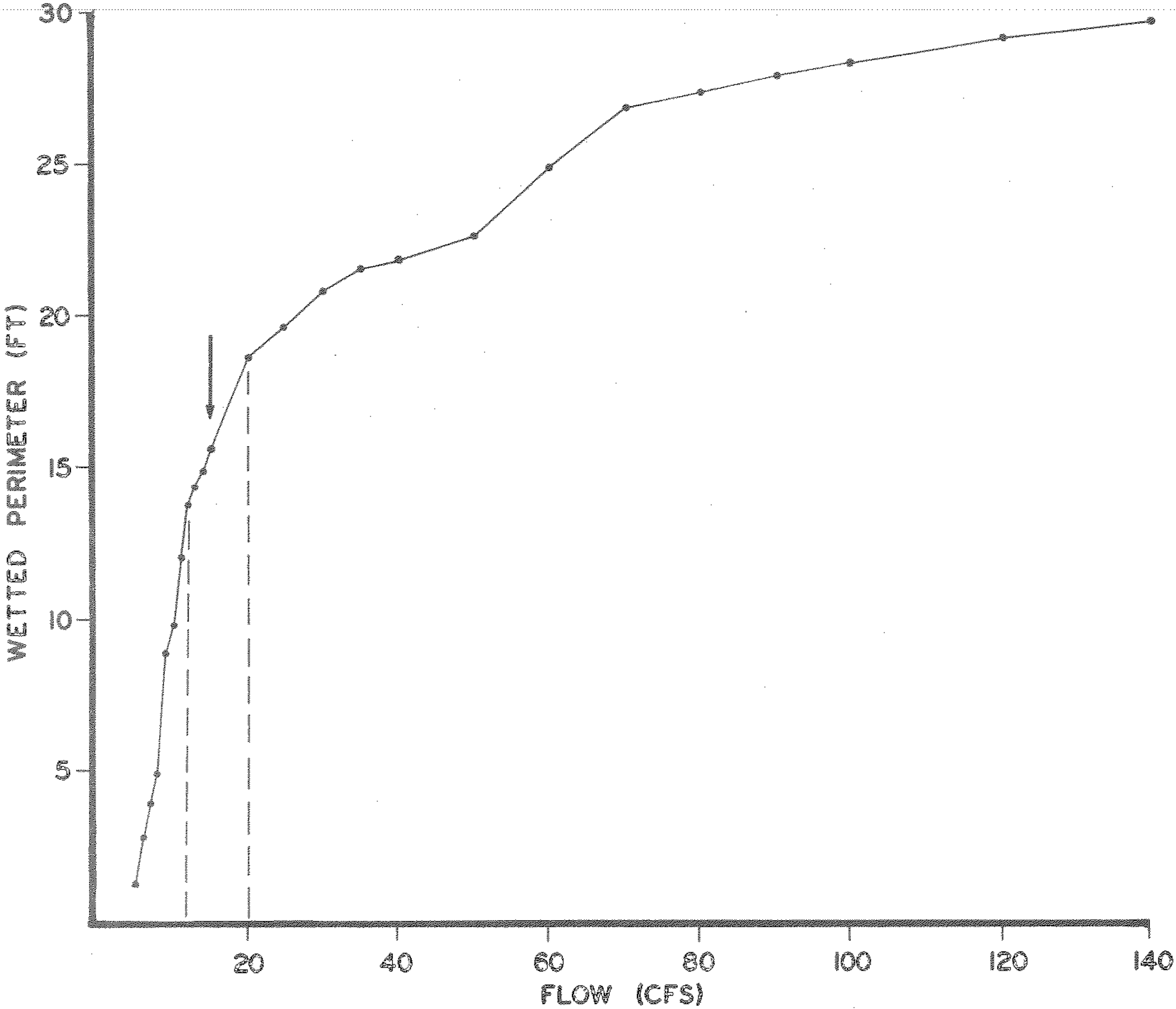

Figure 19. The relationship between wetted perimeter and flow for a single riffle cross-section in LaMarche Creek.

1. STREAM

Miner Creek

2. DESCRIPTION

Miner Creek originates at upper Miner Lakes in the Bitterroot Mountain Range of southwest Montana. It flows for approximately 16 miles in a northeasterly direction before entering the Big Hole River near the town of Jackson, Montana. The drainage is characterized by steeply timbered headwaters, gradually changing to a willow lined channel. The stream then meanders through a narrow floodplain surrounded by grassland/sagebrush hillsides. Much of the lower drainage has been converted into irrigated hay pastures. Ownership of this 27 square mile drainage is shared by the USFS (74%), private landowners (24%) and the State of Montana (2%). In its lower reaches, the stream splits into two channels through much of the private land. The average gradient of the 35 ft wide channel is 29 ft/1,000 ft.

From 1948-1953, a USGS gauging station was operated on Miner Creek approximately 1.5 miles above the USFS boundary (T6S, R16W, Sec. 3). During the 1949-51 water years, the mean annual flow was 33.8 cfs. Minimum and maximum recorded flows were 3 and 336 cfs, respectively.

Lands within the Miner Creek drainage are primarily used for livestock grazing, hay production and recreation in the form of fishing, hunting, camping and hiking. There are two USFS campgrounds along the stream and hiking trails lead to primitive camping sites in the Upper Miner Lakes area. Access is provided by a gravel road paralleling the stream for all but its upper 2.5 miles. The roadless portion of the drainage is presently being considered for inclusion into the National Wilderness System.

Fishing pressure on Miner Creek for the period of May, 1975 to April, 1976 was estimated at 667 person-days (MDFG, 1976). This is an average of 42 person-days/stream mile/year. Miner Creek is one of the more heavily used recreational fisheries in the Big Hole drainage. Catches recorded in angler logs consists of 96 percent brook trout, averaging 10 inches in length, and 4 percent arctic grayling, averaging 7.5 inches in length (MDFWP, 1980b). Fishing pressure on Lower Miner Lakes was estimated in 1975-76 at 1,735 person-days/year.

Livestock grazing in the riparian zone along portions of the Miner Creek drainage has caused damage to fishery habitat through the trampling of banks and the reduction of vegetative stream cover. The diversion of natural flows from the stream for irrigation, coupled with the increase in erosion and bank instability, has caused sediment to deposit in riffle and spawning areas within the lower reaches.

Water chemistry samples were collected for Miner Creek during 1972-1978 (USFS, unpublished data). This stream exhibits the typical chemical characteristics of tributaries to the Big Hole River. The water is characterized by a low specific conductance, neutral pH and low suspended sediment.

3. FISH POPULATIONS

Two 1,000 ft sections located below the Lower Miner Lakes were electrofished on July 24, 1979 and August 27, 1980. Due to the clarity of the water, its low specific conductance and the morphology of the channel, the electrofishing equipment was extremely inefficient. Numerous fish were observed but attempts at capturing these individuals were unsuccessful. Only the species list is relevant and numbers of fish captured do not reflect the magnitude of the population of Miner Creek. Game species present were brook trout and burbot. Longnose sucker and mottled sculpin were the only nongame species captured. Table 29 combines the electrofishing results for the two sections sampled. Due to the low numbers of fish captured, a population estimate using a mark-recapture method was not possible.

Table 29. Summary of electrofishing survey data collected for two 1,000 ft sections of Miner Creek (T6S, R16W, Sec. 3C and Sec. 9A) on July 24, 1979 and August 27, 1980.

Species	No. Captured	Length Range (inches)
Brook Trout	28	2.8- 8.6
Burbot	1	5.9
Longnose Sucker	2	8.2-10.0
Mottled Sculpin	-	-

A 300 ft section located in the vicinity of the present study section was electrofished in 1959 (Heaton, 1960). One hundred and nineteen brook trout, ranging in length from 2.0-11.7 inches, were captured along with one burbot. Liknes (1981) captured arctic grayling in sections of the stream above the Lower Miner Lakes.

Gill nets set in the lower lake in 1959 captured 25 brook trout, six arctic grayling, two mountain whitefish, three burbot and 80 longnose suckers (Heaton, 1960). In 1965, two gill nets set in the lower lake captured 111 fish (Wipperman and Needham, 1965). The catch consisted of 34 brook trout, 11 mountain whitefish, six arctic grayling, seven burbot and 53 longnose suckers. Rainbow trout, ranging from 6.1-17.0 inches in length, have been captured by gill nets in the Upper Miner Lakes (Heaton, 1960 and Peterson, 1974).

The presence of the fluvial arctic grayling in Miner Creek is of importance to the State of Montana. This species is now classified as a species of special concern (Deacon et al., 1979). Once widely distributed throughout the upper Missouri River drainage, the fluvial form is presently found only in remnant populations in the upper Big Hole River drainage. The arctic grayling has very specific habitat requirements with respect to gradient, temperature, velocity and depth (Vincent, 1962). These requirements usually restrict their distribution in smaller streams to the lower reaches. Vincent cites agricultural and logging practices that reduce stream flows, increase siltation and restrict fish movement as possible causes for the decline of the arctic grayling in recent history. For streams that still support arctic grayling, it is imperative that instream flow protection is secured.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 203 ft subreach of Miner Creek about 1.5 miles above the USFS boundary (T6S, R16W, Sec. 3C). Five cross-sections describing the meandering habitat were placed in the subreach. To calibrate the WETP program, field data were collected at flows of 13.1 and 99.1 cfs.

The relationship between wetted perimeter and flow for a single riffle-like cross-section is shown in Figure 20. Lower and upper inflection points occur at 3 and 10 cfs, respectively. Based on an evaluation of existing fishery,recreational use and other resource information, a flow of 10 cfs is recommended for the low flow period of July 1 - April 30. Flow recommendations for the high flow period (May 1 - June 30) cannot be derived for Miner Creek due to the lack of long-term flow records.

The recommendations for the low flow period are compared to the mean monthly flows of record for Miner Creek in Table 30. The recommendations exceed the mean flows for the months of December through March.

Table 30. Instream flow recommendations for Miner Creek using the wetted perimeter/inflection point method (low flow period) compared to the mean flows of record.

	Flow Recommendations (cfs)	Mean Flows (cfs)a/
January	10	6.3
February	10	7.3
March	10	7.6
April	10	29.9
May	b/	91.8
June	b/	141.2
July	10	67.8
August	10	20.4
September	10	10.9
October	10	11.1
November	10	10.7
December	10	9.0

a/ Derived for the June, 1948 - October, 1953 period of record for the USGS gauge at stream mile 9.0 (T6S, R16W, Sec. 3).

b/ Flow recommendations for the high flow period (May 1 - June 30) are unavailable due to the lack of long-term flow records for Miner Creek.

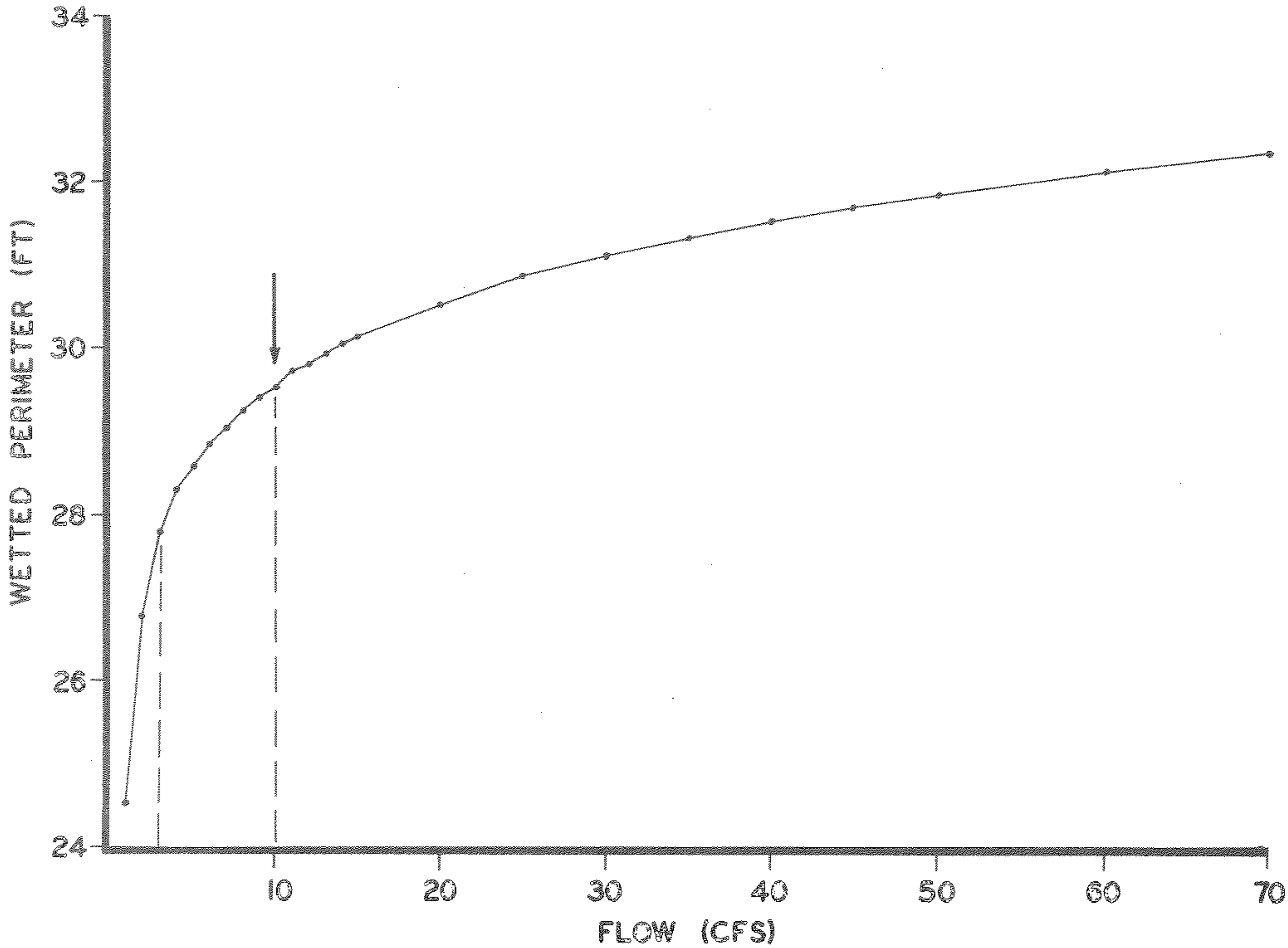

Figure 20. The relationship between wetted perimeter and flow for a single riffle-like cross-section in Miner Creek.

1. STREAM

Mussigbrod Creek

2. DESCRIPTION

Mussigbrod Creek originates in the Anaconda-Pintlar Range of southwest Montana and flows in an easterly direction for about 5 miles before entering Mussigbrod Lake. From the lake outlet the stream flows an additional 9.4 miles before joining the North Fork Big Hole River. Hellroaring Creek is the only named tributary in the 29.5 square mile drainage. Land within the drainage is controlled by the USFS (66%), private landowners (32%) and the State of Montana (2%). Eighteen percent of the USFS land is within the Anaconda-Pintlar Wilderness Area. The upper channel flows steeply through heavily timbered slopes. Upon crossing the USFS boundary, the stream meanders through willow bottoms surrounded by grassland/sagebrush benches. Average gradient of the 21 ft wide channel is 25 ft/1,000 ft.

Land uses within the Mussigbrod Creek drainage consist of recreation in the form of hunting, fishing and camping, cattle grazing, hay production and timber harvesting. A gravel road ends at the USFS campground located on Mussigbrod Lake. Pack trails continue into the upper reaches of the drainage to Surprise and Violet Lakes. Catches reported in angler logs for Mussigbrod Creek consist of 75% brook trout and 25% arctic grayling, both averaging 9.2 inches in length (MDFWP, 1980b).

Cattle are grazed throughout the drainage and hay production occurs on private lands within the lower drainage. Although Mussigbrod Lake is a natural lake, a dam has been constructed on its outlet for irrigation purposes. The storage of irrigation water during the fall and winter months results in the dewatering of the stream. During the summer irrigation season, the flow of lower Mussigbrod Creek is entirely diverted into a series of ditches.

3. FISH POPULATIONS

A 1,000 ft section located immediately above the USFS boundary was electrofished on July 13 and August 9, 1979. Game species present were brook trout and burbot. Mottled sculpin and longnose sucker were the nongame species captured (Table 31).

Table 31 . Summary of electrofishing survey data collected for a 1,000 ft section of Mussigbrod Creek (T1S, R16W, Sec. 9B) on July 13 and August 9, 1979.

Species	No. Captured	Length Range (inches)
Brook Trout	107	1.8-11.2
Burbot	5	9.2-13.4
Mottled Sculpin	-	-
Longnose Sucker	1	7.6

The standing crop of brook trout in the section was estimated using a mark-recapture method (Table 32). This 1,000 ft section supports about 251 brook trout, weighing a total of 27 pounds. The majority of the fish present were less than 10 inches and averaged 9 fish per pound. When comparing this population to other streams draining the Anaconda-Pintlar Range, only one supported a lower population.

Table 32. Estimated standing crop of brook trout in a 1,000 ft section of Mussigbrod Creek (T1S, R16W, Sec. 9B) on July 13, 1979. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Pounds
Brook Trout	4.0- 5.9	143	
	6.0- 9.9	105	
	10.0-11.2	3	
		251 (±118)	27 (±13)

Heaton (1960) electrofished a 300 ft section of Mussigbrod Creek below the lake in 1959. Six brook trout, ranging in length from 1.6-9.3 inches, were captured. He felt the closing of the dam in the fall and winter and the severe dewatering that occurred downstream was responsible for the low population. Wipperman (MDFWP, unpublished data) supported a USFS proposal for a minimum flow of 5 cfs to be released at the dam during the winter months to increase fisheries production.

Mussigbrod Lake is recognized as having one of the best lacustrine arctic grayling populations remaining in the upper Big Hole drainage (Heaton, 1960). Gill nets fished in 1959 captured ten arctic grayling (5.6-11.5 inches), eight brook trout (7.9-17.3 inches), three burbot and 124 longnose suckers (Heaton, 1960). In 1970, Elser and Marcoux (1972) gill netted four arctic grayling (6.8-11.5 inches), three brook trout (10.3-14.4 inches), two burbot and 62 longnose suckers.

In 1979, Liknes (1981) captured 12 arctic grayling, ranging in length from 5.7-9.0 inches, in a section of Mussigbrod Creek below the lake. The fluvial arctic grayling is considered a species of special concern (Deacon et al.,1979). Once distributed throughout the upper Missouri River drainage, remnant populations of the fluvial form now exist in only the upper Big Hole drainage. The arctic grayling has very specific habitat requirements which usually restrict its distribution in small streams to the lower reaches (Vincent, 1962). Much of this habitat is found draining land prime for agricultural development. Vincent cites agricultural practices which decrease natural flows, increase siltation, and restrict fish movement by placement of irrigation dams as possible causes for the decline of the arctic grayling in recent history. It is imperative that flow protection is secured for those streams still supporting arctic grayling populations.

4. FLOW RECOMMENDATIONS

Cross-sectional information was collected in a 49 ft riffle-pool sequence located in T1S, R16W, Sec. 9B. Five cross-sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 4.3 and 71.8 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is illustrated in Figure 21 . Lower and upper inflection points occur at 2 and 7 cfs, respectively. Based on an evaluation of the existing fishery and other resource information, a flow of 5 cfs is recommended for the low flow period (July 16 - May 15). A recommendation for the high flow period (May 16 - July 15) cannot be derived for Mussigbrod Creek due to the lack of long-term flow data.

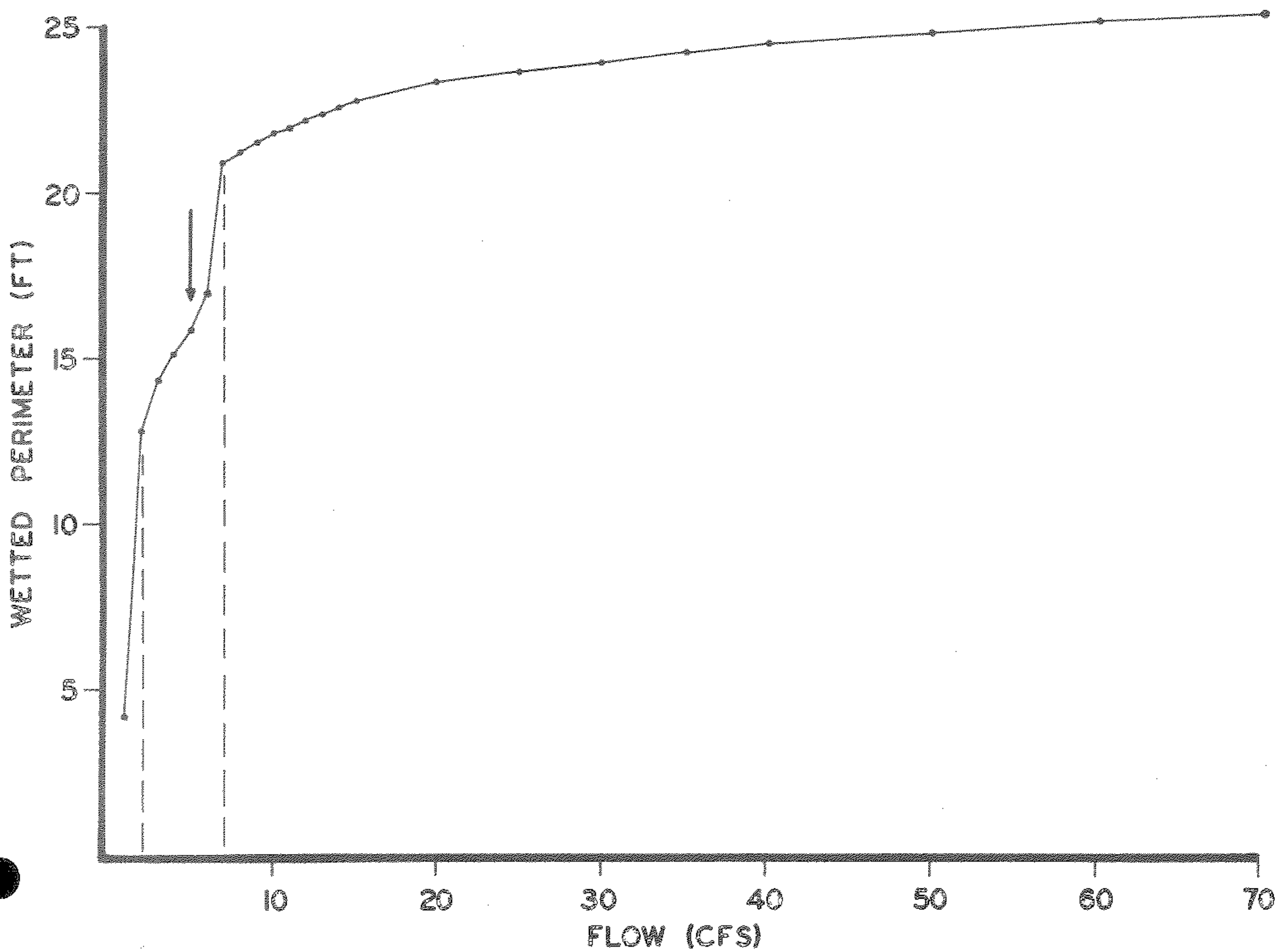

Figure 21. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Mussigbrod Creek.

1. STREAM

Pattengail Creek

2. DESCRIPTION

Pattengail Creek originates in the Pioneer Mountains of southwest Montana and flows in an easterly direction through a narrow floodplain for approximately 14 miles before joining the Wise River, a tributary to the Big Hole River. The stream drains high timbered peaks, scattered alpine meadows and talus slopes. Its 70 square mile drainage is owned entirely by the USFS. Major tributaries to Pattengail Creek include Lumbrecht, Reservoir and Lost Horse Creeks. The 45 ft wide channel has an average gradient of 33 ft/1,000 ft. The lower channel is characterized by extensive beaver pond construction, dense riparian willow growth and gentle meanders.

The Pattengail Creek drainage is managed by the USFS for grazing, hardrock mining and recreation in the form of hunting, fishing and hiking. The upper drainage is presently under consideration for inclusion into the National Wilderness System as part of the West Pioneers Wilderness Area. The upper drainage has an extensive trail network leading to high alpine lakes and pristine meadows.

Fishing pressure on Pattengail Creek in 1975-76 was estimated at 517 person-days per year or about 37 person-days/stream mile/year (MDFG, 1976). This is one of the highest pressures recorded for a tributary to the Big Hole River. Catches reported in angler logs consist entirely of rainbow trout, averaging 8.3 inches in length (MDFWP, 1980b).

In 1901, the Montana Power Company constructed a dam on Pattengail Creek. The purpose of the dam was to regulate flood waters and store water used for power generation at the main river dam at Divide, Montana. The reservoir destroyed about 2½ miles of stream habitat. Further damage to the channel occurred when the dam failed in 1927. This caused considerable scouring of the channels of the lower creek and the Wise River. The vertical banks created by this scouring are still noticeable today.

The 1977 Montana Legislature requested the Department of Natural Resources and Conservation to study the feasibility of constructing an off-stream storage reservoir on a tributary of the Big Hole River. The reservoir is to be used for augmenting instream flows in the Big Hole and Jefferson Rivers, flood control and irrigation (DNRC, 1979). After four years of study, a site on Pattengail Creek was recommended. The proposed 50 ft high dam would inundate 2.25 miles of Pattengail Creek and flood 400 acres, destroying important moose habitat (DNRC, 1981).

Sporadic water sampling has occurred on Pattengail Creek from October, 1972 through September, 1979 (USFS, unpublished data). Water quality is excellent for this stream. The water is characterized by a low specific conductance, neutral pH and low suspended sediment levels.

3. FISH POPULATIONS

A 1,000 ft section of Pattengail Creek was electrofished on July 10, 1979 and August 4, 1980. Brook and rainbow trout were the only game species captured. Nongame species present were longnose sucker, longnose dace and mottled sculpin. Table 33 summarizes the data for the two surveys.

Table 33. Summary of electrofishing survey data collected for a 1,000 ft section of Pattengail Creek (T2S, R12W, Sec. 10A) on July 10, 1979 and August 4, 1980.

Species	No. Captured	Length Range (inches)
Brook Trout	11	4.0-9.5
Rainbow Trout	2	6.1-6.6
Longnose Sucker	-	-
Longnose Dace	-	-
Mottled Sculpin	-	-

Due to the low numbers of fish captured in both years, the standing crop of trout could not be estimated.

An electrofishing survey was conducted by Heaton (1960) in a 300 ft section of Pattengail Creek in the vicinity of the present study section. Fifty-seven rainbow trout, ranging in length from 1.6-11.6 inches, and 22 brook trout from 1.9-6.5 inches were captured.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 137.5 ft riffle-pool sequence located at stream mile 0.5 (T2S, R12W, Sec. 10A). Five cross-sections were placed within the sequence. The WETP program was calibrated to field data collected at flows of 22.8 and 111.3 cfs. This sequence is located below the proposed dam site.

The relationship between wetted perimeter and flow for a single riffle cross-section is illustrated in Figure 22. Lower and upper inflection points occur at 20 and 24 cfs, respectively. Based on evaluation of existing fishery, recreational use and other resource information, a flow of 20 cfs is recommended for the low flow period (July 16 - May 15). Due to the lack of long-term flow data, recommendations for the high flow period (May 16 - July 15) cannot be derived for Pattengail Creek.

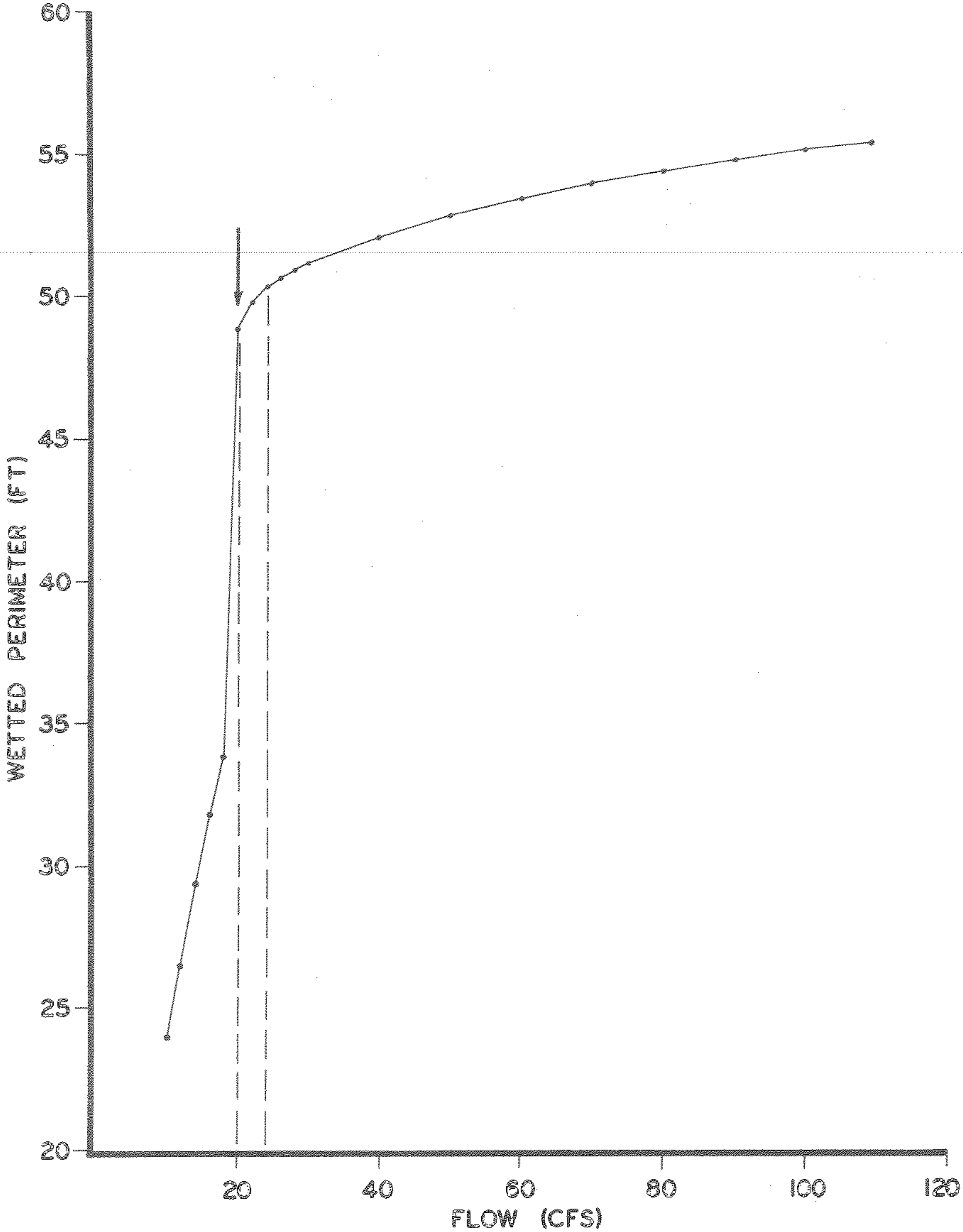

Figure 22. The relationship between wetted perimeter and flow for a single riffle cross-section in Pattengail Creek.

1. STREAM

Pintlar Creek

2. DESCRIPTION

Pintlar Creek originates at Oreamnos Lake in the Anaconda-Pintlar Range of southwest Montana. It flows in a southwesterly direction for about 10.6 miles before entering Pintlar Lake. From the Pintlar Lake outlet the stream flows an additional 10.8 miles before joining the Big Hole River 15 miles east of Wisdom, Montana. The majority of the basin is characterized by steep, timbered slopes. The meandering willow lined channel of the lower valley is surrounded by sagebrush/grassland benches. Ownership of the 31 square mile drainage is shared by the USFS (84%) and private individuals (16%). Seventy-seven percent of the USFS land lie within the Anaconda-Pintlar Wilderness Area. Bear Lake Creek is the only named tributary within the drainage although numerous intermittant streams drain the upper reaches. The 25 ft wide channel has an average gradient of 26 ft per 1,000 ft.

Lands within the Pintlar Creek drainage are primarily used for recreation, cattle grazing, and hay production along the lower reaches. A graveled road parallels the creek along its middle reach, ending at the Wilderness boundary. A USFS campground is located on Pintlar Lake, a natural lake bisecting the drainage.

Fishing pressure on Pintlar Creek in 1975-76 was estimated at 224 person-days/year (MDFG, 1976). This amounts to about 10 person-days/stream mile/year. Fishing pressure on Pintlar Lake was estimated at 221 person-days/year (MDFG, 1976). Angler log data compiled by the DFWP show that catches from Pintlar Creek consist entirely of brook trout, averaging 11.7 inches in length (MDFWP, 1980b).

A dam was built on the outlet of Pintlar Lake to increase its storage capacity for irrigation purposes. The 10.8 mile section of Pintlar Creek below the lake is severely dewatered during the fall and winter when water is stored for the upcoming irrigation season. The lower stream is further dewatered during the summer irrigation season when water is diverted. Consequently, little water enters the Big Hole River during the summer. Peterson (1979) found flows below the irrigation diversions to fluctuate violently during the summer months. Above the USFS boundary, changes in flow were more gradual. Flows were found to again stabilize near the mouth, possibly due to ground water recharge.

A thermograph was in operation from June through October, 1976 on Pintlar Creek directly below the diversions. An inverse relationship between water temperatures and flow was observed (MDFWP, unpublished data). The highest recorded temperature for lower Pintlar Creek was 64.5 F.

Water chemistry samples have been collected sporadically for Pintlar Creek from July, 1976 to September, 1979 (USFS, unpublished data). The stream exhibits the typical pattern of Big Hole tributaries, having a low specific conductance, low alkalinity and hardness levels, a neutral pH and low suspended sediments.

3. FISH POPULATIONS

A 1,000 ft section of Pintlar Creek located 0.2 miles below Pintlar Lake was electrofished on July 12 and August 3, 1979. Game fish captured in descending order of abundance were brook trout, burbot and rainbow x cutthroat hybrids. Mottled sculpin and longnose sucker were the non-game species present (Table 34).

Table 34. Summary of electrofishing survey data collected for a 1,000 ft section of Pintlar Creek (T1N, R15W, Sec. 14B) on July 12 and August 3, 1979.

Species	No. Captured	Length Range (inches)
Brook Trout	74	1.7-10.6
Burbot	21	2.2-12.5
Rainbow x Cutthroat Hybrids	8	5.7- 9.5
Longnose Sucker	-	-
Mottled Sculpin	-	-

The standing crop of brook trout in the section was estimated using a mark-recapture method (Table 35). This 1,000 ft section supports a population of about 87 brook trout, weighing a total of 8 pounds. Of the tributaries of the Big Hole River where population estimates were obtained, Pintlar Creek supports one of the lowest trout populations. The condition of the fish, however, was above average for stream surveys in the Beaverhead N.F. This study section is located immediately below the lake. The severe dewatering that occurs during the fall and winter storage periods may explain the low population of fish in the section.

Table 35. Estimated standing crop of brook trout in a 1,000 ft section of Pintlar Creek (T1N, R15W, Sec. 14B) on July 12, 1979. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft	
		Number	Pounds
Brook Trout	4.0- 5.9	68	
	6.0- 9.9	17	
	10.0-10.6	2	
		87 ($\pm$29)	8 ($\pm$3)

A 300 ft section located directly below Pintlar Lake was electrofished in 1959 (Heaton, 1960). Seven brook trout, ranging in length from 2.3-11.3 inches, and one rainbow trout were captured. Heaton felt that the low numbers of fish may be a result of dewatering during the fall and winter months. This 300 ft section was expanded to 1,200 ft and electrofished in 1972. At this time, nine brook trout, ranging in length from 5.3-11.6 inches, one rainbow trout and two burbot were captured (Peterson, unpublished data).

Pintlar Lake, a 20 acre lake with 50% of its depth less than five feet, has been historically stocked with cutthroat trout (MDFWP, unpublished data). Gill nets set in the lake in 1959 captured 14 brook trout, two rainbow trout, six arctic grayling, two burbot and numerous longnose suckers (Heaton, 1960). Gill nets set in 1966 captured 10 rainbow trout, seven brook trout, one burbot and numerous longnose suckers (Needham and Wipperman, 1967). Spawning and rearing habitat for the lake population of trout is considered poor (Needham and Wipperman, 1967).

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in 87 ft riffle-pool sequence located 0.5 miles below Pintlar Lake (T1N, R15W, Sec. 14B). Five cross-sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 2.0 and 97.1 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is shown in Figure 23. Lower and upper inflection points occur at 3 and 7 cfs, respectively. Based on an evaluation of existing fishery, recreational use and other resource information, a flow of 3.0 cfs is recommended for the low flow period (July 16 - May 15). Recommendations for the high flow period (May 16 - July 15) cannot be derived for Pintlar Creek due to the lack of long-term flow data.

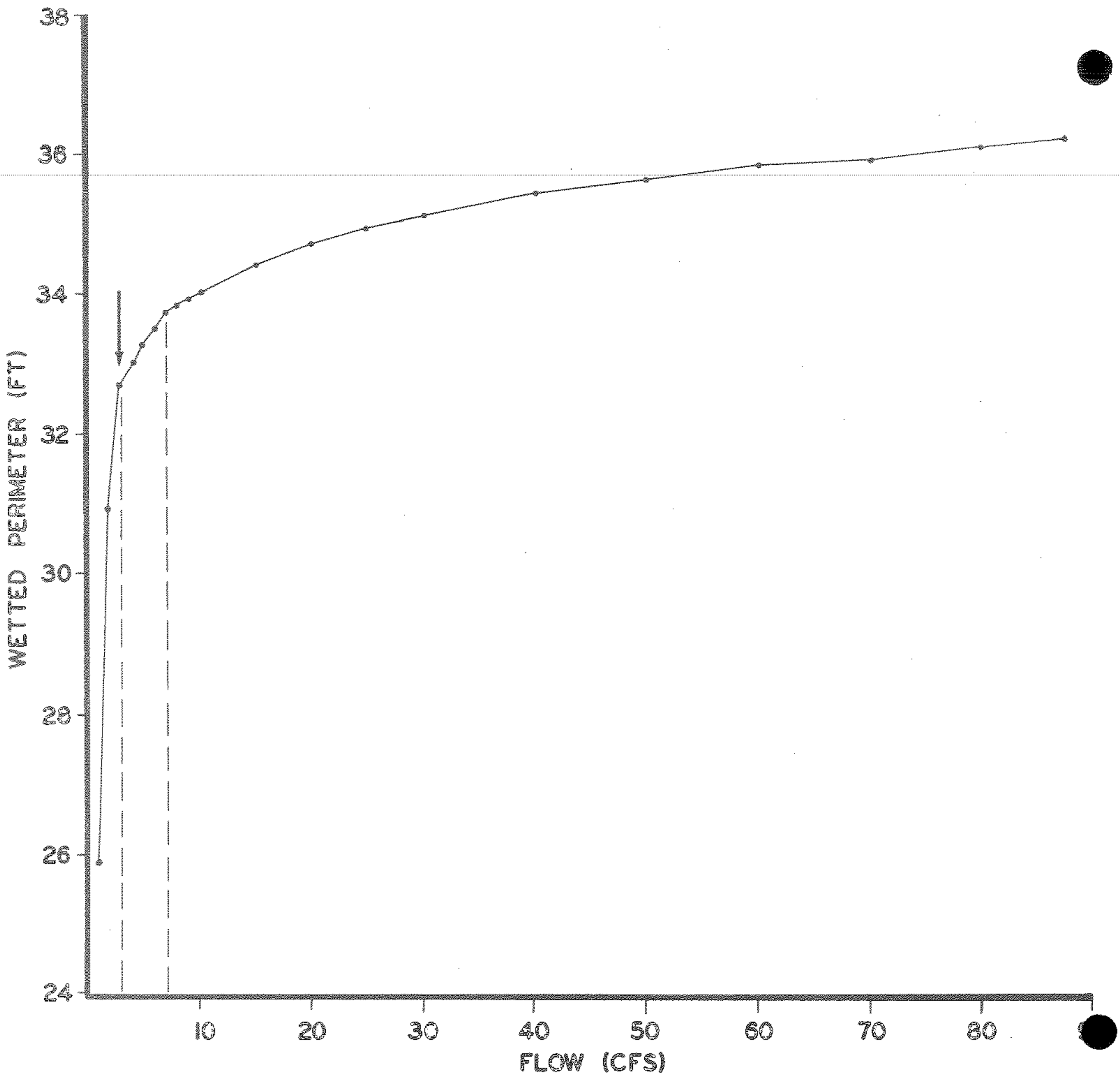

Figure 23. The relationship between wetted perimeter and flow for a single riffle cross-section in Pintlar Creek.

1. STREAM

Ruby Creek

2. DESCRIPTION

Ruby Creek originates on the eastern slope of the Bitterroot Mountain Range in southwest Montana. The stream is formed at the convergence of the West Fork Ruby Creek and Pioneer Creek and flows in a northeasterly direction for 9.5 miles before joining Trail Creek to form the North Fork Big Hole River. The 18 ft wide channel has a moderate gradient of 9 ft/ 1,000 ft. Much of the stream meanders through dense willows and beaver ponds. Only the headwater area and the upper 4 miles drain forested lands. The remainder of the drainage is in an open grassland/sagebrush valley. Ninety-one percent of the 54.5 square mile drainage is controlled by the USFS. The remaining 9% is privately owned. Approximately half the stream length is located on private land. Major tributaries to Ruby Creek include Butler, Cow, Big Moosehorn, Little Moosehorn and Gory Creeks.

Land within the Ruby drainage is used for recreation, cattle grazing, hay production, timber harvesting and mining. Recreational uses include fishing, hunting and backpacking. An extensive pack trail system traverses the headwater area.

Fishing pressure on Ruby Creek during May, 1975 through April, 1976 was estimated from a mail survey at 910 person-days (MDFWP, 1976). This amounts to about 96 person-days/stream mile/year. The pressure was equally divided between resident and nonresident anglers. Ruby Creek receives one of the greatest amounts of pressure per stream mile of any Big Hole tributary. Catches reported in angler logs show brook trout to be the only game fish caught. The brook trout average 10.4 inches in length (MDFWP, 1980b). Several gravel roads within the drainage provide excellent access to the stream and many of its tributaries.

The logging of lodgepole pine is a continuing use in the Ruby drainage. The latest sale began in the summer of 1979. Cattle grazing occurs on private as well as public lands. The improper mangement of these activities could lead to increased sediment loads and loss of riparian habitat. Hay fields throughout the lower drainage are irrigated with water diverted from Ruby Creek. This causes severe dewatering of the natural channel. Much of the water of Ruby Creek enters the North Fork Big Hole River by subsurface irrigation returns.

Historically, placer gold mining occurred in the headwater tributaries of Ruby Creek but the production was never large (Lyden, 1948). Since the fall of 1980, gold exploration has occurred throughout the upper drainage (USFS, unpublished data).

Sporadic water chemistry measurements have been collected for Ruby Creek throughout the 1970's (USFS, unpublished data). The water quality is excellent and is characterized by a low specific conductance, a neutral pH, and low levels of turbidity and suspended sediment.

3. FISH POPULATIONS

A 1,000 ft section located approximately 2.5 miles above the USFS boundary was electrofished on July 20 and August 7, 1979. Brook trout, rainbow x cutthroat hybrids and burbot were the game fish captured. Non-game species present were mottled sculpin and longnose sucker (Table 36).

Table 36 . Summary of electrofishing survey data collected for a 1,000 ft section of Ruby Creek (T3S, R17W, Sec. 20D) on July 20 and August 7, 1979.

Species	No. Captured	Length Range (inches)
Brook Trout	229	2.0-10.3
Rainbow x Cutthroat Hybrids	2	6.2- 6.5
Burbot	3	5.2-12.1
Longnose Sucker	2	4.1- 4.8
Mottled Sculpin	-	-

The standing crop of brook trout in the section was estimated using a mark-recapture method, (Table 37). This 1,000 ft section supports about 503 brook trout, weighing 52 pounds. Ruby Creek supports one of the highest populations of brook trout of the streams sampled in the Big Hole drainage. The majority of the population was less than 10 inches in length.

Table 37 . Estimated standing crop of brook trout in a 1,000 ft section of Ruby Creek (T3S, R17W, Sec. 20D) on July 20, 1979. Eighty percent confidence intervals are in parenthese.

Species	Length Group (inches)	Per 1,000 Ft	
		Number	Pounds
Brook Trout	4.0- 5.9	237	
	6.0- 9.9	266	
	10.0-10.3	2	
		505($\pm$101)	52($\pm$11)

Heaton (1960) electrofished a 300 ft section of Ruby Creek in the vicinity of the present study section. He captured 35 brook trout, ranging in length from 2.2-11.6 inches, and one rainbow trout measuring 4.8 inches. A nearby 683 ft section was electrofished in 1966. Fifty brook trout were captured with 50% of the fish seven inches or longer (Wipperman, 1967a).

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected for a 53 ft subreach located approximately 2.5 miles above the USFS boundary (T3S, R17W, Sec. 20D). Five cross-sections defining the riffle-pool habitat were placed within this subreach. The WETP program was calibrated to field data collected at flows of 5.3 and 30.5 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross sections is shown in Figure 24. Lower and upper inflection points occur at 4 and 12 cfs, respectively. Based on an evaluation of existing fishery, recreational use and other resource information, a flow of 8 cfs is recommended for the low flow period (July 16 - May 15). Due to the lack of long-term flow data, recommendations for the high flow period (May 16 - July 15) cannot be derived for Ruby Creek.

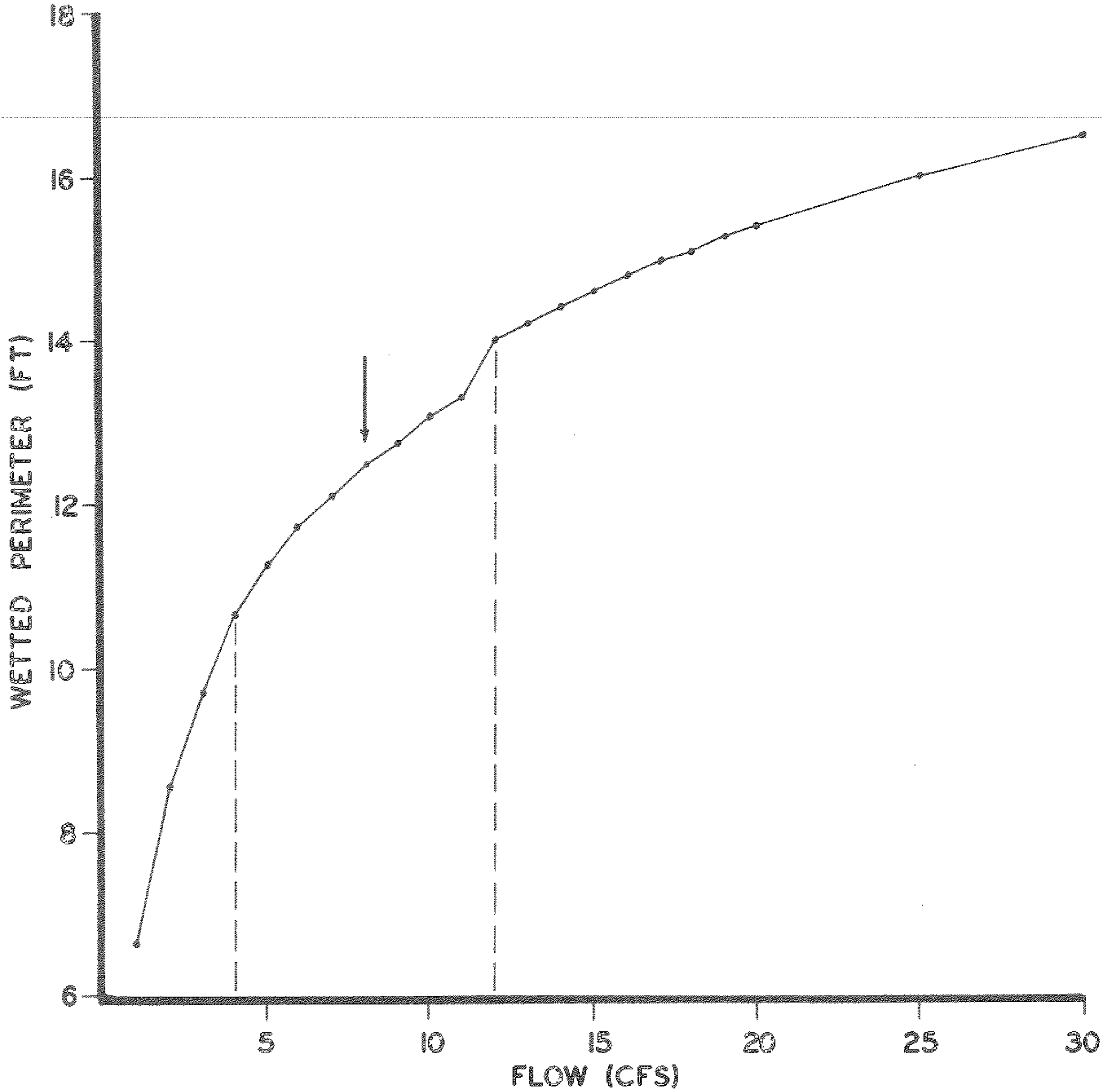

Figure 24. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Ruby Creek.

1. STREAM

South Fork Big Hole River

2. DESCRIPTION

The South Fork Big Hole River originates along the eastern slopes of the Continental Divide. It drains the Bitterrroot Mountains and the Big Hole Divide. It flows in a northerly direction for approximately 14 miles before converging with Governor Creek one mile south of the town of Jackson, Montana, to form the Big Hole River. The meandering channel flows through numerous beaver ponds and is densely lined with willows. The stream drains grassland/sagebrush benches in its lower reaches and dense lodgepole forest in its upper portion. Although only 24% of the 78.5 square mile drainage is privately owned, 10 of the 14 miles of stream flow through private land. The remaining 75% of the basin is managed by the USFS. Tributaries to the South Fork Big Hole River include Pioneer, Darkhorse, Berry, Jahnke, and Saginaw Creeks. Most of these streams originate at alpine lakes. The average gradient of the 25 ft wide channel is 13 ft per 1,000 ft.

From 1948 to 1953, a USGS gauge station was operated on the South Fork Big Hole River approximately one mile above the USFS boundary (T7S, R15W, Sec. 9B). The average annual discharge for the three complete years of record was 52.1 cfs. Minimum and maximum flows for the period of record were 5 and 938 cfs, respectively.

Lands within the South Fork Big Hole drainage are used for recreation, cattle grazing, hay production and, historically, mining. An improved gravel road parallels and crosses the stream throughout the drainage, allowing good access for hunting, camping and fishing. Fishing pressure on the South Fork Big Hole River during May, 1975 through April, 1976 was estimated by mail survey at 580 person-days or approximately 41 person days/stream mile/year (MDFG, 1976). This is one of the highest pressure estimates for a tributary to the Big Hole River.

A USFS campground is located on Van Houten Lake where fishing and camping are popular. Fishing pressure on Skinner Lake, the true headwater of the South Fork Big Hole River, was estimated at 84 person-days during May, 1975 through April, 1976 (MDFG, 1976). Because of an extensive trail system, fishing and camping on numerous alpine lakes in the drainage can be enjoyed.

The grazing of cattle occurs throughout the South Fork Big Hole Valley on public and private land. Grazing within the riparian zone along portions on the lower and middle stretches of the stream has resulted in bank trampling, loss of overhanging vegetative cover, mass wasting and minor erosion. Loss of riparian habitat has also resulted from the physical and chemical removal of willows to increase grazing area and provide access to water. The major land use on private lands within the lower drainage is hay production. These hay lands are irrigated with waters from the South Fork Big Hole River. As a result, the South Fork Big Hole River is entirely diverted into a series of irrigation ditches.

Water chemistry sampling of the South Fork Big Hole River has been conducted by the USFS beginning in 1972 (USFS, unpublished data). This stream exhibits the excellent water quality of the Big Hole drainage. It is characterized by low alkalinity and hardness levels, a low specific conductance, neutral pH, and low nitrate and phosphate concentrations.

3. FISH POPULATIONS

A 1,300 ft section of the South Fork Big Hole River was electrofished on July 31 and August 6 and 27, 1980. Game fish present in descending order of abundance were brook trout, rainbow trout, mountain whitefish and burbot. Longnose sucker and mottled sculpin were the only nongame species captured (Table 38).

Table 38 . Summary of electrofishing survey data collected for a 1,300 ft section of the South Fork Big Hole River (T7S, R15W, Sec. 8A) on July 21 and August 6 and 27, 1980.

Species	No. Captured	Length Range (inches)
Brook Trout	319	3.6-10.7
Rainbow Trout	6	5.3-12.0
Mountain Whitefish	5	12.1-15.0
Burbot	2	15.1-15.3
Mottled Sculpin	-	-
Longnose Sucker	-	-

The standing crop of brook trout was estimated using mark-recapture method (Table 39). This stream supports about 443 brook trout, weighing 64 pounds per 1,000 ft. This is approximately seven fish per pound, which is above average for streams surveyed in the Beaverhead N.F. The South Fork Big Hole River supports one of the highest populations of brook trout within the Big Hole drainage.

Table 39. Estimated standing crop of brook trout in a 1,300 ft section of the South Fork Big Hole River (T7S, R15W, Sec. 8A) on July 31, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Brook Trout	5.0- 5.9	115	
	6.0- 9.9	311	
	10.0-10.7	17	
		443 (±82)	64 (±12)

Heaton (1960) electrofished a 300 ft section of the South Fork located upstream of the present study section. The brook trout was the only game fish present. One hundred and sixty-five brook trout, ranging from 2-10 inches, were captured.

Gill nets fished in Van Houten Lake in 1959 captured five rainbow trout, three brook trout, three burbot and 88 longnose suckers (Heaton, 1960). The lake was rehabilitated in 1962 and planted with brook trout fry and catchable rainbow trout (Needham and Wipperman, 1967). In 1966, gill nets set in the lake captured 108 brook trout and 34 longnose suckers.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 184 ft riffle-pool sequence located in T7S, R15W, Sec. 8A. Five cross-sections were placed within the sequence. The WETP program was calibrated to field data collected at flows of 21.2, 150.5, 306.9 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross sections is shown in Figure 25. Lower and upper inflection points occur at 12 and 24 cfs, respectively. Based on an evaluation of existing fishery, recreational use and other resource information, a flow of 24 cfs is recommended for the low flow period (July 16 - May 15). A recommendation for the high flow period (May 16 - July 15) cannot be derived for the South Fork Big Hole due to the lack of long-term flow data.

The recommendations for the low flow period are compared to the mean monthly flows of record for the South Fork Big Hole River in Table 40. The recommendations exceed the mean flows for the months of September through March.

Table 40. Instream flow recommendations for the South Fork Big Hole River using the wetted perimeter/inflection point method (low flow period) compared to the mean flows of record.

	Flow Recommendations (cfs)	Mean Flows (cfs)[a/]
January	24	9.5
February	24	9.8
March	24	9.8
April	24	53.4
May 1-15	24	159.9
May 16-31	b/	
June 1-15	b/	225.8
June 16-30	b/	
July 1-15	b/	90.2
July 16-31	24	
August	24	27.9
September	24	16.7
October	24	16.3
November	24	14.0
December	24	12.3

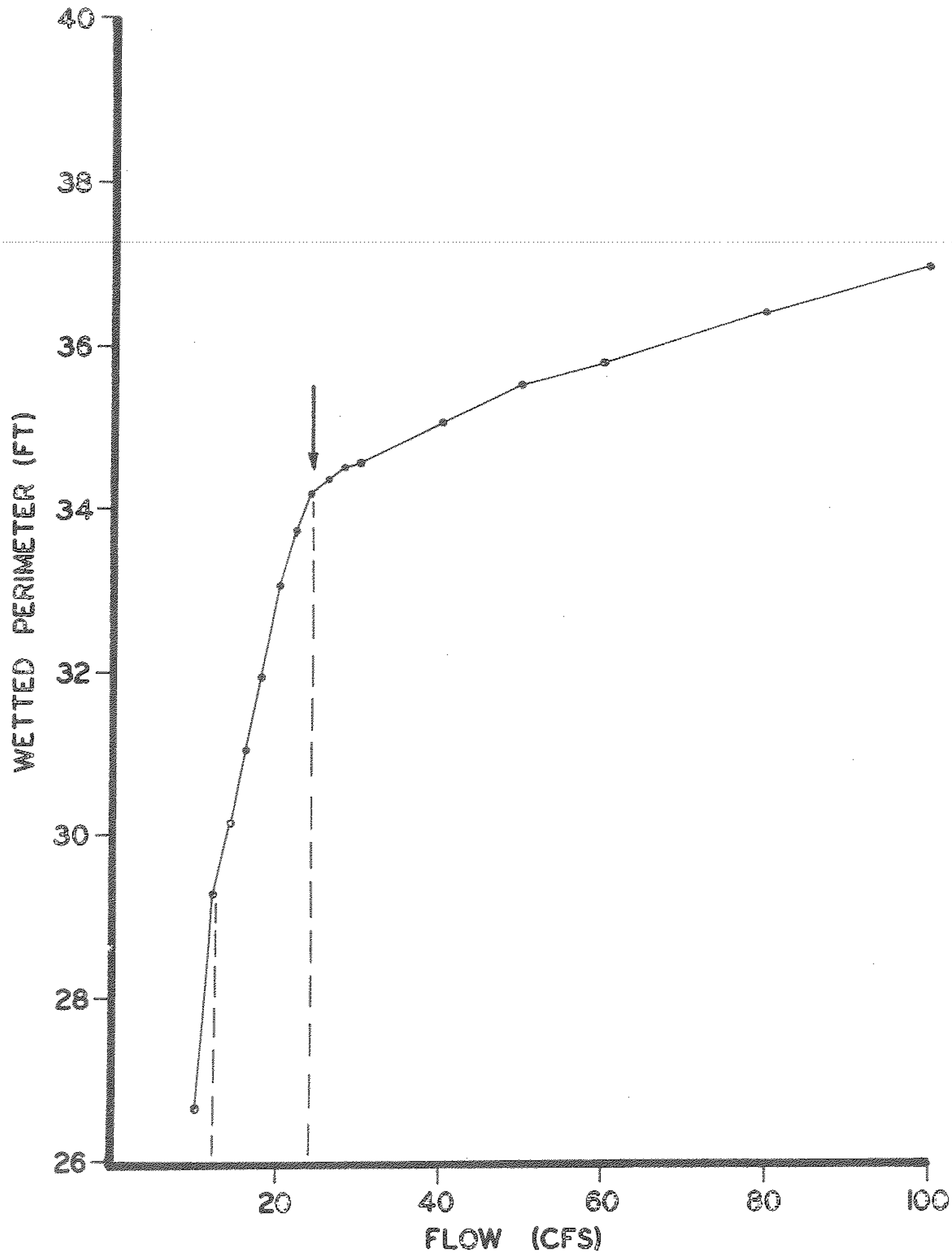

Figure 25. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in the South Fork Big Hole River.

Table 40 continued. Instream flow recommendations for the South Fork Big Hole River using the wetted perimeter/inflection point method (low flow period) compared to the mean flows of record.

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a/ Derived for the June, 1948-October, 1953 period of record for the USGS gauage at approximate stream mile 9 (T7S, R15W, Sec. 9B).

b/ Flow recommendations for the high flow period (May 16-July 15) are unavailable due to the lack of long-term flow records for the South Fork Big Hole River.

1. STREAM

Steel Creek

2. DESCRIPTION

Steel Creek originates in the West Pioneer Mountains of southwest Montana. The stream flows in a westerly direction for 10.5 miles before entering the Big Hole River one mile north of Wisdom, Montana. Topographic and vegetative characteristics of the upper and lower reaches of the drainage differ considerably. Upper Steel Creek cascades through heavily timbered, steep slopes. The bottom substrate consists of cobble and boulder. The lower reaches meander through willow lined and open banks surrounded by grassland/sagebrush benches. The channel has a finer bottom substrate. Average gradient of the 20 ft wide channel is 43 ft/1,000 ft. Major tributaries include Wisconsin, Francis, Stanley and the South Fork Steel Creeks. Ownership of the 80.5 square mile drainage is shared by the USFS (42%), private individuals (35%), the State of Montana (21%) and the BLM (1%).

Lands within the Steel Creek drainage are used for recreation, cattle grazing, hay production and a limited amount of mining. Recreational activities include fishing, hunting, camping and hiking. An extensive trail system leads to numerous alpine lakes. An improved gravel road parallels the stream, ending at a USFS campground. The headwater area is presently being considered for inclusion into the National Wilderness System.

Fishing pressure on Steel Creek during May, 1975 through April, 1976 was estimated by a mail survey at 55 person-days (MDFG, 1976). This is approximately five person-days/stream mile/year. Information gathered from angler logs show that the catch consists entirely of brook trout, averaging 9.5 inches in length (MDFWP, 1980b).

Cattle grazing occurs on private and public land within the Steel Creek drainage. Damage to the riparian zone by overgrazing and trampling is evident along some stretches of the stream. Physical removal of the streambank willows has also occurred along a mile section of private land. Hay production is a major activity along the lower reaches of the stream. Water from Steel Creek is diverted during the summer irrigation months, causing some dewatering. Increased erosion rates coupled with flow reductions have caused sediment to accumulate in riffles and slower pools.

Placer mining occurred on Steel Creek about 4 miles east of Wisdom during the late 1800's (Geach, 1972). Gold production for Steel Creek is unknown. Molybdenum mining and the harvesting of salvageable timber may occur in the headwater area if wilderness protection is not secured (USFS, 1980).

Water chemistry samples have been collected sporadically by the USFS on Steel Creek above the USFS boundary (USFS, unpublished data). In general, Steel Creek exhibits the typical pattern of Big Hole River tributaries of a low specific conductance, neutral pH and low suspended sediment.

3. FISH POPULATIONS

A 1,000 ft section of Steel Creek was electrofished on July 18 and August 6, 1979. Game fish present in descending order of abundance were brook trout, mountain whitefish, burbot and arctic grayling. Longnose sucker, longnose dace, and mottled sculpin were the nongame species captured (Table 41).

Table 41 . Summary of electrofishing survey data collected for a 1,000 ft section of Steel Creek (T2S, R15W, Sec. 34A) on July 18 and August 6, 1979.

Species	No. Captured	Length Range (inches)
Brook Trout	462	1.2-14.7
Mountain Whitefish	9	3.1- 5.8
Burbot	3	6.1-12.0
Arctic Grayling	2	7.4-12.6
Longnose Sucker	-	-
Longnose Dace	-	-
Mottled Sculpin	-	-

The standing crop of brook trout in the section was estimated using a mark-recapture method (Table 42). This 1,000 ft section supports a population of 1,183 brook trout, weighing a total of 150 pounds. This is the highest standing crop of brook trout found in 50 streams surveyed in the Big Hole, Beaverhead and Red Rock drainages. The largest brook trout captured was 14.7 inches and weighed 1.6 pounds. The condition factor (the length to weight ratio) was well above average for all length groups.

Table 42 . Estimated standing crop of brook trout in a 1,000 ft section of Steel Creek (T2S, R15W, Sec. 34A) on July 18, 1979. Eigthy percent confidence intervals are in parentheses.

		Per 1,000 Ft	
Species	Length Group (inches)	Number	Pounds
Brook Trout	4.0- 5.9	646	
	6.0- 9.9	490	
	10.0-14.7	47	
		1,183 ($\pm$291)	150 ($\pm$34)

Heaton (1960) electrofished two 300 ft sections of Steel Creek in 1959. The upper section, located at the USFS campground, was dominated by rainbow x cutthroat hybrids. Twelve hybrids, measuring 2.6-6.2 inches, and four brook trout were captured. On the lower meandering section, brook trout dominated the fishery with 60 individuals, ranging from 2.5-12.9 inches, captured. Other species present were mountain whitefish and longnose sucker.

Liknes (1981) found arctic grayling fry and older individuals in the lower reaches of Steel Creek. This indicates reproduction by a resident population or use of this tributary by the main river population as a spawning area. The presence of fluvial arctic grayling adds to the importance of this stream to the State of Montana. The fluvial arctic grayling is classified as a species of special concern (Deacon et al., 1979). Once widely distributed throughout the upper Missouri River drainage, the grayling is now only found in remnant populations in the upper Big Hole drainage. The decline of the arctic grayling in Montana has followed closely behind agricultural development. Streams draining these agricultural lands are considered prime habitat for the grayling (Vincent, 1962). Vincent (1962) cites agricultural practices which restrict fish movement, decrease natural streamflows, increase water temperatures and increase siltation as possible causes for the decline of the arctic grayling. It is imperative that instream flow protection is secured for those streams still supporting populations of arctic grayling.

4. FLOW RECOMMENDATIONS

A 55 ft subreach of Steel Creek (T3S, R14W, Sec. 4C) was selected for the collection of cross-sectional data. Five cross-sections describing the riffle-pool habitat were placed within the subreach. The WETP program was calibrated to field data collected at flows of 3.2 and 21.0 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is illustrated in Figure 26 . Lower and upper inflection points occur at 2 and 9 cfs, respectively. Based on an evaluation of existing fishery, recreational use and other resource information, a flow of 9.0 cfs is recommended for the low flow period (July 16 - May 15). Recommendations for the high flow period (May 16 - July 15) cannot be derived for Steel Creek due to the lack of long-term flow data.

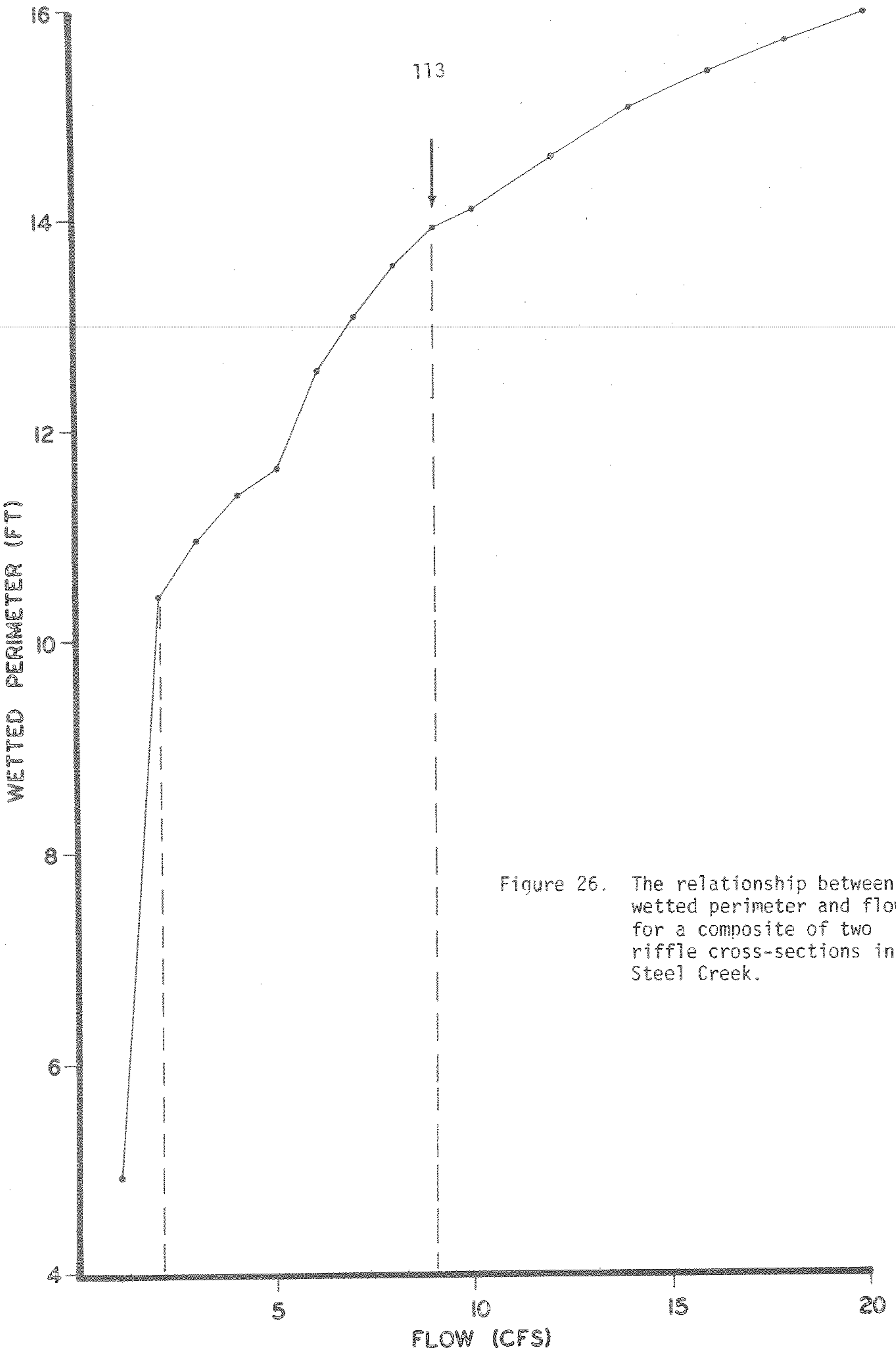


Figure 26. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Steel Creek.

1. STREAM

Swamp Creek

2. DESCRIPTION

Swamp Creek originates in Yank Swamp, a 5.5 mile long marsh located on the eastern slope of the Bitterroot Mountain Range. Swamp Creek flows for about 15 miles in a northeasterly direction before converging with the Big Hole River, 3.5 miles north of Wisdom, Montana. The 85 square mile drainage consists primarily of sagebrush/grassland benches. Much of this land has been converted to irrigated hay pastures. Only Moose Creek, its major tributary, drains moderately timbered slopes. Land ownership of the drainage is shared by private interests (76%), the USFS (19%), the State of Montana (3%) and the BLM (2%). The 30 ft wide channel has a gradient of 8 ft per 1,000 ft.

Lands within the Swamp Creek drainage are primarily used for cattle grazing and hay production. Recreation in the form of hiking and fishing also occurs. Shultz Reservoir, a dammed lake used for irrigation, is a popular fishing area. A series of gravel roads provide access throughout the drainage. Upon leaving USFS land, the waters of Swamp Creek are diverted into an extensive irrigation system. Ditches connect adjacent drainages through man-constructed water paths. The majority of Swamp Creek enters the Big Hole River through irrigation return. Due to this manipulation of the natural watershed, Swamp Creek is severly dewatered throughout its course. Grazing within the riparian zone and the physical removal of stream bordering willows have resulted in increased erosion, trampled banks and the loss of undercut banks and overhanging vegetative cover. Sedimentation within riffle and spawning areas is extensive. Riprapping of banks to prevent bank erosion and channel movement has occurred on several sites along the stream.

3. FISH POPULATIONS

A 1,000 ft section of Swamp Creek located near the mouth was electrofished on July 13 and August 6, 1979. Game fish present in descending order of abundance were brook trout, burbot and mountain whitefish. Longnose sucker, longnose dace and mottled sculpin were the nongame species captured (Table 43).

Table 43. Summary of electrofishing survey data collected for a 1,000 ft section of Swamp Creek (T2S, R15W, Sec. 8A) on July 13 and August 6, 1979.

Species	No. Captured	Length Range (inches)
Brook Trout	78	2.0-13.9
Burbot	30	3.1-11.2
Mountain Whitefish	4	2.5- 3.3
Longnose Sucker	-	-
Longnose Dace	-	-
Mottled Sculpin	-	-

Due to low numbers of trout captured, a population estimate could not be obtained for Swamp Creek. Of the 78 brook trout captured, 54% were less than 4 inches. The severe dewatering and flow fluctuations that occur throughout the Swamp Creek drainage create unstable conditions and the loss of big fish habitat. Spawning areas and fish food producing riffle areas are reduced as a result of siltation caused by increased bank erosion. Elevated water temperatures resulting from the flow reductions and the widening of the channel by cattle overuse may be affecting the trout population.

Liknes (1981) captured fry as well as larger arctic grayling in the lower reaches of Swamp Creek, identifying this stream as spawning habitat for this species. Although older arctic grayling were found, it is unknown whether these individuals were residents or returned to the main river when habitat conditions deteriorated during the irrigation season. Although once widely distributed throughout the upper Missouri River basin, the fluvial population of arctic grayling is now restricted to the upper Big Hole River and its tributaries. The decline of the fluvial arctic grayling in Montana closely followed the agricultural development of bottom lands (Vincent, 1962). The restriction of fish movement by irrigation dams, the reduction of natural flows, and increased siltation are believed to be the probable causes for the decline of the grayling in Montana (Vincent, 1962). It is imperative that instream flow protection is secured for those streams still supporting arctic grayling populations.

4. FLOW RECOMMENDATIONS

A 300 ft subreach located near the mouth of Swamp Creek was selected for the collection of cross-sectional data (T2S, R15W, Sec. 8A). The riffle-run habitat within the subreach was described using five cross-sections. The WETP program was calibrated to field data collected at flows of 7.6 and 74.6 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is illustrated in Figure 27. Lower and upper inflection points occur at 8 and 15 cfs, respectively. Based on an evaluation of existing fishery, water availability and other resource information, a flow of 10 cfs is recommended for the low flow period (July 1 - April 30). Recommendations for the high flow period (May 1 - June 30) cannot be derived for Swamp Creek due to the lack of long-term flow data.

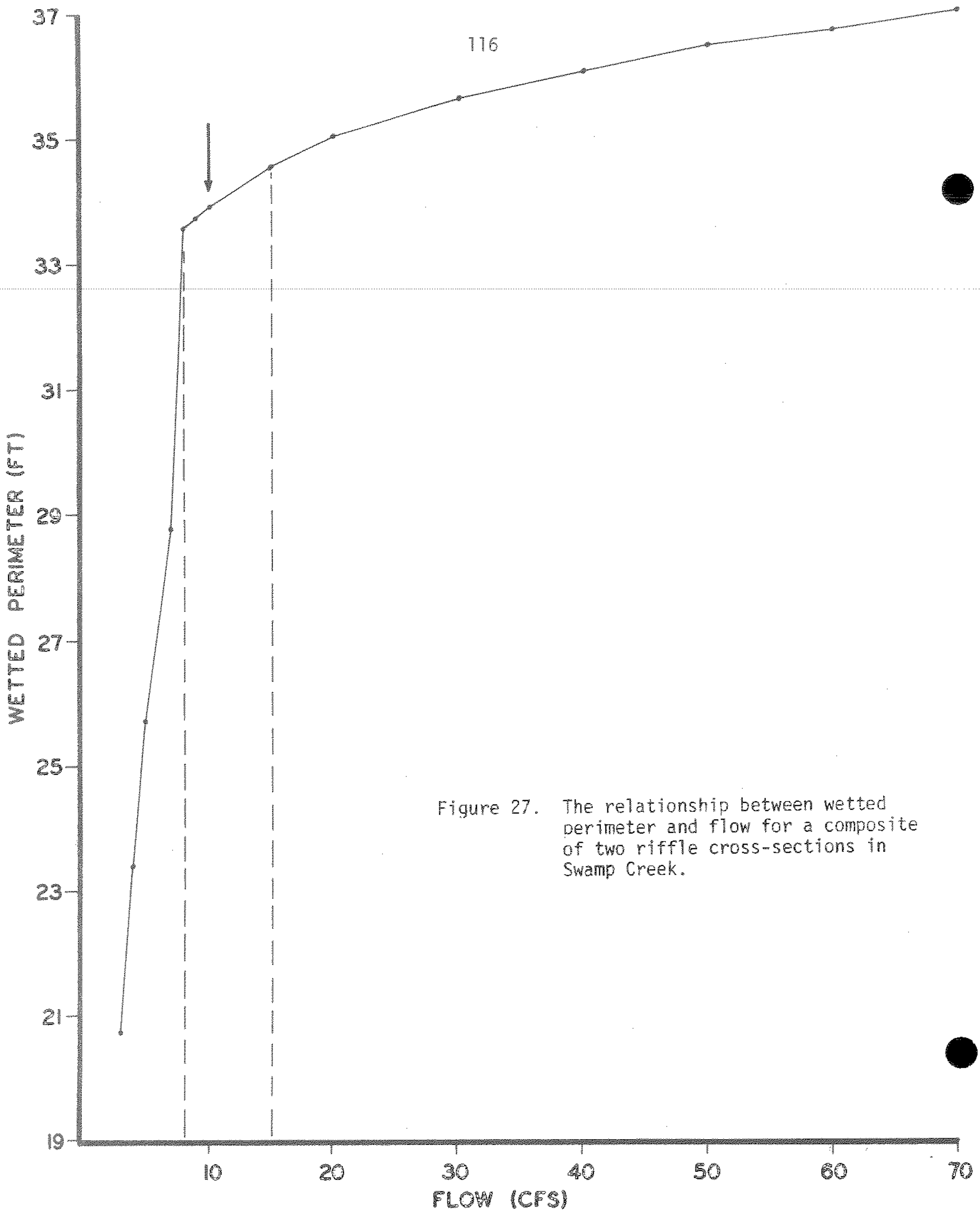


Figure 27. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Swamp Creek.

1. STREAM

Trail Creek

2. DESCRIPTION

Trail Creek originates in the Bitterroot Mountains of southwest Montana. It flows in an easterly direction for 19.5 miles before converging with Ruby Creek to form the North Fork Big Hole River. The majority of the 81 square mile basin is controlled by the USFS (98%). The remaining 2% is divided equally between private landowners and the National Park Service (Big Hole Battlefield National Monument). Joseph, May, Elk, Hogan and Prairie Creeks are among the 19 tributaries to Trail Creek. The Trail Creek drainage in its upper reaches is characterized by steep, timbered slopes and a narrow floodplain. In its lower reaches, the stream meanders through dense willows and numerous beaver ponds. The stream has an average gradient of 11 ft/ 1,000 ft. The channel averages 20-28 ft in width.

A USGS gauging station on lower Trail Creek (stream mile 4.9) was operated from 1948-1953 and 1966-1972. The mean flow for the period of record was 85.3 cfs. Minimum and maximum flows were 1.6 cfs in November, 1969 and 1,350 cfs in June, 1972, respectively.

Lands within the Trail Creek drainage are used for cattle grazing, timber harvesting, wildlife habitat for mule deer, elk and moose and recreation in the form of fishing, hunting and camping. Montana Highway 43 parallels and crosses the stream for its lower 9 miles. Various gravel roads allow access to the remainder of the drainage. A USFS campground and recreational cabin are located on Trail Creek.

Fishing pressure on Trail Creek during May, 1975 through April, 1976 was estimated at 343 person-days (MDFWP, 1976). This is an average of 18 person-days/stream mile/year. Based on angler log data, the catch from Trail Creek consists entirely of brook trout, which average 8.3 inches in length (MDFWP, 1980b).

The 1977 Montana Legislature requested that the Department of Natural Resources and Conservation determine the feasibility of constructing an off-stream storage reservoir on a tributary of the Big Hole River. The reservoir is to be used for augmenting instream flows to the Big Hole and Jefferson rivers, irrigation and flood control (DNRC, 1979). In a preliminary review, two sites on Trail Creek were recommended for further study. These two sites were later eliminated after further consideration due to high construction costs and the necessity to relocate Highway 43 (DNRC,1981).

Historically, Trail Creek and several of its tributaries were extensively placer mined and dredged for gold (Lyden, 1948). The entire main stem from the headwaters to approximately 7 miles above the mouth was worked in the late 1800's and early 1900's. The lower reach from the mouth to 4 miles upstream was tested for possible dredging but never developed (Lyden, 1948). May and Placer Creeks, tributaries to Trail Creek, have also been placer mined.

The water chemistry of Trail Creek was sporadically sampled by the USFS during 1974 through 1976 (USFS, unpublished data). In general, Trail Creek exhibits the typical chemical pattern of the streams in the Big Hole Drainage. It has a low specific conductance, a neutral pH, and low suspended sediments. Although analyzed only once, zinc concentrations were slightly elevated in the lower reaches of Trail Creek.

Currently, no water is being diverted for irrigation purposes.

3. FISH POPULATIONS

A 1,000 ft section of Trail Creek was electrofished on July 19 and August 10, 1979. On August 6, 1980, this section was extended to 1,500 ft and again electrofished. Game fish present were brook trout, mountain whitefish and burbot. Mottled sculpin, longnose sucker and longnose dace were the nongame species captured. Table 44 summarizes the 1979 and 1980 electrofishing data.

Table 44. Summary of electrofishing survey data collected for a 1,000 ft section of Trail Creek (T2S, R17W, Sec. 22C) on July 19 and August 10, 1979 and a 1,500 ft section (T2S, R17W, Sec. 22C) on August 6, 1980.

Species	No. Captured		Length Range (inches)	
	1979	1980	1979	1980
Brook Trout	15	10	2.3-10.3	3.0- 8.3
Mountain Whitefish	13	3	7.2-15.6	9.8-12.1
Burbot	17	3	5.2-1.35	6.5- 9.9
Mottled Sculpin	-	-	-	-
Longnose Dace	-	-	-	-
Longnose Sucker	-	-	-	-

The population of game fish was too sparse to estimate using the mark-recapture method. The causes for this depressed trout population are presently unknown. Although the physical characteristics of the channel, the streambank and instream cover and spawning areas appear to be suitable for trout, the population is depressed.

Three 300 ft sections of Trail Creek were electrofished by Heaton (1960) in 1959 (Table 45). The sections were approximately located at stream miles 10, 3 and 0.25. A substantial decrease in brook trout numbers occurred between sections 10 and 3, a distance of 7 miles. Nine tributaries enter Trail Creek in between these sections. The stream also changes from a cascading to a meandering type channel. The cause of the decline may be related to the placer mining that has occurred between stream miles 10 and 3.

Table 45. Summary of electrofishing survey data collected for three 300 ft sections of Trail Creek in 1959. Length ranges in inches are in parentheses.

Stream Mile	Brook Trout	Rainbow Trout	Mountain Whitefish	Burbot	Longnose Sucker
10	88 (2.1-8.9)	-	-	-	-
3	24 (2.4-7.8)	1 (3.6)	-	1	-
0.25	22 (2.6-12.8)	-	6 (3.6-12.4)	51	-

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 69 ft subreach located near stream mile 2.0 (T2S, R17W, Sec. 22C). Five cross-sections describing the riffle-pool habitat were placed within the subreach. The WETP program was calibrated to field data collected at flows of 17.8 and 108.1 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is shown in Figure 28. Lower and upper inflection points occur at 14 and 25 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 14 cfs is recommended for the low flow period of July 1 - April 30. Recommendations for the high flow period (May 1 - June 30) cannot be derived for Trail Creek due to the lack of adequate flow records.

Table 46. Instream flow recommendations derived for Trail Creek using wetted perimeter/inflection point method (low flow period) compared to the mean flows of record.

	Flow Recommendations (cfs)	Mean Flows (cfs)[a/]
January	14	13.5
February	14	13.1
March	14	14.7
April	14	85.4
May	b/	396.0
June	b/	339.0
July	14	61.6
August	14	26.2
September	14	22.3
October	14	21.5
November	14	20.0
December	14	15.4

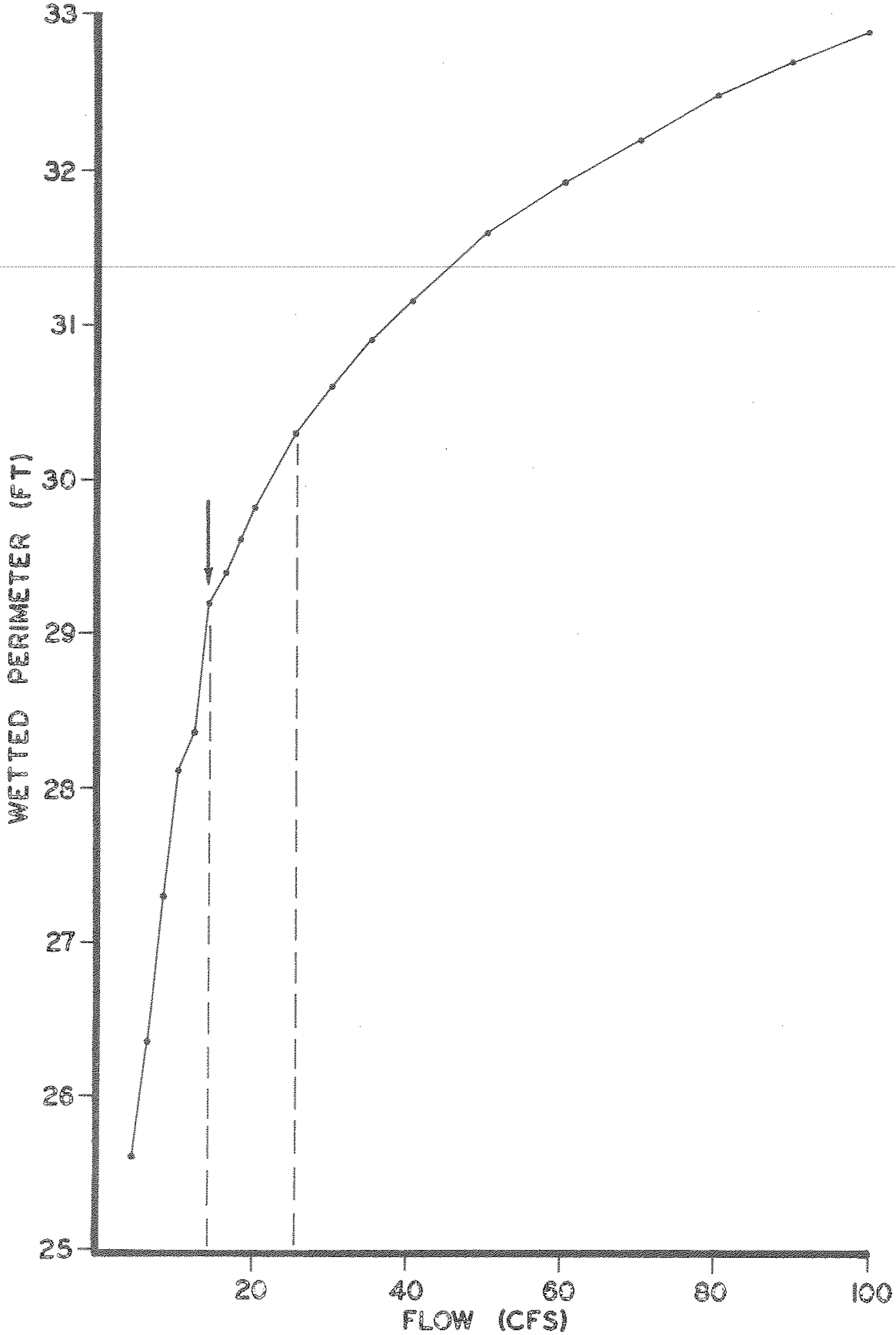


Figure 28. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Trail Creek.

Table 46 continued. Instream flow recommendations derived for Trail Creek using the wetted perimeter/inflection method (low flow period) compared to the mean flows of record.

a/ Derived for the July 1948 to October 1953 and October 1966 to July 1972 period of record for the USGS gauge at stream mile 4.9 (T2S, R17W, Sec. 16C).

b/ Recommendations for the high flow period (May 1 - June 30) are presently unavailable due to the lack of long-term flow records for Trail Creek.

The flow recommendations for the low flow period (July 1 - April 30) are compared to the mean monthly flow of record for the USGS gauge at stream mile 4.9 in Table 46. The flow recommendations exceed the mean flows for the months of January and February.

1. STREAM

Trapper Creek

2. DESCRIPTION

Trapper Creek originates on the eastern slope of the Pioneer Mountains of southwest Montana. It flows in an easterly direction for about 18 miles before entering the Big Hole River at Melrose, Montana. The drainage is characterized by a narrow canyon with steeply timbered slopes and limestone cliffs. The 45 square mile drainage is controlled by the USFS (63%), private individuals (18%), the BLM (17%) and the State of Montana (2%). There are numerous unnamed intermittent tributaries throughout the drainage. Named tributaries include Sucker, Twomile Gulch, Lockridge Canyon and Sappington Creeks. The 10 ft wide, cascading channel has an average gradient of 34 ft/1,000 ft.

Lands within the Trapper Creek drainage are used for recreation in the form of hunting, fishing and hiking, cattle grazing, timber harvesting and hay production in its lower reaches. An improved gravel road parallels the stream for its entire length, allowing access to the numerous high mountain lakes in the area.

Historically, the mining and smelting of metals was the major activity in the upper Trapper Creek drainage. Numerous settlements, housing up to 2,000 people, existed in the upper drainage (Geach, 1972). The Hecla Mining District has produced ores containing mostly silver and lead with some copper, zinc and gold valued at $20 million (Geach, 1972). The Glendale Mill site, located halfway down the drainage, was constructed in 1874 for the smelting of lead. Approximately 2,000 ft of stream was altered as a result of mining activity (Wipperman, 1969). The stream presently flows through old tailing piles and unreclaimed mining areas with possible toxic metals being leached into the stream in the headwaters. Considerable aquatic habitat destruction within the mining area has occurred. The lower stretches of Trapper Creek are diverted for the irrigation of haylands during the summer months. Grazing within the riparian zone has caused bank erosion and the loss of soil stabilizing vegetative cover along portions of the stream. Noticeable mass wasting has occurred on some outside meanders in Trapper Creek, possibly as a result of road encroachment.

3. FISH POPULATIONS

A 1,000 ft section of Trapper Creek located 0.25 miles above the USFS boundary was electrofished on August 4 and 28, 1980. Gamefish present in descending order of abundance were brook trout, cutthroat x rainbow trout hybrids, rainbow trout, cutthroat trout and brown trout. The mottled sculpin was the only nongame species captured (Table 47).

Table 47. Summary of electrofishing survey data collected for a 1,000 ft section of Trapper Creek (T2S, R10W, Sec. 22D) on August 4 and 28, 1980.

Species	No. Captured	Length Range (inches)
Brook Trout	156	2.6- 8.8
Cutthroat x Rainbow Hybrids	10	4.0- 9.8
Rainbow Trout	7	2.6- 9.3
Cutthroat Trout	5	7.0-11.9
Brown Trout	2	6.9- 7.7
Mottled Sculpin	-	-

The standing crop of brook trout, the predominant trout species in the section, was estimated using a mark-recapture method (Table 48). This 1,000 ft section supports about 153 brook trout, weighing 12 pounds. When compared to other streams draining the Pioneer Mountains, Trapper Creek is the only stream where the rainbow trout does not comprise a significant portion of the trout population. Although fish conditions was above average, growth is extremely slow with age III+ and older trout averaging 6.7 inches in length.

Table 48 . Estimated standing crop of brook trout in a 1,000 ft section of Trapper Creek (T2S, R10W, Sec. 22D) on August 4, 1980. Eighty percent confidence intervals are in parentheses.

		Per 1,000 Ft	
Species	Length Group (inches)	Number	Pounds
Brook Trout	4.0-5.9	121	
	6.0-8.8	32	
		153 (±27)	12 (±2)

Haugen (1975) electrofished two sections of Trapper Creek, totalling 435 ft in length,in 1974. The brook trout was the only species captured in the lower section near the USFS boundary. Thirty brook trout, ranging in length from 3.5-9.3 inches, were captured. In the upper section, the cutthroat trout was the only species present. Fourteen cutthroat, measuring 3.5-9.5 inches in length, were captured. Haugen felt that the abatement of mine pollution in the headwater area was necessary to improve the fishery of Trapper Creek.

4. FLOW RECOMMENDATIONS

A 67.3 ft subreach located just above the USFS boundary (T2S, R10W, Sec. 22C) was selected for the collection of cross-sectional data. The meandering riffle-pool habitat within this subreach was described using five cross-sections. The WETP program was calibrated to field data collected at flows of 4.8, 18.8 and 24.7 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is illustrated in Figure 29. Lower and upper inflection points occur at 3 and 6 cfs, respectively. Based on an evaluation of existing fishery and other resource information, a flow of 4.0 cfs is recommended for the low flow period (July 16 - May 15). Due to the lack of long-term flow data, recommendations for the high flow period (May 16 - July 15) cannot be derived for Trapper Creek.

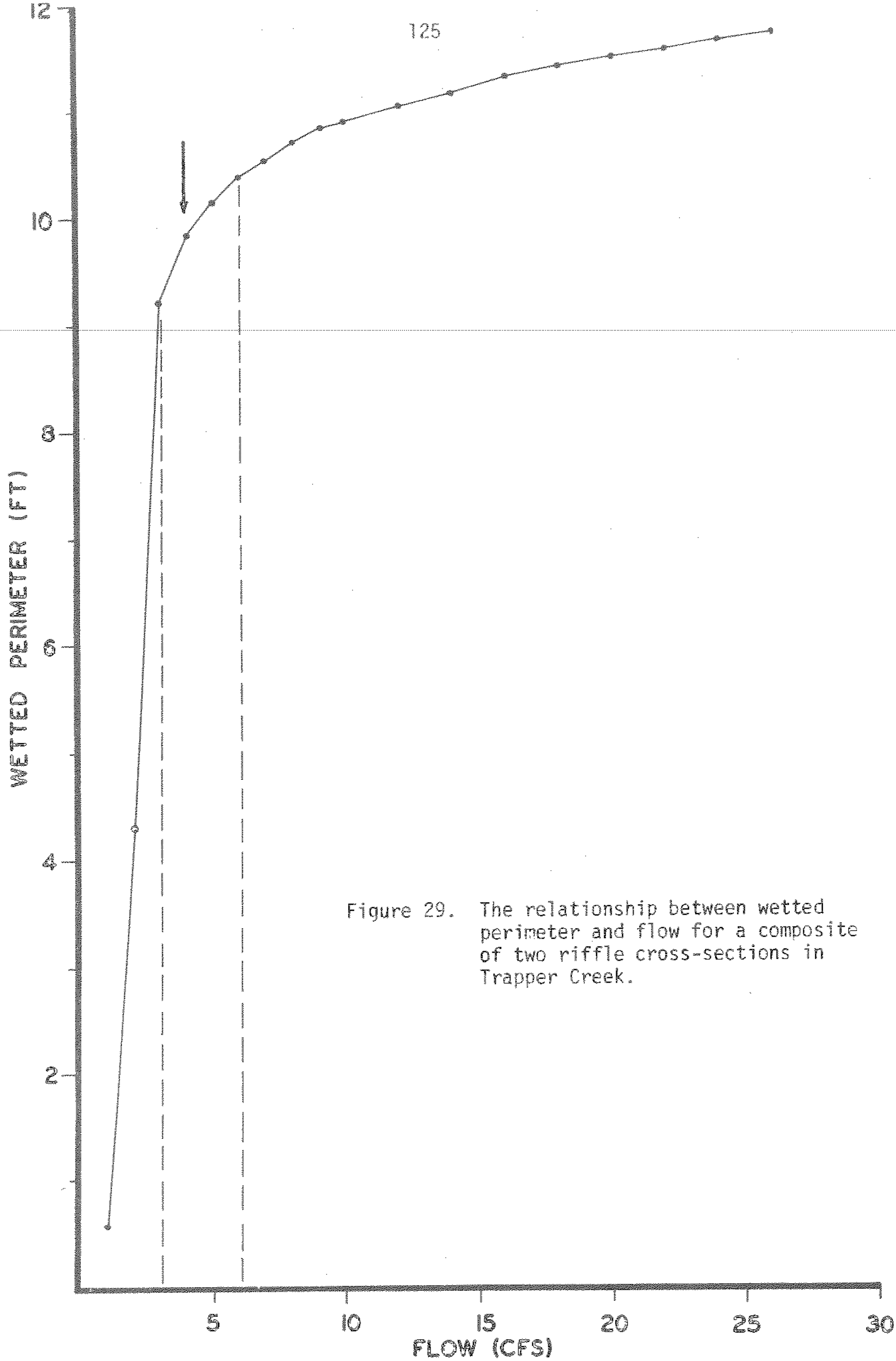


Figure 29. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Trapper Creek.

1. STREAM

Warm Springs Creek

2. DESCRIPTION

The West and East Forks of Warm Springs Creek originate in wet meadows located on the western slope of the Pioneer Mountains of southwest Montana. Upon converging, Warm Springs Creek flows in a southwesterly direction for about 20 miles before entering the Big Hole River at Jackson, Montana. The stream is characterized by a densely willowed riparian zone containing numerous beaver dams. The stream drains grassland/sagebrush hillsides, scattered with stands of aspen and conifers. The average gradient of the 25 ft wide channel is moderate at 12 ft/1,000 ft. Major tributaries to Warm Springs Creek include Bear, Cox, Old Tim and Little Milk Creeks. The 95 square mile drainage is controlled by the USFS (87%), private individuals (12%) and the BLM (1%).

Land uses in the Warm Springs drainage are varied. Uses include recreation, cattle grazing, hay production, timber harvesting and limited amounts of mining and mineral exploration. Recreational activities consist of hunting, fishing, hiking and camping. Unimproved roads and trails border the entire stream, allowing access to the numerous alpine lakes, meadows and rugged peaks of the upper drainage. Presently, the upper roadless portion of the drainage is being considered for inclusion into the National Wilderness System. The harvesting of salvage timber, the extensive development of molybenum and other mineral resources and road construction are being proposed for the roadless portion of the drainage (USFS, 1980).

Fishing pressure on Warm Springs Creek during May, 1975 through April, 1976 was estimated by mail survey at 1,146 person-days (MDFG, 1976). This is approximately 57 person-days/stream mile/year. Warm Springs Creek is one of the more heavily used recreational fisheries in the Big Hole drainage. Angler logs show that catches consist entirely of brook trout, averaging 10.4 inches in length (MDFWP, 1980b). The hunting of mule deer and elk is also popular in the drainage.

Agricultural uses within the drainage consist of cattle grazing on public and private lands and hay production along the lower reaches. There are presently three cattle allotments on USFS lands totaling 1,096 head (USFS, unpublished data). Stretches of the riparian zone have been severely impacted by cattle. Diversion of the lower reaches for irrigation leaves the natural channel severely dewatered during the summer months. The town of Jackson disposes its raw sewage in the channel.

The SCS (Farnes and Schafer, 1975) estimates the mean annual water yield for the Warm Springs drainage at 58,400 acre-feet (80.7 cfs).

3. FISH POPULATIONS

A 1,000 ft section was electrofished on July 25 and August 8, 1979. Brook trout and burbot were the only game species present. Nongame species include longnose sucker, longnose dace and mottled sculpin. The electrofishing survey data are summarized in Table 49 .

Table 49. Summary of electrofishing survey data collected for a 1,000 ft section of Warm Springs Creek (T5S, R14W, Sec. 16C) on July 25 and August 8, 1979.

Species	No. Captured	Length Group (inches)
Brook Trout	90	2.2-11.2
Burbot	10	8.0-11.3
Longnose Sucker	2	7.4- 8.0
Mottled Sculpin	-	-
Longnose Dace	-	-

The standing crop of brook trout in the section was estimated using a mark-recapture method (Table 50). This 1,000 ft section supports an estimated 256 brook trout, weighing 43 pounds. Although the majority of the population exceeds seven inches, their condition (length to weight ratio) was below average for tributaries of the Big Hole River.

Table 50 . Estimated standing crop of brook trout in a 1,000 ft section of Warm Springs Creek (T5S, R14W, Sec. 16C) on July 25, 1979. Eighty percent confidence intervals are in parentheses.

		Per 1,000 Ft	
Species	Length Group (inches)	Number	Pounds
Brook Trout	4.0- 5.9	108	
	6.0- 9.9	128	
	10.0-11.2	20	
		256 ($\pm$139)	43 ($\pm$23)

Wipperman and Needham (1965) electrofished two 300 ft sections of Warm Springs Creek in 1964. Both sections were located on the lower reaches of the stream. The section near the town of Jackson was downstream of the majority of the irrigation diversions. Thirty-five brook trout, ranging in length from 2.5-11.2 inches, were captured. Fifty-three brook trout, ranging in length from 2.6-9.2 inches, were captured in the upper section. Other species captured were burbot, longnose sucker, longnose dace and mottled sculpin. These sections were electrofished again in August, 1966 (Wipperman, 1967a). In addition to brook trout, three rainbow trout were captured in the lower section.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 177 ft riffle-pool sequence of Warm Springs Creek located in T5S, R14W, Sec. 16C. Five cross sections were placed within the subreach. The WETP program was calibrated to field data collected at flows of 14.8 and 86.9 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is illustrated in Figure 30 . Lower and upper inflection points occur at 8 and 18 cfs, respectively. Based on an evaluation of existing fisheries, recreational use and other resource information, a flow of 14 cfs is recommended for the low flow period (July 16-May 15). A recommendation for the high flow period (May 16-July 15) cannot be derived due to the lack of long-term flow data for Warm Springs Creek.

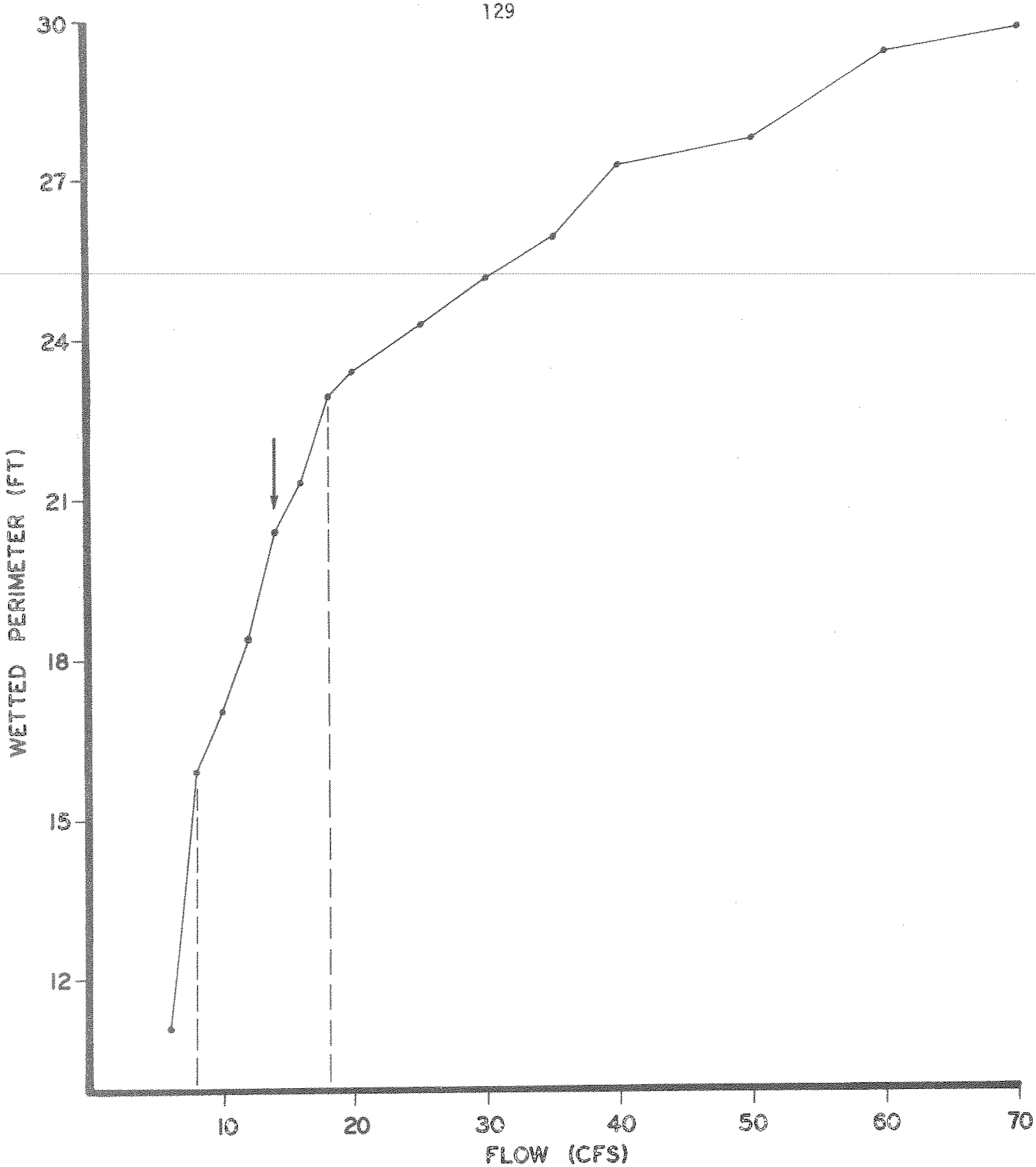


Figure 30. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Warm Springs Creek.

1. STREAM

Willow Creek

2. DESCRIPTION

Willow Creek originates at Tendoy Lake, a small alpine lake on the eastern slope of the Pioneer Mountains. It flows in an easterly direction for 22.5 miles before entering the Big Hole River approximately 4 miles south of Glen, Montana. The Willow Creek drainage is characterized by a fan shaped upper basin with numerous alpine lakes and tributaries. It narrows into a limestone canyon and changes to a meandering, willow and cottonwood lined stream for its lower 4 miles. The drainage consists of lodgepole pine timbered slopes and grassland/sagebrush hillsides. Much of the lower basin has been converted to irrigated hay and grain fields. Major tributaries include Gorge, Buckhorn, Dubois, Bond and North Creeks. Land ownership of the 59 square mile drainage is shared between the USFS (80%), the BLM (10%), private individuals (8%) and the State of Montana (2%). The 20 ft wide channel has a fairly steep gradient of 37 ft per 1,000 ft.

A USGS gauging station at stream mile 10.7 of Willow Creek was operated from August, 1962 through September, 1966. During the 4-year period of record, the mean annual flow was 20.6 cfs. The minimum and maximum flows were 3 and 310 cfs, respectively.

Lands within the Willow Creek drainage are used for recreation, cattle grazing and hay and grass production in the lower reaches. Gravel roads parallel and cross the stream for its entire length, providing access throughout the drainage. An extensive trail system leading to numerous alpine lakes exists in the headwater area. Hunting for mule deer and fishing are also popular in the Willow Creek drainage.

Cattle grazing occurs on private as well as the public lands within the drainage. A cow camp, now abandoned, was located on USFS land. Hay and grains are grown in the lower drainage. A system of dams and ditches are located on Bond and Deerhead Lakes in the Willow Creek drainage. A ditch diverts these waters into Birch Creek, the adjacent drainage to the south, to be used for irrigation. Ditch failures in this system have caused considerable scouring and vertical bank development in the Willow Creek drainage. Numerous ditches on the lower stream further divert water from the channel, causing severe dewatering during the summer months. Extensive damage to portions of the lower channel has occurred as a result of overgrazing in the riparian zone.

3. FISH POPULATIONS

A 1,000 ft section of Willow Creek was electrofished on August 1 and 25, 1980. Game fish present were rainbow trout, brook trout and possible rainbow x cutthroat hybrids. The mottled sculpin was the only nongame species present (Table 51).

Table 51. Summary of electrofishing survey data collected for a 1,000 ft section of Willow Creek (T4S, R10W, Sec. 34A) on August 1 and 25, 1980.

Species	No. Captured	Length Range (inches)
Rainbow Trout and Rainbow x Cutthroat Hybrids	96	3.0-12.5
Brook Trout	83	3.7-10.6
Mottled Sculpin	-	-

The standing crop of trout in the section was estimated using a mark-recapture method (Table 52). This 1,000 ft section supports about 238 trout, weighing 33 pounds. Brook trout accounted for 65% of the trout numbers and 52% of the biomass. Although the condition (length to weight ratio) of rainbow trout was greater than brook trout, the condition of both species was above average for streams surveyed in the Beaverhead N.F.. Rainbow trout averaged five fish per pound versus nine per pound for brook trout. Large pools and excellent instream and overhanging cover contribute to the healthy fishery of this section of stream.

Table 52. Estimated standing crop of trout in a 1,000 ft section of Willow Creek (T4S, R10W, Sec. 34A) on August 1, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Brook Trout	3.7- 5.9	85	
	6.0- 9.9	68	
	10.0-10.6	1	
		154 (±47)	17 (±4)
Rainbow Trout and Rainbow x Cutthroat Hybrids	5.0- 5.9	26	
	6.0- 9.9	52	
	10.0-12.5	6	
		84 (±21)	16 (±4)
Total Trout		238 (±52)	33 (±6)

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 68 ft subreach located 0.5 mile above the USGS gauge station (T4S, R10W, Sec. 34B). Five cross-sections describing the riffle-pool habitat were placed within the sub-reach. The WETP program was calibrated to field data collected at flows of 9.3, 43.8 and 59.2 cfs.

The relationship between wetted perimeter and flow for composite of two riffle cross-sections is illustrated in Figure 31 . Lower and upper inflection points occur at 8 and 13 cfs, respectively. Based on an evaluation of existing fishery, water availability and other resource information, a flow of 10 cfs is recommended for the low flow period (July 16 - May 15). Due to the lack of long-term flow records, recommendations for the high flow period (May 16 - July 15) cannot be derived for Willow Creek.

The low flow recommendations are compared to the monthly mean flows of record for the USGS gauge at stream mile 10.7 in Table 53 . The recommendations exceed the mean flows for the months of November through April.

Table 53 . Flow recommendations derived for Willow Creek using the wetted perimeter/inflection point method (low flow period) compared to the mean flows of record.

	Flow Recommendations (cfs)	Mean Flows (cfs)a/
January	10	7.1
February	10	8.0
March	10	6.9
April	10	9.3
May 1-15	10	32.4
May 16-31	b/	
June 1-15	b/	80.6
June 16-30	b/	
July 1-15	b/	43.3
July 16-31	10	
August	10	17.6
September	10	13.1
October	10	11.4
November	10	8.6
December	10	7.6

a/ Derived for the August, 1962 through September, 1966 period of record for the USGS gauge at stream mile 10.7 (T4S, R10W, Sec. 34).

b/ Recommendations for the high flow period (May 16 - July 15) are presently unavailable due to the lack of long-term flow records for Willow Creek.

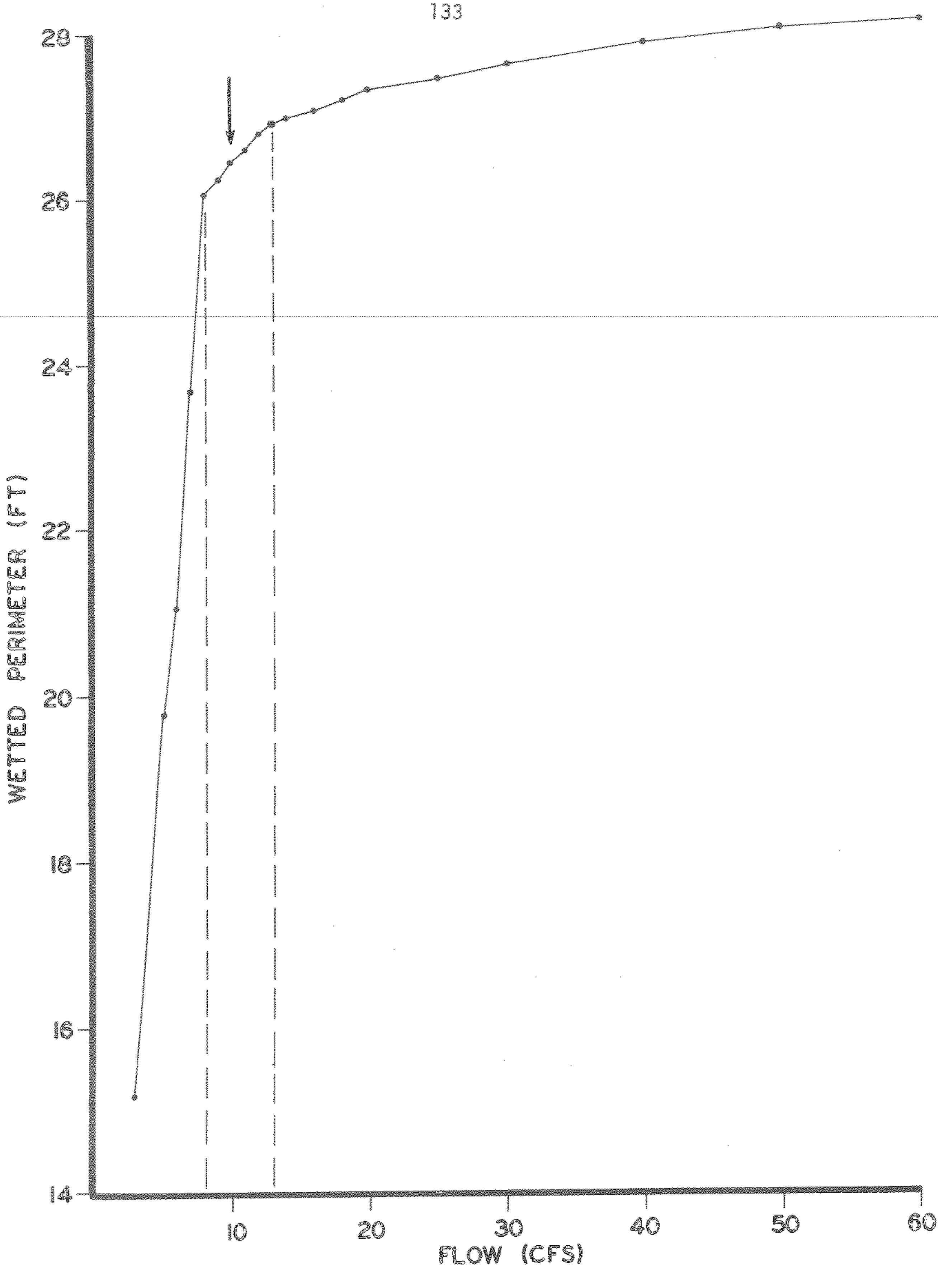


Figure 31. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Willow Creek.

1. STREAM

Wise River

2. DESCRIPTION

Wise River originates in the Pioneer Mountains of southwest Montana. The river flows for approximately 30 miles in a northerly direction before entering the Big Hole River at the town of Wise River. The drainage is characterized by steep, timbered and talus slopes in its headwaters. In the upper reaches, the river meanders through a densely willowed channel with numerous beaver ponds. It slowly loses its sinuosity and increases its gradient in the middle sections and again changes to a more open character in its lower reaches. The channel widens from 20 to 60 ft as distance from its headwaters increases. The gradient averages 8 ft/1,000 ft. Ninety-five percent of the 251 square mile drainage is owned by the USFS, private individuals own 4% and the BLM controls the remaining 1%. Major tributaries of the 50+ streams that drain into the Wise River include Pattengail, Elkhorn, Wyman, Jacobson and Lacy Creeks.

The USGS gauging station at stream mile 9.1 of the Wise River has been operated since 1972. The mean annual flow for the period of record is 187 cfs. The flows ranged from 13 cfs in November, 1976 to 2,730 cfs in June, 1974.

The Wise River drainage is presently administered under the USFS Multiple Use Management Plan. Lands within the drainage are used for recreation, cattle grazing, mining, wildlife management and timber harvest. Recreational activities include fishing, hunting, hiking and camping. A graveled and paved road parallels and crosses the river for its entire length, allowing access throughout the drainage. Five USFS campgrounds are located within the basin and opportunities for more primitive recreation are provided by an extensive trail system. The roadless portion of the drainage is presently under consideration for inclusion into the National Wilderness System.

Fishing pressure on Wise River during May, 1975 through April, 1976 was estimated by mail survey at 3,343 person-days (MDFG, 1976). This amounts to approximately 111 person-days/stream mile/year, the highest recreational use measured for any tributary to the Big Hole River. Information gathered from angler logs shows that the catch is comprised of brook trout (97%) and rainbow trout (3%), both averaging 7.5 inches in length (MDFWP, 1980b). Mule deer, elk and moose are hunted in the drainage during the fall season.

Extensive exploration and mining for silver and other metals has occurred throughout the Elkhorn Creek drainage, a headwater tributary to Wise River. In the early 1900's, a 750 ton treatment mill, two levels of extensive mine shafts and the town of Coolidge were located along Elkhorn Creek. A narrow gauge railroad was constructed between the mill and the town of Wise River to ship ore. It was soon discovered that there was insufficient vein development toprovide even a fraction of the daily mill requirement (Geach, 1972). The mines were eventually closed in the 1940's and reworked in the early 1960's. Three companies are presently exploring and salvaging for silver in the area (USFS, unpublished data).

Old tailings along Elkhorn Creek have leached heavy metals and acid effluents into the stream, creating an aquatic desert below the mines. Cutthroat trout have been collected above the mining area. No fish have been found in the 3.5 miles below the mine development along Elkhorn Creek (Wipperman, 1969 and Haugen, 1975). These effluents are believed to be depressing the aquatic resource of the Wise River as well (MDFWP, unpublished data). Concentrations of dissolved copper and zinc found in Wise River water samples exceed acceptable levels for fish and other aquatic life (USFS, unpublished data and Wentz, 1974). Zinc and copper in the sediments from Elkhorn Creek are also deposited throughout the river, possibly affecting fish food production and trout egg survival (Montana Bureau of Mines and Geology, unpublished data).

The lower 5 miles of the Wise River are privately owned. Lands surrounding the stream are used for hay production. Water from the Wise River is diverted to irrigate these fields. Consequently, severe de-watering occurs in the lower stretches. The lower channel is reported to be completely dry one out of every three years (USFS, unpublished data).

A storage dam on Pattengail Creek, a major tributary of Wise River, failed in 1927. Damage to the river in the form of scouring and channel relocations is still evident today.

The 1977 Montana Legislature requested the Department of Natural Resources and Conservation to study the feasibility of constructing an offstream storage reservoir on a tributary to the Big Hole River (DNRC, 1979). The reservoir is to be used for irrigation, the augmentation of instream flows to the Big Hole and Jefferson Rivers, and flood control. A site on the Wise River was initially considered, but later eliminated because critical moose habitat and portions of the proposed East Pioneer Wilderness Area would be inundated. A site within the Wise River drainage on Pattengail Creek was recommended (DNRC, 1981). If constructed, water stored in the reservoir would augment instream flows in the Wise River as well.

3. FISH POPULATIONS

A 4,200 ft section of the Wise River below the mouth of Lacy Creek was electrofished on August 5 and 26, 1980. Game fish present in descending order of abundance were brook trout, burbot, mountain whitefish and rainbow trout. Longnose sucker, longnose dace and mottled sculpin were the nongame species captured (Table 54).

Table 54 . Summary of electrofishing survey data collected for a 4,200 ft section of Wise River (T3S, R12N, Sec. 4C) on August 5 and 26, 1980.

Species	No. Captured	Length Range (inches)
Brook Trout	69	4.9-10.8
Burbot	37	5.5-12.0
Mountain Whitefish	25	4.5-13.7
Rainbow Trout	11	4.3-13.0
Longnose Sucker	-	-

Table 54 continued. Summary of electrofishing survey data collected for a 4,200 ft section of Wise River (T3S, R12W, Sec. 4) on August 5 and 26, 1980.

Species	No. Captured	Length Range (inches)
Longnose Dace	-	-
Mottled Sculpin	-	-

The standing crop of brook trout in the section was estimated using a mark-recapture method (Table 55). This section supports about 54 brook trout, weighing 10 pounds, per 1,000 ft of stream. The population is extremely low for a stream this size. Fish condition was above average with approximately five trout per pound.

The section electrofished is 3 miles below the confluence of Elkhorn Creek. Elevated metal levels in the sediment and water may be related to the low fish populations found in this section.

Table 55. Estimated standing crop of brook trout in a 4,200 ft section of Wise River (T3S, T12W, Sec. 4) on August 5, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Brook Trout	5.0- 5.9	13	
	6.0- 9.9	36	
	10.0-10.8	5	
		54 ($\pm$24)	10 ($\pm$5)

Results of past and more recent electrofishing surveys indicate that fish populations throughout the entire length of the Wise River are depressed. This could be a result of numerous factors, including metals pollution from Elkhorn Creek, habitat losses and channel alterations resulting from the dam failure and the dewatering of the lower 5 miles of river.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 131 ft subreach located directly below the USGS gauging station (T1S, R12W, Sec. 36C). Five cross-sections describing the riffle-pool habitat were placed within the subreach. The WETP program was calibrated to field data collected at flows of 43.0, 66.1 and 418.5 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is illustrated in Figure 32 . Lower and upper inflection points occur at 45 and 60 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 45 cfs is recommended for the low flow period (July 1 - April 30). Recommendations for the high flow period (May 1 - June 30) cannot be derived due to the lack of long-term flow data for the Wise River.

The low flow recommendations are compared to the mean monthly flows of record at the USGS gauge at stream mile 9.1 in Table 56 . The recommendations exceed the mean flows for the months of January through March.

Table 56 . Instream flow recommendations derived for the Wise River using the wetted perimeter/inflection point method (low flow period) compared to the mean flows of record.

	Flow Recommendations (cfs)	Mean Flows (cfs) a/
Jan	45	43.9
Feb	45	40.6
Mar	45	40.9
Apr	45	84.9
May	b/	489.0
Jun	b/	886.0
Jul	45	291.0
Aug	45	102.8
Sep	45	82.5
Oct	45	72.2
Nov	45	57.2
Dec	45	49.4

a/ Derived for the October, 1972 through September, 1979 period of record for the USGS gauge at stream mile 9.1 (T1S, R12W, Sec. 36).

b/ Recommendations for the high flow period (May 1 - June 30) are presently unavailable due to the lack of long-term flow data for the Wise River.

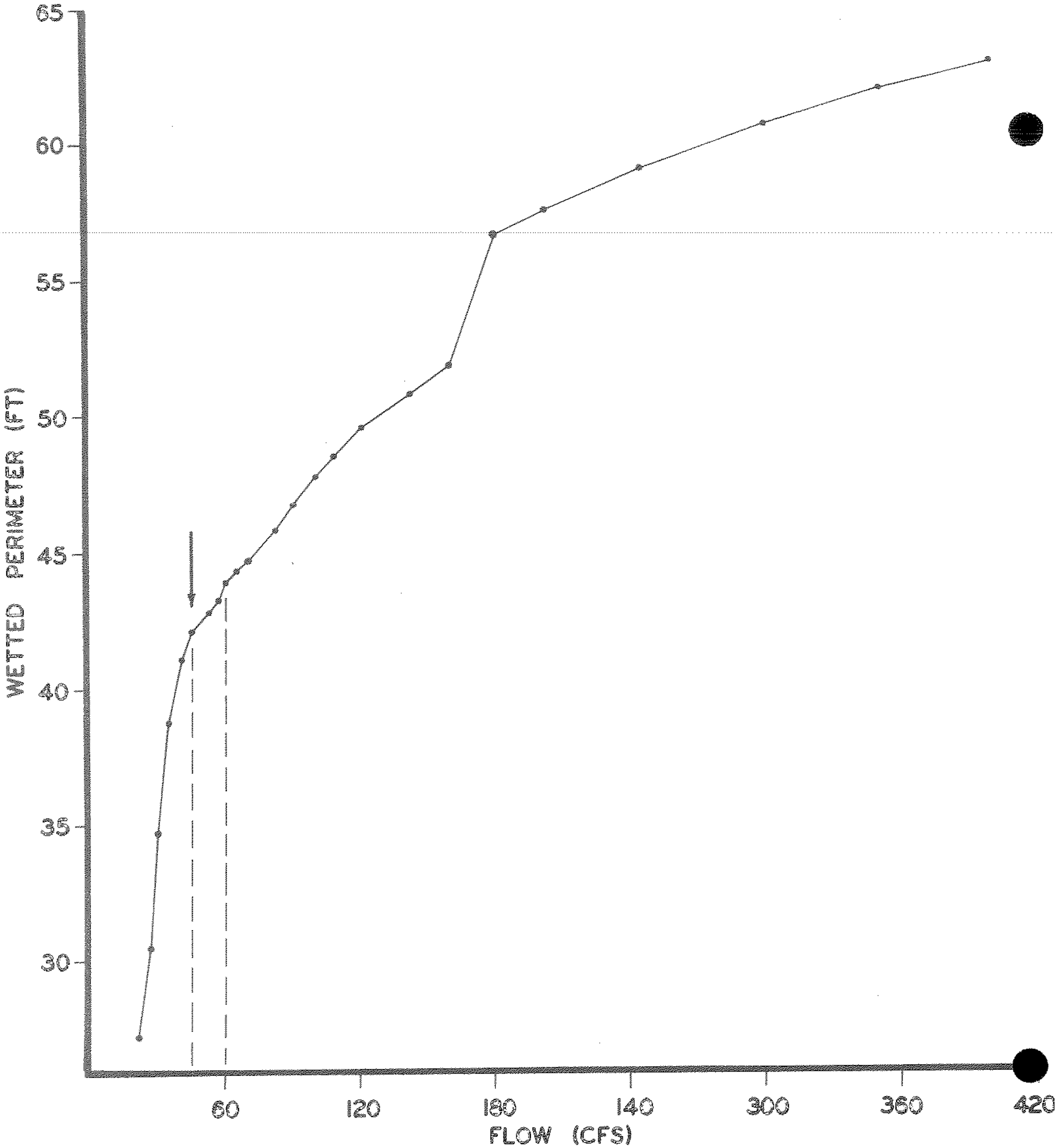


Figure 32. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Wise River.

FLATHEAD RIVER DRAINAGE

1. RIVER

Middle Fork of the Flathead River (from the mouth of Bear Creek in T29N, R15W, Sec. 31 upstream to the mouth of Cox Creek in T27N, R21W, Sec. 38).

2. DESCRIPTION

Stream length

Total length of Middle Fork: 91 miles
Bear Creek to Cox Creek: 33.4 miles
Bear Creek to headwaters: 45.6 miles

Drainage area

Total Middle Fork: 1,128 square miles
Bear Creek to headwaters: 489 square miles

Gradient

Total Middle Fork: 24.4 ft/mile (0.5%)
Bear Creek to headwaters: 32.2 ft/mile (0.6%)

Origin

Middle Fork of the Flathead River originates at the confluence of Bowl and Strawberry Creeks in the Bob Marshall Wilderness Area. The Lewis and Clark Range of the Rocky Mountains, which forms the Continental Divide along the east side of the upper Middle Fork, and the Flathead Range on the west are generally 6,982 to 7,979 feet high.

Flows

A U.S.G.S. gauge located near Essex, Montana, 5.6 miles downstream from Bear Creek,was operated from 1939 to 1953 and 1956 to 1960. A duration hydrograph is available for nine years between water years 1945 and 1953. The maximum discharge was 14,500 cfs (flood estimated at 18,000 cfs) and the minimum was 30 cfs. The mean flow for the period was 1,064 cfs (770,300 acre feet per year).

Recreational usage

This section of the Middle Fork has been classified as a Wild River under the National Wild and Scenic Rivers Act of 1976. It drains the Bob Marshall and Great Bear Wilderness Areas. This section of the Middle Fork is popular for white water rafting in the spring and early summer. Floating becomes marginal by late July as runoff subsides. Forest Service estimates of floating use in 1979 were 125-150 floaters between Schafer Meadows and Bear Creek and 8,000 from Bear Creek downstream.

A creel census in 1975 estimated total fishing pressure in the Middle Fork at 7,372 man-days, or about 81 man-days/river mile/

year. The estimated harvest of fish during the summer period was 6,656. The two most important species were cutthroat (67% of the catch) and bull trout (11% of the catch). The bull trout provides a trophy fishery, as the minimum size limit is 18 inches. An estimated 751 bull trout were creeled by anglers in 1975. The catch in 1975 included 4,454 cutthroat trout and 649 whitefish.

Potential environmental problems

There is a high-head dam site at Spruce Park 5.6 miles upstream from Bear Creek. The classification of the river under the National Wild and Scenic River Act should preclude construction of the dam at this time. No known dewatering threats exist.

Water quality

The Middle Fork has an A-1 classification under the State Water Quality Standards. Waters classified A-1 are suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities. Water quality must be suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

3. FISH POPULATIONS

Fish populations in the Flathead River system are difficult to quantify because of their complex movement patterns both spatially and temporally. Life history information and description of the methods used to quantify fish use are contained in a previous section.

Fish density was estimated in two 6.2 mile (10 km) sections of river using an underwater fish census. Densities varied somewhat on different counting days, but densities were relatively large for cutthroat trout and mountain whitefish (Table 57). Larger juvenile and adult bull trout were also observed throughout this reach of river. Juvenile bull trout are difficult to observe because of their habit of lying on the stream bottom.

Adult bull trout use the river as a spawning migration corridor from July through October. They rest in the pools and below riffles, feeding along shallow bars at night.

A survey of bull trout spawning areas in tributary streams draining into this reach of river was completed in October 1980, following the spawning season. A total of 262 spawning sites (redds), representing 86 percent of the total spawning in the drainage, were located upstream from Bear Creek.

Portions of the cutthroat trout and mountain whitefish populations reside in the river year-round. Migrant adult cutthroat trout from Flathead Lake enter the river in the spring and return to the lake by early summer (April - June). Juvenile cutthroat and bull

Table 57. Estimates of number of cutthroat trout, bull trout and mountain whitefish in 6.2 mile sections of the Middle Fork of the Flathead River above and below Schafer Meadows. Estimates are based on snorkel runs made in late summer.

	Number of fish per 6.2 miles								
	Cutthroat trout			Bull trout				Mountain whitefish	
Area	Age I	Age II	Age III+	Age I	Age II	Age III+	Mature	<150mm	>150mm
Above Schafer Meadows	1.61	6.59	107	9.8	4.66	.96	6.75	115.8	941.4
Below Schafer Meadows	4.5	0.16	64.53	<0.16	8.85	<0.16	9.3	35	1709

trout migrate downstream to the lake during the high water period and throughout July.

4. FLOW RECOMMENDATIONS

Four cross-sections were established in a series of riffle-run areas from river mile 44.4 to 46.9. The cross-sections are in T28N, R16W, Sec. 31-D, T29N, R15W, Sec. 31-D, T28N, R16W, Sec. 1-C, and T28N, R16W, Sec. 12-C. The WETP program was calibrated to field data collected at flows of 193, 1460, and 3624 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is presented in Figure 33. The single inflection point occurs at a flow of approximately 350 cfs. Based on an evaluation of existing fishery, recreational use and water availability information, a flow of 350 cfs is recommended for the low flow period from August through mid-April.

Monthly flow recommendations for both the low and high flow periods are listed in Table 58. The approximate median monthly flows of record for the U.S.G.S. gauge at Essex are listed for comparison. No diversion of water is known to occur that would presently affect these flows.

The flow recommendations exceed the median flows of record from August through March. It is, therefore, recommended that all of the existing flow in the Middle Fork of the Flathead River upstream from Essex be maintained instream for fish, wildlife and recreational purposes during that period.

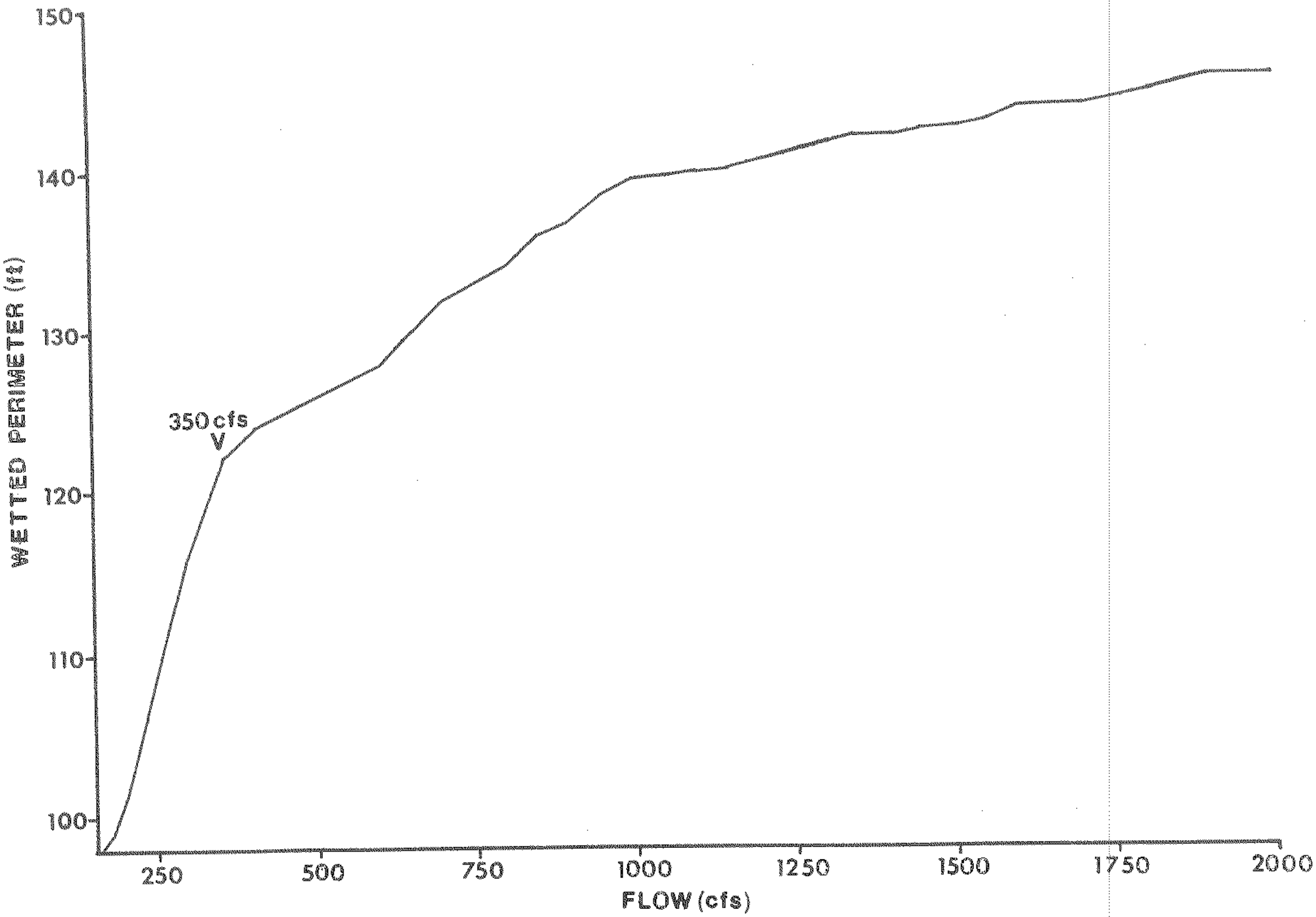


Figure 33 . Wetted perimeter for a riffle-run transect (#1) on the Middle Fork of the Flathead River upstream from Bear Creek.

Table 58. Instream flow recommendations derived for the Middle Fork of the Flathead River upstream from Bear Creek using the wetted perimeter/inflection point method (low flow period) and the dominant discharge/channel morphology concept (high flow period) compared to the median flows of record.

	Recommended flows (cfs)	Approximate median flows (cfs)[a]
January	350	243
February	350	213
March	350	220
April 1-15	350	553
April 16-30	785	2188
May 1-15	2230	3975
May 16-31	3964	5174
June 1-15	2968	4087
June 16-30	1602	2619
July 1-15	881	1122
July 16-31	484	567
August	350	324
September	350	221
October	350	233
November	350	441
December	350	257

a. Derived for a 9-year period of record (1945-1953) for the U.S.G.S. gauge station near Essex, Montana

1. RIVER

North Fork of Flathead River (from mouth of Bowman Creek in T35N, R21W, Sec. 22 to the Canadian border).

2. DESCRIPTION

Stream length

Total length of North Fork: 58.3 miles
Mouth of Bowman Creek to Canadian border: 24.8 miles

Drainage area

Total North Fork: 1548 square miles
Upstream from the Canadian border: 427 square miles

Gradient

Total North Fork: 12.4 ft/mile (0.15%)
Headwaters to border: 23.7 ft/mile (0.45%)
Border to Bowman Creek: 15.7 ft/mile (0.29%)
Bowman Creek to mouth of Middle Fork: 12.4 ft/mile (0.23%)

Origin

North Fork of the Flathead River is named the Flathead River in Canada and downstream from its confluence with the Middle Fork. The river originates in the Rocky Mountains of British Columbia. Twenty-eight percent of the drainage lies in Canada and contributes 32 percent of the mean annual discharge of the North Fork. The U.S. portion of the river drains the Whitefish Range to the west and the Livingston Range in Glacier Park to the east.

Flows

No records are available for the North Fork of the Flathead River near the mouth of Bowman Creek. However, there is a U.S.G.S. gauge at the upstream end of this section, 45 feet north of the international boundary near Flathead, British Columbia at river mile 216.6. Average discharge for a 28 year period of record (1951-79) is 959 cfs, with a maximum of 16,300 cfs and minimum of 62 cfs. This gauge is 24.8 miles upstream from the mouth of Bowman Creek. There is another U.S.G.S. gauge 29.7 miles downstream at river mile 162.1 referred to as North Fork Flathead River near Columbia Falls, Montana (T32N, R20W, Sec. 35). The average discharge for a 48 year period of record was 2,990 cfs with a maximum of 69,100 cfs and a minimum of 198 cfs.

Water quality

The North Fork has an A-1 water quality classification from the state Water Quality Standards. Waters classified A-1 are suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities. Water quality must be suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

Recreational usage

This section of river is classified as Scenic under the National Wild and Scenic Rivers Act. The river is classified Scenic from the U.S. - Canadian border downstream to Camas Creek bridge, and Recreational from Camas Creek bridge to the mouth of the Middle Fork. The river supports a good fishery for cutthroat and bull trout. A census of the summer fishery in 1975 estimated fishing pressure at 8,933 man-days or 153 man-days/river mile. A total of 20,766 fish were harvested. Cutthroat trout comprised 86 percent of the catch and trophy bull trout (>18 inches) six percent. The estimated catch of trophy bull trout in 1975 was 1,233 fish.

The river is popular for rafting and canoeing because it is a relatively easy float with spectacular scenery. Glacier Park forms the east boundary of the river. The upper North Fork contains critical habitat for two endangered species, the grizzly bear and the Rocky Mountain wolf. Estimates of use by floaters on the river in 1979 and 1980 were 2,000 and 3,000 people, respectively. Outfitters guided 220-270 people per year from 1978-1980.

Existing and potential environmental problems

Two potential high-head hydroelectric sites are located in the lower North Fork. The Smoky Range site is eight miles upstream from the mouth of the river. Increased large scale logging of pine-beetle infested lodgepole timber in the U.S. and Canada could increase the spring water yield, causing a widening of the stream channel and a reduced stream flow during the summer and fall. This would reduce the suitability of the river for floating and impact the fishery.

3. FISH POPULATIONS

Fish populations in the Flathead River system are difficult to quantify because of their complex movement patterns both spatially and temporally. Life history information and a description of the methods used to quantify fish use are contained in an earlier section.

Fish density in a series of runs upstream and downstream from Red Meadow Creek is presented in Table 59 . This reach has the largest density of cutthroat trout in the North Fork. Juvenile bull trout are difficult to observe in the river because of their habit of lying on the bottom near or under rocks. A comparison between fish densities in the North and Middle Forks is presented in Table 60 .

Adult bull trout use the river as a migration corridor. They rest in the pools and below riffles, feeding along shallow bars at night.

Table 59. Estimated densities (No./100 ft^2) of fish by age class in run habitats of two sections of the North Fork River during the summer of 1980. Numbers of features snorkeled are in parentheses.

		Fish per 100 ft^2 surface area						
		Cutthroat trout			Bull trout		Mountain whitefish	
Feature	(number)	Age I	Age II	Age III+	Age III+	Mature	150mm	150mm
North Fork above Red Meadow Creek (7/23 - 7/25)								
Runs	(5)	0.1	5.4	5.4	0.1	0.04	5.4	11.7
North Fork below Red Meadow Creek (8/12 - 8/13)								
Runs	(6)	---	0.2	2.8	---	---	10.2	18.9

Table 60. Comparisons of mean densities of fish per 100 ft^2 in North Fork River run habitats and Middle Fork River run-pool habitats. Number of features snorkeled are in parentheses.

		Fish per 100 ft^2 surface area						
		Cutthroat trout			Bull trout		Mountain whitefish	
Feature	(number)	Age I	Age II	Age III+	Age III+	Mature	150mm	150mm
North Fork average								
Run	(11)	0.18	3.3	3.98	0.1	<0.1	6.3	12.7
Middle Fork average								
Run-Pool	(161)	0.21	4.4	7.1	0.1	1.5	3.3	64.0

A survey of spawning areas in Canada and the United States resulted in a count of 183 spawning sites (redds). The estimated successful spawning population in 1980 was in excess of 1,000 adults. Spawning occurs in nine major tributaries draining into this river section or upstream in Canada.

Whitefish, cutthroat and some juvenile bull trout over-winter in the main river. Adult cutthroat trout from Flathead Lake migrate upstream through the river in the spring. They migrate in response to the increased runoff and spring water temperature. Migrations to and from the lake occur largely from April through June. Juvenile cutthroat and bull trout migrating to Flathead Lake leave the tributary streams during the high water period through July.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a series of riffle-run areas near river mile 33.5 (T35N, R21W, Sec. 22). Four cross-sections were placed in this sequence, but only two could be used in the present analysis because hydraulic conditions which occurred at the low water measurement violated a necessary assumption of the WETP model. Two additional transects were established and will be surveyed in the summer of 1981. The WETP program was calibrated to field data collected at flows of 704.8, 3,370 and 6,020 cfs.

The relationship between wetted perimeter and flow for the composite of the two riffle cross-sections is presented in Figure 34. Two inflection points occurred at approximate flows of 300 and 1200 cfs. Based on an evaluation of existing fishery, recreation use, water availability and other resource information, a flow of 750 cfs is recommended for the low flow period from August through March.

Monthly flow recommendations for both low and high flow periods are listed in Table 61. The median monthly flows of record for U.S.G.S. gauges at the U.S. - Canadian border and near the mouth of the North Fork of the Flathead River are listed to compare water availability. The Bowman Creek site is almost mid-way between the two gauge sites. Therefore, a value intermediate to the 80th percentile flows for each gauge was used to calculate recommendations for the high flow period (April 1 - July 31). The flow recommendations would require that all the water during a normal water year be maintained instream from approximately September through March.

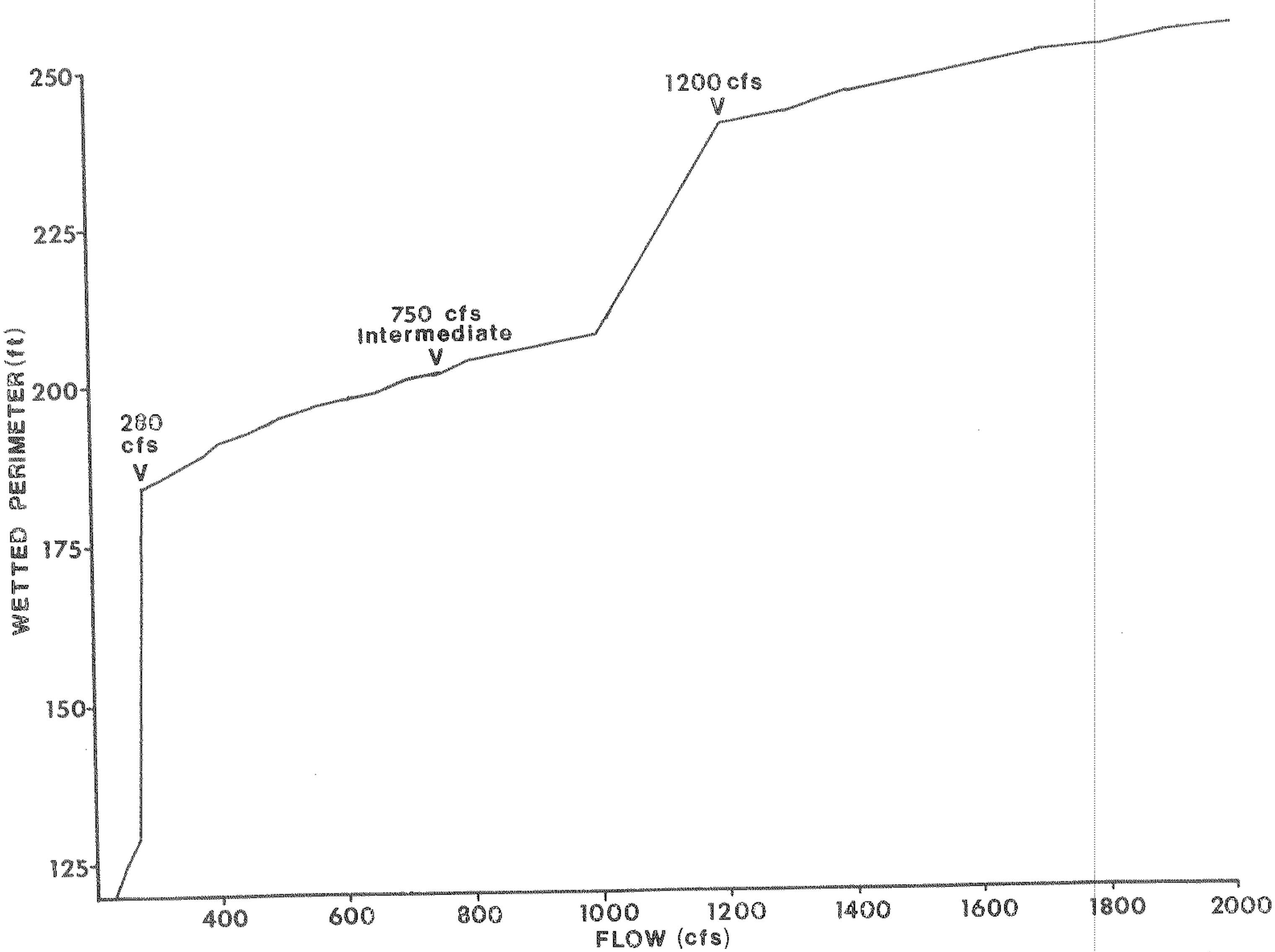


Figure 34 . Average wetted perimeter for two riffle-run cross-sections (3 and 4) near Bowman Creek on the North Fork of the Flathead River.

Table 61. Instream flow recommendations derived for the North Fork of the Flathead River from the mouth of Bowman Creek upstream to the Canadian border using the wetted perimeter/inflection point method (low flow period) and the dominant discharge/channel morphology concept (high flow period) compared to the median flows of record.

	Recommended flows (cfs)	Approximate median flows[a/]	
		International border	Mouth of North Fork
January	750	158	647
February	750	156	665
March	750	176	717
April 1-15	566	323	1497
April 16-30	1099	776	3428
May 1-15	3663	3363	7287
May 16-31	5460	4550	11628
June 1-15	5439	4204	12072
June 16-30	3566	2451	8188
July 1-15	2172	1513	5519
July 16-31	1279	797	2933
August	750	408	1690
September	750	273	1040
October	750	267	996
November	750	259	944
December	750	215	767

a/ U.S.G.S. Border gauge is 45 feet north of the international boundary. Median flows are for a 19-year period of record. The other U.S.G.S gauge is 3.8 miles upstream from the mouth of the North Fork of the Flathead River. Medians are for a 39-year period of record.

1. RIVER

South Fork of the Flathead River (from the head of Hungry Horse Reservoir in T26N, R16W, Sec. 23 upstream to the Powell-Flathead County line in T21N, R13W, Sec. 5 and Sec. 8).

2. DESCRIPTION

Stream length

Total length of South Fork: 104.6 miles
Mouth to the head of the reservoir: 45.5 miles
Head of reservoir to Powell-Flathead County line: 42.8 miles

Drainage area

Total South Fork: 1670 square miles
Head of reservoir to headwaters: 1160 square miles

Gradient

Headwaters (Danaher and Youngs Creeks) to Flathead County line: 19.6 ft/mile (0.4%)
Flathead County line to head of Hungry Horse Reservoir: 19.1 ft/mile (0.4%)

Origin

The South Fork of the Flathead River originates at the confluence of Danaher and Young's Creeks in the Bob Marshall Wilderness Area. The upper 41 miles is entirely within the Wilderness boundary. The Continental Divide forms the east boundary and the Swan Range the west boundary.

Flows

A U.S.G.S. gauge is located 1.2 miles upstream from the head of Hungry Horse Reservoir (T26N, R16W, Sec. 36). Average discharge for a 15 year period of record (1964-1979) was 2,333 cfs, with a maximum discharge of 30,200 cfs and a minimum of 156 cfs. A flood of June 8, 1964 prior to the period of record reached an estimated 50,900 cfs.

Water quality

The South Fork has an A-1 classification under the State Water Quality Standards. Waters classified A-1 are suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities. Water quality must be suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

Recreational usage

The upper 51.3 miles of the South Fork from the headwaters to the Spotted Bear River is classified a Wild River under the National Wild and Scenic Rivers Act of 1976. From the Spotted Bear River downstream to Hungry Horse Rservoir (a distance of 8.8 miles) the river is classified a Recreational River. A major study is presently underway to assess the amount and type of use on the South Fork of the Flathead River by floaters (McLaughlin et al. 1981). Fishing pressure on the river has not been accurately assessed because of the remoteness of the river. Anglers report high catch rates and large fish from the South Fork, particularly for cutthroat trout.

3. FISH POPULATIONS

Species composition in the South Fork is the same as for the North and Middle Forks; westslope cutthroat trout, bull trout, mountain whitefish, and sculpins. They exhibit the same migration patterns as fish in the North and Middle Forks although Hungry Horse Reservoir serves in place of Flathead Lake as the lake residence for adfluvial cutthroat and bull trout.

Fish density estimates were not made in the South Fork this summer because man-power was unavailable to do the type of estimate conducted on the North and Middle Forks. An estimate, as described for the North and Middle Forks, will be conducted on the South Fork during the summer of 1981.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made on a series of riffle-run areas near river mile 46.7 (T26N, R16W, Sec. 36). Four cross-sections were placed in this sequence. Three riffle-run transects are used in this analysis. The fourth transect was in a pool-run area controlled by bedrock.

The relationship between wetted perimeter and flow for the composite of the three riffle-run cross-sections is presented in Figure 35. The inflection point occurs at a flow of approximately 700 cfs. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 700 cfs is recommended for the low flow period from August through mid-April.

Monthly flow recommendations for both low and high flow periods are listed in Table 62. The median monthly flows of record for the U.S.G.S. gauge near Twin Creek is listed for comparison. No diversion of water is known to occur that would presently affect these flows.

The recommended flows exceed the median flows of record from September through March. It is, therefore, recommended that all existing flow in the South Fork of the Flathead River upstream from Hungry Horse Reservoir be maintained instream for fish, wildlife, and recreational purposes during that period.

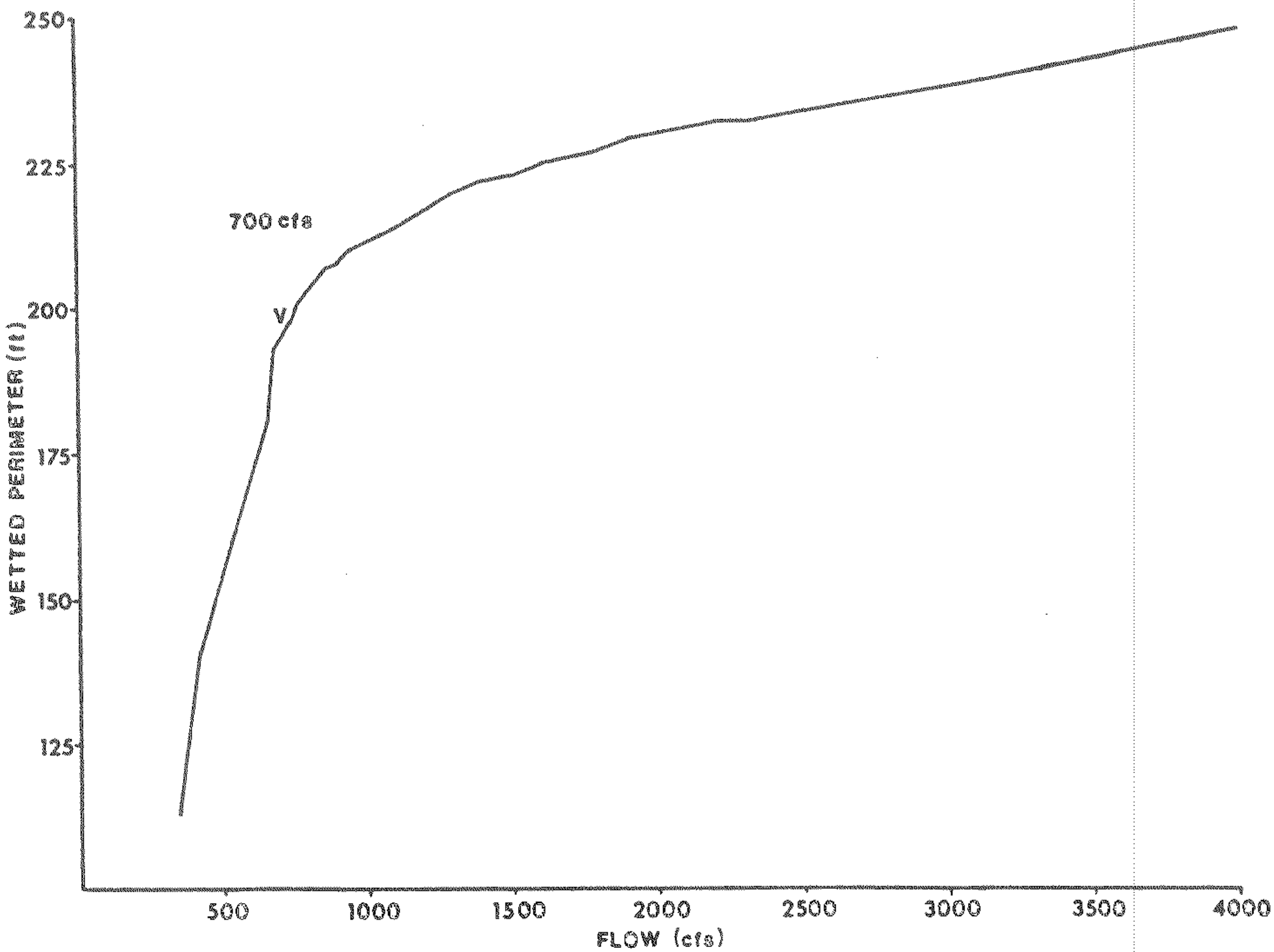


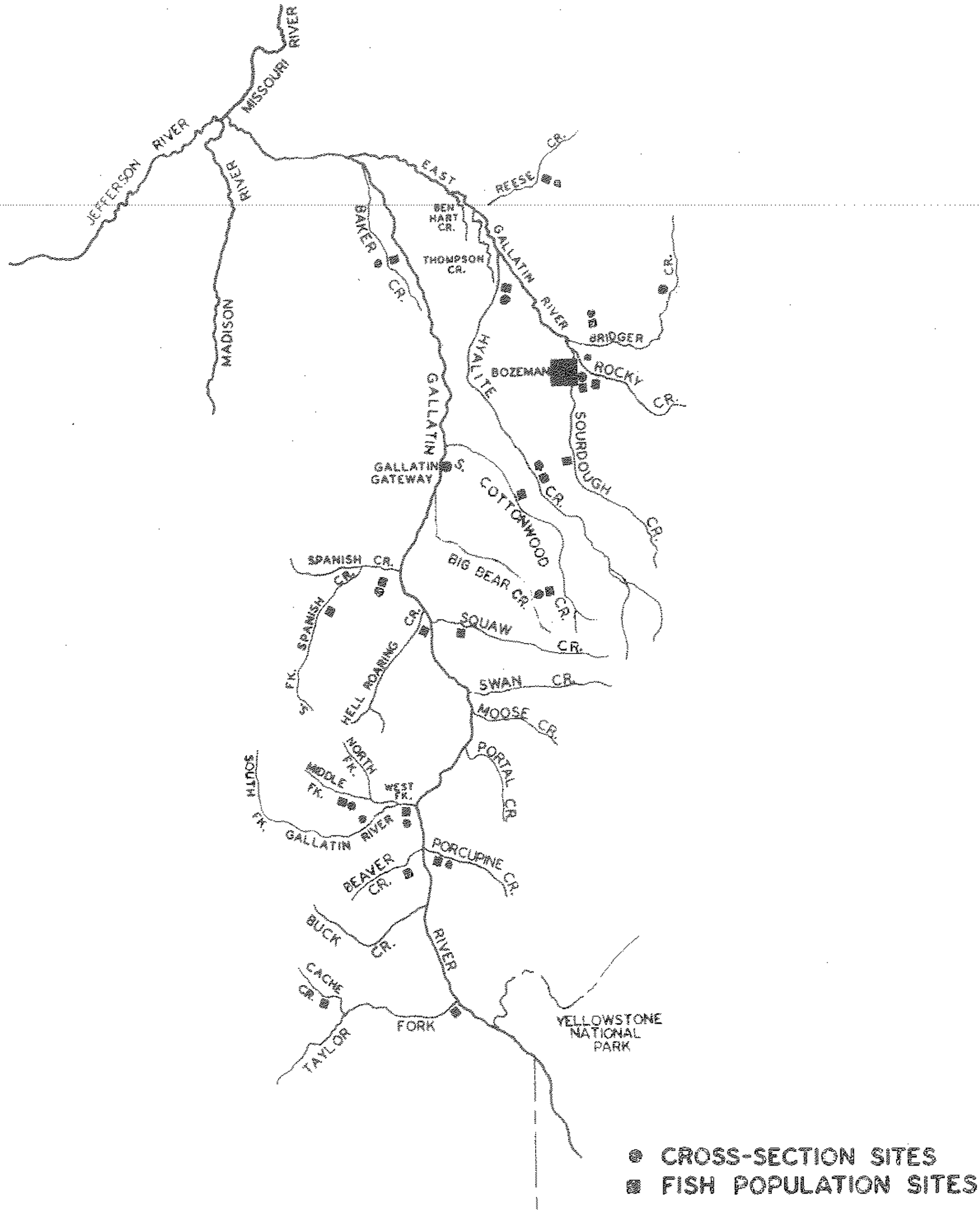
Figure 35. Average wetted perimeter for three riffle-run cross-sections (1, 2, and 4) on the South Fork of the Flathead River upstream from Hungry Horse Reservoir.

Table 62. Instream flow recommendations derived for the South Fork of the Flathead River upstream from Hungry Horse Reservoir using the wetted perimeter/inflection point method (low flow period) and the dominant discharge/channel morphology concept (high flow period) compared to the median flows of record.

	Recommended flows (cfs)	Approximate median flows (cfs)[a/]
January	700	353
February	700	296
March	700	510
April 1-15	700	1037
April 16-30	1180	2167
May 1-15	3126	5257
May 16-31	4252	9026
June 1-15	6477	10605
June 16-30	4471	7595
July 1-15	1957	5156
July 16-31	943	2497
August	700	1030
September	700	543
October	700	406
November	700	412
December	700	389

a/ Derived for a 9-year period of record for the U.S.G.S. gauge located near Twin Creek (T26W, R16W, Sec. 36).

GALLATIN RIVER TRIBUTARIES



The study areas of the Gallatin River Drainage.

1. STREAM

Big Bear Creek

2. DESCRIPTION

Big Bear Creek originates at the northern end of the Gallatin Mountain Range of southwest Montana and flows in a northwesterly direction for about 12 miles before discharging into Wilson Creek. Stream elevations at the origin and mouth are approximately 8,400 and 5,000 ft, respectively. Stream gradient averages about 190 ft/mile and channel widths range from about 3 to 18 ft. Annual precipitation ranges from 20 to 40 inches. Big Bear Creek drains an area of approximately 13.2 square miles.

The reach of Big Bear Creek from the mouth to near stream mile 5.0 is primarily surrounded by agricultural lands. The principle commodities produced are cattle and grains. Access to the stream is controlled by the surrounding private landowners.

The reach from near stream mile 5.0 to the headwaters generally lies within steep, forested lands. Cattle grazing, small grain production and some timber harvesting occur. Approximately 7 miles of Big Bear Creek lie within the Gallatin National Forest. Access to the drainage is provided by a USFS regulated road that crosses 3 miles of private land.

Thirteen water appropriations, amounting to 213 cfs, are filed on Big Bear Creek (The State Engineer's Office, 1953). In addition, 16 decreed rights, amounting to 75.6 cfs, are also filed. About 98 percent of the irrigable land within the drainage (1,553 acres) is being irrigated.

The USGS operated a gauge on Big Bear Creek at stream mile 4.7 from October,1951 to December,1953. The mean flow for the 1952-53 water years was 14.3 cfs. Farnes and Shafer (1972) estimate the 25 and 50 year instantaneous peak flows for Big Bear Creek at 380 and 448 cfs, respectively. Flows measured by Matney and Garvin (1978) on Big Bear Creek (T3S, R4E, Sec 25) for the period of May 31 through July 27, 1976 ranged from 3.8 to 50.7 cfs. The mean flow for the period was 24.7 cfs.

Land uses in the lower Big Bear drainage include ranching and farming. Recreational activities are mainly confined to the portion of the drainage within the National Forest. Recreational activities include hunting, fishing, snowmobiling, cross-country skiing and firewood gathering.

The Big Bear Creek drainage supports populations of big game animals such as elk, deer, moose, black bear and cougar. Upland gamebirds in the upper drainage include ruffed and blue grouse, while ring-necked pheasant and hungarian partridge are found in the lower drainage. Furbearers include weasel, bobcat, mink and coyote.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Big Bear Creek (T4S, R5E, Sec 4D) were surveyed by electro-fishing on July 14, 1980. Cutthroat trout, brook trout and mottled sculpin were the only fish species captured. The electro-fishing survey data are summarized in Table 63 . The population of trout was too sparse to reliably estimate using the mark-recapture method.

Table 63. Summary of electro-fishing survey data collected for a 1,000 ft section of Big Bear Creek (T4S, R5E, Sec 4D) on July 14, 1980.

Fish Species	Number Captured	Length Range (inches)
Cutthroat Trout	3	4.6 - 6.8
Brook Trout	1	6.3
Mottled Sculpin	-	--

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 47 ft riffle-pool sequence located near stream mile 7.6 (T4S, R5E, Sec 4D). Five cross-sections were placed in this sequence. The WETP computer program was calibrated to field data collected at flows of 8.6, 27.2 and 38.7 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 36 . The lower and upper inflection points occur at approximate flows of 4 and 9 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 4 cfs is recommended for the low flow period (July 1 through April 30).

The monthly flow recommendations for the low flow period are listed in Table 64 . The mean monthly flows of record for the USGS gauge at stream mile 4.7 are also listed for comparison. The flow recommendations for the months of January, February and March exceed the normal availability of water, as measured by the mean monthly flows.

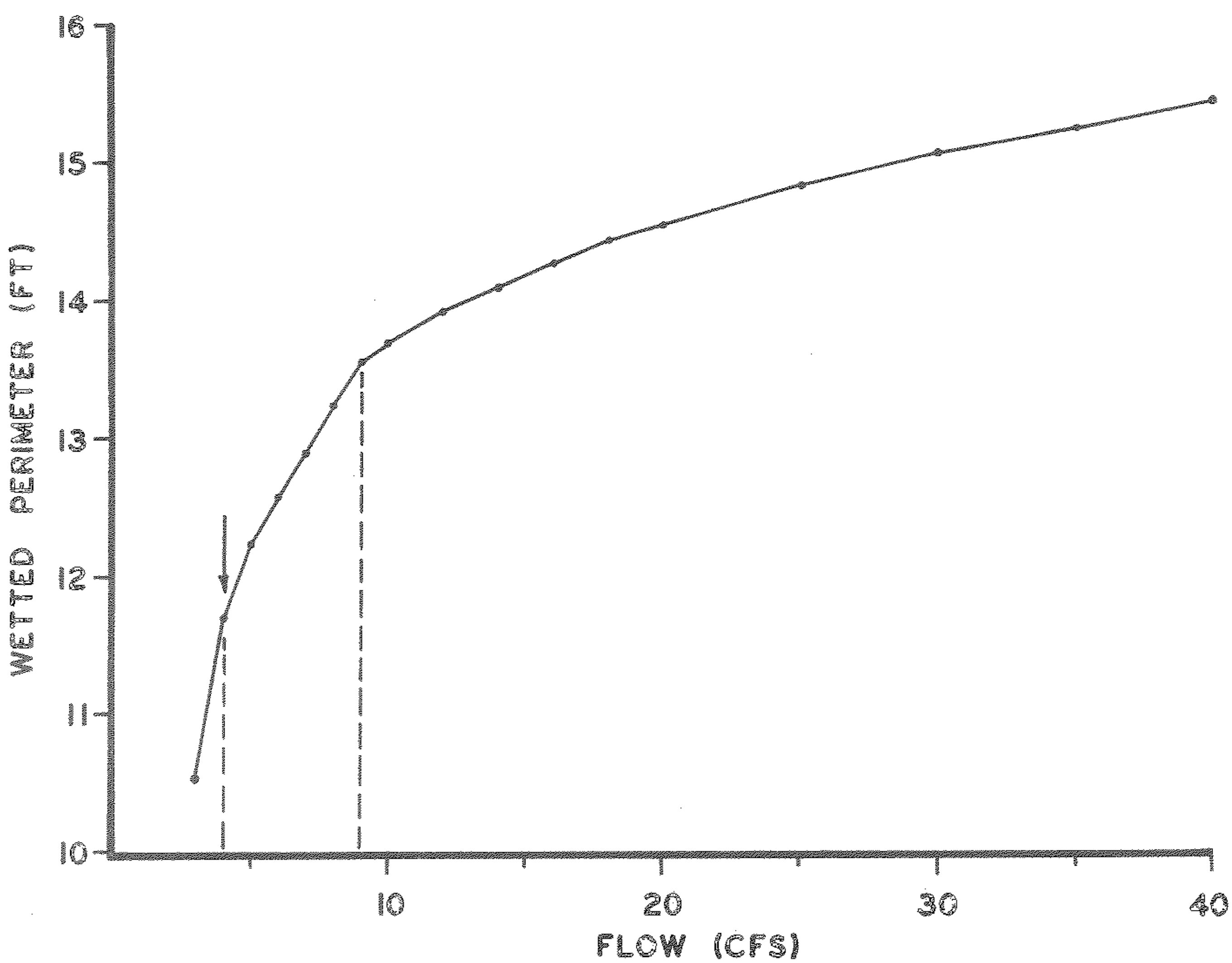


Figure 36. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Big Bear Creek.

Table 64 . Instream flow recommendations derived for Big Bear Creek using the wetted perimeter/inflection point method (low flow period) compared to the mean monthly flows of record.

	Recommended Flows (cfs)	Mean Flows (cfs)[a/]
January	4	3.7
February	4	3.1
March	4	2.7
April	4	7.8
May	b/	39.0
June	b/	69.2
July	4	19.3
August	4	8.1
September	4	5.9
October	4	5.9
November	4	6.1
December	4	4.9

a/ Derived for the October,1951 to December,1953 period of record for the USGS gauge at stream mile 4.7 (T3S, R5E, Sec 29).

b/ Recommendations for the high flow period (May 1 - June 30) cannot be derived due to the lack of long-term flow records.

1. STREAM

Bozeman (Sourdough) Creek

2. DESCRIPTION

Bozeman Creek originates at the outlet of Mystic Reservoir in the north end of the Gallatin Range of southwest Montana and flows in a northwesterly direction for 16.5 miles before discharging into the East Gallatin River at Bozeman, Montana. Stream elevations at the origin and mouth are approximately 6,400 and 4,720 ft, respectively. The stream gradient averages about 102 ft/mile. Bozeman Creek drains an area of about 65 square miles. The average annual precipitation for the drainage is 24 inches.

The reach of Bozeman Creek between the mouth and stream mile 8.5 is surrounded by agricultural, industrial and municipal lands. Land uses include small grain production, cattle ranching, small industry and homesite development. Lands surrounding this reach are rapidly being converted from agricultural to urban-municipal uses. Stream access within this reach is restricted by private landowners. However, short sections within the city of Bozeman are accessible to the public.

The reach from stream mile 8.5 to the headwaters is surrounded by forested lands. About 6.75 miles of Bozeman Creek are within the Gallatin National Forest. The upper drainage has been extensively logged in the past and additional timber sales are being proposed for the future. About 9 miles of controlled access road plus old logging roads, foot trails and horse trails provide public access. Mystic Reservoir, which regulates the flows inthis reach, primarily serves as a municipal water supply for the city of Bozeman.

The USGS operated a gauge on Bozeman Creek at stream mile 9.9 from May 1951 to September 1953. Mean, maximum and minimum flows for the period of record are 27.9, 348 and 5.0 cfs, respectively. The mean monthly flows for the period of record are given in Table 65 .

Table 65 . Mean monthly flows of record for Bozeman Creek.

	Mean Flows (cfs)[a/]
January	8.6
February	7.7
March	7.3
April	33.7
May	80.5
June	71.0
July	30.7
August	21.3
September	19.6
October	13.1
November	11.3
December	9.8

[a/] Derived for the May 1951 to September 1953 period of record for the USGS gauge at stream mile 9.9 (T3S, R6E, Sec 17).

Farnes and Shafer (1972) estimated the mean annual yield of the Bozeman Creek drainage at 26,000 acre-feet (35.9 cfs). The estimated 25 and 50 year instantaneous peak flows at the FS boundary are 510 and 597 cfs, respectively. Flows measured by Matney and Garvin (1978) (T2S, R6E, Sec. 6) for the period of June 1, 1976 through July 26, 1977 ranged from 1.2 to 67.5 cfs.

Twenty-eight water appropriations, amounting to 371.5 cfs, are filed on Bozeman Creek (The State Engineer's Office, 1953). In addition, 23 decreed rights amounting to 88.25 cfs, are also filed. Filed water appropriations on tributaries within the drainage total 365.75 cfs. Approximately 2,288.0 acres of land are being irrigated with water diverted from Bozeman Creek.

Recreational activities within the drainage are primarily confined to that portion within the Gallatin National Forest. These activities include hunting, cross-country skiing, hiking, backpacking, camping and fishing. A mail survey conducted by the MDFWP for the period of May 1975 through April 1976 estimated the fishing pressure on Bozeman Creek at 912 man-days/year or about 55 man-days/stream mile/year. Motor vehicle use is restricted within the National Forest because the drainage serves as a municipal water supply.

Wildlife species found in the Bozeman Creek drainage include big game animals, such as elk, mule deer, moose, black bear and cougar, and furbearers, such as mink, muskrat, raccoon, coyote, fox and bobcat. Upland gamebirds in the area include hungarian partridge, ruffed and blue grouse.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Sourdough Creek were surveyed by electro-fishing on October 16 and 22, 1980. Game fish captured in descending order of abundance were brook and rainbow trout. The mottled sculpin was the only non-game species catured. The electro-fishing survey data are summarized in Table 66.

Table 66. Summary of electro-fishing survey data collected for a 1,000 ft section of Sourdough Creek (T3S, R6E, Sec 7D) on October 16 and 22, 1980.

Fish Species	Number Captured	Length Range (inches)
Brook Trout	102	3.1 - 11.4
Rainbow Trout	36	4.0 - 11.5
Mottled Sculpin	--	-

The standing crops of trout in the section were estimated using a mark-recapture method (Table 67). The estimates show that this 1,000 ft section supports about 216 trout, weighing 28 pounds. Brook trout, the predominant trout species, comprise about 67 and 64% of the total trout numbers and biomass, respectively.

Table 67. Estimated standing crops of trout in a 1,000 ft section of Sourdough Creek (T3S, R6E, Sec 7D) on October 16, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Number	Per 1,000 ft Pounds
Brook Trout	4.5 - 5.9	67	
	6.0 - 9.9	72	
	10.0 - 11.4	5	
		144(±26)	18(±4)
Rainbow Trout	4.0 - 5.9	44	
	6.0 - 9.9	18	
	10.0 - 11.5	10	
		72(±28)	10(±4)
Total Trout		216(±38)	28(±6)

1. STREAM

Hell Roaring Creek

2. DESCRIPTION

Hell Roaring Creek originates in the Spanish Peaks Primitive Area of southwest Montana. The stream heads at an elevation of about 9,200 ft and flows in a northeasterly direction for about 11 miles before discharging into the Gallatin River at an approximate elevation of 5,350 ft. Stream gradient averages approximately 344 ft/mile. Hell Roaring Creek drains an area of about 30 sq miles. The estimated average annual precipitation is 38 inches.

Water resource data are sparse for Hell Roaring Creek. Three water appropriations, amounting to 100 cfs, are filed on Hell Roaring Creek (State Engineer's Office, 1953). In addition, two decreed rights, amounting to 2.25 cfs, are also on file. About 65 acres are presently being irrigated.

The SCS (Farnes and Schafer, 1972) estimates the average annual water yield of the Hell Roaring drainage at 32,600 acre-feet (45.0 cfs). The estimated 25 and 50 year instantaneous peak flows are 640 and 749 cfs, respectively. Water quality is considered excellent (Snyder et al., 1978).

Hell Roaring Creek lies almost entirely within the Spanish Peaks Wilderness Area. Access to the drainage and surrounding area is by a USFS trail heading along U.S. Highway 191. Backpacking, hiking, hunting, horseback riding and fishing are the primary activities within the drainage. Recreational use is considered high.

Wildlife found in the Hell Roaring Creek drainage include elk, mule deer, moose, big horn sheep, mountain goat, black bear and cougar. Upland game birds include ruffed and blue grouse. Small mammals and birds common to southwestern Montana are also found.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Hell Roaring Creek were surveyed by electro-fishing on September 4 and October 8, 1980. Rainbow trout and mottled sculpin were the only fish species captured. The electro-fishing survey data are summarized in Table 68.

Table 68. Summary of electro-fishing survey data collected for a 1,000 ft section of Hell Roaring Creek (T4S, R4E, Sec. 33B) on September 4 and October 8, 1980.

Fish Species	No. Captured	Length Range (inches)
Rainbow Trout	84	3.2 -13.6
Mottled Sculpin	--	--

The standing crop of rainbow trout in the section was estimated using a mark-recapture method (Table 69). The estimate shows that this 1,000 ft section supports about 119 rainbow trout, weighing 18 pounds.

Table 69. Estimated standing crop of rainbow trout in a 1,000 ft section of Hell Roaring Creek (T4S, R4E, Sec. 33B) on September 4, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Rainbow Trout	4.0 - 5.9	55	
	6.0 - 9.9	56	
	10.0 -13.6	8	
		119 ($\pm$36)	18 ($\pm$4)

1. STREAM

Hyalite Creek

2. DESCRIPTION

Hyalite Creek originates at the outlet of Middle Creek (Hyalite) Reservoir in the northwest portion of the Gallatin Range of southwest Montana. The stream heads at an elevation of 8,800 ft and flows in a northwesterly direction for 28.5 miles before discharging into the East Gallatin River at an approximate elevation of 4,400 ft. Stream gradient averages about 154 ft/mile. Annual precipitation within the drainage averages 25 inches. Hyalite Creek drains an area of about 118 square miles.

The reach of Hyalite Creek between the mouth and stream mile 20.5 lies primarily within agricultural lands. Major commodities produced are cattle, grains and alfalfa hay. Access to this reach is controlled by adjacent private landowners. About 10,268 acres of land are irrigated with water diverted from Hyalite Creek and its tributaries. Consequently, much of this reach is severely dewatered during the summer irrigation season.

The reach from about stream mile 20.5 to the headwaters lies within densely forested lands. Approximately 17.5 miles of Hyalite Creek are within the Gallatin National Forest. Access to Middle Creek Reservoir and the upper drainage is provided by a 11.5 mile long USFS road. Logging roads and established foot and horse trails provide additional access into the drainage. Primary land uses include timber harvesting, livestock grazing and recreation.

Middle Creek Reservoir, which has a usable storage capacity of 8,030 acre-feet, regulates the flows of Hyalite Creek. The reservoir was built in 1951 for irrigation and municipal purposes. The municipal water is diverted from Hyalite Creek by the city of Bozeman approximately 8 miles downstream of the reservoir. The city is presently attempting to purchase additional water for municipal uses.

The USGS has operated a gauge at stream mile 20.8 of Hyalite Creek since 1895. The mean, maximum and minimum flows of record are 67.2, 956 and 5.0 cfs, respectively. The approximate median monthly flows of record at the gauge are given in Table 70 .

Table 70 . Approximate median monthly flows of record for Hyalite Creek.

	Approximate Median Flows (cfs)[a/]
January	16.9
February	16.1
March	16.6
April	31.5
May 1-15	88.1
May 16-31	154.3
June 1-15	215.9
June 16-30	189.1
July 1-15	138.9
July 16-31	100.3
August	74.7
September	39.2
October	33.5
November	24.5
December	19.9

[a/] Derived for a 39-year period of record (1935-73) for the USGS gauge at stream mile 20.8 (T3S, R5E, Sec 23).

The SCS (Farnes and Schafer, 1972) estimates the mean annual water yield for the Hyalite drainage at 50,300 acre-feet (69.5 cfs). The estimated 25 and 50 year instantaneous peak flows for Hyalite Creek at the Forest Service boundary are 1,040 and 1,217 cfs, respectively. The percent of annual streamflow occurring during the periods of October-March, April-June, and July-September are estimated at 18, 56 and 26%, respectively.

Recreational activities within the drainage are confined mainly to lands within the Gallatin National Forest. This includes over 17 miles of Hyalite Creek plus tributaries and Middle (Hyalite) Creek Reservoir. Recreational activities include hunting, fishing, camping, backpacking, sightseeing, snow-mobiling, cross-country skiing, picnicking, trail bike riding, horseback riding and firewood gathering.

A mail survey conducted by the MDFWP for the period of May 1975 through April 1976 estimated fishing pressure for Hyalite Creek at 3,479 man-days/year or about 122 man-days/stream mile/year (MDFG, 1976).

Wildlife found in the Hyalite Creek drainage include big game animals such as elk, mule deer, moose, black bear and cougar and upland game birds such as ruffed and blue grouse. Furbearers include mink, weasel, badger and coyote. Small mammals and birds common to southwest Montana are also present.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Hyalite Creek were surveyed by electrofishing on September 5 and October 8, 1980. Game fish captured in descending order of abundance were rainbow and brook trout. The mottled sculpin was the only non-game species captured. The electrofishing survey data are summarized in Table 71 .

Table 71 . Summary of electrofishing survey data collected for a 1,000 ft section of Hyalite Creek (T3S, R5E, Sec 23D) on September 5 and October 8, 1980.

Fish Species	Number Captured	Length Range (inches)
Rainbow Trout	284	3.3 - 17.6
Brook Trout	1	7.6
Mottled Sculpin	-	-

The standing crop of rainbow trout, the predominant trout species, was estimated using a mark-recapture method (Table 72). The estimate shows that this 1,000 ft section supports about 624 rainbow trout, weighing 75 pounds.

Table 72. Estimated standing crop of rainbow trout in a 1,000 ft section of Hyalite Creek (T3S, R5E, Sec 23D) on September 5, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Number	Per 1,000 ft Pounds
Rainbow Trout	3.3 - 5.9	342	
	6.0 - 9.9	261	
	10.0 - 17.6	21	
		624($\pm$115)	75($\pm$15)

1. STREAM

Porcupine Creek

2. DESCRIPTION

Porcupine Creek originates on the west slope of the Gallatin Range of Southwest Montana and flows in a northwesterly direction for about 9.5 miles before discharging into the Gallatin River at river mile 73. Stream elevations at the origin and mouth are approximately 8,800 and 6,240 ft, respectively. The stream gradient average about 269 ft/mile and channel widths range from about 3 to 32 ft. The average annual precipitation for the drainage is approximately 33 inches (<20 to >40 inches). Porcupine Creek drains an area of about 30 square miles.

Water resource information is limited for Porcupine Creek. The State Engineer's Office (1953) lists one water appropriation of 7.5 cfs. In addition, there were two decreed water rights amounting to 4.7 cfs.

The SCS (Farnes and Schafer, 1972) estimates the mean annual water yield for the drainage at 17,600 acre-feet (24.3 cfs). The 25 and 50 year instantaneous peak flows are estimated at 530 and 620 cfs, respectively. The USFS (1973) estimates the mean annual water yield at 22,099 acre-feet (30.5 cfs). Peak flows occur between mid-May and early June.

Porcupine Creek is currently served by approximately 15.5 miles of road, but only 0.5 mile is open to motor vehicle travel year-round. Travel on the remaining 15 miles is regulated by the US Forest Service. Developed foot and horse trails provide most of the access into the drainage. A portion of the Big Sky Snowmobile Trail traverses the upper drainage.

Timber harvesting within the drainage last occurred in 1950 and all grazing leases were terminated in the early 1950's. The drainage is primarily managed as a winter game range by the MDFWP and USFS.

Recreational activities within the drainage include fishing, snowmobiling, hiking, backpacking, horseback riding, cross-country skiing, trail biking and hunting. Hunting exceeds all other recreational uses. The resident and migratory elk populations attract hunters from early fall to mid-winter depending upon permitted late season hunts. Other big game species are also hunted. Six commercial outfitter camps are permitted by special use permit during the big game season.

Elk are the predominant big game species within the Porcupine drainage. The drainage serves as critical winter range for both resident and migratory elk populations. Other big game species include mule deer, moose, bighorn sheep, black bear, cougar and possibly grizzly bear. Upland game birds, including ruffed and blue grouse, and furbearers such as mink, marten, weasel, coyote, bobcat, lynx, wolverine, skunk and badger are also found in the drainage. Small mammals and birds common to southwestern Montana are also present.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Porcupine Creek were surveyed by electrofishing on August 13 and September 4, 1980. Rainbow trout and mottled scuplin were the only species captured. The electrofishing survey data are summarized in Table 73.

Table 73. Summary of electrofishing survey data collected for a 1,000 ft section of Porcupine Creek (T7S, R4E, Sec 16B) on August 13 and September 4, 1980.

Fish Species	Number Captured	Length Range (inches)
Rainbow Trout	64	3.2 - 7.9
Mottled Sculpin	-	-

The standing crop of rainbow trout in the section was estimated using a mark-recapture method (Table 74). The estimate shows that this 1,000 ft section supports about 108 rainbow trout, weighing 6 pounds.

Table 74. Estimated standing crop of rainbow trout in a 1,000 ft section of Porcupine Creek (T7S, R4E, Sec 16B) on August 13, 1980. Eighty percent confidence intervals are in parentheses.

	Length	Per 1,000 Ft	
Species	Group (inches)	Number	Pounds
Rainbow Trout	3.2 - 5.9	91	
	6.0 - 7.9	17	
		108($\pm$30)	6($\pm$2)

A 1,000 ft section of Porcupine Creek was electrofished by the MDFWP in 1975 (Vincent,1976). Game fish captured in descending order of abundance were rainbow trout (40 captured), brown trout (2 captured), cutthroat trout (2 captured) and mountain whitefish (2 captured).

1. STREAM

South Cottonwood Creek

2. DESCRIPTION

South Cottonwood Creek originates on the north slope of the Gallatin Range of southwest Montana and flows in a northwesterly direction for about 17 miles before discharging into the Gallatin River at stream mile 38.4. Stream elevations at the origin and mouth are about 8,600 and 4,880 ft, respectively. The stream gradient averages approximately 219 ft/mile. The average annual precipitation within the drainage is 32 inches. South Cottonwood Creek drains an area of about 42 square miles.

The reach from the mouth to near stream mile 6.7 is primarily surrounded by agricultural lands. The principle commodities produced are cattle, grains and hay. Access is restricted and controlled by private landowners.

The reach from near stream mile 6.7 to the headwaters lies within the Gallatin National Forest. Some private land holdings occur within the FS boundary. Timber harvesting is the major land use while ranching and farming are primarily confined to the lower two miles of the reach. Commodities produced are cattle, hay and some grains.

Flow and water quality data are limited for South Cottonwood Creek. A USGS gauging station at stream mile 8.2 was operated from May 1951 to September 1953. The mean, maximum and minimum flows for the period of record are 34.4, 283, and 9.2 cfs, respectively. The mean monthly flows for the period of record are listed in Table 75.

Table 75. Mean monthly flows of record for South Cottonwood Creek.

	Mean Flows (cfs)[a]
January	12.4
February	11.9
March	11.0
April	17.5
May	63.9
June	120.3
July	57.8
August	25.8
September	19.6
October	18.1
November	15.2
December	13.7

[a] Derived for the May 1951 to September 1953 period of record for the USGS gauge station at stream mile 8.2 (T3S, R5E, Sec 34).

The SCS (Farnes and Schafer, 1972) estimates the mean annual water yield for the South Cottonwood drainage at 25,700 acre-feet (35.5 cfs). The 25 and 50 year instantaneous peak flows at the USFS boundary are estimated at 500 and 585 cfs, respectively.

The State Engineer's Office (1953) lists 17 water appropriations, amounting to 285 cfs, for South Cottonwood Creek. In addition, there are 35 decreed rights amounting to 83 cfs. Ten water appropriations amounting to 309 cfs are also filed on 4 tributaries.

Wildlife species found in the South Cottonwood drainage include big game species such as elk, mule deer, whitetail deer, moose, black bear and cougar and upland game birds such as hungarian partridge, ring-necked pheasant, ruffed grouse and blue grouse. Furbearers include mink, weasel, raccoon, coyote, fox and badger. Small mammals and birds common to southwestern Montana are also found.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of South Cottonwood Creek were surveyed by electrofishing on September 4 and October 8, 1980. Gamefish captured in descending order of abundance were brook and rainbow trout. The mottled sculpin was the only non-game species captured. The electrofishing survey data are summarized in Table 76.

Table 76. Summary of electrofishing survey data collected for a 1,000 ft section of South Cottonwood Creek (T3S, R5E, Sec 21D) on September 4 and October 8, 1980.

Fish Species	Number Captured	Length Range (inches)
Brook Trout	206	3.6 - 12.6
Rainbow Trout	134	2.9 - 14.9
Mottled Sculpin	-	-

The standing crop of trout in the section was estimated using a mark-recapture method (Table 77). The estimate shows that this 1,000 ft section supports about 631 trout, weighing 110 pounds. Brook trout, the predominant trout species, accounted for 67% of the total trout numbers and 61% of the total biomass. Of the tributaries electrofished within the Gallatin drainage, South Cottonwood Creek supports one of the highest standing crops of trout.

Table 77. Estimated standing crops of trout in a 1,000 ft section of South Cottonwood Creek (T3S, R5E, Sec 21D) on September 4, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Numbers	Per 1,000 Ft Pounds
Brook Trout	3.6 - 5.9	203	
	6.0 - 9.9	201	
	10.0 - 12.6	17	
		421(±88)	67(±10)
Rainbow Trout	3.5 - 5.9	73	
	6.0 - 9.9	112	
	10.0 - 14.9	25	
		210(±38)	43(± 7)
Total Trout		631(±96)	110(±12)

1. STREAM

South Fork of Spanish Creek

2. DESCRIPTION

The South Fork of Spanish Creek originates at the outlet of Summit Lake in the Spanish Peaks Wilderness Area of southwest Montana and flows in a northerly direction for about 13 miles before discharging into Spanish Creek. The stream elevations at the origin and mouth are approximately 9,600 and 5,440 ft, respectively. Stream gradient averages about 320 ft/mile. Annual precipitation within the drainage ranges from less than 30 to about 50 inches. The South Fork of Spanish Creek drains an area of about 40.5 square miles.

Water resource data for the South Fork of Spanish Creek is limited. The State Engineer's Office (1953) lists one water appropriation,amounting to 16 cfs,for the South Fork. In addition, one water appropriation and one decreed right, amounting to 6.5 cfs, are filed on a tributary. About 482 acres of land within the drainage are irrigated with water diverted from the South Fork and its tributaries.

Approximately 8.4 miles of the upper South Fork of Spanish Creek lie within the Gallatin National Forest and the Spanish Peaks Wilderness Area. The lower 4.6 miles flow through private lands. Access to the upper drainage is provided by 4.5 miles of USFS road. A USFS maintained campground is located at the end of this road. Several foot and horse trails provide access into the wilderness area.

The primary land use is recreation. Recreational activities include hunting, backpacking, hiking, camping, horseback riding, fishing and sightseeing. Recreational use of the upper drainage is high due to its wilderness designation.

A mail survey conducted by the MDFWP for the period of May 1975 through April 1976 estimated fishing pressure for the South Fork of Spanish Creek at 174 man-days/year or about 13 man-days/stream mile/year.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of the South Fork of Spanish Creek were surveyed by electrofishing on August 12 and 25, 1980. Game fish captured in descending order of abundance were brook, rainbow and brown trout. No other fish species were captured. The electrofishing survey data are summarized in Table 78 .

Table 78. Summary of electrofishing survey data collected for a 1,000 ft section of the South Fork of Spanish Creek (T4S, R3E, Sec 32A) on August 12 and 25, 1980.

Fish Species	Number Captured	Length Range (inches)
Brook Trout	104	3.2 - 9.4
Rainbow Trout	10	3.9 - 9.7
Brown Trout	2	7.9 - 11.7

The standing crop of brook trout, the predominant game species, was estimated using a mark-recapture method (Table 79). The estimate shows that this 1,000 ft section supports about 232 brook trout, weighing 18 pounds. The populations of rainbow and brown trout were too sparse to reliably estimate.

Table 79. Estimated standing crop of brook trout in a 1,000 ft section of the South Fork of Spanish Creek (T4S, R3E, Sec 32A) on August 12, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Numbers	Per 1,000 Ft Pounds
Brook Trout	3.2 - 5.9	167	
	6.0 - 9.4	65	
		232($\pm$63)	18($\pm$5)

1. STREAM

Squaw Creek

2. DESCRIPTION

Squaw Creek originates on the west slope of the Gallatin Mountain Range of southwest Montana and flows in a westerly direction for about 13.5 miles before discharging into the Gallatin River at river mile 52.6. Stream elevations at the origin and mouth are about 9,200 and 5,440 ft, respectively. Stream gradient averages about 279 ft/mile and channel widths range from about 10 to 30 ft. The estimated average annual precipitation for the drainage is 32 inches (30 to 50 inches). Squaw Creek drains an area of approximately 55 square miles.

The SCS (Farnes and Schafer, 1972) estimates the mean annual water yield for the Squaw Creek drainage at 35,100 acre-feet (48.5 cfs). Logan (1973) estimates the mean annual water yield at 29,936 acre-feet (41.3 cfs). The 25 and 50 year instantaneous peak flows are estimated at 780 and 913 cfs, respectively (Farnes and Schafer, 1972). The maximum and minimum peak flows for a 17 year period of record (1959-75) at the USGS crest-stage gauge in T4S, R4E, Sec. 34 are 690 and 136 cfs, respectively. The earliest peak flow for the 1959-75 period occurred on May 6 and the latest on June 30. No water appropriations are filed on Squaw Creek.

Logging is the primary land use within the Squaw Creek drainage. From the 1880's through the early 1900's trees were mainly harvested for railroad ties. Until about 1950, only minor timber harvesting occurred. Since 1950 timber harvesting has been extensive. Approximately 18% of the drainage has been altered, primarily by logging and road building (Logan, 1973). This logging has occurred on both public and private lands. Livestock grazing has occurred within the Squaw Creek drainage since the 1930's. At present, the drainage is allotted about 115 head.

Recreational use of the Squaw Creek drainage is considered high. Approximately 40 miles of road serve the drainage, most of which are open to vehicle travel year-round. Recreational uses include hunting, trailbike riding, horseback riding, hiking, camping, cross-country skiing, backpacking, snowmobiling and fishing. The USFS maintains a campground on Squaw Creek, plus many miles of foot and horse trails.

A mail survey conducted by the MDFWP for the period of May 1975 through April 1976 estimated fishing pressure on Squaw Creek at 705 man-days/year or about 52 man-days/stream mile/year (MDFG, 1976).

Wildlife found in the Squaw Creek drainage include big game animals such as elk, mule deer, moose, black bear, bighorn sheep, mountain goat and cougar. Upland game birds such as ruffed and blue grouse and furbearers such as mink, weasel, coyote and badger also inhabit the drainage. Small mammals and birds common to southwestern Montana are also found.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Squaw Creek were surveyed by electrofishing on August 12 and 25, 1980. Game fish captured in descending order of abundance were rainbow, brown and brook trout. The mottled sculpin was the only non-game species captured. The electrofishing survey data are summarized in Table 80 .

Table 80 . Summary of electrofishing data collected for a 1,000 ft section of Squaw Creek (T4S, R4E, Sec 35D) on August 12 and 25, 1980.

Species	Number Captured	Length Range (inches)
Rainbow Trout	134	3.1 - 12.3
Brown Trout	8	4.7 - 11.4
Brook Trout	4	5.2 - 8.4
Mottled Sculpin	-	-

The standing crop of rainbow trout, the predominant trout species, was estimated using a mark-recapture method (Table 81). The estimate shows that this 1,000 ft section supports about 443 rainbow trout, weighing 45 pounds. The populations of brown and brook trout were too sparse to reliably estimate using the mark-recapture method.

Table 81 . Estimated standing crop of rainbow trout in a 1,000 ft section of Squaw Creek (T4S, R4E, Sec 35D) on August 12, 1980. Eighty percent confidence intervals are in parentheses.

	Length	Per 1,000 ft	
Species	Group (inches)	Number	Pounds
Rainbow Trout	3.1 - 5.9	293	
	6.0 - 9.9	136	
	10.0 - 12.3	14	
		443(±167)	45(±12)

Two 1,000 ft sections of Squaw Creek were electrofished by the MDFWP in 1975 (Vincent, 1976). Game fish captured in the downstream-most section were rainbow trout (49 captured), brown trout (4 captured) and brook trout (1 captured). Game fish collected in the upper section were rainbow trout (12 captured), brook trout (12 captured) and brown trout (2 captured).

1. STREAM

Taylor Fork of the Gallatin River

2. DESCRIPTION

The Taylor Fork of the Gallatin River originates on the east slope of the Taylor Peaks in southwest Montana and flows in an easterly direction for about 18 miles before discharging into the Gallatin River at river mile 85.4. The stream elevations at the origin and mouth are about 9,200 and 6,600 ft, respectively. Stream gradient averages about 144 ft/mile and channel widths range from about 3 to 48 ft. The average annual precipitation in the drainage is about 39 inches (< 30 to > 60 inches). The Taylor Fork drains an area of approximately 107 square miles.

The Taylor Fork drainage encompasses sagebrush-grasslands, forested slopes and steep treeless ridges. The streambanks are considered unstable due to their geological composition (Snyder et al., 1968). Consequently, portions of the Taylor Fork and its tributaries experience severe bank erosion. A large portion of the sediment load of the Taylor Fork is contributed by the Cement Creek drainage.

Land uses in the Taylor Fork drainage include livestock grazing, logging and mining. Gold mining occurred intermittently from about 1880 to 1945 (State Engineer's Office, 1953). Timber harvesting (primarily for railroad ties) was extensive from about 1898 to 1906. Since 1906 only small scale logging has occurred. The clear cutting of private lands within the drainage last occurred in 1976. Livestock grazing has continued since 1890.

Recreational activities in the Taylor Fork drainage include hunting, hiking, backpacking, camping, horseback riding, cross-country skiing, snowmobiling and fishing. A mail survey conducted by the MDFWP for the period of May 1975 through April 1976 estimated fishing pressure at 91 man-days/year or over 5 man-days/stream mile/year. A portion of the Big Sky Snowmobile Trails traverses the southern part of the drainage.

The Taylor Fork drainage supports populations of elk, mule deer, moose, mountain goat, big horn sheep, black bear and cougar. Grizzly bears have been observed in the area. The drainage lies within a major migration route for elk using the summer range in Yellowstone National Park and the winter range along the west slope of the Madison Range. Upland game birds include ruffed and blue grouse. Furbearers and other small mammals common to southwestern Montana are also found.

The State Engineer's Office (1953) lists five water appropriations, amounting to 44 cfs, for the Taylor Fork. In addition, one decreed water right, amounting to 25 cfs, is also on file. Approximately 9% of the irrigable land (13 acres) is being irrigated.

The USGS operated a gauge at stream mile 0.5 of the Taylor Fork from 1946-1953, 1955-1957 and 1966-1967. The mean, maximum and minimum flows for the period of record are 97.9, 1,020 and 7.4 cfs, respectively. The mean monthly flows for the period of record are given in Table 82.

The SCS (Farnes and Schafer, 1972) estimates the mean annual water yield for the Taylor Fork drainage at 77,000 acre-feet (106.4 cfs). The 25 and 50 year instantaneous peak flows are estimated at 1,500 and 1,755 cfs, respectively.

Table 82. Mean monthly flows of record for the Taylor Fork of the Gallatin River.

	Mean Flows (cfs)[a]
January	18.5
February	17.1
March	17.1
April	35.0
May	243.0
June	422.3
July	191.3
August	67.7
September	40.5
October	32.6
November	24.4
December	20.4

[a] Derived for the 1946-67 period of record for the USGS gauge station at stream mile 0.5 (T9S, R4E, Sec 2).

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of the Taylor Fork were surveyed by electrofishing on October 17 and 24, 1980. Game fish captured in descending order of abundance were rainbow trout, mountain whitefish, cutthroat trout and brown trout. The mottled sculpin was the only non-game species collected. The electrofishing survey data are summarized in Table 83.

Table 83. Summary of electrofishing survey data collected for a 1,000 ft section of the Taylor Fork of the Gallatin River (T9S, R4E, Sec 2C) on October 17 and 24, 1980.

Species	Number Captured	Length Range (inches)
Wild Rainbow Trout	84	5.0 - 11.3
Mountain Whitefish	19	6.2 - 11.2
Cutthroat Trout	8	6.7 - 12.0
Brown Trout	7	9.5 - 11.4
Mottled Sculpin	1	-

The standing crop of rainbow trout, the predominant trout species, was estimated using a mark-recapture method (Table 84). The estimate shows that this 1,000 ft section supports about 131 rainbow trout, weighing 41 pounds. Populations of mountain whitefish and brown and cutthroat trout were too sparse to reliably estimate using the mark-recapture method.

Table 84. Estimated standing crop of rainbow trout in a 1,000 ft section of the Taylor Fork of the Gallatin River (T9S, R4E, S2C) on October 17, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Number	Per 1,000 ft Pounds
Wild Rainbow Trout	5.0 - 6.9	a/	
	7.0 - 9.9	100	
	10.0 - 11.3	31	
		131(±44)	41(±14)

a/ An estimate for this length group is unavailable due to insufficient recaptures.

Wipperman (1965a) and Vincent (1976) conducted electrofishing surveys in various sections of the Taylor Fork. The rainbow trout was the predominant trout species in all sections. Also present in small numbers were brown and cutthroat trout.

Since 1954, catchable-size rainbow trout have been planted in the Taylor Fork (T9S, R4E, Sec 2). In recent years, the plant has been reduced to about 1,000 catchables per year.

1. STREAM

West Fork of the Gallatin River

2. DESCRIPTION

The West Fork of the Gallatin River originates at the confluence of its Middle and North Forks and flows in an easterly direction for 4.2 miles before discharging into the Gallatin River at river mile 69.9. The stream elevations at the origin and mouth are about 6,400 and 5,880 ft, respectively. The stream gradient averages about 124 ft/mile. The annual precipitation for the drainage averages 36 inches. The West Fork drains an area of about 78 square miles.

Water resource data for the West Fork is limited. The State Engineer's Office (1953) lists eight water appropriations, amounting to 587.5 cfs, for the West Fork drainage. In addition, one decreed right, amounting to 1.25 cfs, was filed on a tributary. None of the irrigable lands are presently under irrigation.

The SCS (Farnes and Schafer, 1972) estimates the mean annual water yield for the West Fork drainage at 49,900 acre-feet (68.9 cfs). The estimated 25 and 50 year instantaneous peak flows are 1,050 and 1,229 cfs, respectively.

The West Fork carries a high sediment load during spring runoff. The primary source of the sediment is a tributary where extensive logging is occurring (Snyder et al., 1978).

Much of the land in the immediate vicinity of the West Fork is a part of the Big Sky resort complex. The complex contains condominiums, a golf course and shopping and eating establishments. Several smaller private holdings have been developed as home sites. Prior to the construction of the Big Sky complex in the mid 1970's, the area was primarily used to graze cattle and sheep.

Sightseeing, skiing and fishing are the primary recreational activities in the West Fork drainage. A mail survey conducted by the MDFWP for the period of May 1975 through April 1976 estimated fishing pressure on the West Fork at 640 man-days/year or over 152 man-days/stream mile/year (MDFG, 1976).

The West Fork is served by about four miles of paved road. The drainage has a total of about 40 miles of roads.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of the West Fork of the Gallatin River were surveyed by electrofishing on August 20 and September 4, 1975 (Vincent, 1976). Game fish captured in descending order of abundance were rainbow trout, mountain whitefish, brown trout, cutthroat trout and hatchery rainbow trout. The mottled sculpin was the only non-game species captured. The electrofishing survey data are summarized in Table 85 .

Table 85. Summary of electrofishing survey data collected for a 1,000 ft section of the West Fork of the Gallatin River (T6S, R4E, Sec 32C) on August 20 and September 4, 1975.

Fish Species	Number Captured	Length Range (inches)
Rainbow Trout	75	3.3 - 12.4
Mountain Whitefish	9	9.3 - 15.6
Brown Trout	5	7.9 - 13.9
Cutthroat Trout	4	3.2 - 8.7
Hatchery Rainbow Trout	3	9.0 - 9.7
Mottled Sculpin	-	-

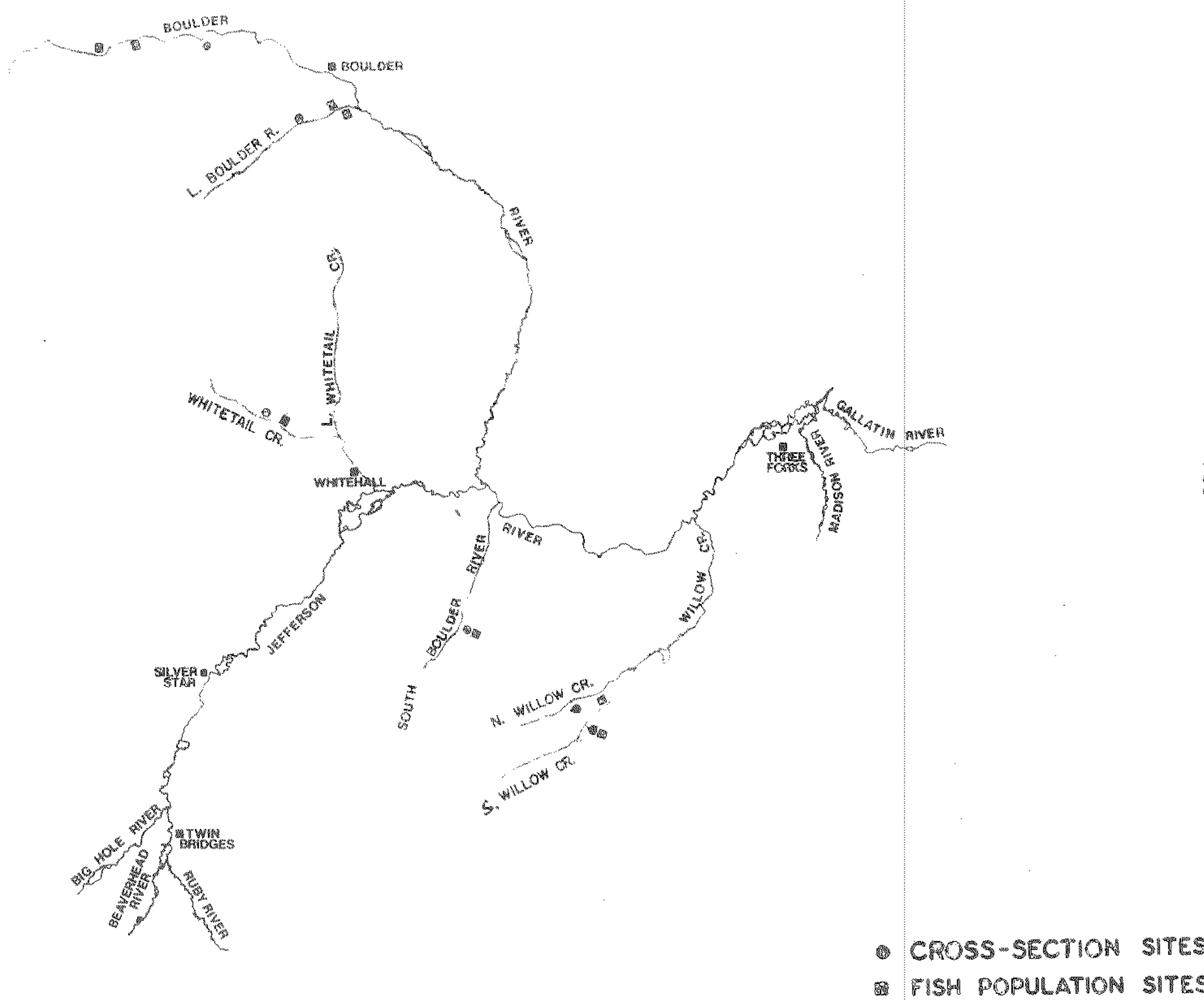
The standing crop of rainbow trout, the predominant trout species, was estimated using a mark-recapture method (Table 86). The estimate shows that this 1,000 ft section supports about 95 rainbow trout, weighing 18 pounds. Populations of mountain whitefish and brown, cutthroat and hatchery rainbow trout were too sparse to reliably estimate using the mark-recapture method.

Table 86. Estimated standing crop of rainbow trout in a 1,000 ft section of the West Fork of the Gallatin River (T6S, R4E, Sec 32C) on August 20, 1975. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Wild Rainbow Trout	4.0 - 5.9	27	
	6.0 - 9.9	58	
	10.0 - 12.4	10	
		95(±20)	18(±5)

The MDFWP planted catchable-size rainbow trout in the West Fork from 1956 to 1976. The number of catchables planted ranged from 200 to over 4,000 per year.

JEFFERSON RIVER TRIBUTARIES



The study areas of the Jefferson River Drainage.

1. STREAM

Boulder River (above Basin, Montana)

2. DESCRIPTION

The Boulder River is formed at the confluence of its South and West Forks (elevation 6740 ft) on the east side of the Continental Divide north of Butte, Montana. It flows east to Boulder, Montana then south to its confluence with the Jefferson River near Cardwell, Montana. It is approximately 78 miles in total length and has a mean gradient of 33.7 ft per mile. At the Deerlodge National Forest boundary above Basin, the stream averages 47.4 ft in width at spring flow levels. Only the upper 26 percent is within the forest boundary. Major tributaries, in downriver progression,are Lowland, Bison, Basin, Cataract and Muskrat Creeks and the Little Boulder River. The Boulder River drains an area of approximately 763 sq miles.

The river upstream of the town of Boulder has a narrow floodplain, a high elevation and a steep gradient. Riparian vegetation primarily consists of willows, alder, conifers and, to a lesser extent, cottonwoods and aspen. Rainbow trout, brook trout and mountain whitefish are the salmonids found in this reach of river.

The reach of river downstream of the town of Boulder has a wider floodplain through which the river meanders, a lower elevation and a more gradual gradient. Riparian vegetation primarily consists of cottonwoods, aspen and willows. Brown trout dominate the gamefish in this reach (Vincent, 1975).

Fishing pressure on the Boulder River in 1975-1976 was estimated at 4,948 man-days/year (MDFG, 1976). This amounts to about 63 man-days/stream mile/year.

Flows in the river depend primarily on snowpack in the mountains with a number of large springs adding to the river in the lower valley. The major use of water from the Boulder River below the town of Boulder is for the irrigation of alfalfa and hay meadows. In low water years, irrigation diversions severely dewater about 12 miles of the lower river (North Boulder Drainage and Jefferson Conservation Districts, 1975).

The USGS operated a gauge at stream mile 44.1 of the Boulder River (T5N, R4W, Sec. 3) from 1929-1932 and 1934-1972. The mean, maximum and minimum flows of record are 121, 3,490 and 0 cfs, respectively.

A gauge at stream mile 73.1 (T6N, R7W, Sec. 20) was also operated by the USGS for the period of 1936, 1946-1953 and 1955-1957. The mean, maximum and minimum flows of record are 11.7, 582 and 0.5 cfs, respectively.

Hard rock mining for metallic minerals in the Boulder River drainage was intensive in the late 1800's and early 1900's. This past mining is still affecting the river below the town of Basin. Appraisal of the water quality in the drainage by Braico and Botz (1974) revealed heavy metals from acid mine seeps and mill tailings were causing a major water quality problem. Sampling of the sediments in the river channel and floodplain disclosed high concentrations of zinc, copper and lead extending some 25 miles downstream of the source areas (Vincent,1975). In the river below Basin, Nelson (1976) found depressed standing crops of trout associated with higher metals concentrations in the river. Vincent (1975) partially attributed the low standing crops of trout in the lower Boulder River to metals pollution. Gardner (1977) showed that environmental problems, most notably metals pollution and stream sedimentation,were affecting the distribution and abundance of aquatic insects in the river.

Approximately 12 miles (14%) of the Boulder River have been relocated as a result of mining, agriculture and road and railroad building activities (Bishop and Peck, 1962). In addition, riprapping has altered 8 miles of stream and channel clearance another 2½ miles. Portions of the upper river channel (Boulder to Bernice) are presently being relocated to make way for Interstate 15.

3. FISH POPULATIONS

Fish populations in a 2,900 ft section of the upper Boulder River were surveyed by electrofishing on August 26 and September 2 and 11, 1975. Gamefish captured in descending order of abundance were rainbow trout, mountain whitefish and brook trout. Nongame species captured were white sucker, longnose sucker, mottled sculpin and longnose dace. The electrofishing survey data are summarized in Table 87 .

Table 87 . Summary of electrofishing survey data collected for a 2,900 ft section of the upper Boulder River (T6N, R6W, Sec. 13 and 24) on August 26 and September 2 and 11, 1975 (from Nelson, 1976).

Fish Species	No. Captured	Length Range (inches)
Rainbow Trout	285	3.7-13.7
Mountain Whitefish	137	5.6-15.9
Brook Trout	77	2.6-11.4
White Sucker	16	3.9-10.9
Longnose Sucker	2	4.3- 6.1
Mottled Sculpin	-	-
Longnose Dace	-	-

The standing crops of trout in the section were estimated using a mark-recapture method (Table 88). The estimates show that this section supports about 202 trout,weighing 26 pounds, per 1,000 ft of stream. Rainbow trout, the predominant trout species, comprise about 86 and 85% of the total trout numbers and biomass, respectively. Brook trout accounted for about 14% of the total trout numbers and 15% of the total biomass. The standing crop of mountain whitefish in the section could not be estimated because adult whitefish were suspected of entering the study section subsequent to the marking run, thereby violating a a condition necessary for valid mark-recapture estimates.

Table 88. Estimated standing crops of trout in a 2,900 ft section of the upper Boulder River (T6N, R6W, Sec. 13 and 24) on September 2, 1975 (adapted from Nelson, 1976). Eighty percent confidence limits are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Rainbow Trout	4.0- 5.9	97	
	6.0- 9.9	63	
	10.0-13.7	13	
		173 (±28)	22 (±3)
Brook Trout	5.0- 5.9	7	
	6.0- 9.9	20	
	10.0-11.4	2	
		29 (±6)	4 (±1)
Total Trout		202 (±29)	26 (±3)

In the summer of 1976, fish populations were also surveyed in a 1,050 ft section of the upper Boulder River located about 2 miles upstream of the 1975 population section and upstream of the confluence of Bison Creek. Game fish captured in descending order of abundance were brook trout, rainbow trout and mountain whitefish. Nongame species captured were longnose sucker, white sucker and mottled sculpin. The electrofishing survey data are summarized in Table 89.

Table 89. Summary of electrofishing survey data collected for a 1,050 ft section of the upper Boulder River (T6N, R6W, Sec. 22) on August 5 and 9, 1976.

Fish Species	No. Captured	Length Range (inches)
Brook Trout	197	3.2-14.8
Rainbow Trout	81	4.1-10.6
Mountain Whitefish	26	7.5-16.6
Longnose Sucker	127	-
White Sucker	11	-
Mottled Sculpin	-	-

The standing crops of gamefish in this section were estimated using a mark-recapture method (Table 90). This section supports about 435 game fish, weighing 75 pounds, per 1,000 ft of stream. Brook trout, the predominant game species, accounted for about 66% of the total game fish numbers and 55% of the total biomass.

Table 90 . Summary of the standing crop estimates of gamefish in a 1,050 ft section of the upper Boulder River (T6N, R6W, Sec. 22) on August 5, 1976. Eighty percent confidence intervals are in parentheses.

		Per 1,000 Ft	
Species	Length Range (inches)	Number	Pounds
Brook Trout	3.2-14.8	289 (±47)	41 (±5)
Rainbow Trout	4.1-10.6	114 (±26)	16 (±3)
Mountain Whitefish	7.5-16.6	32 (± 9)	18 (±5)
Total Gamefish		435 (±54)	75 (±8)

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 412 ft riffle-pool sequence located immediately above the forest boundary (T6N, R5W, Sec. 24B). Five cross-sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 41.0, 68.1 and 206.5 cfs.

The relationship between wetted perimeter and flow for the composite of four riffle cross-sections is shown in Figure 37 . The lower and upper inflection points occur at approximate flows of 18 and 22 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 22 cfs is recommended for the low flow period (July 1 - April 30).

Monthly flow recommendations for both the low and high flow periods are listed in Table 91 . The approximate median monthly flows of record for the USGS gauge near Boulder are also listed for comparison. The recommended monthly flows amount to approximately 43,725 acre-feet of water per year or about 53% of the annual flow that is normally available at the USGS gauge near Boulder, Montana.

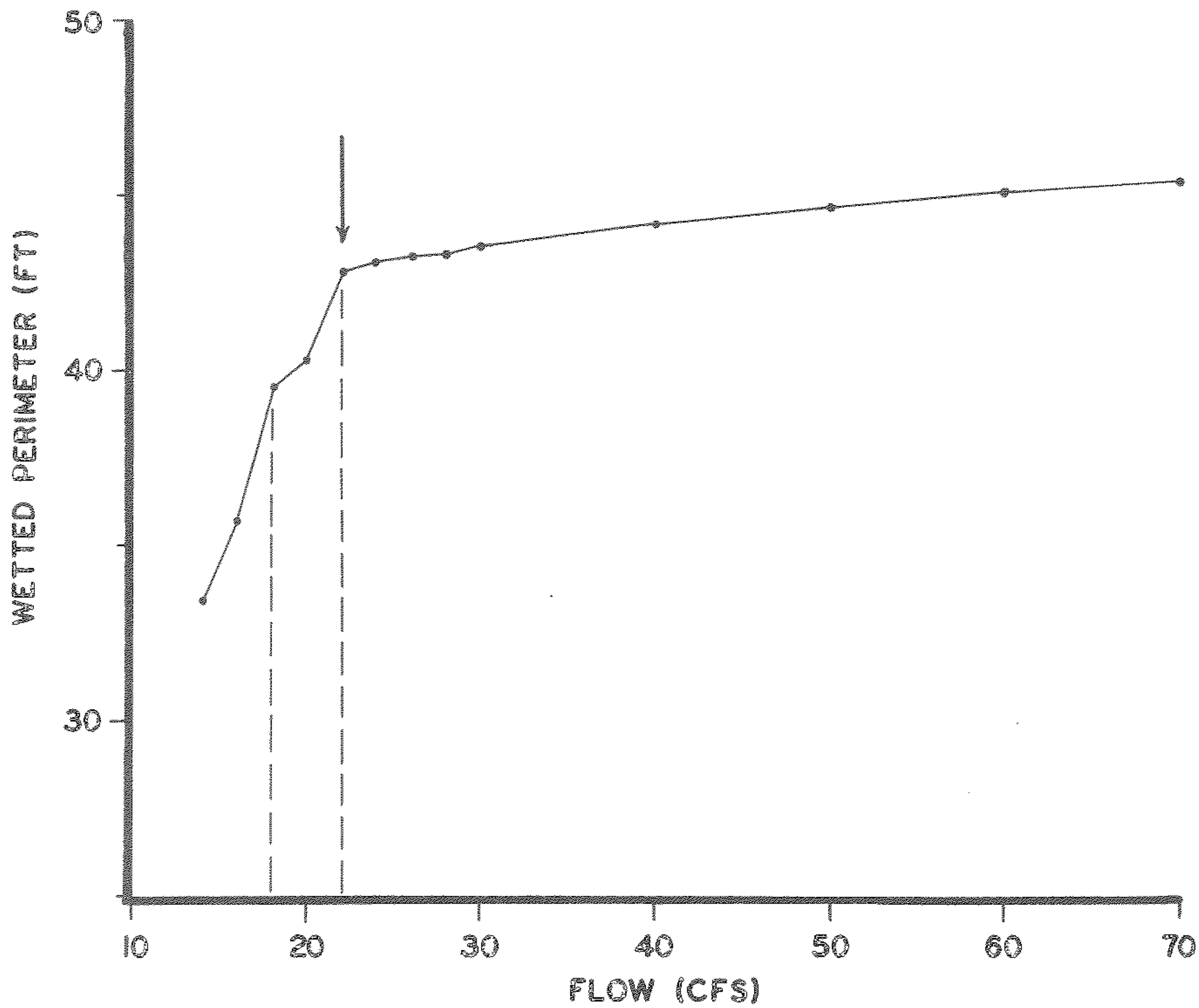


Figure 37. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in the Boulder River.

Table 91 . Instream flow recommendations derived for the Boulder River (above Basin) using the wetted perimeter/inflection point method (low flow period) and the dominant discharge/channel morphology concept (high flow period) compared to the median flows of record.

	Recommended Flows		Approximate Median Flows[a/]	
	CFS	Acre-Feet	CFS	Acre-Feet
January	22	1,352	29.4	1,807
February	22	1,222	32.0	1,777
March	22	1,352	41.8	2,570
April	22	1,309	134.0	7,972
May 1-15	183	5,443	327.0	9,727
May 16-31	348 [b/]	11,041	612.0	19,418
June 1-15	316	9.399	553.0	16,449
June 16-30	154	4,581	308.0	9,161
July	22	1,352	84.1	5,170
August	22	1,352	24.7	1,518
September	22	1,309	24.9	1,481
October	22	1,352	35.3	2,170
November	22	1,309	36.0	2,142
December	22	1,352	29.5	1,813
		43,725		85,175

a/ Derived for a 29-year period of record (1944-1972 water years) for the USGS gauge at stream mile 44.1 (T5N, R4W, Sec. 3).

b/ The bankful flow, which is presently undefined, should be maintained for 24-hours during this period.

1. STREAM

Little Boulder River

2. DESCRIPTION

The Little Boulder River begins near Haystack Mountain (elevation 8,000 ft) on the east slope of the Continental Divide in an area known as Bull Mountain. It flows 15.7 miles before joining the Boulder River near Boulder, Montana. The mean gradient of the Little Boulder River is 204 feet per mile. At spring flow levels, it averages 17.6 feet in width. Approximately 79% of the stream is within the Deerlodge National Forest. Major tributaries of the Little Boulder are the North Fork Little Boulder, Elder, West, Beaver, Wilson and Moose Creeks. The Little Boulder drains an area of about 66 square miles. The Little Boulder is free-flowing its entire length. However, a dam proposal is pending for its lower reaches.

Recreational activities along the stream are mainly confined to fishing. The fishing pressure in 1975-1976 was estimated at 1,756 fisherman-days per year (MDFG, 1976).

Environmental problems that presently affect the Little Boulder are the severe dewatering that occurs in the lower reaches, bank instability where mining and road building have encroached on the floodplain and overuse of streamside vegetation by livestock.

The SCS (Farnes and Shafer, 1975) estimates the mean annual water yield for the Little Boulder drainage at 12,700 acre-feet (17.5 cfs). The 25 and 50 year instantaneous peak flows are estimated at 500 and 575 cfs, respectively.

No historic or current flow information is available for the Little Boulder River. The SCS has begun compiling flow information in regards to the proposed dam project.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of the Little Boulder River were surveyed by electrofishing on July 30 and August 14, 1974. Gamefish captured in descending order of abundance were brook, rainbow and brown trout. The electrofishing survey data are summarized in Table 92 .

Table 92 . Summary of electrofishing survey data collected for a 1,000 ft section of the Little Boulder River (T5N, R4W, Sec. 9B) on July 30 and August 14, 1974.

Fish Species	No. Captured	Length Range (inches)
Brook Trout	45	5.0-10.5
Rainbow Trout	20	4.2-10.7
Brown Trout	10	4.3-15.9

The standing crop of brook trout, the predominant trout speices in the section, was estimated using a mark-recapture method (Table 93). This 1,000 ft section supports an estimated population of 58 brook trout, weighing 9 pounds.

Table 93 . Estimated standing crop of brook trout in a 1,000 ft section of the Little Boulder River (T5N, R4W, Sec. 9B) on July 30, 1974. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Brook Trout	5.0- 5.9	11	
	6.0- 9.9	46	
	10.0-10.9	1	
		58 ($\pm$12)	9 ($\pm$2)

The standing crop of trout in a 440 ft section of the Little Boulder River near the mouth was also estimated in 1974 (Vincent, 1975). Game-fish captured in descending order of abundance were brown, rainbow and brook trout. The lower stream supports about 141 trout, weighing 57 pounds, per 1,000 ft (Table 94). Brown trout, the predominant trout species, accounted for about 55% of the total trout numbers and 60% of the biomass.

Table 94 . Estimated standing crop of trout in a 440 ft section of the Little Boulder River (T5S, R4W, Sec. 10C) on July 30, 1974. Eighty percent confidence intervals are in parentheses.

Species	Length Range (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Brown Trout	4.2-23.1	77 ($\pm$36)	34 ($\pm$7)
Rainbow Trout	5.5-14.1	48 ($\pm$ 9)	16 ($\pm$2)
Brook Trout	8.0-12.1	16 ($\pm$ 5)	7 ($\pm$2)
Total Trout		141 ($\pm$37)	57 ($\pm$8)

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 109 ft riffle-pool sequence located immediately upstream of the forest boundary (T5N, R4W, Sec. 18A). Five cross-sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 39.3, 23.7 and 9.5 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 38. The lower and upper inflection points occur at approximate flows of 8 and 19 cfs, respectively. Based on an evaluation of existing fishery, recreational use and other stream resource information, a flow of 10 cfs is recommended for the low flow period (July 1 - April 30). Recommendations for the high flow period (May 1 - June 30) cannot be derived due to the lack of long term gauge information.

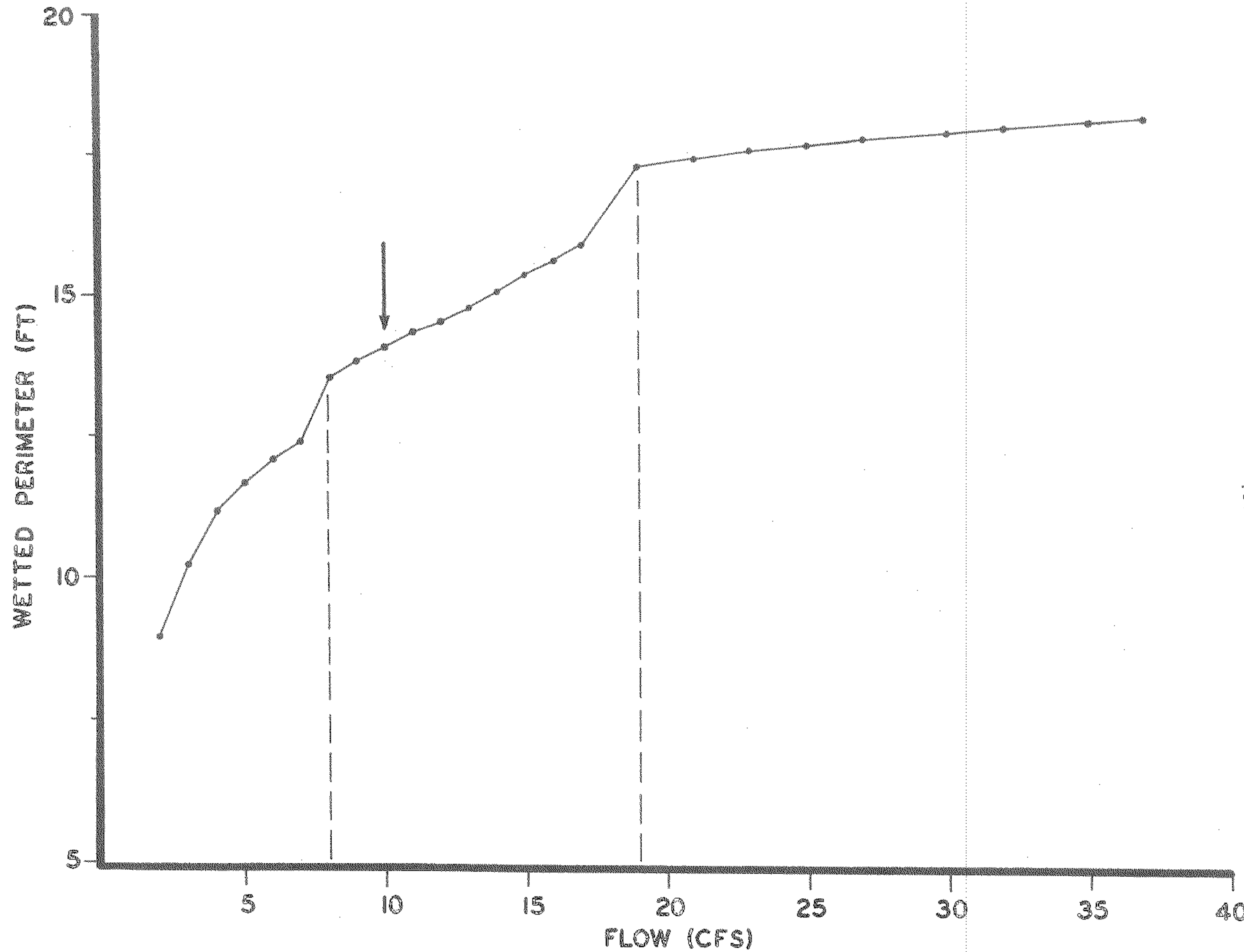


Figure 38. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in the Little Boulder River.

1. STREAM

North Willow Creek

2. GENERAL DESCRIPTION

North Willow Creek arises on the east slope of the Tobacco Root Mountains at Hollow Top Lake (elevation 8,560 feet) and flows 11.0 miles to its confluence with South Willow Creek (elevation 5,060 feet) to form Willow Creek, a tributary of Willow Creek (Harrison) Reservoir. The stream gradient averages 318 feet per mile. At spring flow levels, North Willow Creek averages 12.0 feet in width.

The upper half of the drainage is within the Beaverhead National Forest while the lower portion is surrounded by privately owned agricultural land. The major tributaries are Cataract, Pony and Charcoal Creeks. Presently, the flow in North Willow Creek is unregulated. In the past, lakes within the drainage have been artifically raised and installed with headgates to control the flow. There is no existing discharge information or any gauging sites in this drainage.

Recreational activities along North Willow Creek are primarily limited to fishing. Fishing pressure in 1975-76 was estimated at 53 fisherman-days annually (MDFG, 1976)

The lower half of North Willow Creek is dewatered during the summer irrigation season. Other concerns that could affect the stream resource include the extensive mining operations within the area, road building and the resulting sedimentation,and overgrazing of the riparian zone by cattle.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of North Willow Creek were surveyed by electrofishing on September 16 and October 23, 1980. Game fish captured in descending order of abundance were brook, brown and rainbow trout. The mottled sculpin was the only non-game species captured. The electrofishing survey data are summarized in Table 95.

Table 95. Summary of electrofishing survey data collected for a 1,000 ft section of North Willow Creek (T2S, R3W, Sec 24A) on September 16 and October 23, 1980.

Species	Number Captured	Length Range (inches)
Brook Trout	143	3.2 - 10.5
Brown Trout	2	8.1 - 10.7
Rainbow Trout	1	9.8
Mottled Sculpin	-	-

The standing crop of brook trout, the predominant trout species in the section, was estimated using a mark-recapture method (Table 96). This 1,000 ft section supports an estimated population of 325 brook trout, weighing 45 pounds. The populations of brown and rainbow trout are too sparse to estimate using the mark-recapture method.

Table 96 . Estimated standing crop of brook trout in a 1,000 ft section of North Willow Creek (T2S, R3W, Sec 24A) on September 17, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Number	Per 1,000 ft Pounds
Brook Trout	3.2 - 5.9	140	
	6.0 - 9.9	177	
	10.0 - 10.5	8	
		325(±66)	45(±11)

The DFWP began a program in 1978 to reestablish a self-sustaining population of rainbow trout in Harrison Reservoir by planting fingerlings of a wild strain of trout into the Willow Creek drainage. The continued stocking of a domestic strain of hatchery rainbow trout over the years had apparently eliminated the reproducing wild trout population, resulting in a poor recreational fishery in the reservoir. The plant of wild fingerlings was expected to rear in the tributaries, move downstream to the reservoir and, when sexually mature, return to the tributaries to spawn. In the spring of 1981, the reestablished rainbow spawning run was large enough to be used as an egg source by the department's Anaconda Trout Hatchery. A portion of the run in Willow Creek was trapped, eggs were taken and fertilized, then transferred to the hatchery to be raised for release into other waters. It is anticipated that in future years the recreational fishery of Harrison Reservoir will be maintained entirely by the natural reproduction that is occurring in Willow Creek and other tributaries.

It is presently unknown whether North Willow Creek is accessible to spawners from Harrison Reservoir. North Willow Creek, however, does serve as an important source of the water that is needed for maintaining the crucial spawning and rearing habitat of Willow Creek.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 75.5 ft cascading sub-reach located immediately above the forest boundary (T2S, R3W, Sec 25B). Five cross-sections were placed in the sub-reach. The WETP program was calibrated to field data collected at flows of 18.2, 8.7 and 8.2 cfs.

The relationship between wetted perimeter and flow for the composite of all five cross-sections is shown in Figure 39. The lower and upper inflection points occur at approximate flows of 2.5 and 7 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 6 cfs is recommended for the low flow period (July 16 - April 30).

Flow recommendations for the high flow period (approximately May 1 - July 15) can not be derived due to the lack of long-term flow records for North Willow Creek.

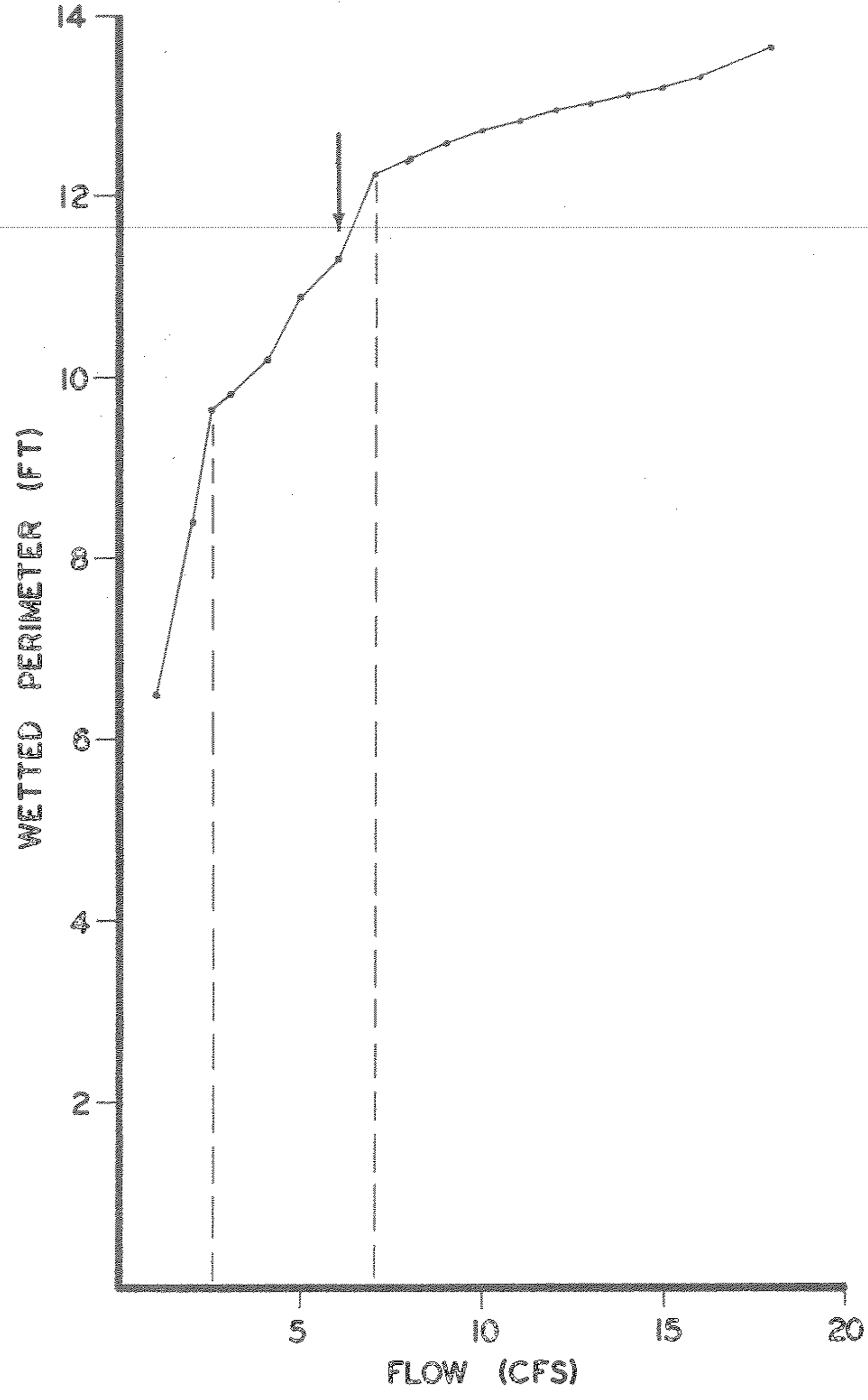


Figure 39. The relationship between wetted perimeter and flow for a composite of five cross-sections in North Willow Creek.

1. STREAM

South Boulder River

2. GENERAL DESCRIPTION

The South Boulder River begins at the confluence of its East and West Forks (elevation 6,880 feet) in the Tobacco Root Mountains of southwest Montana and flows north for 17.5 miles to its confluence with the Jefferson River near Cardwell, Montana. The mean gradient is 149 feet per mile. At spring flow levels the stream averages 38.1 feet in width. The upper 41 percent of the South Boulder is within the Deerlodge National Forest. Major tributaries of the South Boulder River include Limekiln, Carmichael, Rock, McGovern and Curly Creeks as well as the East and West Forks. The South Boulder drains an area of approximately 95 square miles.

The USGS operated a gauge at stream mile 15.2 from 1926-34. The mean, maximum and minimum flows for the period of record are 32.8, 434 and 2.0 cfs, respectively.

The SCS (Farnes and Shafer, 1975) estimates the mean annual water yield for the South Boulder drainage at 37,000 acre-feet (51.1 cfs). The 25 and 50 year instantaneous peak flows are estimated at 1,000 and 1,150 cfs, respectively.

Recreational use along the South Boulder River is substantial. It is a popular place to picnic, camp and fish. The fishing pressure in 1975-76 was estimated at 674 fisherman-days per year (MDFG, 1976).

Sections of the lower South Boulder are totally dewatered during the summer irrigation season. Other concerns that could potentially affect the stream resource include the subdivision of land surrounding the stream and the mining activity within the drainage.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of the South Boulder River were surveyed by electrofishing on September 16 and October 24, 1980. Game fish captured in descending order of abundance were rainbow and brook trout. No non-game species were collected. The electrofishing survey data are summarized in Table 97.

Table 97. Summary of electrofishing survey data collected for a 1,000 ft section of the South Boulder River (T1S, R3W, Sec 21D) on September 16 and October 24, 1980.

Species	Number Captured	Length Range (inches)
Rainbow Trout	171	2.5 - 11.3
Brook Trout	64	3.1 - 10.4

The standing crop of rainbow trout, the predominant trout species in the section, was estimated using a mark-recapture method (Table 98). This 1,000 ft section supports an estimated population of 343 rainbow trout, weighing 40 pounds. The population of brook trout was too sparse to reliably estimate using the mark-recapture method.

Table 98. Estimated standing crop of rainbow trout in a 1,000 ft section of the South Boulder River (T1S, R3W, Sec 21D) on September 16, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Number	Per 1,000 ft Pounds
Rainbow Trout	2.5 - 5.9	204	
	6.0 - 9.9	129	
	10.0 - 11.3	10	
		343($\pm$76)	40($\pm$8)

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 237 ft riffle-pool sequence located near the forest boundary (T1S, R3W, Sec 28A) at about stream mile 9.4. Five cross-sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 162.4, 75.0 and 41.3 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 40. The lower and upper inflection points occur at approximate flows of 15 and 40 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 25 cfs is recommended for the low flow period (July 1 - April 30).

The monthly flow recommendations for the low flow period are listed in Table 99. The mean monthly flows of record for the USGS gauge on the South Boulder are also listed for comparison. The recommendations exceed the mean flows for the months of September through April.

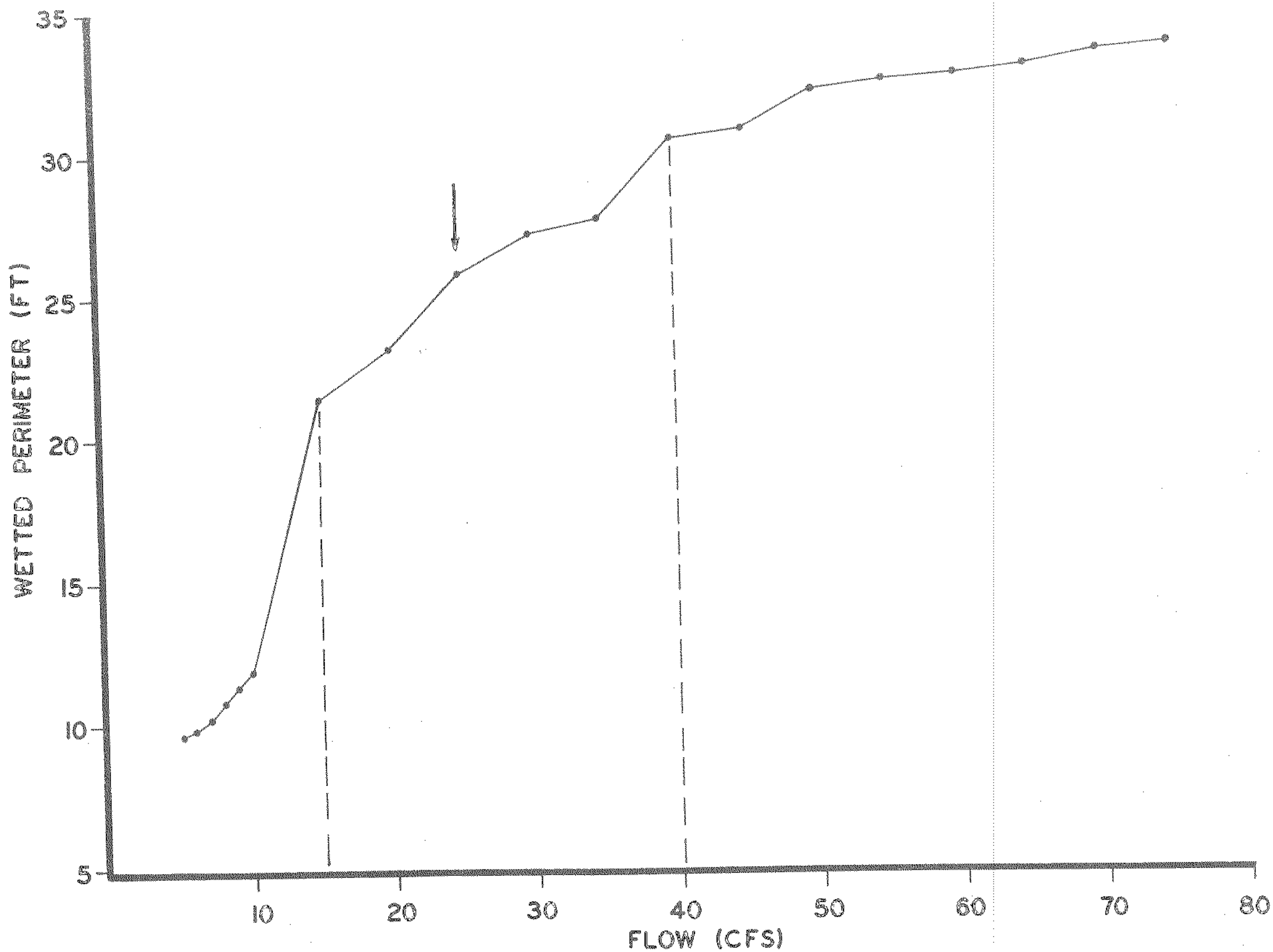


Figure 40. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in the South Boulder River.

Table 99. Instream flow recommendations derived for the South Boulder River using the wetted perimeter/inflection point method (low flow period) compared to the mean flows of record.

	Recommended Flows (CFS)	Mean Flows[a/] (CFS)
January	25	8.9
February	25	8.1
March	25	6.9
April	25	11.6
May	b/	58.4
June	b/	134.5
July	25	68.5
August	25	28.4
September	25	20.8
October	25	18.2
November	25	14.0
December	25	11.5

a/Derived for the June 1926 - September 1934 period of record for the USGS gauge at stream mile 15.2 (T2S, R3W, Sec 18).

b/Recommendations for the high flow period (May 1 - June 30) are presently unavailable due to the lack of adequate flow data for the South Boulder River.

1. STREAM

South Willow Creek

2. GENERAL DESCRIPTION

South Willow Creek arises on the southeast side of the Tobacco Root Mountains in southwest Montana. The stream originates at Granite Lake (elevation 8,920 ft) and flows 16.6 miles before joining North Willow Creek to form Willow Creek, a tributary of Harrison (Willow Creek) Reservoir. The mean gradient is 232 feet per mile. At spring flow levels, South Willow Creek averages 26.4 feet in width. Although the upper 60 percent of the stream is within the forest boundary, substantial private holdings exist within the boundary primarily along the creek. Two major tributaries are Potosi Creek and Rock Creek. No discharge information is presently available for South Willow Creek.

Recreational activities along South Willow Creek are mainly confined to camping and fishing. The Beaverhead National Forest maintains a popular campground adjacent to the creek. Fishing pressure on South Willow Creek in 1975-76 was estimated at 55 fisherman-days annually (MDFG, 1976).

The lower portion of South Willow Creek is dewatered during the summer irrigation season. Other problems potentially affecting the stream resource include mining, sedimentation resulting from road construction,and over grazing of the riparian zone by cattle.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of South Willow Creek were surveyed by electrofishing on September 17 and October 23, 1980. Game fish captured in descending order of abundance were rainbow, brook and brown trout. No non-game species were captured. The electrofishing survey data are summarized in Table 100.

Table 100. Summary of electrofishing survey data collected for a 1,000 ft section of South Willow Creek (T3S, R2W, Sec 6A) on September 17 and October 23, 1980.

Species	Number Captured	Length Range (inches)
Rainbow Trout	188	3.3 - 12.9
Brook Trout	33	4.2 - 9.9
Brown Trout	3	9.3 - 10.8

The standing crop of rainbow trout, the predominant trout species in the section, was estimated using a mark-recapture method (Table 101). This 1,000 ft section supports about 325 rainbow trout, weighing 38 pounds. The populations of brook and brown trout were too sparse to reliably estimate using the mark-recapture method.

Table 101. Estimated standing crop of rainbow trout in a 1,000 ft section of South Willow Creek (T3S, R2W, Sec 6A) on September 17, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Numbers	Per 1,000 ft Pounds
Rainbow Trout	3.3 - 5.9	195	
	6.0 - 9.9	123	
	10.0 - 12.9	7	
		325($\pm$56)	38($\pm$5)

The DFWP began a program in 1978 to reestablish a self-sustaining population of rainbow trout in Harrison Reservoir by planting fingerlings of a wild strain of trout into the Willow Creek drainage. The continued stocking of a domestic strain of hatchery rainbow trout over the years had apparently eliminated the reproducing wild trout population, resulting in a poor recreational fishery in the reservoir. The plant of wild fingerlings was expected to rear in the tributaries, move downstream to the reservoir and, when sexually mature, return to the tributaries to spawn. In the spring of 1981, the reestablished rainbow spawning run was large enough to be used as an egg source by the department's Anaconda Trout Hatchery. A portion of the run in Willow Creek was trapped, eggs were taken and fertilized, then transferred to the hatchery to be raised for release into other waters. It is anticipated that in future years the recreational fishery of Harrison Reservoir will be maintained entirely by the natural reproduction that is occurring in Willow Creek and other tributaries.

It is presently unknown whether South Willow Creek is accessible to spawners from Harrison Reservoir. South Willow Creek, however, does serve as an important source of the water that is needed for maintaining the crucial spawning and rearing habitat of Willow Creek.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 116 ft riffle-pool sequence located immediately above the forest boundary (T3S, R2W, Sec 6A). Five cross-sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 77.7, 35.7 and 18.8 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 41. The lower and upper inflection points occur at approximate flows of 14 and 17 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 14 cfs is recommended for the low flow period (July 16 - April 30). Flow recommendations for the high flow period (approximately May 1 - July 15) cannot be derived due to the lack of long-term flow records for South Willow Creek.

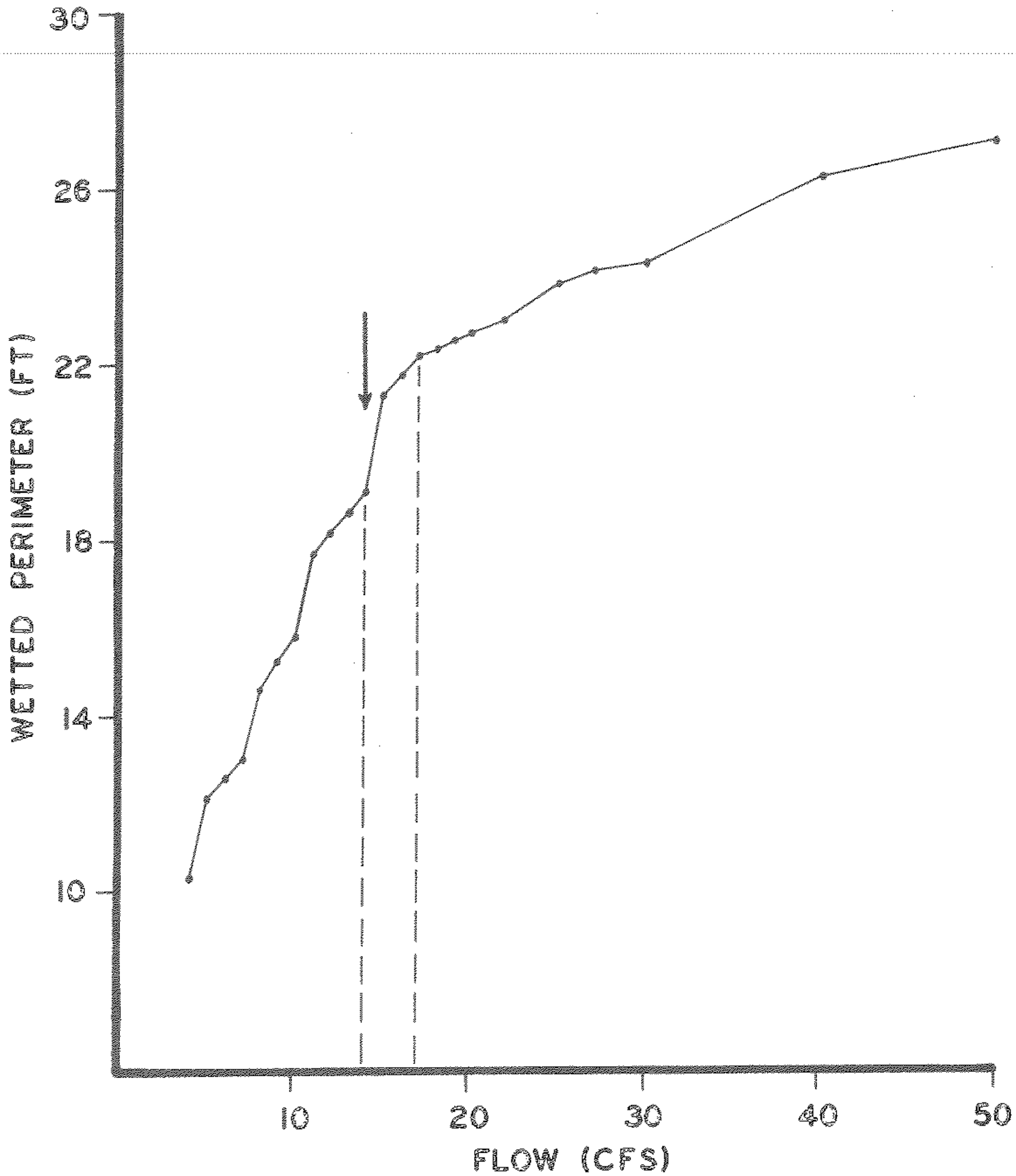


Figure 41. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in South Willow Creek.

1. STREAM

Whitetail Creek

2. GENERAL DESCRIPTION

Whitetail Creek originates at the outlet of Whitetail Reservoir (elevation 7,249 ft) and flows southeasterly for 23.7 miles before discharging into the Jefferson Slough, a tributary of the Jefferson River. The stream gradient averages 114 feet per mile. At spring flow levels, Whitetail Creek averages 17.7 feet in width. Approximately 31 percent of the stream is within the boundaries of the Deerlodge National Forest. The flow of Whitetail Creek is regulated by Whitetail Reservoir. Little Whitetail Creek is the major tributary and lesser tributaries include Spring, Grouse, Sage, Wall and Gillispie Creeks. Whitetail Creek drains an area of about 186 square miles.

The USGS operated a gauge on Whitetail Creek at stream mile 18.6 from 1949-53, 1955-58 and 1959-68. Winter records are unavailable after 1951. The maximum and minimum flows for the period of record are 126 and 0.2 cfs, respectively.

The SCS (Farnes and Schafer, 1975) estimates the mean annual water yield for the Whitetail Creek drainage at 15,900 acre-feet (22.0 cfs). The 25 and 50 year instantaneous peak flows are estimated at 900 and 1,035 cfs, respectively.

Angler use of Whitetail Creek is substantial. Fishing pressure in 1975-76 was estimated at 797 man-days per year (MDFG, 1976).

Existing environmental concerns that are potentially capable of impacting the stream resource include the severe dewatering of the lower reaches during the summer irrigation season, bank instability and mining activity within the drainage.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Whitetail Creek were surveyed by electrofishing on September 15 and October 24, 1980. Game fish captured in descending order of abundance were brown and rainbow trout. The mottled sculpin was the only non-game species collected. The electrofishing survey data are summarized in Table 102.

Table 102. Summary of electrofishing survey data collected for a 1,000 ft section of Whitetail Creek (T3N, R5W, Sec 25B) on September 15 and October 24, 1980.

Species	Number Captured	Length Range (inches)
Brown Trout	252	4.5 - 15.4
Rainbow Trout	13	5.1 - 12.0
Mottled Sculpin	-	-

The standing crop of brown trout, the predominent trout species in the section, was estimated using a mark-recapture method (Table 103). This 1,000 ft section supports an estimated population of 318 brown trout, weighing 107 pounds. The population of rainbow trout was too sparse to reliably estimate using the mark-recapture method.

Numerous beaver ponds along Whitetail Creek provide essential trout habitat during the winter when the reservoir stores all flows for release during the upcoming irrigation season.

Table 103. Estimated standing crop of brown trout in a 1,000 ft section of Whitetail Creek (T3N, R5W, Sec 25B) on September 15, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Number	Per 1,000 ft Pounds
Brown Trout	4.5 - 5.9	15	
	6.0 - 9.9	200	
	10.0 - 15.4	103	
		318(±43)	107(±15)

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 110 ft riffle-pool sequence located immediately upstream of the forest boundary (T3N, R5W, Sec 23D). Five cross-sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 26.4, 7.3 and 4.4 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 42. The lower and upper inflection points occur at approximate flows of 4 and 7 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 7 cfs is recommended for the low flow period (July 1 - April 30).

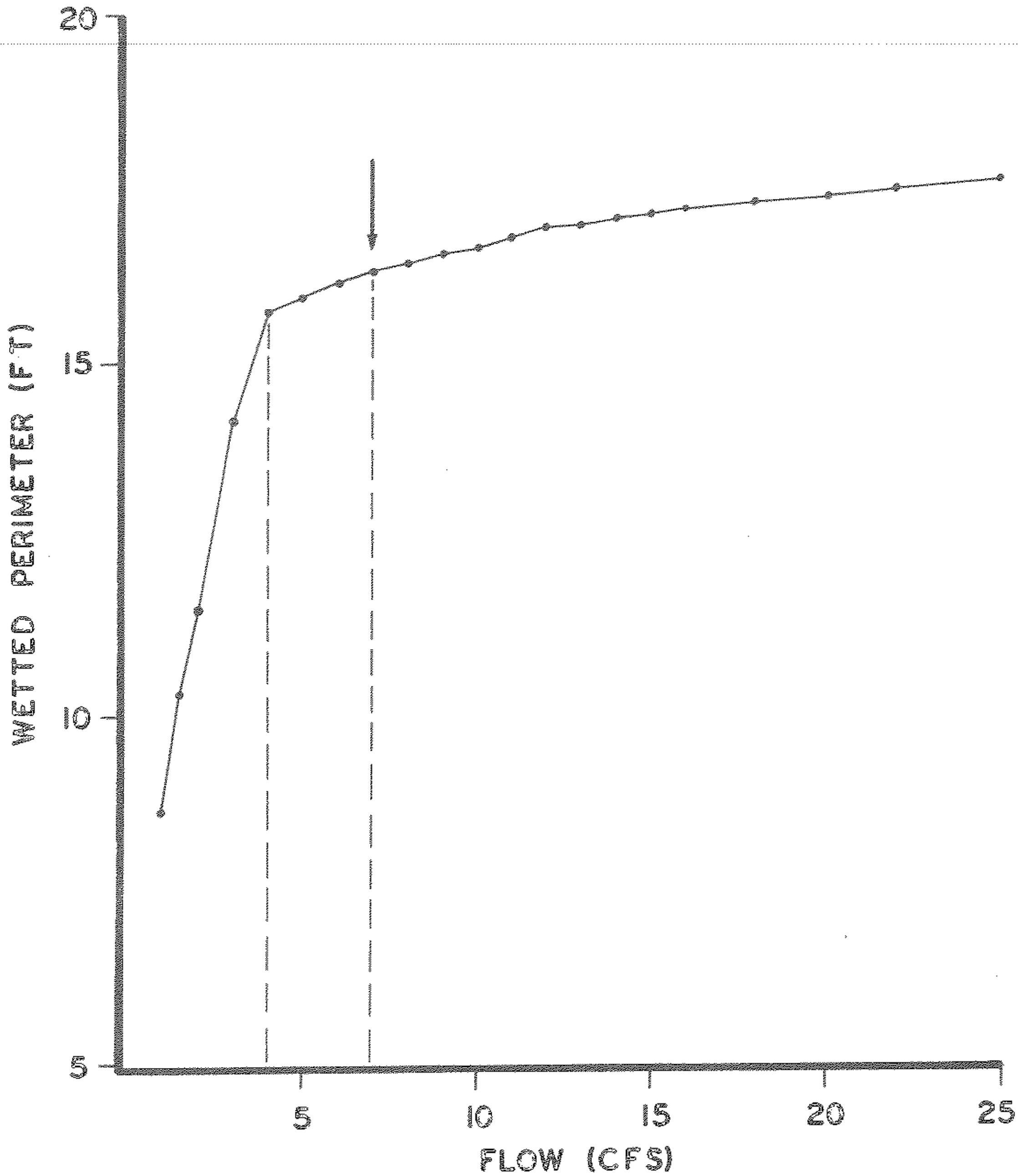


Figure 42. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Whitetail Creek.

Monthly flow recommendations for the low flow period are listed in Table 104. The mean monthly flows of record at the USGS gauge on Whitetail Creek are also listed for comparison. The recommendations exceed the mean flows for the months of November through April.

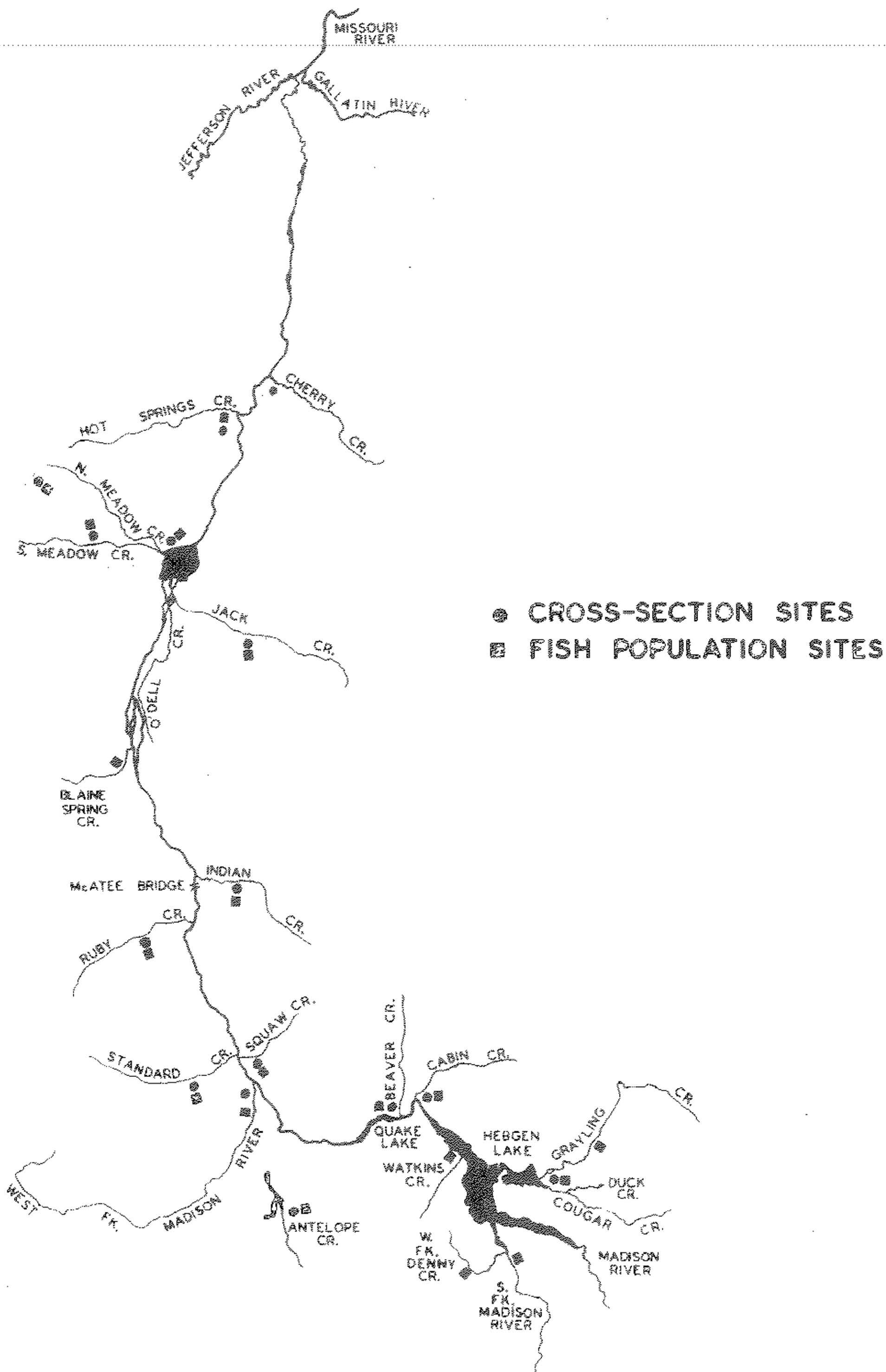
Table 104. Instream flow recommendations derived for Whitetail Creek using the wetted perimeter/inflection point method (low flow period) compared to the mean flows of record.

	Recommended Flows (cfs)	Mean Flows (cfs)[a]
January	7	1.4
February	7	1.8
March	7	1.8
April	7	3.6
May	b/	22.9
June	b/	41.9
July	7	25.1
August	7	27.7
September	7	17.4
October	7	7.3
November	7	2.6
December	7	2.1

a/ Derived for the 1949-53, 1955-58 and 1959-68 period of record for the USGS gauge at stream mile 18.6 (T3N, R5W, Sec. 10D).

b/ Recommendations for the high flow period (May 1 - June 30) are presently unavailable due to the lack of adequate flow data for Whitetail Creek.

MADISON RIVER TRIBUTARIES



The study areas of the Madison River Drainage.

1. STREAM

Antelope Creek

2. DESCRIPTION

Antelope Creek originates on the north slope of the Henry's Lake Mountains of southwest Montana. It flows in a northerly direction for about 8.5 miles before discharging into Cliff Lake. Stream elevations at the origin and mouth are 7,680 and 6,320 ft, respectively. The stream gradient averages 160 ft/mile and channel width range from about 1.5 to 20 ft. Annual precipitation within the drainage ranges from 16 to over 30 inches.

A majority of the land encompassing Antelope Creek consists of timber stands interspersed in a sagebrush-grass rangeland. Stock grazing is the major land use activity in the drainage.

Recreational activities within the drainage include hunting, fishing, and horseback riding. Access to Antelope Creek is by boat (via Cliff Lake) or motor vehicle via a single lane road.

Water resource information is very limited for Antelope Creek. The State Engineer's Office (1954) lists two water appropriations, amounting to 10 cfs, for Antelope Creek. No flow information is available.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Antelope Creek were surveyed by electrofishing on July 9 and 24, 1980. The rainbow trout and white sucker were the only species captured. The electrofishing survey data are summarized in Table 105.

Table 105. Summary of electrofishing survey data collected for a 1,000 ft section of Antelope Creek (T12S, R1E, Sec. 36A) on July 9 and 24, 1980.

Species	No. Captured	Length Range (inches)
Rainbow Trout	115	2.1-16.0
White Sucker	6	13.4-14.6

The standing crop of rainbow trout in the section was estimated using a mark-recapture method (Table 106). The estimate shows that this 1,000 ft section supports about 247 rainbow trout, weighing 54 pounds.

Table 106. Estimated standing crop of rainbow trout in a 1,000 ft section of Antelope Creek (T12S, R1E, Sec. 36A) on July 9, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Pounds
Rainbow Trout	3.0- 5.9	115	
	6.0- 9.9	105	
	10.0-16.0	27	
		247 (±76)	54 (±13)

In addition to supporting a resident trout population, Antelope Creek also provides crucial spawning and rearing habitat for the rainbow trout population of Cliff Lake. The sport fishery of the lake is wholly maintained by the natural reproduction that occurs in Antelope Creek and other tributaries.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 102 ft riffle-run sequence located near stream mile 0.2 (T12S, R1E, Sec. 36A). Seven cross-sections were placed in this sequence.

The site was visited on May 29, July 1, 9 and 24, and September 9, 1980. During this period the flow of Antelope Creek remained stable at 14.2-15.3 cfs. Consequently, the collection of the field data needed for calibrating the WETP program could not be completed.

Antelope Creek appears to be spring fed and not appreciably influenced by snow-melt. Spring creeks receive special consideration in the instream flow program of the DFWP. Spring creeks in general are a highly utilized recreational resource that can provide outstanding habitat for trout and waterfowl. Due to the unique features of the spring creek environment and their high recreational value, all effort should be made to prevent the further degradation of the few remaining spring creeks in southwest Montana. Water withdrawals would only accelerate the demise of this already declining aquatic resource.

It is, therefore, recommended that all existing unappropriated waters in Antelope Creek remain instream for the maintenance of fish and wildlife habitat for the period of January 1 - December 31. Based on limited stream flow data, this recommendation amounts to an approximate year-round flow of 14 cfs or about 10,133 acre-feet of water per year.

1. STREAM

Beaver Creek

2. DESCRIPTION

Beaver Creek originates in the Taylor-Hilgard Mountains of southwest Montana and flows in a southerly direction for about 11.3 miles before discharging into Earthquake Lake on the Madison River. It drains an area of about 53 square miles. From the headwaters at about 8,880 ft to the mouth at about 6,460 ft, the stream gradient averages 207 ft/mile. Channel widths range from 3 to 60 ft. Annual precipitation within the drainage ranges from 20-60 inches and averages 44 inches.

Between the mouth and stream mile 5.9, the stream flows through a sparsely forested, marshy floodplain vegetated with lodgepole pine, douglas fir, willows and aspen. Numerous log jams, floodplain debris piles and unstable banks have created a multi-channel streambed. Excessive bedload movement has been observed in this reach. The stream gradient is approximately 59 ft/mile and channel widths range from about 20-60 ft. Big game animals found in the lower drainage are elk and mule deer. Black bear are occasionally seen during the summer and early fall months. Moose commonly winter along the stream. The beaver is the principle furbearer in the area. Other furbearers include mink, marten, weasel, coyote and bobcat. Upland gamebirds found in the area are ruffed and blue grouse.

The reach between stream mile 5.9 and the headwaters lies within a steep valley vegetated with lodgepole pine and Douglas fir. Numerous log jams and bankside debris piles are present. The stream gradient averages about 373 ft/mile and channel widths range from about 4-25 ft. This upper drainage primarily serves as summer range for moose. Elk are also present. Two important elk winter migration routes traverse this upper reach. Small numbers of mountain goat and bighorn sheep use the adjacent slopes and peaks. Upland game birds in the area include ruffed, blue and Franklin grouse. Furbearers include mink, marten, bobcat, weasel, coyote, badger and wolverine. A portion of the upper drainage is included in the Taylor-Hilgard Wilderness Area.

Water resource data for the Beaver Creek drainage have been gathered sporadically since 1959. The USFS operated a gauge at the Highway 287 bridge (T11S, R3E, Sec. 21) from 1971-80. The approximate mean flows of record for the months of April through October are summarized in Table 107 . The maximum and minimum flows for the period of record are 937 cfs (June, 1971) and 34 cfs (April, 1977), respectively.

The SCS (1976) estimates the mean annual water yield for the Beaver Creek drainage at 54,000 acre-feet (74.6 cfs). The 25 and 50-year instantaneous peak flows are estimated at 724 and 833 cfs, respectively.

The Beaver Creek drainage is divided in an east-west direction into two geological soil types (Snyder et al., 1978). Tributaries in the eastern half of the drainage lie in an unstable sedimentary formation. During periods of high runoff, high sediment and dissolved solid loads are produced. The western tributaries lie in a stable formation that produces low sediment and dissolved solid loads during runoff.

Table 107. Approximate mean monthly flows of record for Beaver Creek.

Month	Approximate Mean Flows (cfs)[a]
May	142
June	300
July	203
August	117
September	117
October	60

a/ Derived for the 1971-73 and 1975-77 period of record for the USFS gauge in T11S, R3E, Sec. 21.

The two principle activities in the Beaver Creek drainage are logging and recreation. Some logging has occurred in the eastern half of the drainage during the last 20 years, but is now limited to salvage operations.

Approximately 8 miles of controlled-access road serve the eastern half of the drainage. The western half is undeveloped with limited access. USFS trails provide access to the entire drainage. Major recreational activities include big game hunting (September-November), backpacking, fishing and snowmobiling. Although no mining has occurred in the Beaver Creek drainage, deposits of copper have been found and some prospecting for mica has occurred.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Beaver Creek were surveyed by electrofishing on August 21, 1980. The rainbow trout and longnose sucker were the only species captured. The electrofishing survey data are summarized in Table 108.

Table 108. Summary of electrofishing survey data collected for a 1,000 ft section of Beaver Creek (T11S, R3E, Sec. 16A) on August 21, 1980.

Species	No. Captured	Length Range (inches)
Rainbow Trout	10	3.0- 7.0
Longnose Sucker[a]	4	13.7-16.0

a/ Many other longnose suckers were seen but not captured.

The population of trout in this section was too sparse to reliably estimate using the mark-recapture method.

Trout residing in Earthquake Lake and the Madison River are believed to use Beaver Creek for spawning and the rearing of their young. However, spawning runs are presently undocumented.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 231 ft riffle-pool sequence located near stream mile 1.2 (T11S, R3E, Sec. 16D). Eight cross-sections were placed in this sequence. The WETP computer program was calibrated to field data collected at flows of 60.4, 101.9 and 142.5 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 43. The lower and upper inflection points occur at approximate flows of 24 and 48 cfs, respectively.

Flow recommendations for Beaver Creek were derived from the water management plan for Hebgen Reservoir and the upper Madison River rather than the wetted perimeter/inflection point method. A description of this plan and pertinent background information follows.

Flows in the Madison River are regulated by Hebgen Reservoir, which stores water for downstream hydro-electric generation. The present water management plan for the reservoir, which was formulated through a cooperative agreement between the Montana Power Company (the operator of Hebgen Dam), the US Forest Service and the Montana Department of Fish, Wildlife and Parks, calls for a minimum flow release of 50 cfs when Hebgen Reservoir is filled from about May 15 to July 15. This allows the reservoir to fill during the runoff period. Prior to the initiation of the plan in 1968, the reservoir was filled during late winter and early spring, a period when the natural flows of the river are lowest for the year. As a result, the entire 100 miles of free-flowing river below Hebgen Dam were severely dewatered from February through April. Electrofishing data collected by the DFWP confirmed that this winter dewatering substantially reduced trout populations throughout the river.

The management plan has eliminated the winter dewatering problem since water is no longer stored during the February through April period, thereby, allowing winter flow releases to approximate the natural condition. During the runoff period when the reservoir is filled and releases are reduced, only the river fishery between Hebgen Dam and Earthquake Lake is seriously jeopardized since the runoff flows of the many tributaries of the upper river insure that dewatering does not occur in the remaining 97 miles of free-flowing river. The plan basically compromises the trout fishery in 3 miles of the Madison River in order to protect the fishery in the remaining 97 miles.

The tributaries of the upper Madison River are essential for maintaining an acceptable flow in the upper river during the runoff period when Hebgen Reservoir is filled. In some years, drought conditions or abnormal seasonal flow patterns may require a temporary modification of this water management plan. Consequently, the tributaries may become an essential water source in other than the normal snow runoff period. To protect this crucial water supply, it is recommended that all unappropriated waters of the major tributaries of the upper Madison River, including Beaver Creek, be maintained instream for the period of January 1 through December 31. For Beaver Creek, this recommendation amounts to about 54,000 acre-feet of water in an average year.

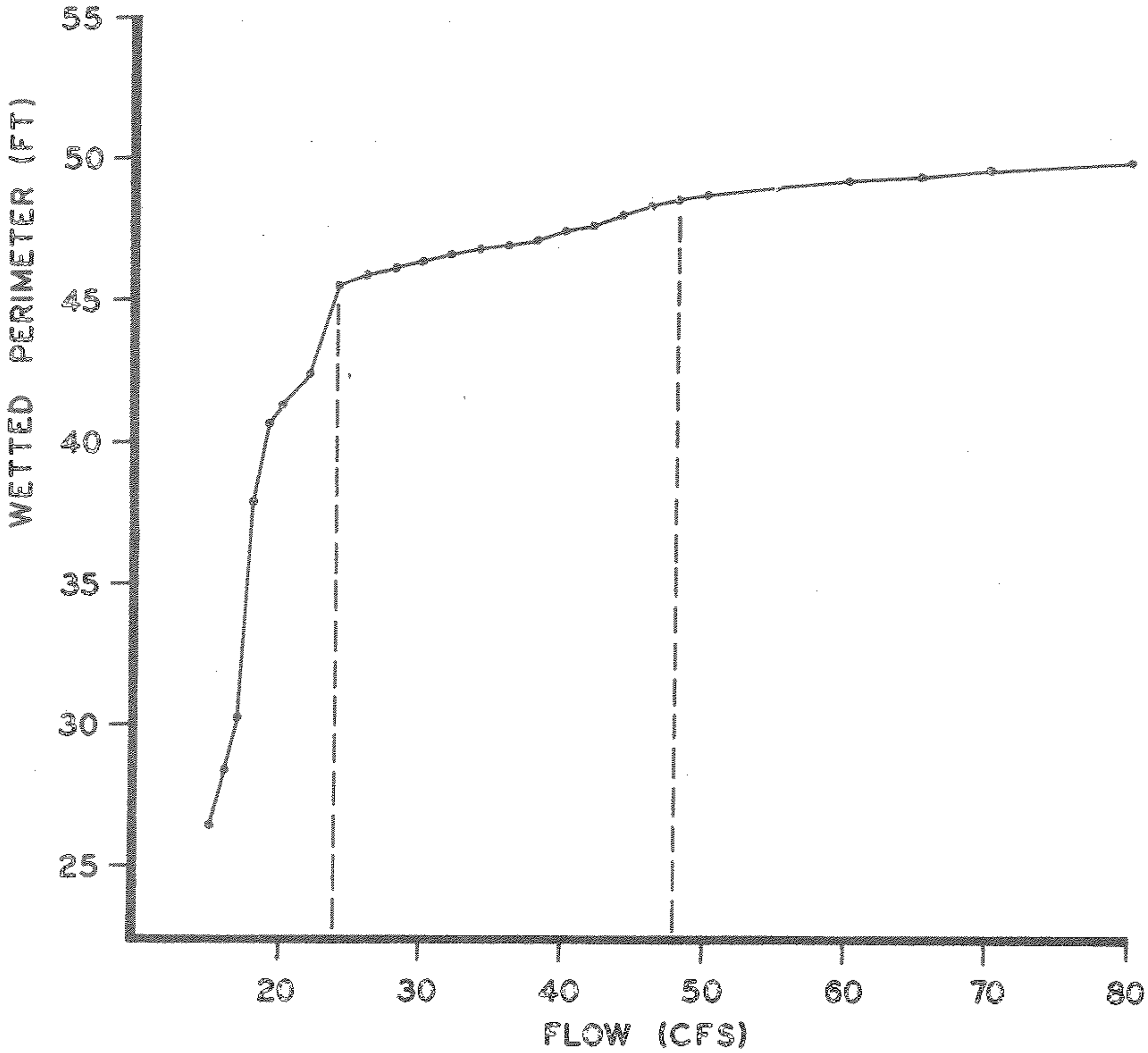


Figure 43. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Beaver Creek.

1. STREAM

Cabin Creek

2. DESCRIPTION

Cabin Creek arises in the Taylor-Hilgard Mountains of southwest Montana and flows in a southwesterly direction for about 10 miles before joining the Madison River at river mile 107. Stream elevations at the origin and mouth are about 8,400 and 6,470 ft, respectively. The stream gradient averages approximately 193 ft/mile and channel widths range from about 4-25 ft. The annual precipitation within the drainage ranges from 10-50 inches and averages 39 inches. Cabin Creek drains an area of about 30 sq miles.

From 1910 through 1968, the primary nonrecreational land use within the Cabin Creek drainage was the grazing of domestic sheep. Since 1968, stock grazing has been curtailed. Recreation, most notably big game hunting, is now the predominant activity within the drainage. Other recreational activities include backpacking, trailbiking, snowmobiling, horseback riding and fishing. Fishing pressure on Cabin Creek in 1975-76 was estimated at 37 man-days/year (MDFG, 1976).

The Cabin Creek drainage is presently unroaded. Two USFS trails, which traverse the drainage, receive only light use. No logging or mining are known to have occurred in the drainage. However, deposits of copper and good quality limestone are present.

The USFS has operated a gauge on Cabin Creek since 1971. Flow data are available for the months of May through October for the years 1971-80. The gauge is located near the Highway 287 bridge near the mouth (T11S, R3E, Sec. 15). The maximum and minimum flows of record are 1,280 cfs (May, 1971) and 5.3 cfs (October, 1976), respectively. The approximate mean monthly flows of record are listed in Table 109.

The USGS has operated a crest-stage gauge near the mouth of Cabin Creek (T11S, R3E, Sec. 15) since 1974. The maximum flow recorded was 460 cfs. The SCS (1976) estimates the 25 and 50 year instantaneous peak flows at 560 and 644 cfs, respectively.

Table 109. Approximate mean monthly flows of record for Cabin Creek.

Month	Approximate Mean Flows (cfs)[a/]
May	227
June	362
July	96
August	28
September	22
October	15

a/ Derived from partial flow records collected by the USFS for the May, 1971 - October, 1977 period at the USFS gauge site in T11S, R3E, Sec. 15.

The Cabin Creek drainage supports populations of elk, mule deer, moose, black bear, grizzly bear, cougar, mountain goat and bighorn sheep. High densities of elk and moose are found in the drainage during the period from early summer through fall. The drainage also contains important habitat for grizzly bear (USDA-USFS, 1977). Small populations of mountain goat and bighorn sheep are associated with adjacent foothills and peaks. Upland game birds found are ruffed, blue and franklin grouse. Furbears include mink, marten, bobcat and beaver.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Cabin Creek were surveyed by electrofishing on July 16 and 22, 1980. Game fish captured in descending order of abundance were rainbow and brown trout. Nongame species captured were longnose sucker and mottled sculpin. The electrofishing survey data are summarized in Table 110. Cutthroat trout, which have been reported in Cabin Creek and its tributaries by other investigators, were not collected during this investigation.

Table 110. Summary of electrofishing survey data collected for a 1,000 ft section of Cabin Creek (T11S, R3E, Sec. 15D) on July 16 and 22, 1980.

Species	No. Captured	Length Range (inches)
Rainbow Trout	6	3.9-6.2
Brown Trout	2	3.8-5.0
Longnose Sucker	1	14.7
Mottled Sculpin	-	-

The standing crop of trout was too sparse to reliably estimate using the mark-recapture method.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 123 ft riffle-run sequence located near stream mile 0.2 (T11S, R3E, Sec. 15D). Five cross-sections were placed within the sequence. The WETP computer program was calibrated to field data collected at flows of 30.6, 53.7 and 102.7 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is shown in Figure 44 . The lower and upper inflection points occur at approximate flows of 11 and 20 cfs, respectively.

Flow recommendations for Beaver Creek were derived from the flow management plan for the upper Madison River rather than the wetted perimeter/ inflection point method. A discussion of this plan and pertinent background information follows.

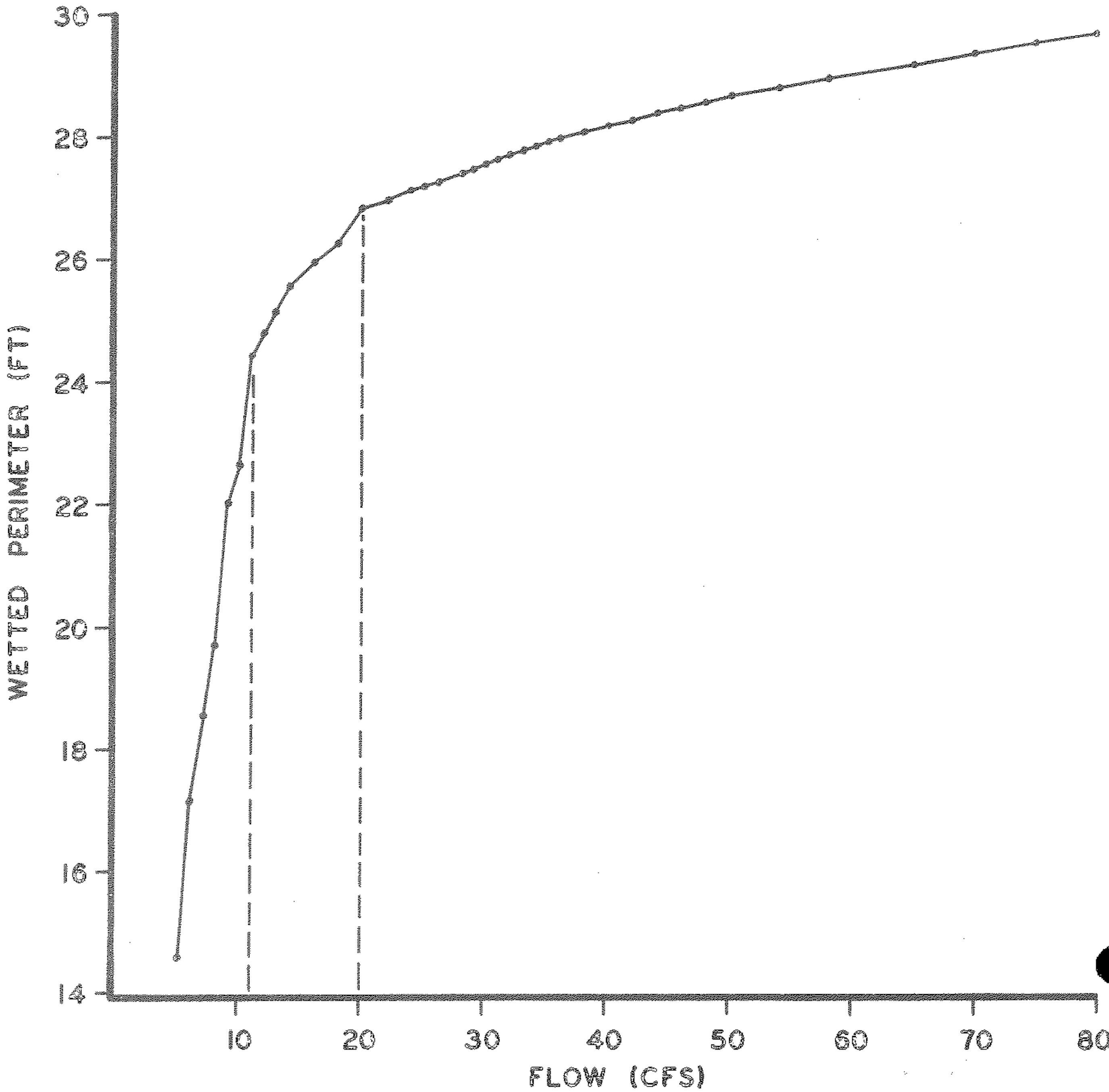


Figure 44. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Cabin Creek.

Flows in the Madison River are regulated by Hebgen Reservoir, which stores water for downstream hydro-electric generation. The present water management plan for the reservoir, which was formulated through a cooperative agreement between the Montana Power Company (the operator of Hebgen Dam), the US Forest Service and the Department of Fish, Wildlife and Parks, calls for a minimum flow release of 50 cfs when Hebgen Reservoir is filled from about May 15 to July 15. This allows the reservoir to fill during the snow runoff period. Prior to the initiation of the plan in 1968, the reservoir was filled during late winter and early spring, a period when the natural flows of the river are lowest for the year. As a result, the entire 100 miles of free-flowing river below Hebgen Dam were severely dewatered from February through April. Electrofishing data collected by the DFWP confirmed that this winter dewatering substantially reduced trout populations throughout the river.

The management plan has eliminated the winter dewatering problem since water is no longer stored during the February through April period, thereby, allowing winter flow releases to approximate the natural condition. During the runoff period when the reservoir is filled and releases are reduced, only the river fishery between Hebgen Dam and Earthquake Lake is seriously jeopardized since the runoff flows of the many tributaries of the upper river insure that serious dewatering does not occur in the remaining 97 miles of free-flowing river. The plan basically compromises the trout fishery in 3 miles of the Madison River in order to protect the fishery in the remaining 97 miles.

The tributaries of the upper Madison River are essential for maintaining an acceptable flow in the upper river during the runoff period when Hebgen Reservoir is filled. In some years, drought conditions or abnormal seasonal flow patterns may require a temporary modification of this water management plan. Consequently, the tributaries may become an essential water source in other than the normal snow runoff period. To protect this crucial water supply, it is recommended that all unappropriated waters of the major tributaries to the upper Madison River, including Cabin Creek, be maintained instream for the period of January 1 through December 31. For Cabin Creek, this recommendation amounts to about 53,700 acre-feet of water in an average year (SCS, 1975).

1. STREAM

Grayling Creek

2. DESCRIPTION

Grayling Creek originates in the northwest corner of Yellowstone National Park and flows in a southwesterly direction for approximately 26 miles before discharging into Hebgen Reservoir. It drains an area of approximately 91 square miles. The stream gradient averages about 61.5 feet per mile and channel widths range from 3-50 ft.

The floodplain of the 2.5 miles of stream upstream from the mouth is vegetated primarily with willow, aspen and some sagebrush. The remaining 23.5 miles of stream flows through a coniferous forest interspersed with marshy areas.

Flow information is limited for Grayling Creek. Between 1960 and 1976, various state and federal agencies have measured flows at the Highway 287 bridge (T12S, R5E, Sec. 8D) near the stream mouth. These measurements ranged from about 20 cfs in October, 1960 to nearly 1,100 cfs in May, 1972. The USGS (Horpstad, 1976) estimates the mean annual flow for Grayling Creek at 80 cfs (57,917 acre-feet). The SCS (1976) estimates the mean annual water yield of the Grayling Creek drainage at 74,700 acre-feet (103.2 cfs). The 25 and 50 year instantaneous peak flows are estimated at 990 and 1,139 cfs, respectively (SCS, 1976).

Recreational activities in the Grayling Creek drainage include backpacking, hiking, snowmobiling, cross-country skiing, hunting and fishing. A mail survey conducted by the MDFWP for the period of May, 1975 through April, 1976 estimated the fishing pressure for Grayling Creek at 951 man-days/year or about 37 man-days/stream mile/year (MDFG, 1976). In 1974, fishing pressure for the 16.5 miles of Grayling Creek within Yellowstone National Park was estimated at 325 man-days/year (Dean et al., 1975).

Presently, the USFS is conducting instream habitat improvements in a half-mile section of Grayling Creek (T12S, R5E, Sec. 10). These improvements are primarily designed to provide holding areas for resident adult trout and spawning trout from Hebgen Reservoir.

Wildlife species found in the Grayling Creek drainage include such big game species as elk, mule deer, moose, black bear, grizzly bear and cougar and upland game species such as ruffed and blue grouse. Furbearers include mink, marten, weasel, wolverine, coyote, fox , badger, lynx and bobcat.

3. FISH POPULATIONS

Two fish population surveys were conducted on Grayling Creek in 1980. A 1,000 ft section near the stream mouth (T12S, R5E, Sec. 17B) was electrofished on August 14, 1980. Game fish captured in descending order of abundance were brown, rainbow and brook trout. The mottled sculpin was the only nongame species collected. The electrofishing survey data are summarized in Table 111.

Table 111. Summary of electrofishing survey data collected for a 1,000 ft section of Grayling Creek (T12S, R5E, Sec. 17B) on August 14, 1980.

Species	No. Captured	Length Range (inches)
Brown Trout	3	3.2-7.1
Rainbow Trout	2	4.0-6.3
Brook Trout	1	8.2
Mottled Sculpin	-	-

The standing crop of trout in this section could not be estimated due to the low numbers of fish captured.

A second 1,000 ft section (T12S, R5E, Sec. 10A) was electrofished on August 1 and 13, 1980 in conjunction with a USFS stream habitat improvement study. Game fish captured in descending order of abundance were rainbow trout and rainbow x cutthroat hybrids, brown trout, cutthroat trout, mountain whitefish and brook trout. The mottled sculpin was the only nongame species captured. The electrofishing survey data are summarized in Table 112.

Table 112. Summary of electrofishing survey data collected for a 1,000 ft section of Grayling Creek (T12S, R5E, Sec. 10A) on August 1 and 13, 1980.

Species	No. Captured	Length Range (inches)
Rainbow Trout and Rainbow x Cutthroat Hybrids	55	3.2-10.1
Brown Trout	15	5.4-17.8
Cutthroat Trout	11	3.3- 5.6
Mountain Whitefish	3	7.0
Brook Trout	1	7.3
Mottled Sculpin	-	-

The standing crop of trout in the section was estimated using a mark-recapture method (Table 113). The estimate shows that this 1,000 ft section supports about 123 trout, weighing 8 pounds. Fifteen brown trout and one brook trout captured in the section are not included in the total trout estimate.

Table 113. Estimated standing crop of trout in a 1,000 ft section of Grayling Creek (T12S, R5E, Sec. 10A) on August 1, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Rainbow Trout, Cutthroat Trout and Rainbow x Cutthroat Hybrids	3.2- 5.9	104	
	6.0- 9.9	16	
	10.0-10.1	3	
		123(±38)	8(±2)

In 1979, the MDFWP began a program to establish a reproducing cutthroat trout fishery in Hebgen Reservoir. Cutthroat trout are believed to be better adapted for high elevation reservoirs than are rainbow trout, which presently provide a poor recreational fishery in the reservoir and provide little natural reproduction.

Tributaries to Hebgen Reservoir, including Grayling Creek, are being planted with fingerlings of a strain of lake-dwelling cutthroat trout. It is anticipated that these planted fingerlings will rear in the tributaries, migrate to Hebgen Reservoir and,when sexually mature, return to these tributaries to spawn. Grayling Creek was planted with 26,000 fingerlings in 1979 and 27,500 in 1980.

In 1970, the US Fish and Wildlife Service conducted a comprehensive survey on the 16.5 miles of Grayling Creek within the Park boundary. The stream was found to contain what appeared to be the original cutthroat genotype for this area (Dean and Mills, 1971). This is a significant finding since most tributaries have been heavily planted with a cutthroat stock originating from Yellowstone Lake and have, thereby, contaminated the gene pool of the original native stocks.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 240 ft riffle-pool sequence located near stream mile 1.0 (T12S, R5E, Sec. 8C). Six cross-sections were placed in this sequence. The WETP computer program was calibrated to field data collected at flows of 49.5, 91.3, 143.7, 265.7 and 466.6 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 45. The lower and upper inflection points occur at approximate flows of 31 and 60 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 60 cfs is recommended for the low flow period (July 1 - April 30). A recommendation for the high flow period (May 1 - June 30) cannot be derived due to the lack of long-term flow data for Grayling Creek.

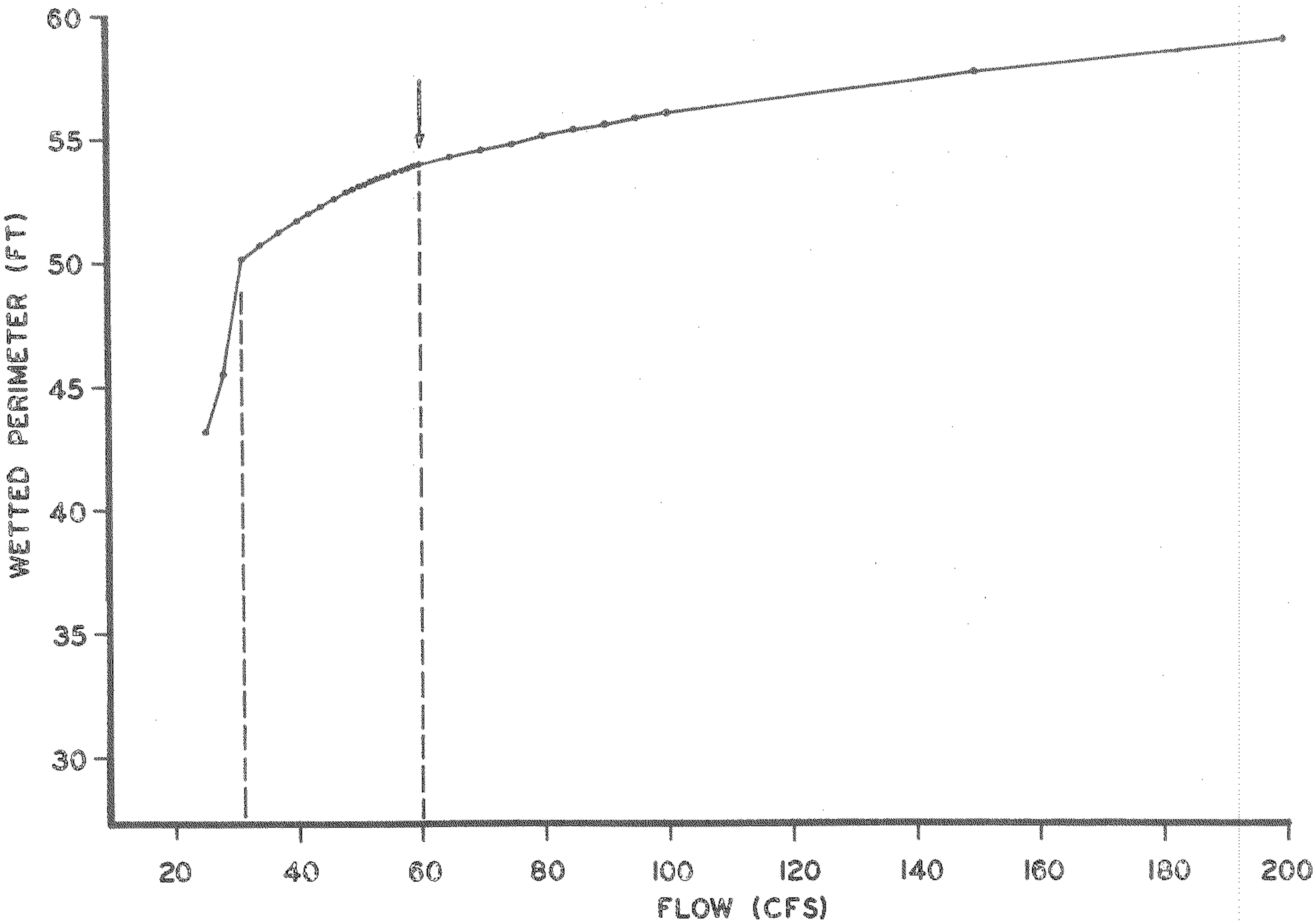


Figure 45. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Grayling Creek.

1. STREAM

Indian Creek

2. DESCRIPTION

Indian Creek arises on the west slope of the Madison Range and flows in an westerly direction for about 16.5 miles before discharging into the Madison River at stream mile 70.7. Stream elevations at the origin and mouth are approximately 8,400 and 3,000 ft, respectively. The stream gradient averages 180 ft/mile. Annual precipitation within the drainage ranges from 10-60 inches and averages 37 inches. Indian Creek drains an area of about 74 square miles.

Primary activities within the Indian Creek drainage are ranching and recreation. Ranching is primarily limited to the lower one-third of the drainage with some stock grazing within the Forest Service boundary. Because the lower 5.5 miles of Indian Creek drainage lies entirely within private lands, public access to the upper drainage within the USFS boundary is severely restricted. Big game hunting (September through November) is the primary recreational use followed by fishing and hiking. Fishing pressure on Indian Creek during the period of May 1975 through April 1976 was estimated from mail surveys at 440 man-days per year or about 27 man-days/stream mile/year (MDFG, 1976).

Some logging has occurred within the drainage. Future timber harvesting will depend on the outcome of the Hilgard Wilderness Study. Water quality is believed to be excellent for Indian Creek although flow and water quality data are unavailable for the drainage.

The reach of Indian Creek between the mouth and USFS boundary is approximately 5.5 miles in length with an average gradient of about 111 ft/mile. Stream widths range from 18-40 ft. This reach is bordered by rangeland and irrigated crop, pasture and hay lands. The riparian vegetation includes cottonwood, aspen, willow and grasses. Resident big game species along this reach include pronghorn antelope and whitetail deer. Mule deer winter along the west slope of the foothills bordering the stream. Recreation opportunities are severely restricted by the private landowners surrounding this reach. The majority of the irrigated lands within this lower reach receive water from Indian Creek via a canal that originates at stream mile 5.5.

There are 23 filed water appropriations, amounting to about 747 cfs, listed for Indian Creek (State Engineer's Office, 1954). Seven decreed rights, amounting to 157 cfs and used to irrigate 1,458 acres, are filed by the stockholders of the Indian Creek Ditch and Irrigating Company. A total of about 1,947 acres are irrigated within the drainage. In some years, this lower reach is totally dewatered during the months of July and August. During 1966, 5.8 miles of Indian Creek were severely or totally dewatered during the summer irrigation season (Wipperman, 1967).

The reach of Indian Creek between the USFS boundary and the headwaters is approximately 10 miles in length. Stream elevations decrease from 8,400 ft at the headwaters to 6,040 ft at the USFS boundary. The gradient averages about 220 ft/mile and stream widths range from about 4-20 ft. Willow, aspen, conifers and grasses border the stream.

This upper reach supports resident and transient populations of elk, mule deer, black bear, grizzly bear, moose, cougar and mountain goat. A major elk migration route lies in the northeast portion of the upper drainage. Important furbearers include mink, marten, weasel, skunk, fox, coyote, badger, bobcat, lynx and beaver. Game birds include ruffed, blue and Franklin grouse. Access to the Indian Creek drainage within the National Forest is severely restricted by the private landowners which border these public lands. The southeast portion of the upper drainage is currently under study for inclusion into the Hilgard Wilderness area.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Indian Creek were surveyed by electrofishing on August 21 and October 3, 1980. Game fish captured in decending order of abundance were rainbow trout and brown trout. The mottled sculpin was the only non-game species collected. The electrofishing survey data are summarized in Table 114.

Table 114. Summary of electrofishing survey data collected for a 1,000 ft section of Indian Creek (T8S, R1E, Sec 26D) on August 21 and October 3, 1980.

Species	Number Captured	Length Range (inches)
Rainbow Trout	98	3.0 - 12.9
Brown Trout	2	10.8 - 11.3
Mottled Sculpin	-	-

The standing crop of rainbow trout, the predominant trout species in the section, was estimated using a mark-recapture method (Table 115). The estimate shows that this 1,000 ft section supports about 157 rainbow trout, weighing 46 pounds.

Table 115. Estimated standing crop of rainbow trout in a 1,000 ft section of Indian Creek (T8S, R1E, Sec 26D) on August 21, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Numbers	Per 1,000 ft Pounds
Rainbow Trout	3.0 - 5.9	a/	
	6.0 - 9.9	118	
	10.0 - 12.9	39	
		157(±46)	46(±12)

a/ No estimate is available due to insufficient recaptures.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 110 ft riffle-pool sequence located near stream mile 5.5 (T8S, R1E, Sec 26D). Seven cross-sections were placed within the sequence. The WETP computer program was calibrated to field data collected at flows of 46.2, 73.1 and 88 6 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 46 . The lower and upper inflections points occur at approximately 20 and 48 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 34 cfs is recommended for the low flow period (July 1 through April 30). Flow recommendations for the high flow period (May 1 through June 30) cannot be derived due to the lack of long-term flow records for Indian Creek.

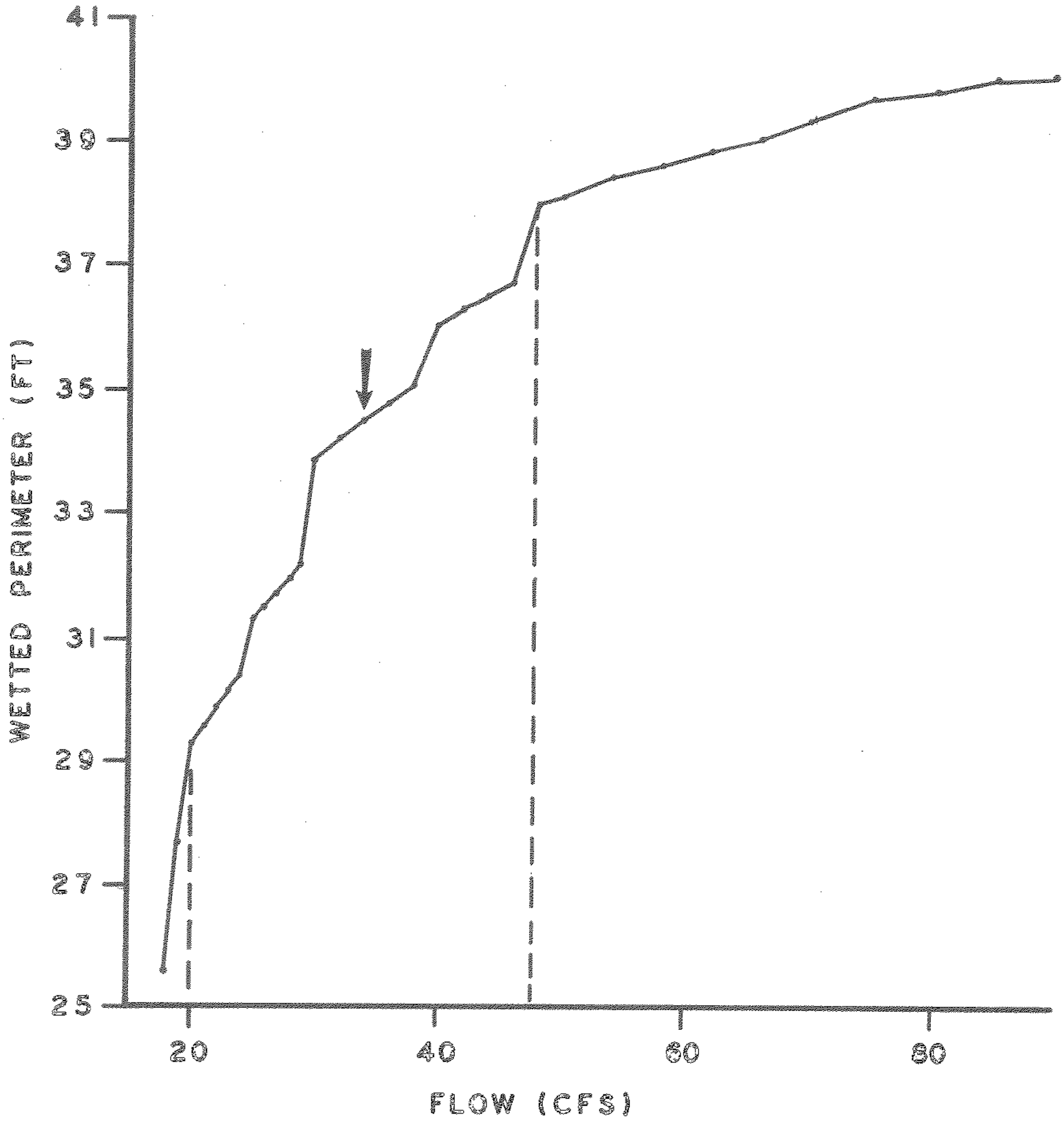


Figure 46. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Indian Creek.

1. STREAM

Jack Creek

2. DESCRIPTION

Jack Creek originates at Ulrey's Lakes on the west slope of the Madison Range and flows in a westerly direction for about 16.5 miles before joining the Madison River near Ennis, Montana. The drainage area is approximately 64 sq miles. Between its headwaters and mouth, the stream elevation decreases from about 7,800 to 4,680 ft. Annual precipitation within the drainage ranges from 10 to 40 inches and averages 27 inches.

The mean annual flow, as measured at the USGS gauge at stream mile 6.5, is 46.1 cfs. Extremes for the 6-year period of record (1973-79) range from 5.0-555 cfs. This gauge is located upstream of all major irrigation diversions and, therefore, reflects natural flow conditions.

The SCS (1976) estimates the mean annual water yield for the Jack Creek drainage at 25,600 acre-feet (35.4 cfs). The 25 and 50 year instantaneous peak flows are estimated at 565 and 650 cfs, respectively.

Much of the Jack Creek drainage lies within fragile geological soil formations, making this stream less tolerant to man caused disturbances (Matney and Garvin, 1978). Although water quality is rated good, spring runoff can produce high sediment yields.

The primary recreational use within the drainage is big game hunting (October - November). Fishing is of secondary importance. Fishing pressure on Jack Creek during the May,1975 through April,1976 period was estimated from mail surveys at 408 man-days/year or about 25 man-days/stream mile/year (MDFG, 1976).

The reach of Jack Creek between the mouth and USFS boundary contains 6.5 miles of stream. The gradient of this reach averages 121 ft/mile and channel widths range from about 9 to 27 ft. Much of this lower reach is surrounded by irrigated hay and pastureland. A 1954 survey shows that 27 water appropriations, amounting to 295 cfs, are filed on this reach. In addition, 16 decreed rights, amounting to 84 cfs, are also on file. Approximately 2,095 acres of land are being irrigated (State Engineer's Office, 1954). This reach is subject to dewatering and bank stabilization problems.

The lower drainage supports resident herds of pronghorn antelope, whitetail deer and also serves as a wintering area for mule deer. The Hungarian partridge is the dominant upland game bird. Recreational use is limited due to private ownership of the streambanks and surrounding area.

The reach of Jack Creek between the USFS boundary and the headwaters contains approximately 10 miles of stream. The gradient averages 238 ft/mile and channel widths range from about 5 to 30 ft. Streambank vegetation consists of cottonwood, aspen, willow and conifers. This upper drainage supports resident and transient populations of elk, mule deer, moose, mountain goat, bighorn sheep, black bear, cougar and grizzly bear. Upland game birds within the upper drainage are ruffed, blue and Franklin grouse. Furbearers include mink, marten, weasel, skunk, red fox, coyote, badger, bobcat, lynx and beaver.

A portion of the upper drainage has been proposed for inclusion into the Spanish Peaks Wilderness Area. Extensive timber harvesting is presently underway on private lands within the upper drainage. Plans for a 161 KV power line corridor are under study.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Jack Creek were surveyed by electrofishing on August 20 and October 3, 1980. Gamefish captured in descending order of abundance were rainbow and brown trout. Hatchery rainbow trout were also present in small numbers. Since 1954, the MDFWP has annually planted Jack Creek with about 850 catchable size rainbow trout. The mottled sculpin was the only nongame species collected. The electrofishing survey data are summarized in Table 116.

Table 116. Summary of electrofishing survey data collected for a 1,000 ft section of Jack Creek (T5S, R1E, Sec. 34D) on August 20 and October 3, 1980.

Species	No. Captured	Length Range (inches)
Rainbow Trout	120	3.5-14.8
Hatchery Rainbow Trout	6	8.1-11.1
Brown Trout	2	11.3-16.8
Mottled Sculpin	-	-

The standing crop of rainbow trout, the predominant trout species in the section, was estimated using a mark-recapture method (Table 117). The estimate shows that this 1,000 ft section supports about 214 rainbow trout, weighing 32 pounds. The six hatchery rainbow trout captured in the section are not included in the standing crop estimate.

Table 117. Estimated standing crop of rainbow trout in a 1,000 ft section of Jack Creek (T5S, R1E, Sec. 34D) on August 20, 1980. Eighty percent confidence intervals are in parentheses.

		Per 1,000 Ft	
Species	Length Group (inches)	Number	Pounds
Rainbow Trout	3.5- 5.9	87	
	6.0- 9.9	121	
	10.0-14.8	6	
		214($\pm$48)	32($\pm$6)

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 112 ft riffle-run sequence located near stream mile 6.5 (T5S, R1E, Sec. 34D). Five cross-sections were placed within the sequence. The WETP computer program was calibrated to field data collected at flows of 41.6, 58.3 and 79.7 cfs.

The relationship between wetted perimeter and flow the composite of two riffle cross-section is shown in Figure 47. The lower and upper inflection points occur at approximate flows of 30 and 62 cfs, respectively. Based on an evaluation of the existing fishery, recreational use, water availability and other resource information, a flow of 30 cfs is recommended for the low flow period (July 1 - April 30). Flow recommendations for the high flow period (approximately May 1 - June 30) cannot be derived due to the lack of long-term flow records for Jack Creek.

Monthly flow recommendations for the low flow period are listed in Table 118. The mean monthly flows derived for the USGS gauge on Jack Creek are also listed for comparison. The recommended flows exceed the mean monthly flows of record for the months of September through April.

Table 118. Instream flow recommendations derived for Jack Creek using the wetted perimeter/inflection point method (low flow period) compared to the mean flows of record.

	Recommended Flows (cfs)	Mean Flows (cfs)a/
January	30	14.6
February	30	13.1
March	30	13.8
April	30	28.4
May	b/	95.2
June	b/	170.5
July	30	86.3
August	30	40.7
September	30	29.1
October	30	24.2
November	30	19.0
December	30	16.7

a/ Derived for the October, 1973 - September, 1979 period of record for the USGS gauge at stream mile 6.5 (T5S, R1E, Sec. 34).

b/ Recommendations for the high flow period are unavailable due to the lack of long-term flow records for Jack Creek.

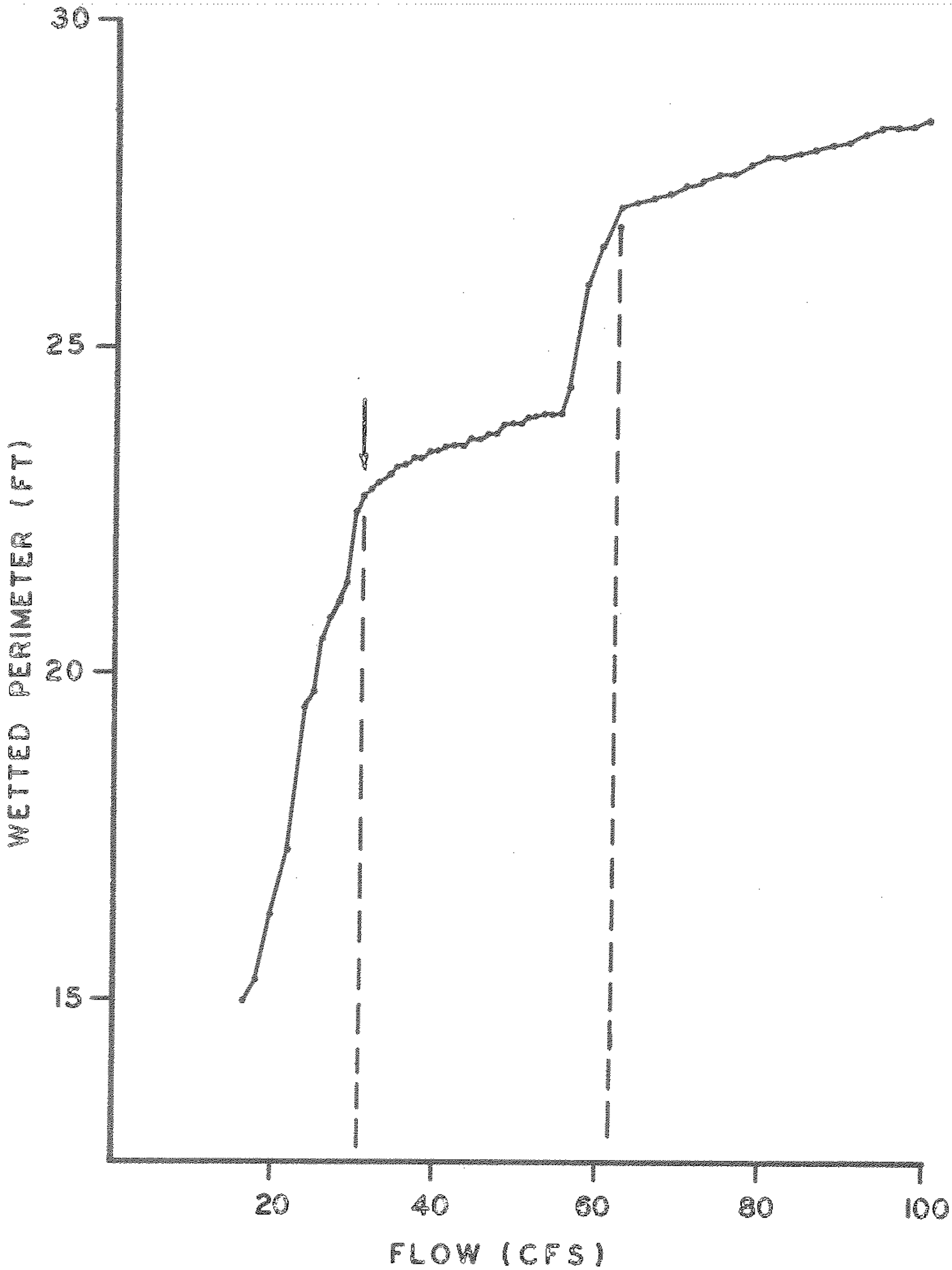


Figure 47. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Jack Creek.

1. STREAM

North Meadow Creek

2. DESCRIPTION

North Meadow Creek originates on the east slope of the Tobacco Root Mountains in southwest Montana and flows about 17.5 miles before joining South Meadow Creek to form Meadow Creek, a tributary of Ennis Reservoir. Stream elevations at the origin and mouth are about 8,400 and 4,840 ft, respectively. The stream gradient averages 204 ft/mile. Annual precipitation within the drainage ranges from 12 to 50 inches. North Meadow Creek drains an area of approximately 53 sq miles.

The stream reach from the mouth to about stream mile 7 is surrounded by private agricultural lands. Commodities produced are wheat, hay and forage. The upper 10.5 miles of stream is surrounded by forest interspersed with sagebrush-grass meadows. Numerous beaver ponds are contained within this reach. The drainage is served by 13.5 miles of road of which 3 miles lie on public lands.

Nonrecreational activities in the North Meadow Creek drainage are associated with agriculture and mining, which began in the late 1800's. There are about six small mines in operation today. The precious metals and low grade ores of copper, tungsten, iron and molybdenum that occur within this drainage may precipitate increased mining activity in the future. Grazing also occurs on public lands within the drainage.

Recreational activities include hunting, snowmobiling, picnicking, camping, hiking and fishing. A mail survey conducted by the DFWP for the period of May 1975 - April 1976 estimated fishing pressure on North Meadow Creek at 360 man-days/year or about 21 man-days/stream mile/year (MDFG, 1976).

The State Engineer's Office (1954) lists a total of 77 water appropriations, amounting to about 1,264 cfs, for the North Meadow Creek drainage. In addition there are 28 decreed rights, amounting to 191.5 cfs. In 1966, 10.1 miles of North Meadow Creek were critically affected by dewatering during the summer irrigation season (Wipperman, 1967). Dewatering problems still occur.

Flow information is limited for North Meadow Creek. The approximate mean flow, derived for a USFS gauge site near stream mile 13.8 for the period of April - November, 1965-79, was 36 cfs. Flows during this period ranged from 3 to 240 cfs. The 25 and 50 year instantaneous peak flows are estimated by the SCS (1976) at 460 and 529 cfs, respectively.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of North Meadow Creek were surveyed by electrofishing on July 21 and 31 and August 5, 1980. Game fish captured in descending order of abundance were brook and cutthroat trout. The mottled sculpin was the only nongame species present. The electrofishing survey data are summarized in Table 119.

Table 119. Summary of electrofishing survey data collected for a 1,000 ft section of North Meadow Creek (T3S, R2W, Sec. 32C) on July 21 and 31 and August 5, 1980.

Species	No. Captured	Length Range (inches)
Brook Trout	156	3.4-9.9
Cutthroat Trout	1	6.9
Mottled Sculpin	-	-

The standing crop of brook trout was estimated using a mark-recapture method (Table 120). The estimate shows that this 1,000 ft section supports about 349 brook trout, weighing 24 pounds.

Table 120. Estimated standing crop of brook trout in a 1,000 ft section of North Meadow Creek (T3S, R2W, Sec. 32C) on July 21, 1980. Eighty percent confidence intervals are in parentheses.

		Per 1,000 Ft	
Species	Length Group (inches)	Number	Pounds
Brook Trout	4.0-5.9	298	
	6.0-9.9	51	
		349(±114)	24(±7)

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 144 ft riffle-run sequence located near stream mile 13.8 (T3S, R2W, Sec. 32C). Five cross-sections were placed in this sequence. The WETP computer program was calibrated to field data collected at flows of 17.4, 21.5 and 50.0 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 48 . The lower and upper inflection points occur at approximate flows of 13 and 22 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 22 cfs is recommended for the low flow period (July 1 - April 30). Flow recommendations for the high flow period (May 1 - June 30) cannot be derived due to the lack of long-term flow data for North Meadow Creek.

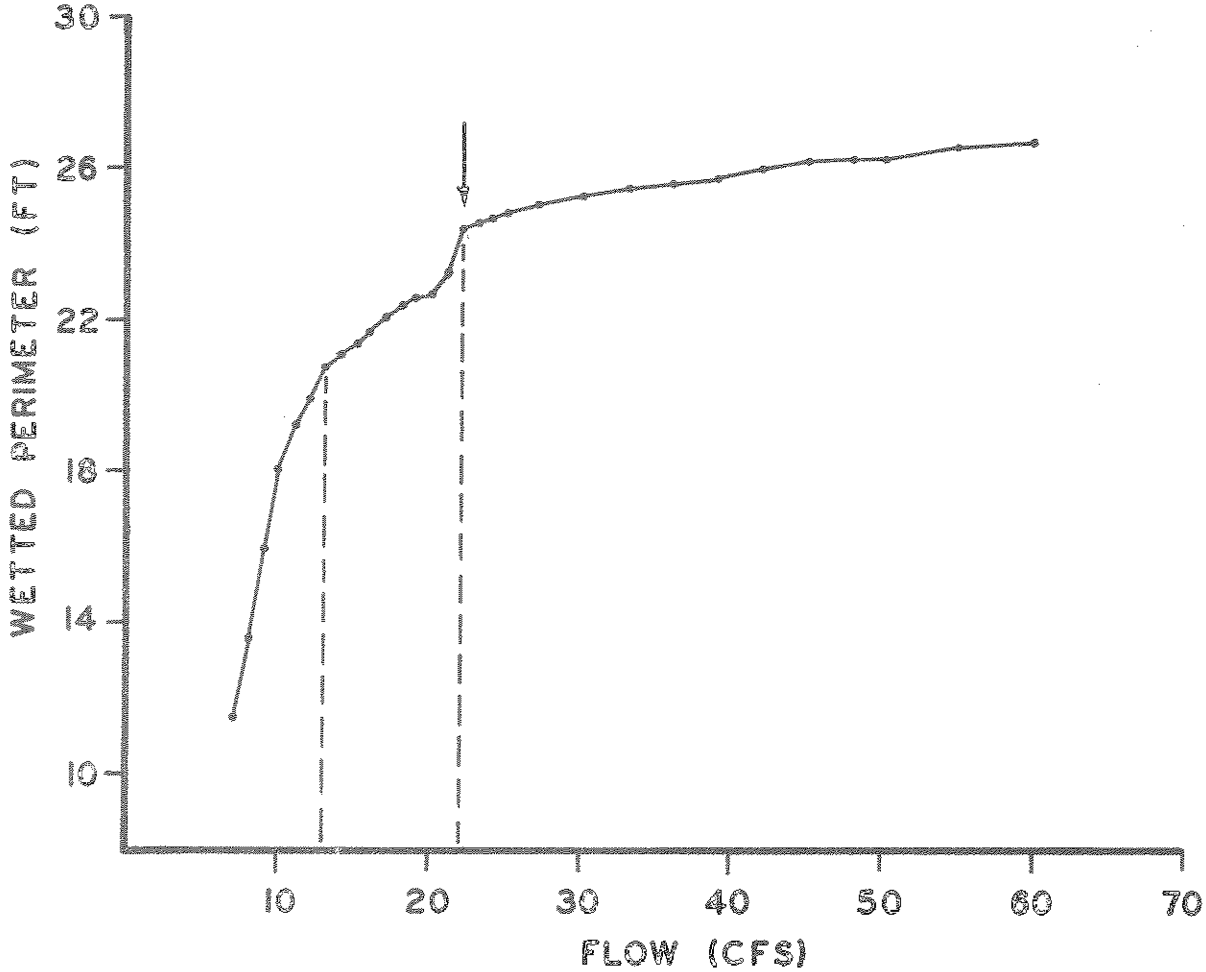


Figure 48. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in North Meadow Creek.

1. STREAM

Ruby Creek

2. DESCRIPTION

Ruby Creek originates on the east slope of the Gravelly Mountain Range of southwest Montana. The stream heads at an elevation of about 8,800 ft then flows in an easterly direction for about 11 miles before discharging into the Madison River at an approximate elevation of 5,520 ft. The stream gradient averages about 305 ft/mile and channel widths range from about 2 to 20 ft. The annual precipitation within the drainage ranges from 12 to over 20 inches and averages 21 inches. Ruby Creek drains an area of approximately 33 sq miles.

Ruby Creek lies entirely on public lands. The lower 3.5 miles of stream are on the Wall Creek Game Range, which is administered by the Montana Department of Fish, Wildlife and Parks, and the remaining 7.5 miles are within the Beaverhead National Forest. The BLM maintains a campground and picnic area near the mouth.

Water resource information is limited for Ruby Creek. Sporadic flow measurements taken by the USFS for the months of May - September, 1976-77, range from 8 to 49 cfs. The SCS (1976) estimates the instantaneous 25 and 50 year peak flows at 295 and 339 cfs, respectively. Ruby Creek carries a high sediment load during spring run-off (USFS, 1977). A 1954 survey showed that 17 water appropriations, amounting to 149 cfs, and 3 decreed rights, amounting to 21.5 cfs, are filed on Ruby Creek (State Engineer's Office, 1954). Approximately 620 acres within the drainage are irrigated.

In 1966, 0.4 miles of Ruby Creek were critically affected by dewatering during the summer irrigation season (Wipperman, 1967). Existing irrigation diversions still severely dewater the lower creek from August to mid-September.

Major activities in the drainage are grazing and timber harvesting. Recreational activities include hunting, hiking, camping and fishing. A mail survey conducted by the DFWP for the period of May 1975 - April 1976 estimated fishing pressure on Ruby Creek at 70 man-days/year or about 6 man-days/stream mile/year (MDFG, 1976).

The major wildlife species found in the Ruby Creek drainage are elk, mule deer, moose, black bear and a few cougar. Elk and deer (approximately 500 of each species) winter in the lower drainage and on the Wall Creek Game Range. A few moose winter along the stream bottom. Upland game birds include ruffed and blue grouse. Furbearers include beaver, mink, weasel, coyote, badger and wolverine.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Ruby Creek were surveyed by electrofishing on July 10 and August 28, 1980. The rainbow trout was the only fish species captured. The electrofishing survey data are summarized in Table 121 .

Table 121. Summary of electrofishing survey data collected for a 1,000 ft section of Ruby Creek (T9S, R1W, Sec. 16C and 17D) on July 10 and August 28, 1980.

Species	No. Captured	Length Range (inches)
Rainbow Trout	256	2.9-11.0

The standing crop of rainbow trout in the section was estimated using a mark-recapture method (Table 122). The estimate shows that this 1,000 ft section supports about 523 rainbow trout, weighing 40 pounds.

Table 122. Estimated standing crop of rainbow trout in a 1,000 ft section of Ruby Creek (T9S, R1W, Sec. 16C and 17D) on July 10, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft	
		Number	Pounds
Rainbow Trout	3.5- 5.9	380	
	6.0- 9.9	137	
	10.0-11.0	6	
		523 (±118)	40 (±6)

In 1963-64, five sections of Ruby Creek, totaling 1,635 ft, were electrofished by the DFWP (Wipperman and Needham, 1965). A total of 432 trout (rainbow, cutthroat and rainbow x cutthroat hybrids), weighing 54.4 pounds, were captured. Lengths ranged from 1.9 to 12.6 inches. Two hundred and fifty-three trout (59%) were of catchable size.

4. FLOW RECOMMENDATIONS

Cross sectional measurements were made in a 102 ft riffle-run sequence located near stream mile 3.8 (T9S, R1W, Sec. 16C and 17D). Six cross-sections were placed in this sequence. The WETP computer program was calibrated to field data collected at flows of 10.4, 12.6, 21.9 and 41.7 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 49. The lower and upper inflection points occur at approximate flows of 8 and 19 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow 13 cfs is recommended for the low flow period (July 1 - April 30). Flow recommendations for the high flow period (May 1 - June 30) cannot be derived due to the lack of long-term flow data for Ruby Creek.

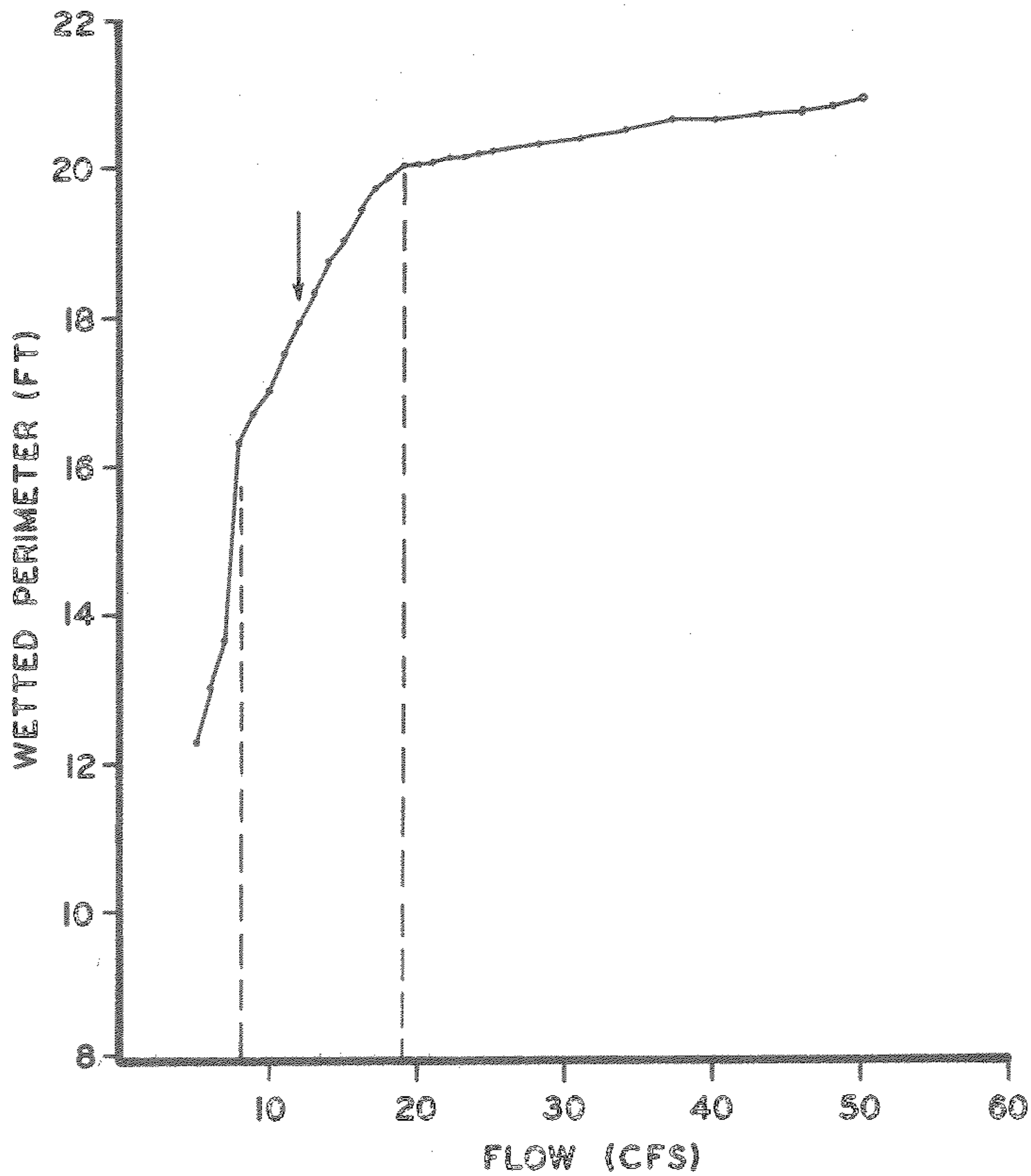


Figure 49. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Ruby Creek.

1. STREAM

South Fork of the Madison River

2. DESCRIPTION

The South Fork of the Madison River originates at the southern end of the Henry's Lake Mountains of southwest Montana. The stream begins at an elevation of about 7,200 ft and flows approximately 16 miles before discharging into the South Arm of Hebgen Reservoir at an elevation of about 6,560 ft. The stream gradient averages 40 ft/mile and channel widths range from several feet to over 75 ft. The average annual precipitation within the drainage is 41 inches. The South Fork drains an area of approximately 140 sq miles.

Flow information is limited for the South Fork of the Madison River. The USGS estimates the mean annual flow at the mouth at 138.6 cfs or 100,334 acre-feet (Horpstad, 1976). The SCS (1976) estimates the mean annual flow at 200.0 cfs or 144,800 acre-feet. The estimated 25 and 50 year instantaneous peak flows are 1,500 and 1,725 cfs, respectively.

The State Engineer's Office (1953) lists one water appropriation, amounting to 0.17 cfs, for the South Fork. In addition, 37 water appropriations and decreed rights, amounting to 162 cfs, are filed on 11 tributaries. About 149 acres within the drainage are irrigated.

Lands within the South Fork drainage are primarily used for recreation and some logging. Timber harvesting has occurred in the past and additional timber sales are proposed for the future. Recreational use is considered high. Recreational activities include hunting, sight seeing, snowmobiling, cross-country skiing and fishing. Fishing pressure on the South Fork was estimated in 1975-76 at 4,965 man-days/year or about 310 man-days/stream mile/year (MDFG, 1976). The area adjacent to Reas Pass, proximate to the headwaters of the South Fork, has been identified as having potential for semi-primitive recreation (Drake, 1981). Access to the South Fork drainage is provided by several miles of USFS controlled road.

At present, there is a proposal to construct a 115 KV transmission line from Macks Inn, Idaho to West Yellowstone, Montana via the South Fork drainage. The final environmental impact statement will be completed in March, 1981. A subdivision is also planned along the South Fork near the mouth.

Wildlife species found in the South Fork drainage include big game animals such as elk, mule deer, moose, black bear and an occasional grizzly bear. Upland game birds, such as ruffed and blue grouse, and furbearers, such as beaver, mink, weasel and bobcat, are also present. Bald eagles winter along the South Fork. Waterfowl (ducks, geese and trumpeter swans) and sandhill cranes can be found in the wetlands adjacent to the stream.

3. FISH POPULATIONS

Fish populations in a 7,920 ft section of the South Fork of the Madison River were surveyed by electrofishing in August, 1970 (Vincent, 1971a). The brown trout was the predominant trout species in the section. Rainbow trout comprised less than 2% of the trout captured and brook trout were present in very small numbers. Mountain whitefish were also present in the section but not enumerated.

The standing crop of brown trout in the section was estimated using a mark-recapture method (Table 123). The estimate shows that this section supports about 1,393 brown trout, weighing 108 pounds, per 1,000 ft. The brown trout population consisted primarily of yearling trout (96%) with few adult trout. Since Hebgen Reservoir lies only 1.5 miles downstream from the end of the section, the preponderance of yearling trout suggests that the South Fork is primarily a spawning and rearing stream for the reservoir population of brown trout.

Table 123. Estimated standing crop of brown trout by age class for a 7,920 ft section of the South Fork of the Madison River (T13S, R5E, Sec. 30C, 31A, and 32B) on August 6, 1970. Eighty percent confidence intervals are in parentheses.

Species	Age Class	Mean Length (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Brown Trout	I+	4.7	1,333	
	II+	8.0	34	
	III+	12.0	11	
	IV+	16.5	10	
	V+ and older	18.7	5	
			1,393(±501)	108(±25)

In 1979, the MDFWP began a program to establish a reproducing cutthroat trout fishery in Hebgen Reservoir. Cutthroat trout are believed to be better adapted for high elevation reservoirs than are rainbow trout, which presently provide a poor recreational fishery in the reservoir and provide little natural reproduction.

Tributaries to Hebgen Reservoir, including the South Fork, are being planted with fingerlings of a strain of lake-dwelling cutthroat trout. It is anticipated that these planted fingerlings will rear in the tributaries, migrate to Hebgen Reservoir and, when sexually mature, return to these tributaries to spawn.

1. STREAM

South Meadow Creek

2. DESCRIPTION

South Meadow Creek originates at the outlet of South Meadow Lake on the east slope of the Tobacco Root Mountains of southwest Montana. It flows 11.2 miles before joining North Meadow Creek to form Meadow Creek, a tributary to Ennis Reservoir. Stream elevations at the origin and mouth are approximately 8,920 and 4,840 ft, respectively. The stream gradient averages 364 ft/mile and channel widths range from about 3 to 25 ft. Annual precipitation within the drainage ranges from about 12 to 50 inches. South Meadow Creek drains an area of approximately 26 sq miles.

The reach of South Meadow Creek from the mouth to near stream mile 5.8 is surrounded by agricultural lands. Livestock, hay and some grains are the principle commodities produced. Stream access is very limited due to private ownership of these lands.

The reach from stream mile 5.8 upstream to the outlet of South Meadow Lake lies within agricultural and forested lands of public and private ownership. Stock grazing and firewood gathering are the principle activities in this portion of the drainage.

The flow of South Meadow Creek has been regulated by an irrigation dam at the outlet of South Meadow Lake since 1902. The dam was reconstructed in 1978 to increase the storage capacity of South Meadow Lake to 1,138 acre-feet. Water releases for downstream irrigation occur between early August and late September. Storage occurs from October through July.

The 25 and 50 year instantaneous peak flows for South Meadow Creek were estimated by the SCS (1976) at 275 and 316 cfs, respectively. Miscellaneous flow measurements collected by various agencies range from 1-60 cfs.

A 1954 survey shows that 27 water appropriations, amounting to about 407 cfs, are filed on South Meadow Creek (State Engineer's Office, 1954). There are 22 additional decreed rights, amounting to 102 cfs, on file. About 1,644 acres of land within the drainage are irrigated. In 1966, 6.0 miles of South Meadow Creek were critically dewatered during the summer irrigation season (Wipperman, 1967). Portions of the creek are still severely dewatered from mid-August to mid-September.

Nonrecreational activities within the drainage include grazing, ranching, farming and mining. Grazing occurs throughout the drainage, while agricultural activities are confined to the lower 5.5 miles. Gold is the principle metal mined within the drainage. Many scattered patented mining claims are located along the creek.

Recreational activities include hunting, camping, picnicking and fishing. A mail survey conducted by the MDFG (1976) for the period of May 1975-April 1976 estimated fishing pressure on South Meadow Creek at 193 man-days/year or about 17 man-days/stream mile/year. Hunting pressure is considered heavy in this drainage.

Wildlife species found in the South Meadow Creek drainage include big game species, such as elk, mule deer, moose, black bear, and cougar, and upland game birds, such as ruffed and blue grouse. Furbearers include beaver, mink, weasel, coyote, badger and wolverine.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of South Meadow Creek were surveyed by electrofishing on July 17, 1980. Brook and rainbow trout were the only species captured. The electrofishing survey data are summarized in Table 124.

Table 124. Summary of electrofishing survey data collected for a 1,000 ft section of South Meadow Creek (T4S, R2W, Sec.28C) on July 17, 1980.

Species	No. Captured	Length Range (inches)
Brook Trout	2	3.9-7.9
Rainbow Trout	1	6.4

The population of trout was too sparse to estimate using the mark-recapture method. The USFS (1977) reports that cutthroat trout are also found in South Meadow Creek.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 60 ft riffle-pool sequence located near stream mile 7.8 (T4S, R2W, Sec. 28C). Five cross-sections were placed in this sequence. The WETP computer program was calibrated to field data collected at flows of 16.2, 25.4 and 55.8 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is shown in Figure 50. The lower and upper inflection points occur at approximate flows of 8.5 and 11.5 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 8.5 cfs is recommended for the low flow period (July 1 - April 30). Flow recommendations for the high flow period (May 1 - June 30) cannot be derived for South Meadow Creek due to the lack of long-term flow data.

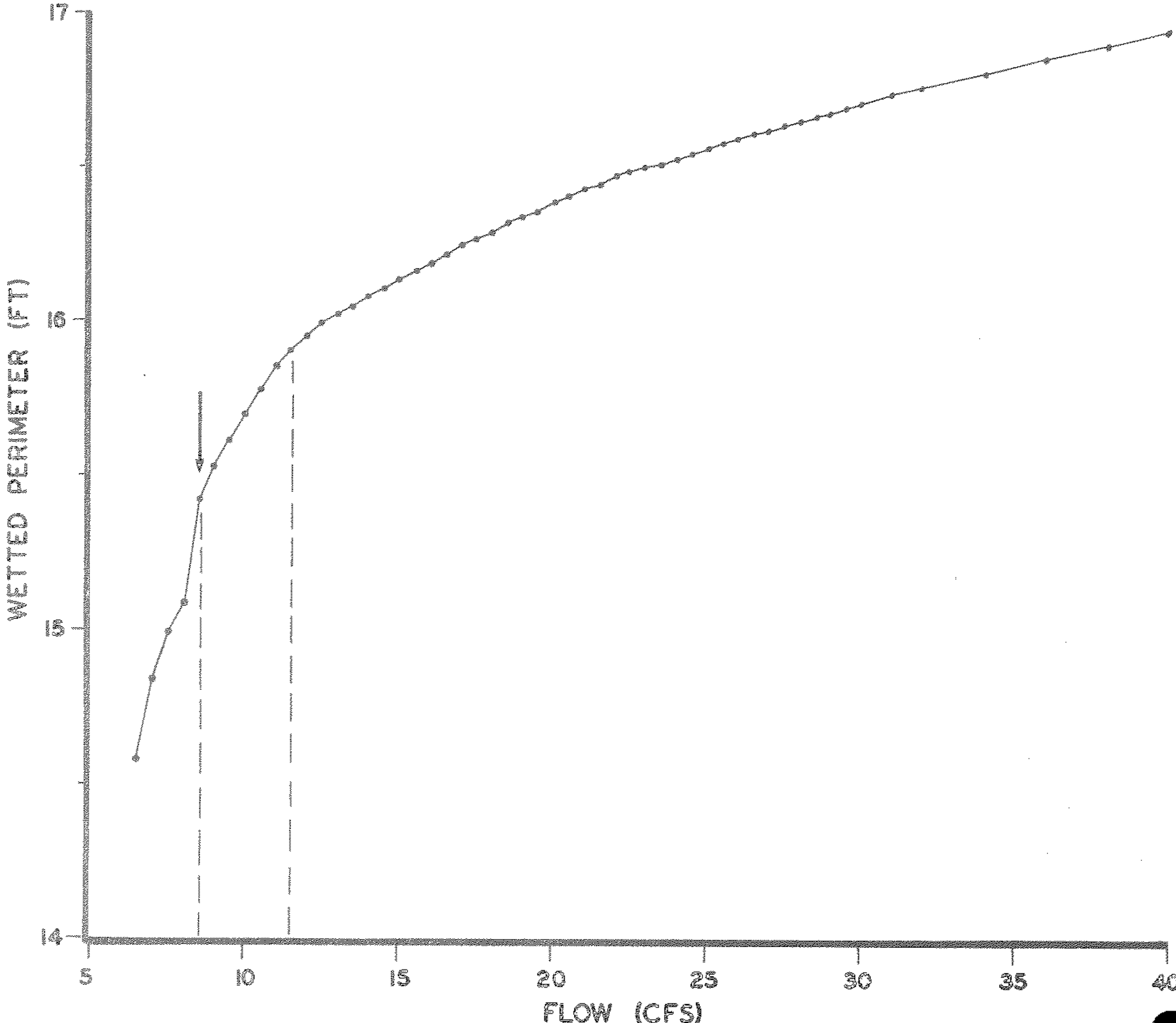


Figure 50. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in South Meadow Creek.

1. STREAM

Squaw Creek

2. DESCRIPTION

Squaw Creek arises from several lakes on the west slope of the Madison Range of southwest Montana and flows in a southwesterly direction for about 9.2 miles before joining the Madison River at stream mile 87.5. It drains an area of approximately 22 square miles. The stream elevations decrease by about 3,760 ft between the headwaters (9,600 ft) and the mouth (5,840 ft). The gradient averages about 409 ft/mile and stream widths range from about 4.5 to 20 ft. Annual precipitation within the drainage ranges from 10-50 inches.

The private landowners, which border USFS lands, severely restrict recreational use within the Squaw Creek drainage. Big game hunting followed by hiking and fishing are the principle recreational activities. Fishing pressure for Squaw Creek and its tributaries is considered light while pressure on the headwater alpine lakes is moderate (USFS, 1977).

Flow and water quality data are limited for the Squaw Creek drainage. Instantaneous flows measured by the USGS near the mouth in August, 1961 and October, 1972 were 12.6 and 17.2 cfs, respectively. The SCS (1976) estimates the 25 and 50 year instantaneous peak flows at 375 and 431 cfs, respectively. Water quality is rated good within USFS lands (USFS, 1977).

A 1954 survey showed that nine water appropriations, amounting to 186 cfs, are filed in the drainage (State Engineer's Office, 1954). Approximately 258 acres of land are irrigated.

The drainage supports resident and transient populations of elk, mule deer, moose, black bear, grizzly bear, mountain goat and big horn sheep. Moose winter along the stream bottoms and big horn sheep winter on the lower elevations of the basin. Upland game birds in the drainage include ruffed, blue and Franklin grouse. Furbearers are also present.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Squaw Creek were surveyed by electrofishing on July 29 and August 8, 1980. Game fish captured in descending order of abundance were brown and rainbow trout. The mottled sculpin was the only nongame species collected. The electrofishing survey data are summarized in Table 125.

Table 125. Summary of electrofishing survey data collected for a 1,000 ft section of Squaw Creek (T10S, R1E, Sec. 34D) on July 29 and August 8, 1980.

Species	No. Captured	Length Range (inches)
Brown Trout	77	3.7-14.9
Rainbow Trout	47	3.3-11.2
Mottled Sculpin	-	-

The standing crops of brown and rainbow trout were estimated using a mark-recapture method (Table 126). The estimates show that this 1,000 ft section of Squaw Creek supports about 175 trout, weighing 34 pounds. Brown trout, the predominant trout species, accounted for 63% of the total trout numbers and 71% of the total biomass.

Table 126. Estimated standing crop of trout in a 1,000 ft section of Squaw Creek (T10S, R1E, Sec. 34D) on July 29, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Brown Trout	5.5- 5.9	19	
	6.0- 9.9	83	
	10.0-14.9	8	
		110 (± 36)	24 (± 8)
Rainbow Trout	3.3- 5.9	28	
	6.0- 9.9	35	
	10.0-11.2	2	
		65 (± 17)	10 (± 3)
Total Trout		175 (± 40)	34 (± 9)

4. FLOW RECOMMENDATIONS

Cross sectional measurements were made on a 98 ft riffle-run sequence located near stream mile 1.5 (T10S, R1E, Sec. 34D). Five cross-sections were placed within this sequence. The WETP computer program was calibrated to field data collected at flows of 6.4, 30.5 and 48.9 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 51 . The lower and upper inflection points occur at approximate flows of 7 and 14 cfs, respectively. Based on evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 7 cfs is recommended for the low flow period (July 1 - April 30). Flow recommendations for the high flow period (May 1 - June 30) cannot be derived due to the lack of long-term flow records for Squaw Creek.

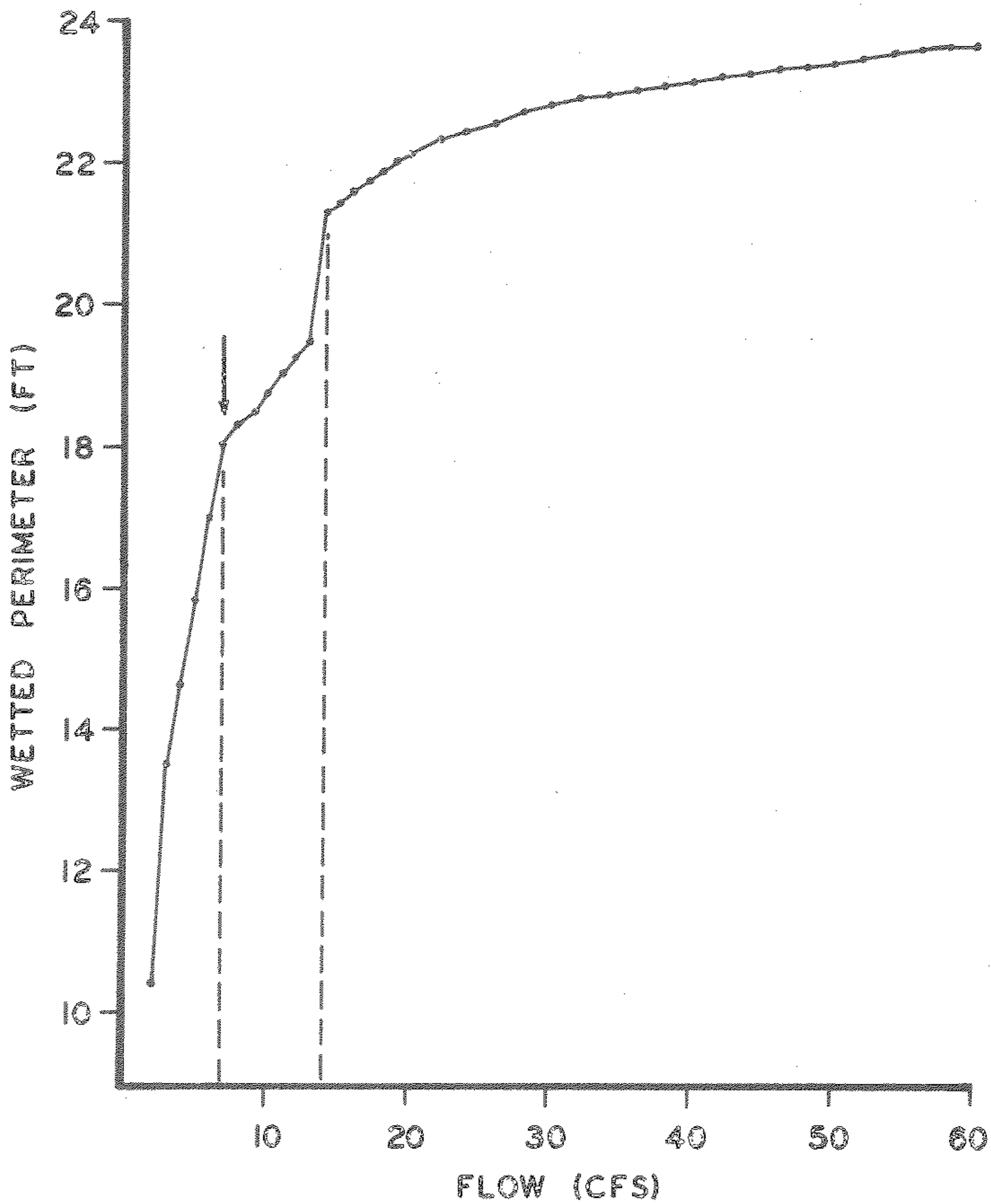


Figure 51. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Squaw Creek.

1. STREAM

Standard Creek

2. DESCRIPTION

Standard Creek originates on the east slope of the Gravelly Mountain Range in southwest Montana. The stream heads at an elevation of about 9,300 ft and flows in an easterly direction for about 13 miles before discharging into the Madison River at an elevation of about 5,800 ft. The stream gradient averages approximately 269 ft/mile. Annual precipitation for the drainage ranges from 12-30 inches and averages 25 inches. Standard Creek drains an area of about 23 sq miles.

The floodplain is moderately sloped and forested with conifers interspersed in sagebrush-grass meadows. A half mile series of beaver ponds is located near stream mile 4.0. The width of the stream channel ranges from about 3-30 ft. The channel is considered stable. Instream debris is found throughout the stream length becoming very dense in places and could be a problem in the future (Snyder et al., 1978).

Water resource information is limited for Standard Creek. Sporadic flow measurements collected by the USFS in 1976-78 range from 14 to 141 cfs. The USFS estimates the low and high flows, based on miscellaneous flow measurements for the period of August 1972 - July 1978, at 5 and 92 cfs, respectively. The 25 and 50 year peak instantaneous flows are estimated by the SCS (1976) at 275 and 316 cfs, respectively.

Land use activities are limited primarily to grazing and some timber harvesting. Sheep and cattle grazing has occurred throughout the drainage. Logging operations began in the mid-1960's. The US Steel Corporation is planning to mine iron ore from the drainage sometime in the future. Major recreational activities include hunting, fishing, firewood gathering and camping. The drainage is served by about 9 miles of controlled access road. Several miles of logging roads and skid trails also provide access.

Wildlife found in the Standard Creek drainage include big game species, such as elk, mule deer, moose, black bear and cougar and upland game birds, such as ruffed and blue grouse. Furbearers include beaver, mink, weasel, coyote, badger and wolverine.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Standard Creek were surveyed by electrofishing on July 23 and August 8, 1980. Game fish captured in descending order of abundance were rainbow x cutthroat hybrids and brown trout. The electrofishing survey data are summarized in Table 127 .

Table 127. Summary of electrofishing survey data collected for a 1,000 ft section of Standard Creek (T11S, R1W, Sec. 12B) on July 23 and August 8, 1980.

Species	No. Captured	Length Range (inches)
Rainbow x Cutthroat Hybrids	63	4.7-12.0
Brown Trout	1	9.8

The standing crop of hybrid trout in the section was estimated using a mark-recapture method (Table 128). The estimate shows that this 1,000 ft section supports about 115 trout, weighing 15 pounds.

Table 128. Estimated standing crop of rainbow x cutthroat hybrids in a 1,000 ft section of Standard Creek (T11S, R1W, Sec. 12B) on July 23, 1980. Eighty percent confidence intervals are in parentheses.

		Per 1,000 Ft	
Species	Length Group (inches)	Number	Pounds
Rainbow x Cutthroat Hybrids	4.7- 5.9	46	
	6.0- 9.9	67	
	10.0-12.0	2	
		115(±45)	15(±6)

In 1974, Haugen (1975) captured one arctic grayling (9.5 inches) and two cutthroat trout (5.2 - 10.5 inches) in a section of Standard Creek within 3.1 miles of the mouth. Eleven other cutthroat trout (2.0 - 10.2 inches) were collected in another upstream section. No other game species were captured.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 41 ft riffle-run sequence located near stream mile 3.7 (T11S, R1W, Sec. 12B). Five cross-sections were placed in this sequence. The WETP computer program was calibrated to field data collected at flows of 18.4, 23.3 and 63.4 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 52. The lower and upper inflection points occur at approximate flows of 10 and 20 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 10 cfs is recommended for the low flow period (July 1 - April 30). Flows for the high flow period (May 1 - June 30) cannot be derived for Standard Creek due to the lack of long-term flow data.

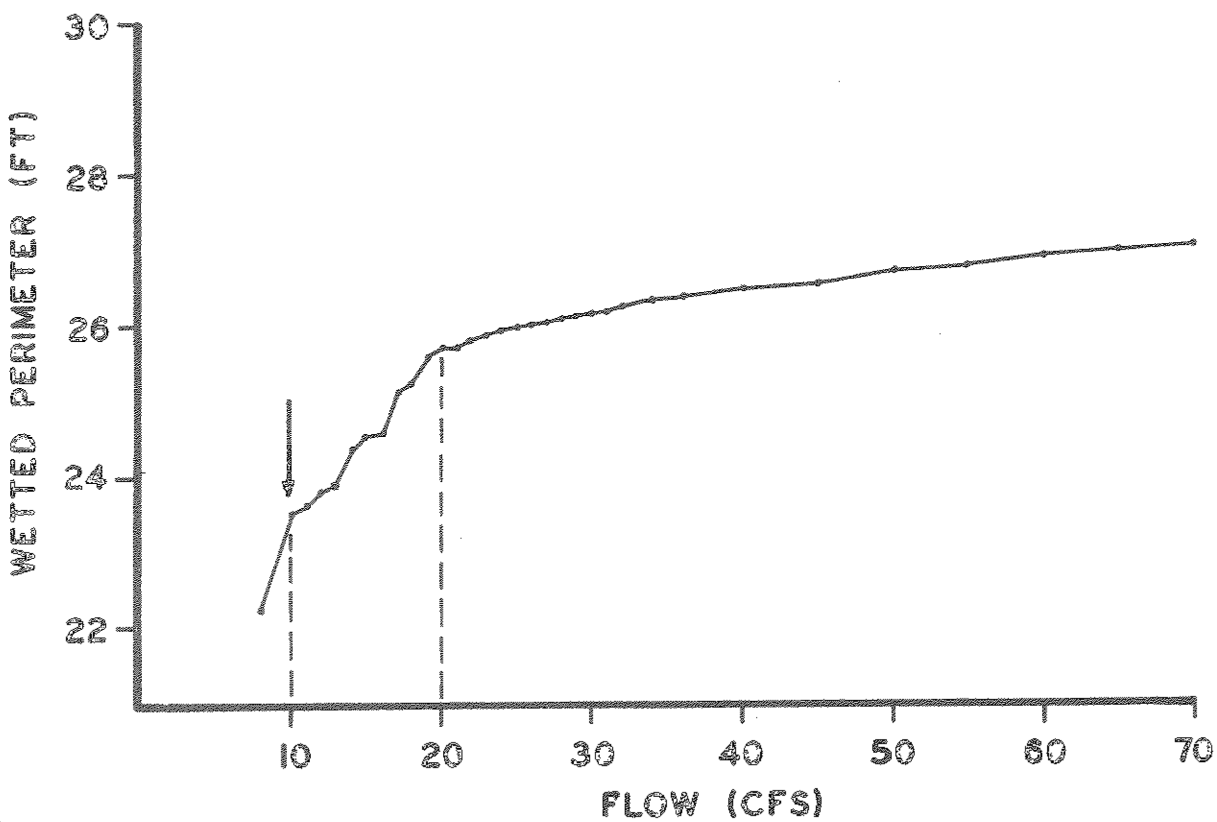


Figure 52. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Standard Creek.

1. STREAM

Watkins Creek

2. DESCRIPTION

Watkins Creek originates in the Henry's Lake Mountains in southwest Montana and flows in a northeasterly direction for about 5 miles before discharging into Hebgen Reservoir. Stream elevations at the origin and mouth are approximately 8,800 and 6,560 ft, respectively. The stream gradient averages about 448 ft/mile. Average annual precipitation within the drainage is 38 inches. Watkins Creek drains an area of about 27 sq miles.

The mean annual flow for Watkins Creek was estimated by the USGS (Horpstad, 1976) at 3.4 cfs (2,497 acre-feet). The State Engineer's Office (1953) lists 4 water appropriations, amounting to 26 cfs, for Watkins Creek. Water diverted from the creek irrigates about 63 acres.

At present, there is no logging activity within the drainage. However, a timber sale is proposed for a portion of the drainage. Livestock grazing occurs along the first mile of stream.

Public access to Watkins Creek is via a USFS road located on the southern shore of Hebgen Reservoir. Foot and horse trails serve the remainder of the drainage.

Recreational activities in the drainage include hunting, backpacking, trail biking and fishing. Fishing pressure on Watkins Creek in 1975-1976 was estimated at 92 man-days/year or about 18 man-days/stream mile/year (MDFG, 1976).

Wildlife species found in the drainage include big game animals, such as elk, mule deer and moose, and upland game birds, such as ruffed and blue grouse. Furbearers include beaver, mink and weasel.

3. FISH POPULATIONS

Fish populations in a 513 ft section of Watkins Creek were surveyed by electrofishing on October 17, 1980. A 1,000 ft section could not be electrofished because numerous deadfalls within the channel hindered the electrofishing effort. Rainbow trout and mottled sculpin were the only fish species captured in the section. The electrofishing survey data are summarized in Table 129. The population of rainbow trout, which averaged 4.7 inches in length, was too sparse to reliably estimate using the mark-recapture method.

Table 129. Summary of electrofishing survey data collected for a 513 ft section of Watkins Creek (T12S, R4E, Sec. 7D) on October 17, 1980.

Fish Species	No. Captured	Length Range (inches)
Rainbow Trout	33	3.3-9.2
Mottled Sculpin	-	-

1. STREAM

West Fork of Denny Creek

2. DESCRIPTION

The West Fork of Denny Creek originates on the east slope of the Continental Divide in the Henry's Lake Mountains of southwest Montana. It flows in a southeasterly direction for about 5 miles before discharging into Denny Creek at stream mile 2.9. Stream elevations at the origin and mouth are approximately 8,200 and 6,680 ft, respectively.

Public access to the West Fork of Denny Creek is via a U.S.F.S. road that serves about 2 miles of the drainage. Foot and horse trails also provide access.

Wildlife species found in the drainage include big game species such as elk, moose, mule deer, black bear and cougar and upland game birds such as ruffed and blue grouse. Furbearers found are beaver, mink, weasel, coyote and bobcat.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of the West Fork of Denny Creek were surveyed by electrofishing on July 30 and August 13, 1980. Rainbow X cutthroat hybrids and mottled sculpin were the only fish captured. The electrofishing survey data are summarized in Table 130.

Table 130. Summary of electrofishing data collected for a 1,000 ft section of the West Fork of Denny Creek (T13S, R4E, Sec 20D) on July 30 and August 13, 1980.

Species	Number Captured	Length Range (inches)
Rainbow X Cutthroat Hybrids	28	3.5 - 7.4
Mottled Sculpin	-	-

The standing crop of rainbow x cutthroat hybrids was estimated using a mark-recapture method (Table 131). The estimate shows that this 1,000 ft section supports about 38 trout, weighing 3 pounds.

Table 131. Estimated standing crop of trout in a 1,000 ft section of the West Fork of Denny Creek (T13S, R4E, Sec 20D) on July 30, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Numbers	Per 1,000 ft Pounds
Rainbow X Cutthroat Hybrids	3.5 - 5.9	26	
	6.0 - 7.4	12	
		38(+12)	3(+1)

1. STREAM

West Fork of the Madison River

2. DESCRIPTION

The West Fork of the Madison River originates on the east slope of the southern portion of the Gravelly Mountains in southwest Montana. It flows in an easterly direction for about 34 miles before discharging into the Madison River. Stream elevations at the origin and mouth are approximately 9,060 and 5,910 ft, respectively. The stream gradient averages approximately 93 ft/mile and stream widths range from 3-80 ft. Mean annual precipitation for the drainage is about 25 inches. The West Fork drains an area of about 220 square miles.

Water resource data for the West Fork of the Madison River have been sporadically collected since the early 1960's. A nine year summary of flow data, based on miscellaneous flow information for the period of May 1969 - October 1978, shows flows as high as 1,220 cfs and as low as 31 cfs (USFS, 1978). For the months of April through October, 1974-79, the USFS recorded flows ranging from 38 to 744 cfs (USFS, unpublished data).

The USGS operated a gauge on the West Fork at stream mile 0.2 intermittently from 1959-67. The mean, maximum and minimum flows for the period of record are 91.9, 957 and 21.0 cfs, respectively. The mean monthly flows of record are listed in Table 132.

Table 132. Mean monthly flows of record for the West Fork of the Madison River.

	Mean Flows (cfs)[a]
January	38.0
February	38.2
March	43.9
April	55.5
May	251.5
June	298.5
July	111.9
August	62.9
September	57.2
October	55.9
November	46.2
December	37.9

[a] Derived for the October, 1965-September, 1967 period of record for the USGS gauge at stream mile 0.2 (T11S, R1E, Sec 10).

The SCS (1976) estimates the mean annual water yield for the drainage at 50,900 acre-feet (70.3 cfs). The 25 and 50 year instantaneous peak flows are estimated at 1,100 and 1,265 cfs, respectively.

The West Fork is considered to be a major contributor of sediment to the Madison River. A 1970 study estimated over 10 tons of sediment, of which 47% came from the immediate stream banks, is annually discharged into the Madison River (Lisle, 1972). This sediment problem is a direct result of extensive grazing damage on the surrounding slopes. Grazing has occurred in the drainage since the late 1800's. At present, there are grazing allotments for sheep, cattle and horses.

The West Fork drainage has approximately 30 miles of road regulated by the USFS. There are also countless miles of closed jeep-trails and maintained trails. These corridors provide excellent access to the back country and maintained campsites.

Recreational activities within the drainage include big game hunting (September - November), fishing, snowmobiling, hiking, camping and sightseeing. Fishing pressure on the West Fork in 1975-76 was estimated at 1,732 man-days/ year or about 51 man-days/ stream mile/year (MDFG, 1976).

Wildlife found in the West Fork drainage include big game species such as elk, mule deer, moose, black bear and cougar. Grizzly bear are occasionally sighted. The willow covered flood plain serves as a winter range for moose. Furbearers include beaver, mink, marten, weasel, bobcat, coyote, fox, badger and wolverine. Upland game birds include ruffed, blue and Franklin grouse.

3. FISH POPULATIONS

Fish population estimates were made on a section of the West Fork of the Madison River near its mouth using a mark-recapture method. A gamefish estimate was made in both August, 1971 and August, 1972 (Vincent, 1973). These estimates are summarized in Table 133. The rainbow trout was the most abundant trout species, comprising 68% of the trout numbers in both 1972 and 1973.

The 1972 estimate shows that this section supports about 251 salmonids (rainbow trout, brown trout and mountain whitefish), weighing 87 pounds, per 1,000 feet of stream. Rainbow and brown trout accounted for 84% of the total game fish by numbers and 47% by weight.

Two other sections have been electrofished to determine species composition. The game fish population in the section 11 miles upstream from the mouth consisted of 82% cutthroat trout, 12% rainbow trout and 6% brown trout. The game fish population in the other section (6 miles upstream from the mouth) consisted of 73% rainbow trout, 20% brown trout and 7% cutthroat trout.

Table 133. Estimated standing crops of game fish in a 2,640 ft section of the West Fork of the Madison River (T11S, R1E, Sec 10D) in August of 1971 and 1972. Eighty percent confidence intervals are in parentheses.

August 1971

Species	Age-Class	Mean Length (inches)	Per 1,000 ft Numbers	Per 1,000 ft Pounds
Rainbow Trout	I+	6.1	128	
	II+	8.2	49	
	III+	10.8	5	
	IV+ & Older	16.4	1	
			183(±74)	27(±8)
Brown Trout	I+	6.4	46	
	II+	9.3	27	
	III+	13.5	11	
	IV+ & Older	17.7	1	
			85(±28)	27(±8)
Total Trout			268(±79)	54(±11)

August 1972

Species	Age-Class	Mean Length (inches)	Per 1,000 ft Numbers	Per 1,000 ft Pounds
Rainbow Trout	I+	5.9	123	
	II+	8.6	13	
	III+ & Older	12.8	7	
			143(±23)	19(±3)
Brown Trout	I+	6.1	35	
	II+	8.8	21	
	III+	13.0	11	
	IV+ & Older	16.1	1	
			68(±13)	22(±5)
Mountain Whitefish	II+	11.7	6	
	III+ & Older	14.9	34	
			40(±17)	46(±20)
Total Game Fish			251(±31)	87(±21)

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 226 ft riffle-run sequence located near stream mile 0.8 (T11S, R1E, Sec 10D). Five cross-sections were placed in this sequence. The WETP computer program was calibrated to field data collected at flows of 182.6, 94.0 and 67.6 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 53. The lower and upper inflection points occur at approximate flows of 45 and 68 cfs, respectively.

Flow recommendations for the West Fork were derived from the water management plan for Hebgen Reservoir and the upper Madison River rather than the wetted perimeter/inflection point method. A description of this plan and pertinent background information follows.

Flows in the Madison River are regulated by Hebgen Reservoir, which stores water for downstream hydro-electric generation. The present water management plan for the reservoir, which was formulated through a cooperative agreement between the Montana Power Company (the operator of Hebgen Dam), the U.S. Forest Service and the Montana Department of Fish, Wildlife and Parks, calls for a minimum flow release of 50 cfs when Hebgen Reservoir is filled from May 15 to July 15. This allows the reservoir to fill during the runoff period. Prior to the initiation of the plan in 1968, the reservoir was filled during late winter and early spring, a period when the natural flows of the river are lowest for the year. As a result, the entire 100 miles of free-flowing river below Hebgen Dam were severely dewatered from February through April. Electrofishing data collected by the DFWP confirmed that this winter dewatering substantially reduced trout populations throughout the river.

The management plan has eliminated the winter dewatering problem since water is no longer stored during the February through April period, thereby allowing winter flow releases to approximate the natural condition. During the runoff period when the reservoir is filled and releases are reduced, only the river fishery between Hebgen Dam and Earthquake Lake is seriously jeopardized since the runoff flows of the many tributaries of the upper river insure that dewatering does not occur in the remaining 97 miles of free-flowing river. The plan basically compromises the trout fishery in 3 miles of the Madison River in order to protect the fishery in the remaining 97 miles.

The tributaries of the upper Madison River are essential for maintaining an acceptable flow in the upper river during the runoff period when Hebgen Reservoir is filled. In some years, drought conditions or abnormal seasonal flow patterns may require a temporary modification of this water management plan. Consequently, the tributaries may become an essential water source in other than the normal snow runoff period. To protect this crucial water supply, it is recommended that all unappropriated waters of the major tributaries to the upper Madison River, including the West Fork, be maintained instream for the period of January 1 through December 31. For the West Fork, this recommendation amounts to about 50,900 acre-feet of water in an average water year.

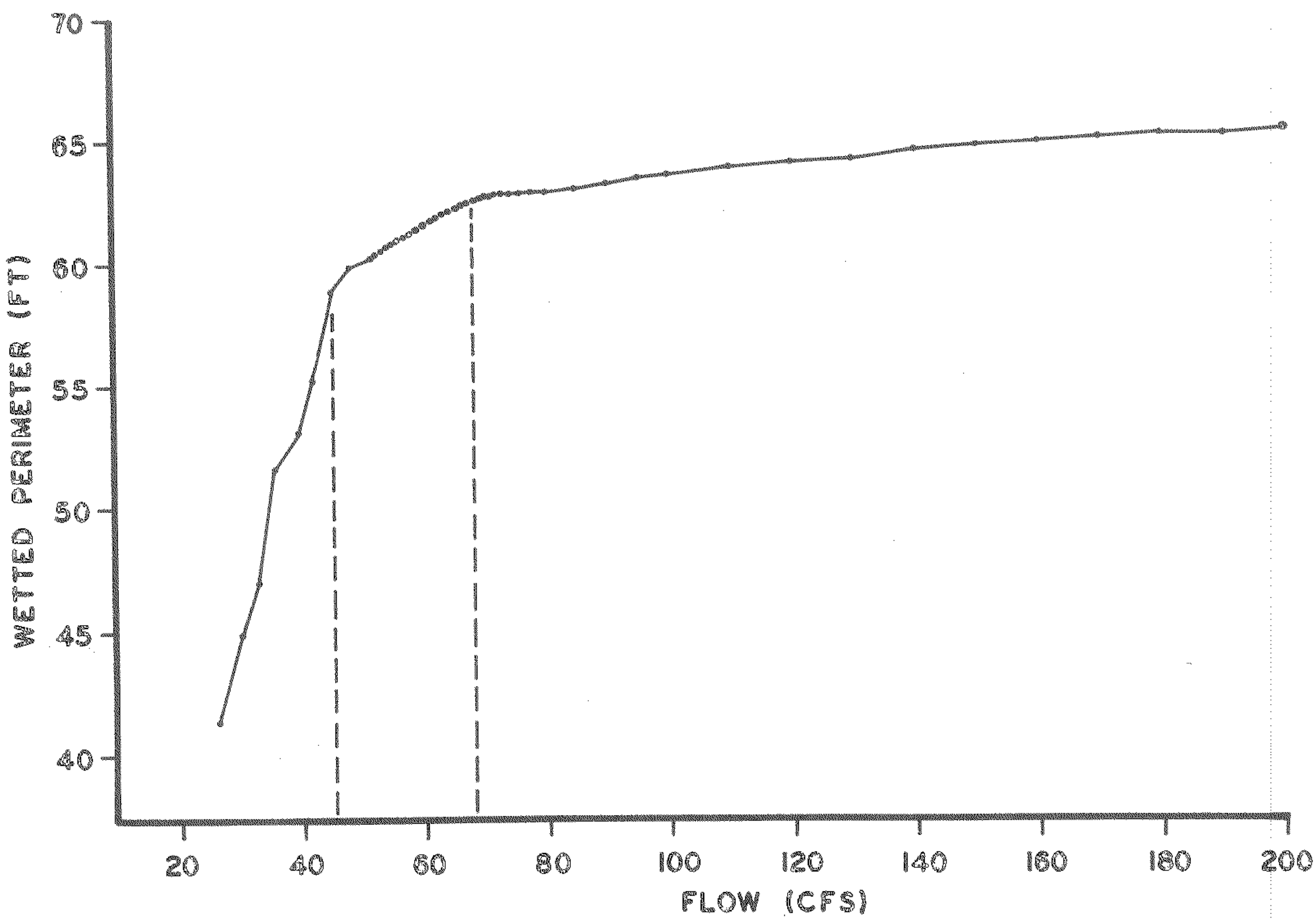
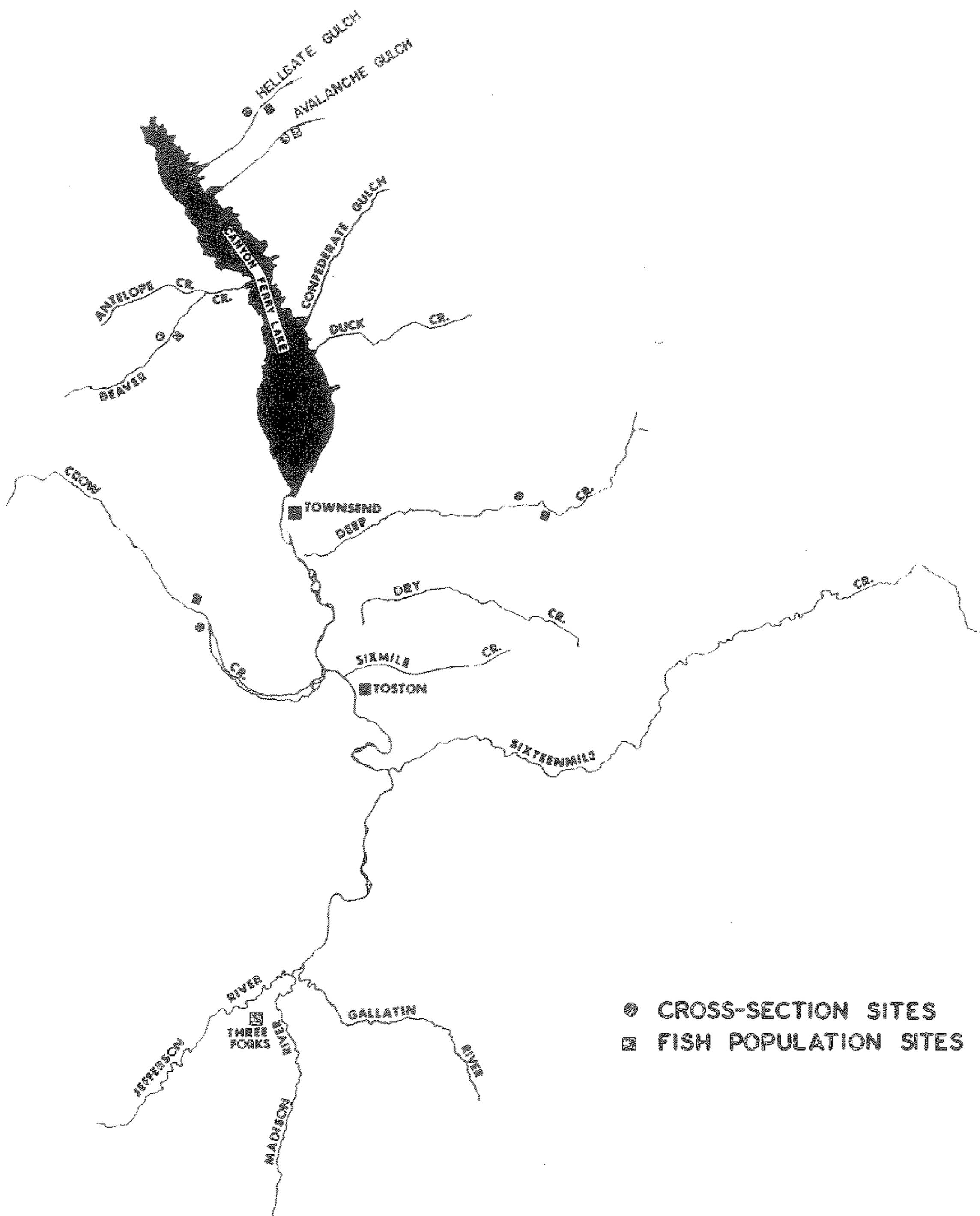


Figure 53. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in the West Fork of the Madison River.

MAINSTEM

MISSOURI RIVER TRIBUTARIES

ABOVE CANYON FERRY DAM



The study areas of the Mainstem Missouri River Drainage upstream of Canyon Ferry Dam.

1. STREAM

Avalanche Gulch Creek

2. GENERAL DESCRIPTION

Avalanche Gulch Creek arises on the west slope of the Belt Mountains, southwest of Avalanche Butte, and flows 13.9 miles before discharging into Canyon Ferry Reservoir. The mean gradient of the creek is 158 feet per mile. At spring flow levels, the average width of the creek is 10.5 feet. Approximately 70 percent of the creek is located within the Helena National Forest. Major tributaries are Nary Time, Spilling, and Shannon Gulches and Cayuse Creek.

Recreational activities along Avalanche Gulch Creek are primarily confined to camping and fishing

No historic or current discharge information is available for the drainage.

Avalanche Gulch Creek is dewatered below the forest boundary during the summer irrigation season. Other concerns that could potentially affect the stream resource include mining, road construction and resulting sedimentation and the overgrazing of the riparian zone by cattle.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Avalanche Gulch Creek were surveyed by electrofishing on September 18 and October 15, 1980. Rainbow X cutthroat hybrids and mottled sculpin were the only fish captured. The electrofishing survey data are summarized in Table 134.

Table 134. Summary of electrofishing survey data collected for a 1,000 ft section of Avalanche Gulch Creek ((T10N. R1E, Sec 11A) on September 18 and October 15, 1980.

Species	Number Captured	Length Range (inches)
Rainbow X Cutthroat Hybrids	110	3.8 - 10.6
Mottled Sculpin	-	-

The standing crop of trout in the section was estimated using a mark-recapture method (Table 135). This 1,000 ft section supports about 132 hybrid trout, weighing 13 pounds.

Table 135. Estimated standing crops of trout in a 1,000 ft section of Avalanche Gulch Creek (T10N, R1E, Sec 11A) on September 18, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Number	Per 1,000 ft Pounds
Rainbow X Cutthroat Hybrids	3.8 - 5.9	75	
	6.0 - 9.9	55	
	10.0 - 10.6	2	
		132(±14)	13(±2)

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 168 ft riffle-pool sequence located 1.5 miles above the forest boundary (T10N, R1E, Sec 11A). Five cross-sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 13.3, 10.7 and 6.2 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 54. The lower and upper inflection points occur at approximate flows of 1.5 and 4 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 3 cfs is recommended for the low flow period (July 1 - April 30).

Flow recommendations for the high flow period (May 1 - June 30) can not be derived due to the lack of long-term flow records for Avalanche Gulch Creek.

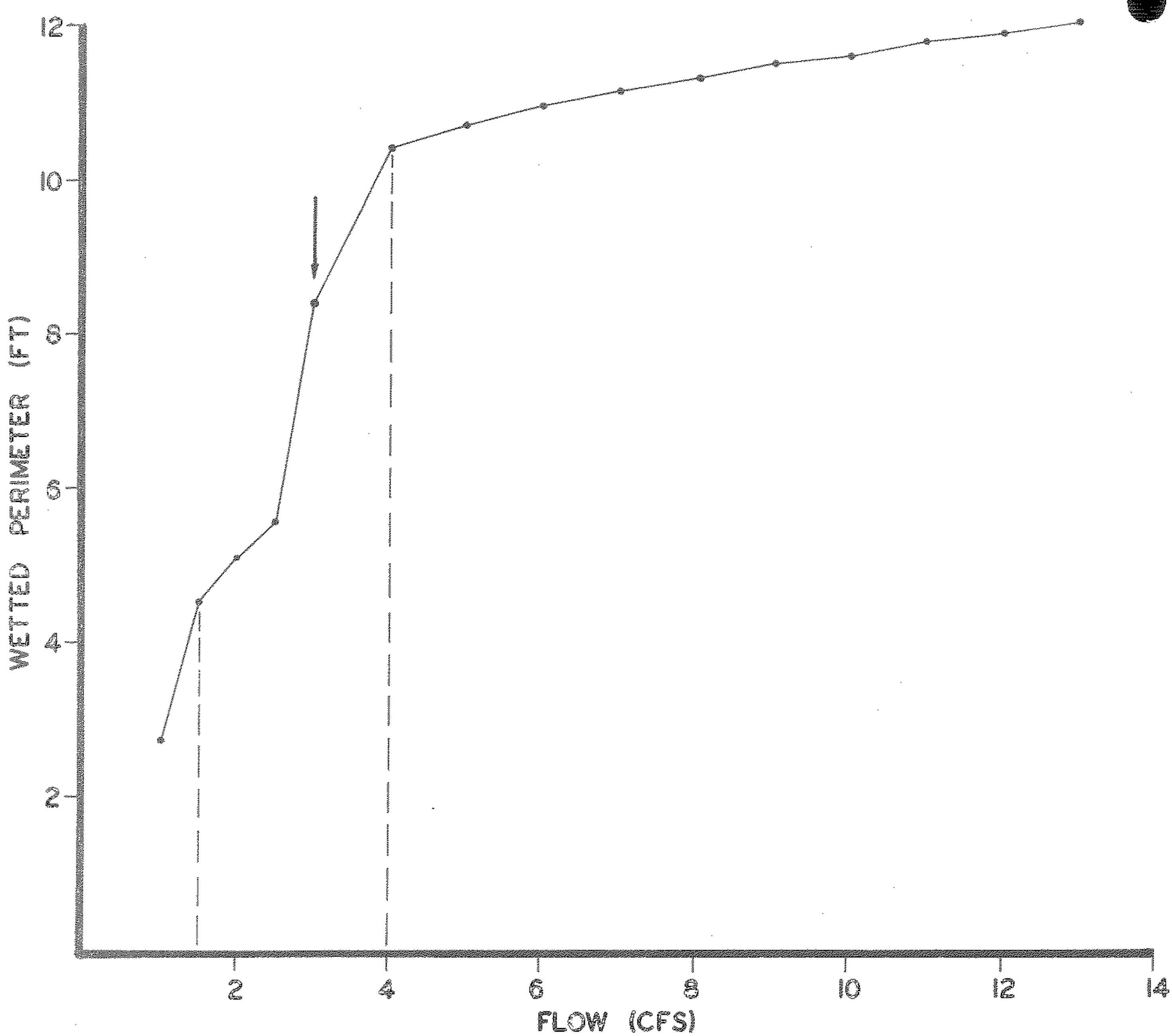


Figure 54. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Avalanche Gulch Creek.

1. STREAM

Beaver Creek

2. GENERAL DESCRIPTION

Beaver Creek arises on the east slope of the Elkhorn Mountains near High Peak (elevation 8,534 ft) and flows east for 13.3 miles before discharging into Canyon Ferry Reservoir near Winston, Montana. The mean gradient of Beaver Creek is 252 feet per mile. At spring flow levels, it averages 26.4 feet in width. Major tributaries include South Fork Beaver Creek, North Pole Creek and Sawmill Creek.

Recreational use of the area along Beaver Creek is limited to camping and fishing. Fishing pressure in 1975-76 was estimated at 233 fisherman-days per year (MDFG, 1976). The upper 60 percent of the stream is located within the Helena National Forest. Land surrounding the lower portion is privately owned and is used mainly for grazing livestock.

An existing environmental problem in the Beaver Creek drainage is the severe dewatering of the privately owned portion of Beaver Creek during the summer irrigation season. Possible mine development, road building, logging activity and bank stability problems resulting from livestock grazing are concerns that could affect the stream resource.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Beaver Creek were surveyed by electrofishing on September 18 and October 16, 1980. Brook trout and mottled sculpin were the only fish species captured. The electrofishing survey data are summarized in Table 136.

Table 136. Summary of electrofishing survey data collected for a 1,000 ft section of Beaver Creek (T8N, R1W, Sec 15D) on September 18 and October 16, 1980.

Species	Number Captured	Length Range(inches)
Brook Trout	192	3.7 - 8.9
Mottled Sculpin	-	-

The standing crop of brook trout in the section was estimated using a mark-recapture method (Table 137). This 1,000 ft section supports an estimated population of 458 brook trout, weighing 30 pounds.

Table 137. Estimated standing crop of brook trout in a 1,000 ft section of Beaver Creek (T8N, R1W, Sec 15D) on September 18, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Number	Per 1,000 ft Pounds
Brook Trout	3.7 - 5.9	332	
	6.0 - 8.9	126	
		458(±101)	30(±6)

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 233 ft riffle-pool sequence located near the forest boundary (T8N, R1W, Sec 15D). Five cross-sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 72.6, 12.4 and 5.3 cfs.

The relationship between wetted perimeter and flow for the composite of all five cross-sections (cascading type stream) is shown in Figure 55 . The lower and upper inflection points occur at approximate flows of 4 and 15 cfs, respectively. Based on an evaluation of existing fishery, recreational use and other resource information, a flow of 6 cfs is recommended for the low flow period (July 1 - April 30). Flow recommendations for the high flow period (May 1 - June 30) can not be derived due to the lack of long-term flow records for Beaver Creek.

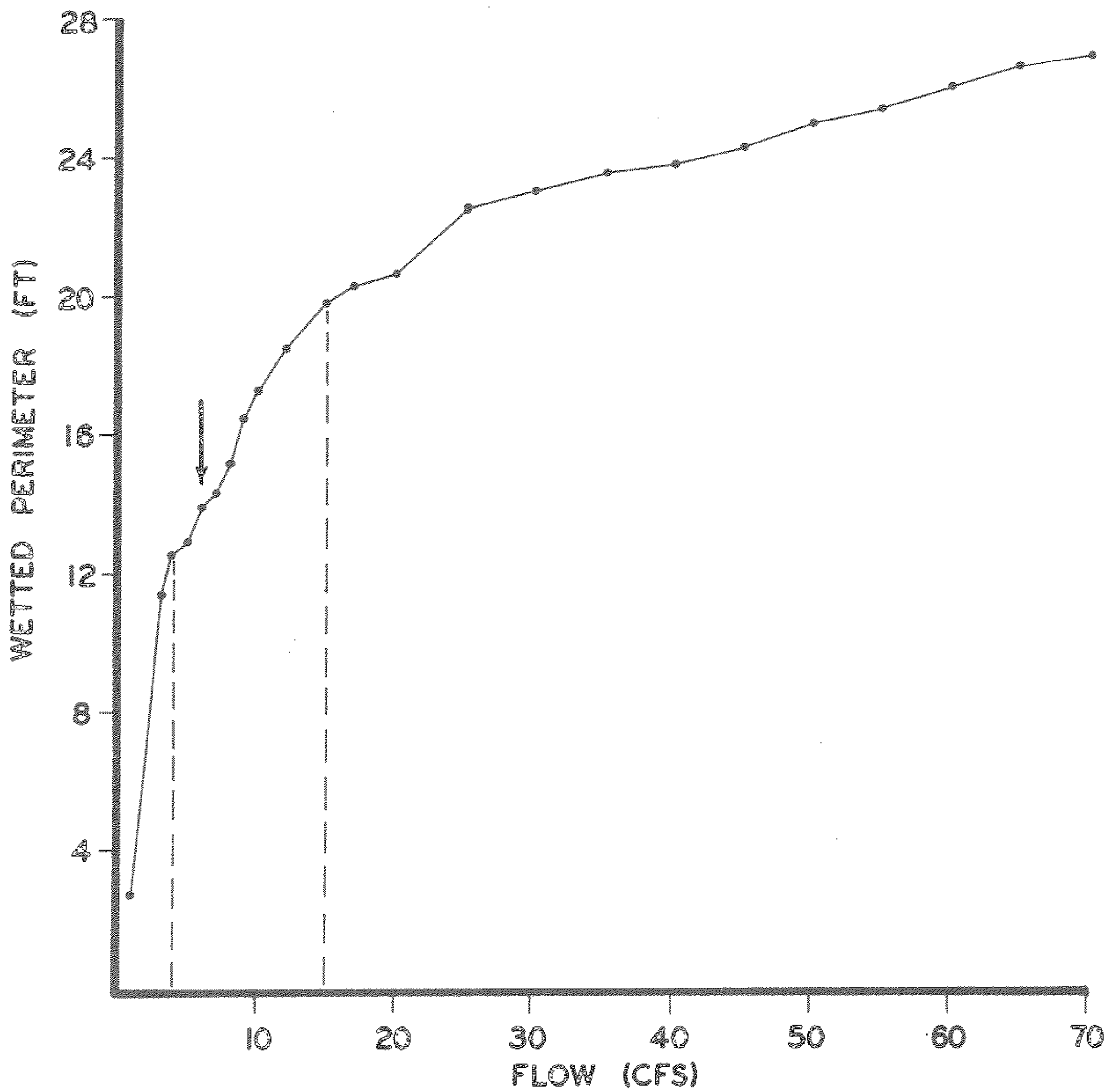


Figure 55. The relationship between wetted perimeter and flow for a composite of five cross-sections in Beaver Creek.

1. STREAM

Crow Creek

2. GENERAL DESCRIPTION

Crow Creek begins at the confluence of Tizer and Little Tizer Creeks on the east slope of the Elkhorn Mountains (elevation 6,320 ft) and flows 26 miles before joining the Missouri River near Toston, Montana. The stream gradient averages 93.5 feet per mile. Crow Creek averages 23.7 ft in width at spring flow levels. It is free flowing for its entire length. Major tributaries to Crow Creek are South Fork, Tizer, Little Tizer, Moose, Clear and Crazy Creeks. The upper 41 percent of the stream is within the Helena National Forest.

Crow Creek is severely dewatered during the summer irrigation season soon after leaving public lands. The mining that is occurring in and near the stream channel and stream sedimentation resulting from over-grazing are other environmental concerns.

Angler use of Crow Creek is substantial. Fishing pressure in 1975-76 was estimated at 662 fisherman-days annually (MDFG, 1976).

The USGS operated a gauge on Crow Creek at stream mile 16.7 in 1901, 1919-29 and 1966-72. The mean, maximum and minimum flows for the period of record are 47.7, 1,000 and 1.4 cfs, respectively.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Crow Creek were surveyed by electrofishing on September 19 and October 16, 1980. Game fish captured in descending order of abundance were rainbow, brook and brown trout. The mottled sculpin was the only non-game species collected. The electrofishing survey data are summarized in Table 138.

Table 138. Summary of electrofishing survey data collected for a 1,000 ft section of Crow Creek (T6N, R1W, Sec 23A) on September 19 and October 16, 1980.

Species	Number Captured	Length Range (inches)
Rainbow Trout	287	4.0 - 11.3
Brook Trout	35	3.1 - 12.0
Brown Trout	2	5.7 - 19.5
Mottled Sculpin	-	-

The standing crop of rainbow trout, the predominant trout species in the section, was estimated using a mark-recapture method (Table 139). This 1,000 ft section supports an estimated population of 409 rainbow trout, weighing 40 pounds. The populations of brook and brown trout were too sparse to reliably estimate using the mark-recapture method.

Table 139. Estimated standing crop of rainbow trout in a 1,000 ft section of Crow Creek (T6N, R1W, Sec 23A) on September 19, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Number	Per 1,000 ft Pounds
Rainbow Trout	4.0 - 5.9	215	
	6.0 - 9.9	193	
	10.0 - 11.3	1	
		409(±52)	40(±4)

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 177 ft riffle-pool sequence located near the forest boundary (T6N, R1W, Sec 25B). Five cross-sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 21.7, 40.0 and 72.3 cfs.

The relationship between wetted perimeter and flow for the composite of four riffle cross-sections is shown in Figure 56. The lower and upper inflection points occur at approximate flows of 11 and 25 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 14 cfs is recommended for the low flow period (July 1 - April 30).

Monthly flow recommendations for both the low and high flow periods are listed in Table 140. The approximate median monthly flows of record for the USGS gauge on Crow Creek are also listed for comparing to the recommendations. The recommendations exceed the median flows for the months of December through March.

The monthly recommendations, when adjusted to fall withing the constraints of water availability for a median water year, amount to approximately 18,177 acre-feet of water per year or about 61 percent of the flow that is normally available at the USGS gauge site.

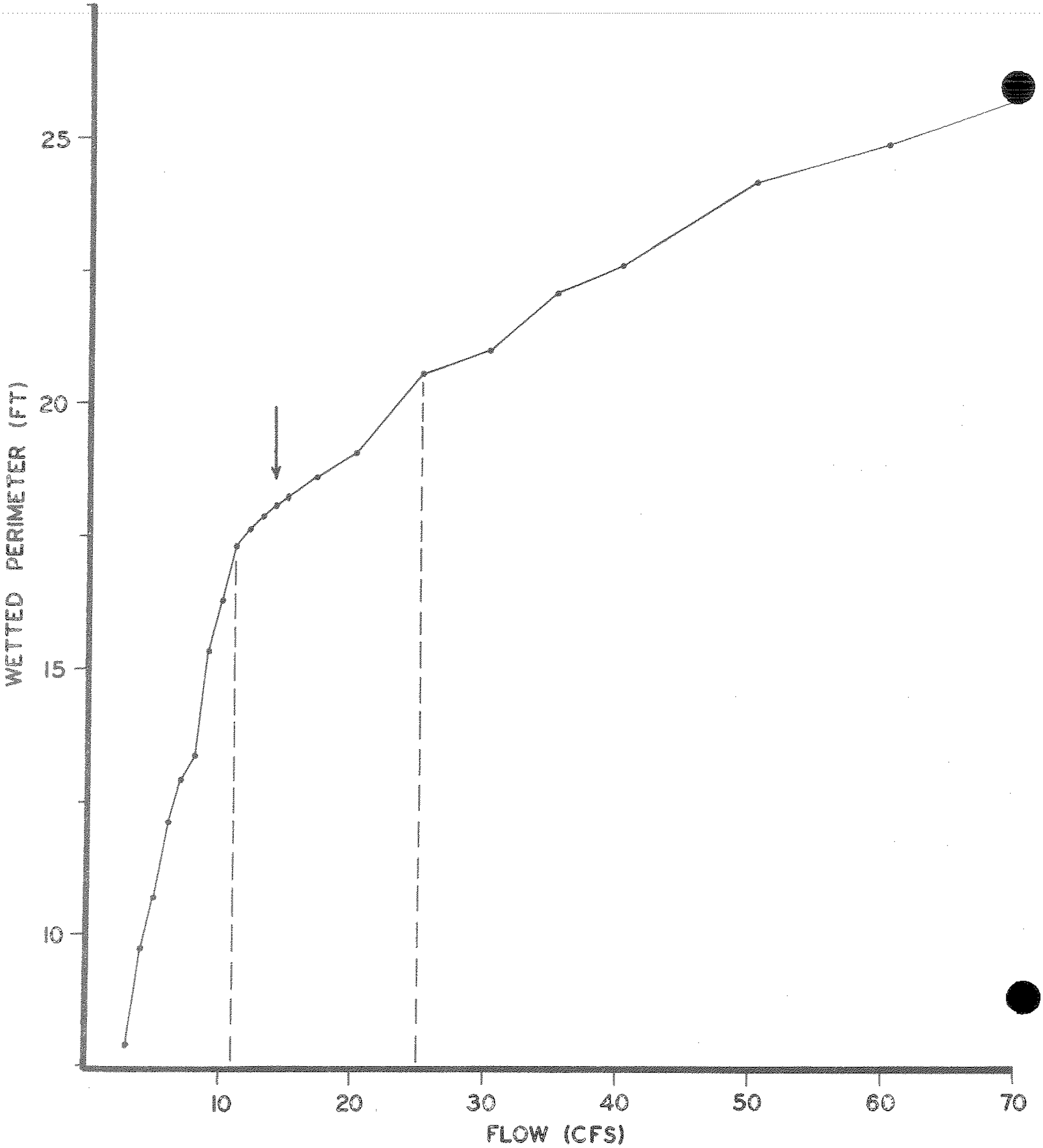


Figure 56. The relationship between wetted perimeter and flow for a composite of four riffle cross-sections in Crow Creek.

Table 140. Instream flow recommendations derived for Crow Creek using the wetted perimeter/inflection point method (low flow period) and the dominant discharge/channel morphology concept (high flow period) compared to the approximate median flows of record.

	Recommended Flows	Approximate Median Flows [a/]	
	CFS	CFS	AF
January	14	8.0	492
February	14	8.0	444
March	14	11.7	719
April	14	32.5	1,933
May 1-15	52	114.0	3,391
May 16-31[b/]	155	215.0	6,822
June 1-15	80	150.0	4,462
June 16-30	67	118.0	3,510
July	14	49.9	3,068
August	14	21.4	1,316
September	14	19.8	1,178
October	14	17.6	1,082
November	14	14.9	886
December	14	9.8	602
			29,905

[a/] Derived for a 9 year period of record (1921-29) for the USGS gauge at stream mile 16.7 (T6N, R1W, Sec 23).

[b/] The bankful flow, which is presently undefined, should be maintained for 24 hours during this period.

1. STREAM

Deep Creek

2. DESCRIPTION

Deep Creek begins on the west slope of the Belt Mountains at an elevation of 6,520 feet and flows 28.6 miles to the "Montana Ditch" south of Townsend, Montana. The mean gradient is 94 ft per mile. The stream width during spring runoff averages 34.3 ft. Major tributaries include North Fork Deep Creek, Cabin Gulch, Sulphur Bar Creek and the Russell Fork. The upper 56% of Deep Creek is within the Helena National Forest. Land surrounding the lower portion is privately owned and is used primarily for hay production.

Recreational use of the Deep Creek drainage is mainly confined to fishing. The fishing pressure in 1975-1976 was estimated at 450 fisherman-days annually (MDFG, 1976).

Deep Creek is dewatered immediately downstream of the forest boundary. The stream has had problems with flooding in the past. Sections of Deep Creek have been severely altered as a result of highway construction.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Deep Creek were surveyed by electrofishing on September 17 and October 15, 1980. Game fish captured in descending order of abundance were rainbow, brook and brown trout. The mottled sculpin was the only nongame species collected. The electrofishing survey data are summarized in Table 141.

Table 141. Summary of electrofishing survey data collected for a 1,000 ft section of Deep Creek (T7N, R3E, Sec. 25D) on September 17 and October 15, 1980.

Species	No. Captured	Length Range (inches)
Rainbow Trout	202	4.0-13.0
Brook Trout	25	4.6- 8.9
Brown Trout	24	3.1-15.5
Mottled Sculpin	-	-

The standing crop of rainbow trout, the predominant trout species in the section, was estimated using a mark-recapture method (Table 142). This 1,000 ft section supports an estimated population of 182 rainbow trout, weighing 25 pounds. The populations of brook and brown trout were too sparse to reliably estimate using the mark-recapture method.

Table 142. Estimated standing crop of rainbow trout in a 1,000 ft section of Deep Creek (T7N, R3E, Sec. 25D) on September 17, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Pounds
Rainbow Trout	4.0- 5.9	83	
	6.0- 9.9	88	
	10.0-13.0	11	
		182 (±18)	25 (±2)

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 222 ft riffle-pool sequence located near the forest boundary (T7N, R4E, Sec. 30C). Five cross-sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 122.2, 44.8 and 18.0 cfs.

The relationship between wetted perimeter and flow for the composite of three riffle cross-sections is shown in Figure 57 . The lower and upper inflection points occur at approximate flows of 25 and 50 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information a flow of 35 cfs is recommended for the low flow period (July 1 - April 30). Flow recommendations for the high flow period (May 1 - June 30) cannot be derived due to the lack of long-term flow information for Deep Creek.

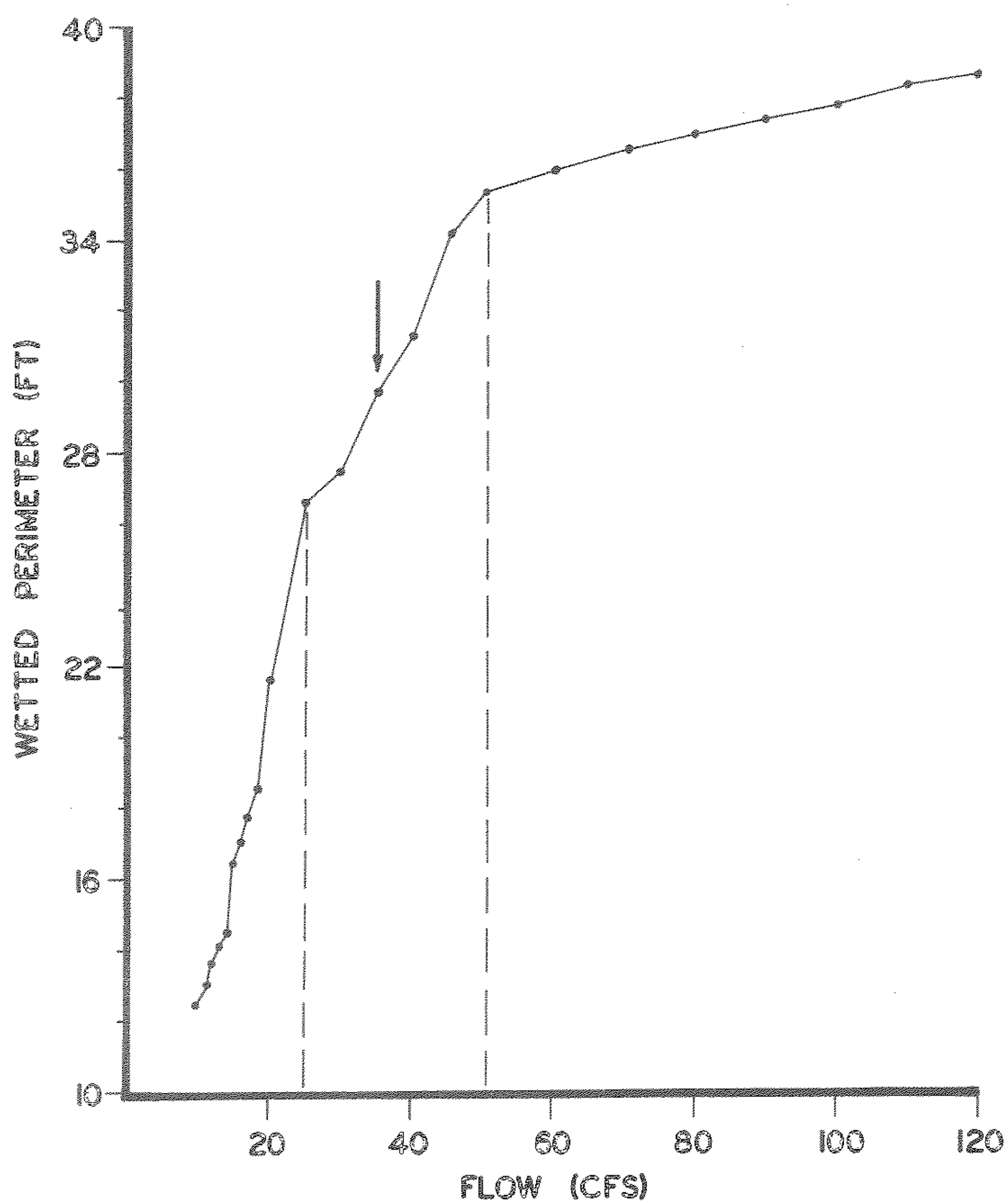


Figure 57. The relationship between wetted perimeter and flow for a composite of three riffle cross-sections in Deep Creek.

1. STREAM

Hellgate Gulch Creek

2. GENERAL DESCRIPTION

Helgate Gulch Creek arises on the west side of the Belt Mountains and flows approximately 9.9 miles before discharging into Canyon Ferry Reservoir. Hellgate Gulch Creek has a mean gradient of 212 feet per mile. At spring flow levels, the creek averages 4.2 feet in width.

The upper 70 percent of Hellgate Gulch Creek is within the Helena National Forest. Tributaries include Quartzite, Gabish, Fisher and Killgallon Gulches and Thompson Creek. No historic discharge information is available for the drainage.

Environmental concerns that could potentially affect the stream resource include mining, sedimentation from road construction and overgrazing by cattle. The creek is totally dewatered near the forest boundary during the summer irrigation season.

3. FISH POPULATIONS

A 1,000 ft section of Hellgate Gulch Creek was electrofished on July 30, 1980. The section is located upstream of the forest boundary (T10N, R1E, Sec 3C). No fish were captured or seen during the survey.

4. FLOW RECOMMENDATIONS

Cross-sectional measurements were made in a 110 ft riffle-pool sequence located immediately upstream of the forest boundary (T10N, R1E, Sec 3C). Five cross-sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 0.8, 1.7 and 2.1 cfs.

The relationship between wetted perimeter and flow for the composite of all cross-sections is shown in Figure 58. The lower and upper inflection points occur at approximate flows of 0.5 and 0.8 cfs, respectively. Based on an evaluation of existing resource information, a flow of 0.5 cfs is recommended for the low flow period (approximately July 1 - April 30).

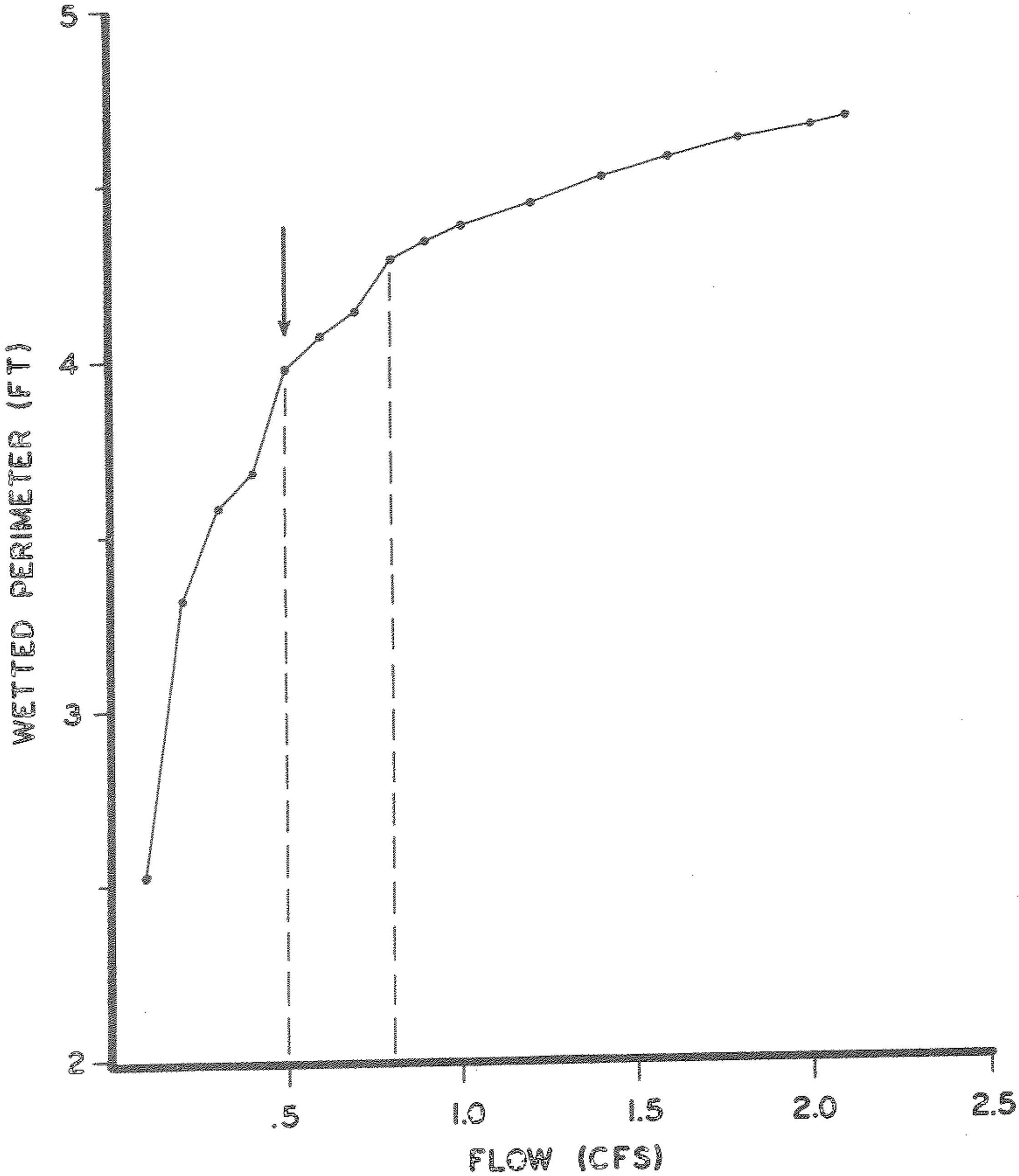
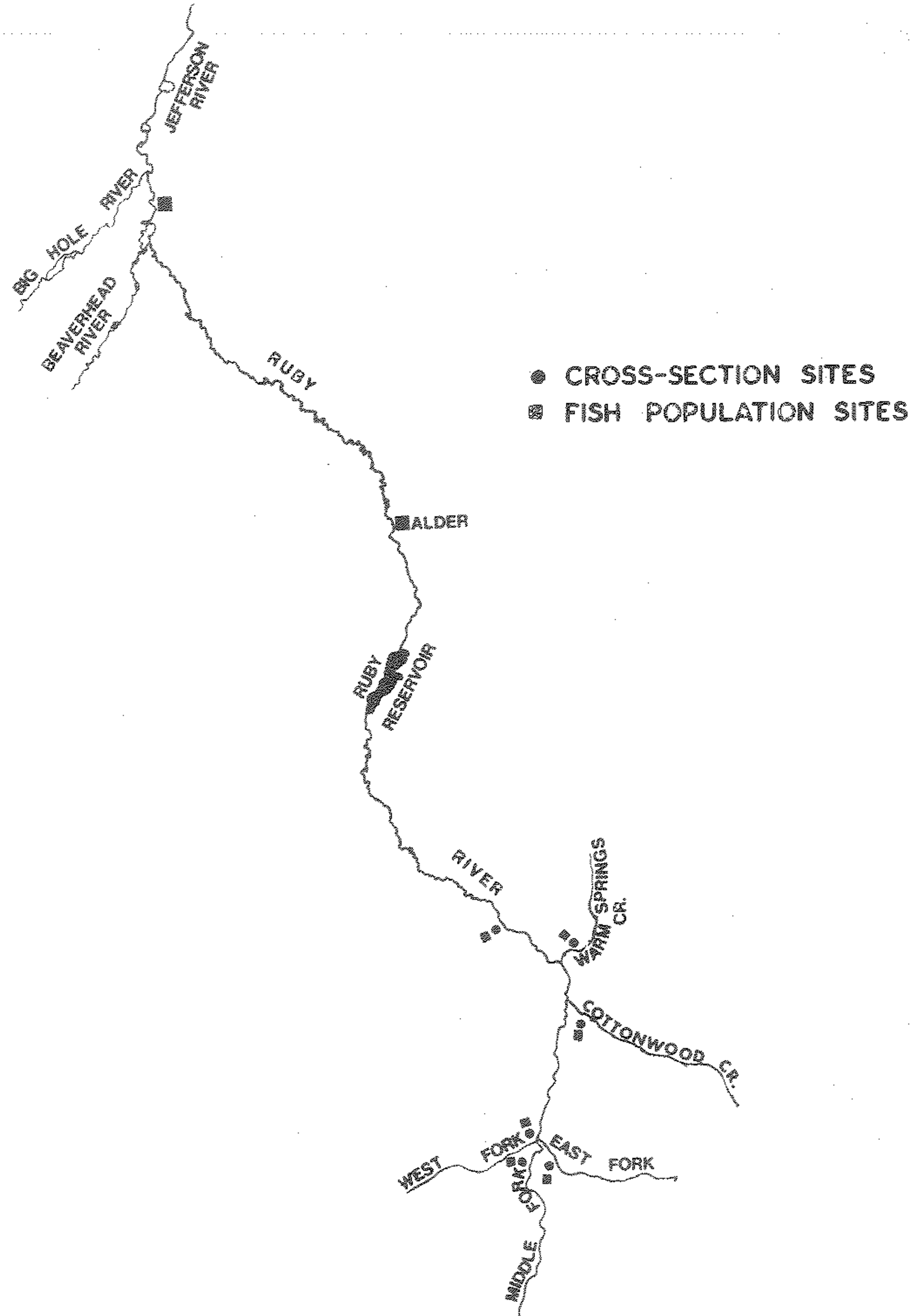


Figure 58. The relationship between wetted perimeter and flow for a composite of five cross-sections in Hellgate Gulch Creek.

RUBY RIVER TRIBUTARIES



The study area of the Ruby River Drainage.

1. STREAM

Cottonwood Creek

2. DESCRIPTION

Cottonwood Creek originates in the Gravelly Range approximately 34 miles south of Alder, Montana. The stream flows in a northeasterly direction for 10.1 miles before converging with the Ruby River. The 21.3 square mile drainage is entirely within the Beaverhead National Forest. Cottonwood Creek has a fairly steep gradient of 59 ft/1,000 ft. It flows through sparesely timbered slopes in its upper reaches and mountain grassland/ sagebrush communities in its lower reaches. The riparian zone is vegetated with alder, birch, rose, willow, aspen and various grasses. Major tributaries include the North Fork Cottonwood, Geyer and Iron Creeks. The bottom substrate within the 25 ft wide channel consists of boulder, cobble and gravel. Gravel roads provide access to the upper and lower reaches of the stream. A USFS campground and picnic area are located along the lower portion of Cottonwood Creek.

The USFS collected flow data sporadically from May through October of 1972-1976 (Page, 1978). Flows in Cottonwood Creek ranged from a low of 3.8 in September, 1972 to a high of 161.4 cfs in June of 1975. The highest recorded flow in 1976 was 101.7 cfs in May. It should be noted that the 1975 and 1976 water years were the highest and the 5th highest, respectively, for a 38-year period of record for the Ruby drainage.

Lands within the Cottonwood Creek drainage are primarily used for sheep and cattle grazing and recreation in the form of hunting, fishing and camping. The effects of past and present land use activities, especially livestock grazing, on the highly erosive soils of the upper Ruby River drainage have been a point of debate and controversy in recent years.

Page (1978) found extensive rill and gully formation in the upper Cottonwood Creek drainage, which he attributed to past overuse by livestock. Twenty-three percent of the annual sediment yield in 1975-1976 in the upper Ruby River was contributed by Cottonwood Creek. This amounted to 377 tons/square mile of drainage (Page, 1978). Upper channels are very confined and of a highly erosive nature with 20-30 ft vertical raw banks (USFS, unpublished data). Suspended sediment and turbidity readings in Cottonwood Creek were the highest and second highest, respectively, out of 14 sampling stations in the upper Ruby drainage (Page, 1978). In a 1970 study, Cottonwood Creek was found to have the highest average turbidity reading of the 39 stations sampled in the Beaverhead River drainage (Elser and Marcoux, 1972).

Water chemistry data collected sporadically from 1973-1977 on Cottonwood Creek show an overall good quality (Page, 1978). The water has high levels of sulfate and major nutrients and a high total alkalinity, hardness and specific conductance. Water quality should not hinder aquatic productivity.

3. FISH POPULATIONS

A 1,000 ft section located near the mouth of Cottonwood Creek was electrofished on July 22, 1980. Low numbers of cutthroat and rainbow trout were captured in Cottonwood Creek (Table 143). Of the five trout captured, none were less than 5.9 inches, suggesting poor reproduction in the stream. Mottled sculpin and longnose dace were the nongame species present.

Table 143. Summary of electrofishing survey data collected for a 1,000 ft section of Cottonwood Creek (T10S, R3W, Sec. 9D) on July 22, 1980.

Species	No. Captured	Length Range (inches)
Rainbow Trout	4	5.9-11.3
Cutthroat Trout	1	15.5
Mottled Sculpin	-	-
Longnose Dace	-	-

Due to the low numbers of fish captured, a population estimate could not be obtained for Cottonwood Creek.

Haugen (1975) electrofished three sections of Cottonwood Creek in 1974. He found no game fish in the section corresponding to the 1980 study section, one cutthroat trout in the middle section and no game fish in the upper section. He believed that bank instability and the lack of adequate stream cover, pools and spawning areas were limiting the fishery.

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 79 ft riffle-run sequence near the mouth of Cottonwood Creek (T10S, R3W, Sec. 9D). Five cross-sections were placed in this sequence. The WETP program was calibrated to field data collected at flows of 5.3, 22.7 and 29.8 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-sections is shown in Figure 59 . Lower and upper inflection points occur at 4.5 and 6.5 cfs, respectively. Based on an evaluation of existing fishery and other resource information, a flow of 4.5 cfs is recommended for the low flow period (July 16 - May 15). Due to the lack of long-term flow data for Cottonwood Creek, recommendations for the high flow period (May 16 - July 15) cannot be derived.

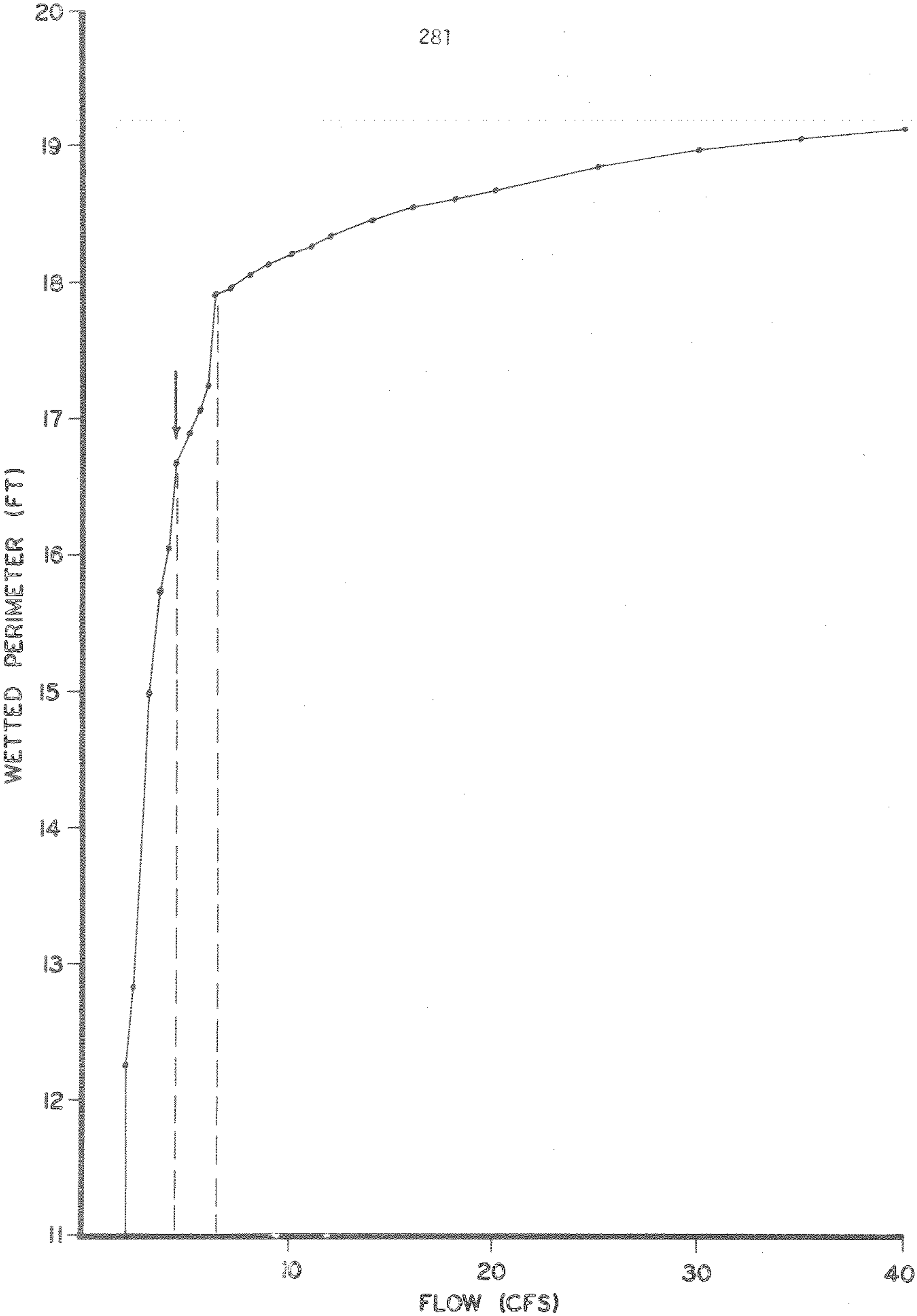


Figure 59. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in Cottonwood Creek,

1. STREAM

East Fork Ruby River

2. DESCRIPTION

The East Fork Ruby River originates in the Gravelly Range of southwest Montana and flows for 7 miles in a northeasterly direction before converging with the West and Middle Forks to form the Ruby River. The 16.3 square mile drainage is controlled entirely by the USFS. Although there are numerous small tributaries to the East Fork Ruby River, Tributary Creek is the only named stream. The East Fork Ruby River has a fairly steep gradient of 50 ft per 1,000 ft. The riparian zone is vegetated with willow, birch, alder and cinquefoil. The bottom substrate of the 15 ft wide channel consists primarily of boulder and cobble.

Flows have been sporadically measured by the USFS from May through September, 1975-1976 (USFS, unpublished data). Flows ranged from a low of 6.9 cfs in September, 1975 to a high of 140.7 cfs in July, 1975. The highest recorded flow for 1976 was 132.6 cfs in late May. It should be noted that 1975 and 1976 were the highest and fifth highest water years, respectively, in a 38-year period of record for the Ruby River drainage. No water is presently being diverted from the East Fork.

Lands within the East Fork Ruby River drainage are primarily used for cattle and sheep grazing and recreation in the form of hunting, fishing and camping. A cow camp is located on the lower portion of the stream near the mouth. Other than a road paralleling the lower mile and the headwater area, this stream is accessible only by foot or horse.

The effects of past and present land use practices, especially livestock grazing, on the fragile and highly erosive soils of the East Fork Ruby River drainage have been debated for the past decade.

Page (1978) attributed extensive gully and rill formation near the crest of the Gravelly Range to grazing abuse early in the century. This land deterioration has concentrated and increased runoff in the East Fork Ruby River drainage. The average annual suspended sediment yield for the East Fork during 1975-1976 was 246 tons/square mile of drainage, second only to Cottonwood Creek in the upper Ruby River drainage. In 1970, Elser and Marcoux (1972) found the East Fork Ruby River to have the second highest turbidity of 39 stations, the shallowest average depth, and the lowest amount of undercut banks. The USFS identified poor habitat conditions, extensive bank and bottom scour, inadequate pool development and stock trampling as factors affecting the aquatic resource (MDFWP, 1980b).

Sporadic water chemistry samples collected by the USFS during 1974-1977 suggest good water quality for the East Fork Ruby River (USFS, unpublished data and Page, 1978). Major nutrients and total dissolved solids are available for a productive aquatic ecosystem.

3. FISH POPULATIONS

A 2,000 ft section of the East Fork Ruby River was electrofished in August, 1970 and a 3,566 ft section was electrofished in September, 1975 (Elser and Marcoux, 1972 and Peterson, 1976). Game fish captured were rainbow trout, cutthroat trout and rainbow x cutthroat hybrids. The mottled sculpin was the only nongame species present (Table 144).

Table 144. Summary of electrofishing survey data collected for a 2,000 ft section of the East Fork Ruby River (T11S, R3W, Sec. 5) on August 19 and 25, 1970 and a 3,566 ft section (T11S, R3W, Sec. 5) on September 19, 26 and 30, 1975.

Species	No. Captured		Length Range (inches)	
	1970	1975	1970	1975
Rainbow Trout	46	30	3.7-13.6	4.0-15.0
Cutthroat Trout	-	6	-	4.0- 8.8
Rainbow x Cutthroat Hybrids	26	18	4.2-10.6	6.1- 8.5
Mottled Sculpin	-	-	-	-

The standing crop of trout in the 2,000 ft section was estimated in 1970 using a mark-recapture method (Table 145). This section supports about 47 trout, weighing 6 pounds, per 1,000 ft of stream. This population is severely depressed when compared to other streams electrofished in the Beaverhead National Forest. Of the three forks of the Ruby River, the East Fork supports the lowest trout biomass.

Table 145. Estimated standing crop of trout in a 2,000 ft section of East Fork Ruby River (T11S, R3W, Sec. 5) on August 19, 1970. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft	
		Number	Pounds
Cutthroat, Rainbow and Rainbow x Cutthroat Trout Hybrids	4.0- 5.9	28	
	6.0- 9.9	15	
	10.0-13.6	4	
		47 ($\pm$10)	6 ($\pm$2)

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 50 ft subreach located near the mouth of the East Fork Ruby River (T11S, R3W, Sec. 5B). Five cross-sections describing the riffle-run habitat were placed within the subreach. The WETP program was calibrated to field data collected at flows of 7.9, 24.2 and 34.3 cfs.

The relationship between wetted perimeter and flow for a single riffle cross-section is shown in Figure 60. Lower and upper

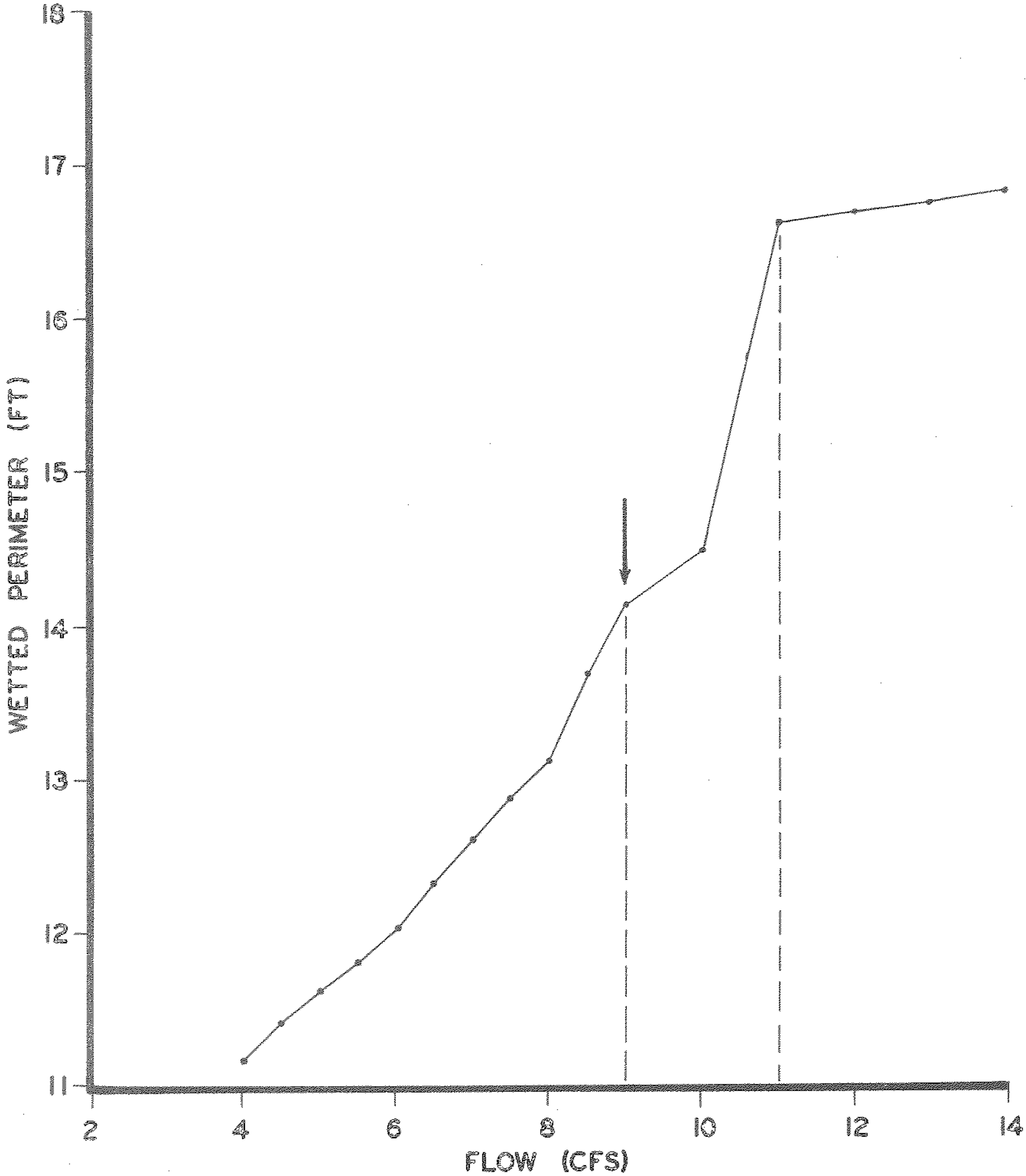


Figure 60. The relationship between wetted perimeter and flow for a single riffle cross-section in the East Fork Ruby River.

inflection points occur at flows of 9.0 and 11.0 cfs, respectively. Based on an evaluation of existing fishery, water availability, recreational use and other resource information, a flow of 9.0 cfs is recommended for the low flow period (July 16 - May 15). Flow recommendations for the high flow period (May 16 - July 15) cannot be derived due to the lack of long-term flow data for the East Fork Ruby River.

1. STREAM

Middle Fork Ruby River

2. DESCRIPTION

The Middle Fork Ruby River originates in the Gravelly and Snowcrest Ranges in southwest Montana approximately 36 miles south of the town of Alder, Montana. It flows for 9 miles before converging with the East and West Forks to form the Ruby River. The 55.4 square mile drainage, which consists of sagebrush covered lowlands and sparsely timbered foothills and mountains, is controlled entirely by the USFS. Major tributaries to the Middle Fork Ruby River include Basin, Corral, Shovel, Deer, Poison, Hawkeye and Bear Creeks. The 20 ft wide meandering channel has a gradient of 12 ft per 1,000 ft. The riparian zone is vegetated with birch, alder, willow, grasses and forbs. A graveled road parallels the stream its entire length. Angler log information collected by the DFWP show that the catch of gamefish consists entirely of rainbow trout, averaging 10.6 inches in length (MDFWP, 1980b).

The USFS collected sporadic flow data from May through September, 1975-1976 (USFS, unpublished data). Flows during this period ranged from 14.4 cfs in August, 1975 to 224.3 cfs in June, 1975. The highest recorded flow in 1976 was 79.2 cfs in June. It should be noted that 1975 and 1976 were the highest and fifth highest water years, respectively, in a 38-year period of record for the upper Ruby drainage. No water is presently being diverted from the stream.

Cattle and sheep grazing and recreation are the primary land use activities in the Middle Fork drainage. The effects of past and present land use activities, especially livestock grazing, on the fragile and easily erodible soils of the upper Ruby River Valley have been debated for over a decade.

Haugen (1977) found bank instability in the Ruby drainage to be the greatest above the three forks. Much of the instability was attributed to livestock or livestock related activities. In comparing the three forks of the Ruby River and streams from other drainages in the Beaverhead River basin, Elser and Marcoux (1972) collected physical data showing the Middle Fork Ruby River to have the greatest average stream width, highest total exposed bank and the lowest percent cover to total surface area. Although turbidity readings in the Middle Fork Ruby River were average in comparison to other streams in the Ruby River drainage, measurements were two to three times higher than those found in other streams in the Beaverhead River drainage (Elser and Marcoux, 1972).

Haugen (1977) recommended that allotments on the upper Ruby River (Middle and West Forks) should be analyzed to see what adjustments could be made to improve riparian habitat quality and quantity. The USFS identified a general deteriorating habitat trend in the Middle Fork with specific limiting factors being the sedimentation of riffles, inadequate pool development, bank scour and a generally highly erosive drainage (MDFWP, 1980b). During the 1980 field season, a cooperative effort by the USFS and MDFWP for habitat rehabilitation of a section on the Middle Fork Ruby River was eliminated from the Sheridan Ranger District Work Plan.

In reviewing water chemistry data collected sporadically during 1974-1977 by the USFS, water quality of the Middle Fork Ruby River appears good (USFS, unpublished data). Based on existing levels of major nutrients, the stream is capable of sustaining a higher aquatic productivity than is presently occurring.

3. FISH POPULATIONS

A 1,650 ft section of the Middle Fork Ruby River was electrofished on August 20 and 25, 1970 (Elser and Marcoux, 1972). A 2,643 ft section in the immediate vicinity of the 1970 section was electrofished on September 19, 26 and 30, 1975 (Peterson, 1976). Game fish present were cutthroat trout, rainbow trout and rainbow x cutthroat hybrids. The mottled sculpin was the only nongame species captured. The 1970 and 1975 electrofishing survey data are summarized in Table 146.

Table 146. Summary of electrofishing survey data collected for a 1,650 ft section of the Middle Fork Ruby River (T11S, R3W, Sec. 7D) on August 20 and 25, 1970 and a 2,643 ft section (T11S, R3W, Sec. 7D) on September 19, 26 and 30, 1975.

Species	No. Captured		Length Range (inches)	
	1970	1975	1970	1975
Cutthroat Trout	12	12	4.2-10.3	5.0-11.8
Rainbow Trout	11	2	6.4-10.1	6.0- 9.7
Rainbow x Cutthroat Hybrids	11	31	4.7-10.9	5.0-11.6
Mottled Sculpin	-	-	-	-

The standing crops of trout in the sections were estimated using a mark-recapture method (Table 147). In 1970, the Middle Fork supported an estimated 6 pounds of trout per 1,000 ft of stream and 8 pounds per 1,000 ft in 1975. Of the streams electrofished in the Beaverhead National Forest, the Middle Fork Ruby River supports one of the lowest trout populations. The condition (length to weight ratio) for all length groups of trout was well below average for streams surveyed in the Beaverhead N.F.

Table 147. Estimated standing crop of trout in a 1,650 ft section of the Middle Fork Ruby River (T11S, R3W, Sec. 7D) on August 20, 1970 and a 2,643 section (T11S, R3W, Sec. 7D) on September 19, 1975. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft			
		1970		1975	
		Number	Pounds	Number	Pounds
Rainbow Trout, Cutthroat Trout and Rainbow x Cutthroat Hybrids	4.2- 5.9	2		5	
	6.0- 9.9	16		30	
	10.0-11.8	9		6	

Table 147 continued. Estimated standing crop of trout in a 1,650 ft section of the Middle Fork Ruby River (T11S, R3W, Sec. 7D) on August 20, 1970 and a 2,643 section (T11S, R3W, Sec. 7D) on September 19, 1975. Eighty percent confidence intervals are in parentheses.

		Per 1,000 Ft			
		1970		1975	
Species	Length Group (inches)	Number	Pounds	Number	Pounds
		27($\pm$6)	6($\pm$2)	41($\pm$17)	8($\pm$3)

4. FLOW RECOMMENDATIONS

Cross-sectional data were collected in a 105.8 ft subreach located in T11S, R3W, Sec. 5B. Five cross-sections describing the riffle-pool habitat were placed within the subreach. The WETP program was calibrated to field data collected at flows of 11.2, 42.5 and 96.7 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is shown in Figure 61. Lower and upper inflection points occur at 7 and 17 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 9 cfs is recommended for the low flow period (July 1 - April 30). Due to the lack of long-term flow data for the Middle Fork Ruby River, recommendations for the high flow period (May 1 - June 30) cannot be derived.

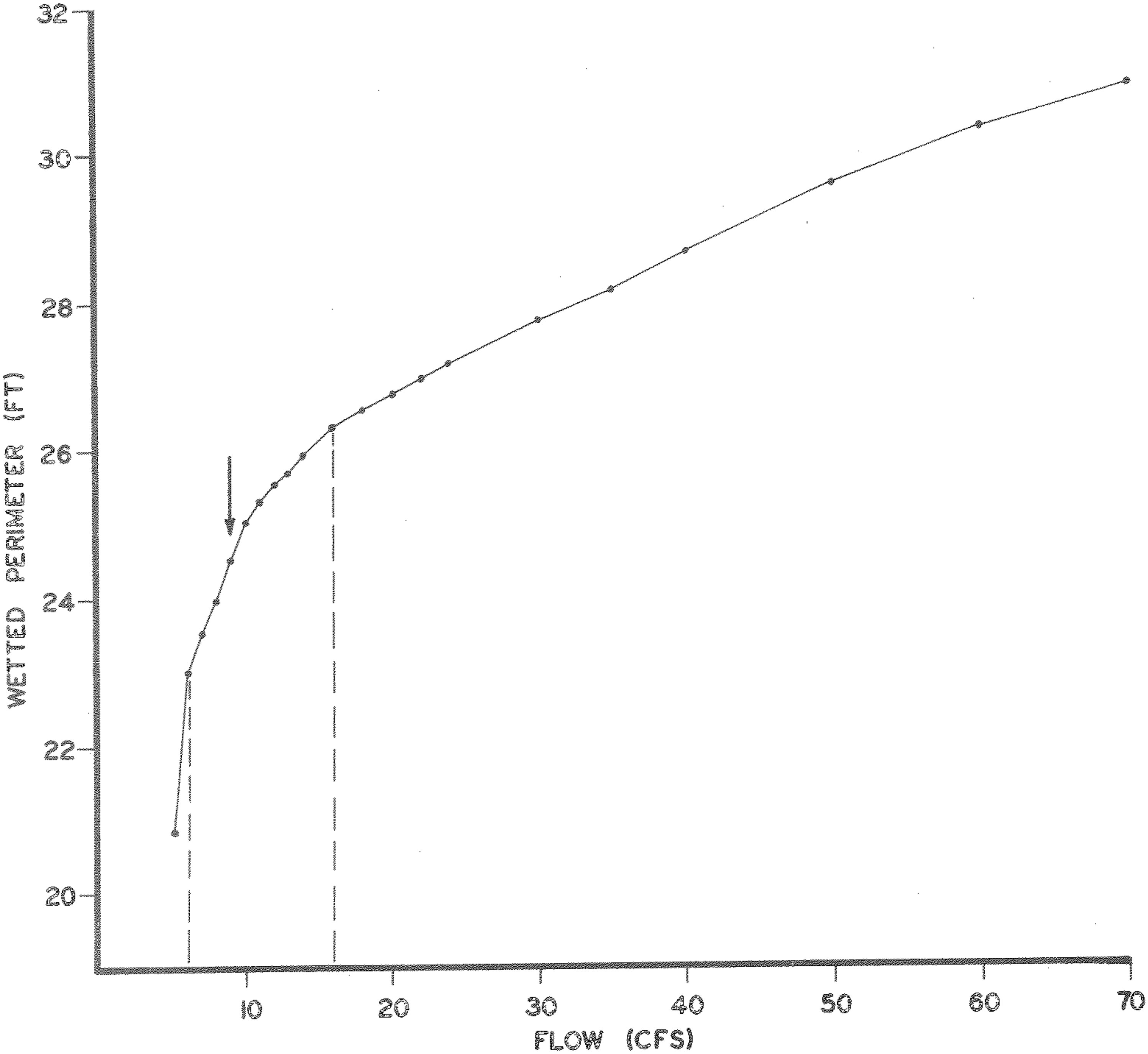


Figure 61. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in the Middle Fork Ruby River.

1. STREAM

Ruby River (above Ruby Reservoir)

2. DESCRIPTION

The Ruby River originates at the convergence of its East, West and Middle Forks and flows in a northwesterly direction for about 92 miles before converging with the Beaverhead River near the town of Twin Bridges, Montana. The upper 14 miles of river flows through the Beaverhead N.F.. Ruby Reservoir, an irrigation impoundment with a usable storage capacity of 38,850 acre-feet, is located approximately half-way down the drainage. The upper Ruby Valley is characterized by a broad floodplain bounded on the west by the steep, mountainous Snowcrest Range and the east by the more gentle, rolling Gravelly Range. Elevations in the upper Ruby River Valley range from 5,900 to 10,500 ft. Average annual precipitation varies between 20-45 inches.

Vegetative cover in the upper drainage is composed of 61% grassland, 12% forest, 13% subalpine grassland, 12% noncommercial timber and 2% wet meadow and willow bottom (Page, 1978). Riparian species are primarily willow, alder, birch and numerous grasses and sedges.

Lands within the upper Ruby River drainage are primarily controlled by the USFS (97%) with the remaining three percent owned by private individuals. The 214 sq mile drainage contains 925 miles of stream channel. Average gradient of the 50 ft wide Ruby River channel is fairly constant at 7 ft/1,000 ft.

Sporadic flow measurements have been collected for the Ruby River at the USFS boundary from August, 1975 - October 1976 (Page, 1978). Flows during this period varied from a low of 80.5 cfs in October, 1976 to a maximum of 536.3 cfs in June, 1976. It should be noted that the 1975 and 1976 water years were the highest and 5th highest, respectively, in the 38 years of record for the upper Ruby River.

Historically, the summer range of the upper Ruby basin was used by american bison, bighorn sheep, pronghorn antelope and grizzly bear. Beginning in the late 1800's this superior grassland was severely overgrazed by domestic sheep and cattle (Page, 1978). In 1902, with the establishment of national forests, the high country was alloted for sheep pasture and the low ranges for cattle. Today, after a 30% and 50% reduction of sheep and cattle, respectively, the range lands of the upper Ruby are managed on a rest rotation grazing system (Best, 1979). Presently 5,309 cattle and 3,800 sheep are using the summer rangeland (Best, 1979).

Other land uses in the upper Ruby Valley include recreation in the form of fishing, hunting and camping, timber harvesting and limited amounts of mining. Gravel roads, which parallel the river and many of its tributaries, allow excellent access to the entire drainage.

Fishing pressure from the headwaters of Ruby River to the USFS boundary during May, 1975 to April, 1976 was estimated by mail survey at 302 person-days (MDFG, 1976). This averages about 22 person-days/stream mile/year. The hunting district encompassing the upper Ruby drainage is one of the most popular hunting areas for mule deer and elk in Montana. Over 13,000 hunter-days were recorded for elk in 1979 (MDFWP, 1980a).

The effects of livestock grazing on the unstable and easily erodible soils of the upper Ruby River Valley have received considerable debate and research. Continued heavy livestock use denude upland areas of soil stabilizing plants, reducing the water holding capacity of the soil and increasing sediment yields to the watershed (Bowers et al., 1979). Livestock trampling and grazing of the riparian zone will eliminate needed fish cover and shade and lead to bank stability problems. This could further lead to water temperature increases, the widening of the stream channel and reductions in water depth.

The soils of the upper Ruby River valley are highly susceptible to erosion and mass wasting (Page, 1978). The overgrazing of these areas in the late 1800's resulted in the formation of extensive rills and gullies. The annual suspended sediment yield in the upper Ruby River averaged 35,274 tons in 1975-1976 (Page, 1978).

A riparian zone survey conducted in 1976 identified 621 bank instability sites on the upper 14 miles of Ruby River (Haugen, 1977). Livestock and livestock related activities were the apparent cause in 46% of these sites. Streambank and cover ratings were lowest in the channel above the convergence of the three forks. Only 30-40% of the streambanks surveyed had overhanging cover that was available for fish.

Severe sedimentation by extremely fine materials exists in the main river as well as in the major tributaries to the upper drainage (Haugen, 1977). Turbidity measurements in the main river were found to increase considerably below the confluence of the three forks (Elser and Marcoux, 1972). The upper Ruby River drainage had the higest turbidity readings when compared to three other drainages in the Beaverhead River Basin (Elser and Marcoux, 1972). Intergravel permeability was found to be below those levels needed for good trout egg survival (Haugen, 1977).

The water chemistry of the upper Ruby River falls in the range common to streams in southwestern Montana (Page, 1978). Major nutrients are available for a productive aquatic environment. These waters are classified as a calcium bicarbonate to sodium sulfate type.

It is believed that Warm Springs Creek, a tributary of the upper Ruby River, has substantially increased the aquatic productivity of the main river below its confluence. Levels of major nutrients, the specific conductance and the dissolved solids in the main river below the confluence are greater than those reported above (Page, 1978). The 68-70 F Warm Springs water stabilizes the temperature of the Ruby River throughout the year and increases minimum water temperatures (Peterson, 1976). This influence is of a positive nature to the aquatic resource by decreasing the severity of winter water temperatures and increasing fish food production throughout the year.

3. FISH POPULATIONS

Due to existing current fisheries information for the upper Ruby River, fish populations information was not collected during the present study. In September, 1975 and August, 1976, a 4,100 ft section located at the USFS boundary and downstream of the mouth of Warm Springs Creek was electrofished (Peterson, 1976 and 1979). Game fish captured in descending order of abundance were rainbow trout, mountain whitefish and brown trout. Mottled sculpin, longnose dace and longnose, white, and mountain suckers were the nongame species present (Table 148).

Table 148. Summary of electrofishing survey data collected for a 4,100 ft section of the upper Ruby River (T9S, R3W, Sec. 17C and 18D) on September 3 and 11, 1975 and August 11 and 25, 1976.

Species	No. Captured		Length Range (inches)	
	1975	1976	1975	1976
Rainbow Trout	727	564	3.5-15.2	3.4-13.5
Mountain Whitefish	143	83	4.0-17.9	8.3-15.5
Brown Trout	51	32	13.3-17.6	11.9-18.2
Longnose Dace	-	-	-	-
Mottled Sculpin	-	-	-	-
Longnose Sucker	-	-	-	-
White Sucker	-	-	-	-
Mountain Sucker	-	-	-	-

The standing crops of gamefish in the section were estimated using a mark-recapture method (Table 149). In 1975, the section supported about 720 gamefish, weighing 114 pounds, per 1,000 ft of stream. The estimate for 1976 was 608 gamefish, weighing 137 pounds, per 1,000 ft. The rainbow trout, the predominant game species, comprised over 90 and 55% of the gamefish numbers and biomass, respectively, in both years.

Table 149. Estimated standing crops of gamefish in a 4,100 ft section of the upper Ruby River (T9S, R3W, Sec. 17C and 18D) on September 3, 1975 and August 11, 1976. Eighty percent confidence intervals are in parentheses.

September, 1975

Species	Length Group (inches)	Per 1,000 Ft	
		Number	Pounds
Rainbow Trout	4.0- 5.9	532	
	6.0- 9.9	89	
	10.0-15.2	38	

Table 149 continued. Estimated standing crops of gamefish in a 4,100 ft section of the upper Ruby River (T9S, R3W, Sec. 17C and 18D) on September 3, 1975 and August 11, 1976. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
September, 1975			
		659 (±136)	63 (±8)
Brown Trout	13.3-17.6	15 (±2)	19 (±2)
Mountain Whitefish	10.0-17.9	46 (±9)	32 (±6)
Total Gamefish		720 (±136)	114 (±10)
August, 1976			
Rainbow Trout	4.0- 5.9	281	
	6.0- 9.9	228	
	10.0-13.5	40	
		549 (±123)	81 (±14)
Brown Trout	14.0-18.2	16 (±7)	22 (±10)
Mountain Whitefish	10.0-15.5	43 (±14)	34 (±12)
Total Gamefish		608 (±124)	137 (±21)

Five sections of the upper Ruby River, ranging from 4,100 to 7,125 ft in length, were electrofished in 1976 (Peterson, 1979). Four of the sections were located upstream of the USFS boundary and one was downstream. Rainbow trout were the predominant gamefish in all sections. Brown trout were present in the lower three sections, while mountain whitefish were present in all five sections. Gamefish standing crop estimates were obtained for the five sections.

The biomass of gamefish in the section immediately below the confluence of Warm Springs Creek is 4-7 times greater than the biomass in the three sections upstream of the confluence (Figure 62). Several factors, including the flow contibution of Warm Springs Creek and a general improvement in bank cover may be causing this increase. Gamefish populations again substantially decrease as the river progresses downstream of Warm Springs Creek (Figure 62). Irrigation diversions,

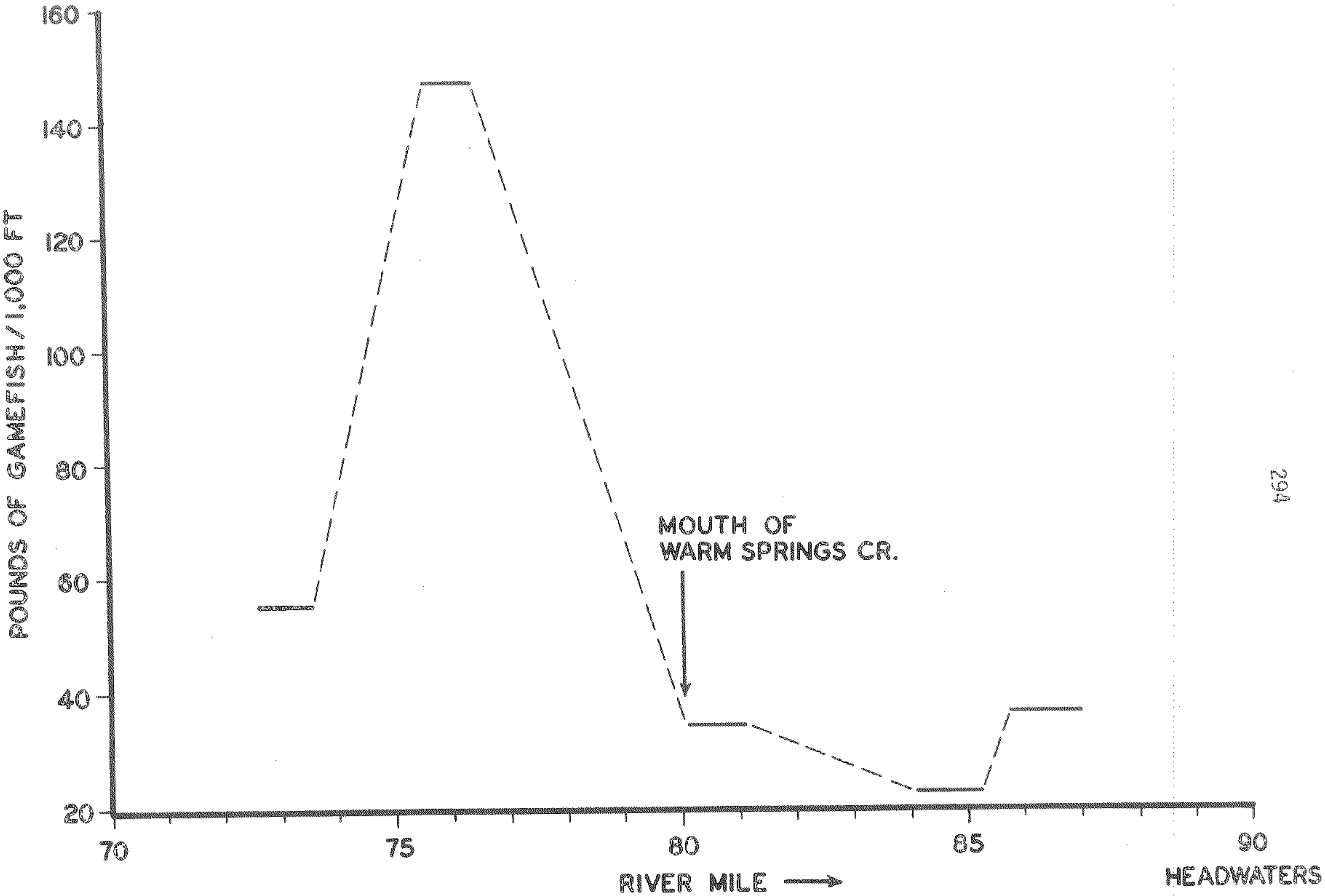


Figure 62. Estimated pounds of gamefish (rainbow trout, brown trout and mountain whitefish) in five sections of the upper Ruby River in 1976 (data from Peterson, 1977).

poor aquatic habitat conditions resulting from overgrazing, and the progressive dilution of the flow of Warm Springs Creek are probably contributing to this decline.

4. FLOW RECOMMENDATIONS

A 155 ft subreach on the upper Ruby River at the USFS boundary (T9S, R3W, Sec. 18D) was selected for the collection of cross-sectional data. Five cross-sections defining the riffle-pool habitat were placed within the subreach. The WETP program was calibrated to field data collected at flows of 93.4, 177.8 and 321.3 cfs.

The relationship between wetted perimeter and flow for a composite of two riffle cross-sections is shown in Figure 63 . Lower and upper inflection points occur at 55 and 120 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 85 cfs is recommended for the low flow period (July 16 - May 15). A recommendation for the high flow period (May 16 - July 15) cannot be derived for the upper Ruby River due to the lack of long-term flow information.

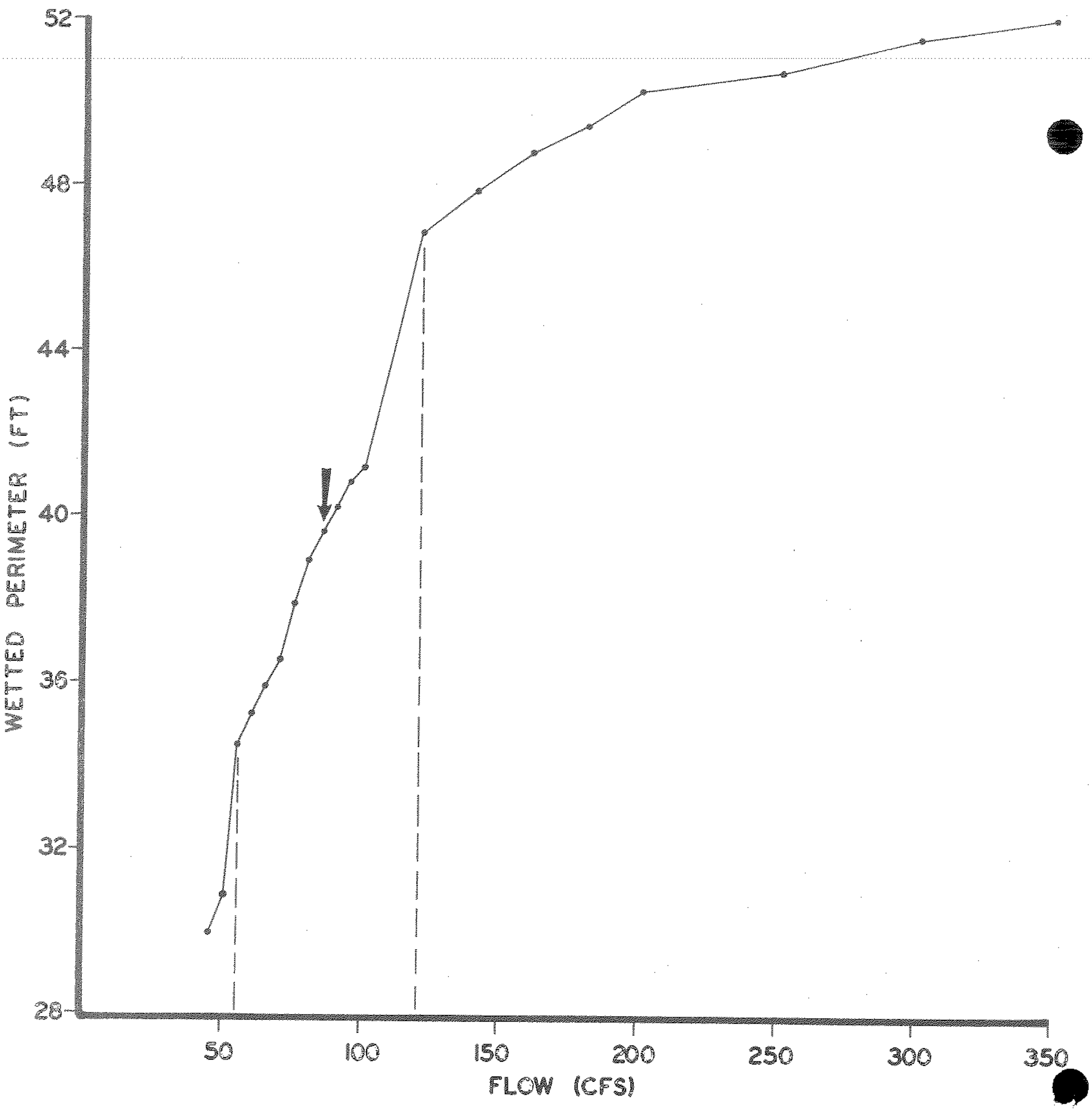


Figure 63. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in the Upper Ruby River.

1. STREAM

Warm Springs Creek

2. DESCRIPTION

Warm Springs Creek flows in a westerly direction for 9.4 miles before converging with the Ruby River, 3.5 miles above the USFS boundary. It flows through a broad valley bordered by the steep, rocky Greenhorn Range on the west and the more gentle Gravelly Range on the east. Ninety-eight percent of its 48.8 square mile drainage is controlled by the USFS. The remaining 2% is owned by private individuals and miners. Vegetative cover within the drainage consists of 72% grassland/sagebrush, 14% forest, 10% noncommercial forest and rocky slopes, 2% subalpine grassland and 2% willow bottom and wet meadow (Haugen, 1977). The riparian zone is vegetated with conifer, willow, birch and various grasses and forbs. Tributaries include Coyote, Davis and the Middle and South Forks Warm Springs Creeks. The majority of the flow in the lower 2.5 miles originates from numerous warm springs. During the summer months these 70 F waters contribute approximately 91% of the flow in the lower stretches (Pierce, 1966). The channel has an average gradient of 39 ft per 1,000 ft.

Flows in Warm Springs Creek have been sporadically measured by the USFS during the snow-free months of 1972-1976 (USFS, unpublished data). Flows during the summer season are fairly constant at 62-70 cfs. The minimum and maximum flows measured were 48.5 cfs in October, 1976 and 148.8 cfs in June, 1975, respectively. In July, 1966, Pierce (1966) measured the additive flows of the Warm Springs at 54.5 cfs.

Lands within the Warm Springs Creek drainage are used for sheep and cattle grazing, logging, mining and recreation in the form of hunting, hiking and fishing. Fishing pressure on Warm Springs Creek during the period of May, 1975 through April, 1976 was estimated from a mail survey at 373 person-days (MDFG, 1976). This amounts to about 40 person-days/stream mile/year. Angler log data compiled by the DFWP shows that 50% of the catch consists of rainbow trout, averaging 11.8 inches in length. Brown trout, averaging 14.1 inches, comprise the remaining 50% (MDFWP, 1980b). An improved gravel road parallels the lower and upper stretches of the stream, providing easy access throughout much of the basin.

Siltation, bank encroachment by agriculture, road building and overgrazing of the riparian zone have been identified as existing environmental problems in the Warm Springs Creek drainage (MDFWP, unpublished data and Haugen, 1975). It is believed that Warm Springs Creek, through increased water quality and quantity, increased nutrient levels and stabilizing water temperatures, has substantially increased the aquatic productivity in the Ruby River below its confluence. When comparing major nutrient levels, specific conductance, and total dissolved solids in the Ruby River above and below the confluence of Warm Springs Creek, these parameters were higher downstream (Page, 1978). The 68-70 F water of Warm Springs Creek tends to stabilize water temperatures in the Ruby River below its confluence (MDFWP, unpublished data). This warm water has a positive influence on the aquatic productivity by increasing food supply and reducing winter water temperatures and ice formation. A 4-7 fold increase in the gamefish population of the Ruby River immediately below the confluence has been documented by Peterson (1979). The flow of Warm Springs Creek is extremely important for the maintenance of gamefish populations in the Ruby River. Warm Springs Creek also provides spawning and rearing habitat for trout residing in the Ruby River.

Measurements of suspended sediment and turbidity in Warm Springs Creek were the lowest and second lowest, respectively, of 13 stations in the upper Ruby River drainage (Page, 1978). Sediment yield from this drainage during 1975-76 was measured at 83 tons/square mile, the lowest of any of the sampling stations in the Upper Ruby drainage (Page, 1978).

3. FISH POPULATIONS

A 1,000 ft section located downstream of most of the Warm Springs was electrofished on July 22 and August 14, 1980. Game fish present included rainbow trout, cutthroat trout, rainbow x cutthroat hybrids and mountain whitefish (Table 150). No game fish smaller than 7 inches were captured. Nongame species present were longnose dace, longnose sucker, mountain sucker and a species of special concern, the stonecat (Notorus flavus). This is the only mountain stream in western Montana where this small member of the catfish family is found (Brown, 1971). Its normal habitat is lowland warm water streams throughout the lower Missouri River drainage of Montana.

Table 150. Summary of electrofishing survey data collected for a 1,000 ft section of Warm Springs Creek (T9S, R3W, Sec. 22B) on July 22 and August 14, 1980.

Species	No. Captured	Length Range (inches)
Rainbow, Cutthroat and Rainbow x Cutthroat Hybrids	24	7.7-12.7
Mountain Whitefish	3	13.6-14.6
Stonecat	3	4.0- 6.1
Longnose Sucker	-	-
Mountain Sucker	-	-
Longnose Dace	-	-

Due to the low numbers of trout captured, the standing crop could not be estimated. Although conditions appear favorable for trout, water temperatures during the summer months are evidently high enough to limit their abundance below the warm springs.

Pierce (1966) sampled three sections of Warm Springs Creek, above, within and below the inlet of the springs. When all other parameters were equal, i.e. habitat, cover, and volume of flow, he found the distribution of stonecats tied directly to temperature. Their numbers increased tenfold below the warm springs. Numbers of longnose sucker, longnose dace and mountain sucker also increased. Only trout and mottled sculpin decreased downstream of the springs.

An electrofishing survey of Warm Springs Creek by Haugen (1975) found no game fish below the inlet of the springs. Rainbow and cutthroat trout were captured in sections above the springs. Thirty to thirty-nine trout, measuring 2.1-12.1 inches in length, were captured in each 300 ft section.

4. FLOW RECOMMENDATIONS

A 153 ft subreach in T9S, R3W, Sec. 22B was selected for the collection of cross-section data. Because the majority of the flow in this reach originates from springs, the flows remained stable at 72-76 cfs throughout the field season. Consequently, the collection of the field data needed to calibrate the WETP program could not be completed.

Warm Springs Creek is spring fed and not appreciably influenced by snow-melt. Spring creeks receive special consideration in the instream flow program of the DFWP. Spring creeks in general are a highly utilized recreational resource that can provide outstanding habitat for waterfowl, trout and other fish species. Due to the unique features of the spring creek environment and their high recreational value, all effort should be made to prevent the further degradation of the few remaining spring creeks in southwest Montana. Water withdrawals would only accelerate the demise of this already declining aquatic resource.

It is, therefore, recommended that all existing unappropriated waters of Warm Springs Creek remain instream for purposes of maintaining fish and wildlife habitat in both Warm Springs Creek and the Ruby River below its confluence for the period of January 1 through December 31. Based on limited flow data, this recommendation amounts to an approximate year-round flow of 70 cfs or about 50,666 acre-feet of water per year.

1. STREAM

West Fork Ruby River

2. DESCRIPTION

The West Fork Ruby River originates in the Snowcrest Range of southwest Montana and flows in a northeasterly direction for 6.5 miles before converging with the Middle and East Forks to form the Ruby River. Lands within the 21.5 square mile drainage are entirely within the Beaverhead National Forest. Major tributaries include Timber, Noname, Beaver, Big Spring, Coal Spring and Yakama Creeks. The 12 ft wide channel has a fairly steep gradient of 63 ft/1,000 ft. The riparian zone is vegetated with alder, birch, cinquefoil, willow and grasses. The bottom substrate is composed of gravel and cobble. The upper drainage consists of sparsely timbered slopes while the lower portion is comprised of grassland-sagebrush plant communities. An undeveloped road parallels the stream between its mouth and headwaters.

The USFS collected sporadic flow data for the West Fork from May through October, 1975-1976 (USFS, unpublished data). Flows ranged from a low of 8.8 cfs in October, 1975 to a high of 107.6 cfs in July, 1975. The highest flow recorded in 1976 was 48.6 cfs in June. It should be noted that 1975 and 1976 were the highest and fifth highest water years, respectively, for a 38-year period of record for the Ruby drainage. No water is presently being diverted from the West Fork.

Lands within the West Fork Ruby River drainage are primarily used for sheep and cattle grazing and recreation in the form of hunting, fishing and camping. The effects of past and present land use activities, especially livestock grazing, on the fragile and easily erodible soils of the East Fork Ruby River drainage have been debated for the past decade.

Haugen (1977) found that the West Fork Ruby River had the highest entrapped bedload, which consisted of extremely fine material, in the upper Ruby River drainage. In comparing the three forks of the Ruby River and streams from other drainages in the Beaverhead River basin, Elser and Marcoux (1972) reported the West Fork to have the lowest amount of streambank cover available to fish, the lowest total cover and the lowest percent total cover to total streambank. The West Fork Ruby River also had the third highest suspended sediment levels in a study of 14 stations in the Ruby drainage (Page, 1978). The average sediment yield for 1975-1976 in the West Fork Ruby River was 201/tons square mile or 12% of the total suspended sediment in the Ruby River. Haugen (1977) recommended that allotments on the upper Ruby River (Middle and West Forks) should be analyzed to see what adjustments could be made to improve riparian habitat and quality and quantity.

Water chemistry samples from the West Fork Ruby River collected sporadically from 1974-1977 by the USFS suggest that water is of overall good quality (USFS, unpublished data). From the levels of all major nutrients, sum of dissolved constituents, and specific conductance measured, there appears to be available nutrients in the system for greater productivity than is presently occurring.

3. FISH POPULATIONS

A 1,900 ft and 4,125 ft section of the West Fork Ruby River was electrofished in August, 1970 and September, 1975, respectively (Elser and Marcoux, 1972 and Peterson, 1976). Game fish present during both years were rainbow and cutthroat trout, rainbow x cutthroat hybrids and mountain whitefish. The mottled sculpin was the only nongame species captured. The electrofishing survey data for both years are summarized in Table 151.

Table 151. Summary of electrofishing survey data collected for a 1,900 ft section of the West Fork Ruby River (T11S, R3W, Sec. 5 and 6) on August 19 and 25, 1970 and a 4,125 ft section (T11S, R3W, Sec. 5 and 6) on September 16 and 30, 1975.

Species	No. Captured		Length Range (inches)	
	1970	1975	1970	1975
Cutthroat Trout	-	16	-	5.3-10.4
Rainbow Trout	5	4	5.4-13.1	6.2-15.5
Rainbow x Cutthroat Hybrid Trout	19	14	6.2-10.8	6.1-12.4
Mountain Whitefish	4	-	10.7-15.2	-
Mottled Sculpin	-	-	-	-

The standing crop of trout in the 1,900 ft section was estimated in 1970 using a mark-recapture method (Table 152). This section supports about 32 trout, weighing 12 pounds, per 1,000 ft of stream. Of the streams electrofished in the Beaverhead National Forest, the West Fork Ruby River supports one of the lowest standing crops of trout. Few of the trout captured were less than 7 inches, suggesting reproduction problems due to the scarcity of silt-free spawning areas and/or the inability of trout eggs to survive in the silt laden gravels. Immigration from tributary streams may be the only form of recruitment to the West Fork trout population.

Table 152. Estimated standing crop of trout in a 1,900 ft section of the West Fork Ruby River (T11S, R3W, Sec. 5 and 6) on August 19, 1970. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Pounds
Rainbow, Cutthroat and Rainbow x Cutthroat Hybrids	5.0- 5.9	1	
	6.0- 9.9	16	
	10.0-13.1	15	
		32 (±12)	12 (±4)

4. FLOW RECOMMENDATIONS

A 61 ft subreach located near the mouth of the West Fork Ruby River was selected for the collection of cross-sectional data (T11S, R3W, Sec. 5B). Five cross-sections describing the riffle-run habitat were placed within the subreach. The WETP program was calibrated to field data collected at flows of 10.6, 14.1 and 31.2 cfs.

The relationship between wetted perimeter and flow for the composite of two riffle cross-section is shown in Figure 64. The lower and upper inflection points occur at 6 and 14 cfs, respectively. Based on an evaluation of existing fishery, recreational use, water availability and other resource information, a flow of 6 cfs is recommended for the low flow period (July 16 - May 15). Flow recommendations for the high flow period (May 16 - July 15) cannot be derived for the West Fork Ruby River due to the lack of long-term flow information.

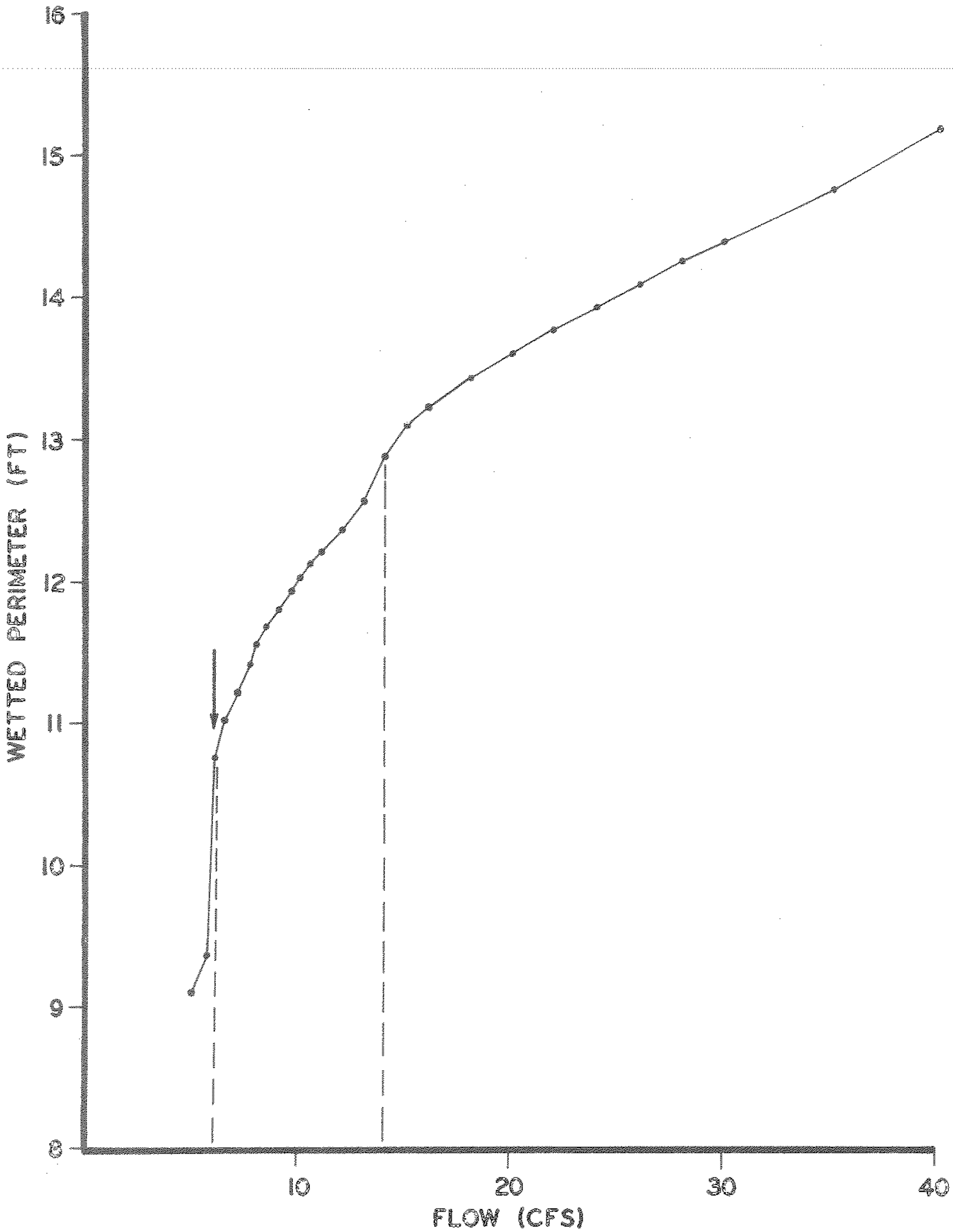


Figure 64. The relationship between wetted perimeter and flow for a composite of two riffle cross-sections in the West Fork Ruby River.

SMITH RIVER DRAINAGE

SMITH RIVER AND TRIBUTARY INSTREAM FLOW STUDY

Introduction:

Under provisions of an act passed by the 1969 Montana Legislature (Section 89-801, RCM 1947) the Montana Department of Fish, Wildlife and Parks (MDFWP) was able to file for instream water rights on 12 high quality trout streams in the state. The MDFWP filed in 1970 on the Smith River for instream rights for the preservation of fish and wildlife habitat in the amounts and locations given as follows:

> Smith River from the mouth of Hound Creek in T17N, R3E, Sec. 20 to the Cascade County line in T15N, R3E, Sec. 36 -- 150 cfs from September 1 to March 31 and 400 cfs from April 1 to August 31.
>
> Smith River from Meagher-Cascade County line in T14N, R3E, Sec. 1 to Fort Logan Bridge in T11N, R5E, Sec. 31 -- 125 cfs from September 1 to March 31 and 150 cfs from April 1 to August 31.

As a result of a court decision concerning a contested water right on the Smith River, it was determined that the MDFWP had an instream right, but it is unquantified at the present time. The passage of Senate Bill 76 (An Act to Adjudicate Claims of Existing Water Rights in Montana) by the 1979 Montana Legislature lends urgency to the quantification of instream filed rights. The deadline for refiling to confirm rights is January 1, 1982.

It may be necessary to file for all unappropriated waters in the Smith River tributaries in order for the MDFWP to maintain their instream water rights. These filings would be to secure the water source that is needed for maintaining the instream rights the MDFWP is presently quantifying on the Smith River. The appropriation of waters in the Smith River drainage for irrigation and domestic uses has resulted in the partial dewatering of the river during the summer (July-September). Low river flow is probably the single factor most limiting to present game fish populations.

This study was undertaken to determine the timing and magnitude of the flow contributions of various tributary streams. This information is necessary to determine what impact this water would have in satisfying the instream flow needs for the main river.

Description of Study Area

The Smith River drainage lies in west central Montana, almost due South of Great Falls, between the Big Belt Mountains on the west and the Little Belt and Castle Mountains on the east. The drainage is approximately 75 miles in length and the width varies from 3 to 45 miles. The total area is slightly over 2,000 square miles. The elevation of the floor of the drainage varies from 3,350 to 5,400 feet above sea level. The highest mountain peaks range from 8,500 to 9,500 feet above sea level.

The Smith River is formed by the junction of the North and South Forks of the Smith River about 4 miles southwest of the town of White Sulphur Springs. The North Fork drains part of the southwest slopes of the Little Belt Mountains and the northwest slopes of the Castle Mountains. The South Fork originates along the southwest flank of the Castle Mountains and from the bench lands between the Castle and Big Belt Mountains. The main stem of the Smith River then flows northwesterly through a narrow valley until it enters a deep mountain canyon about 10 miles north of Fort Logan. After emerging from the canyon, the river meanders through a relatively narrow valley flanked by rolling grasslands until it joins the Missouri River near the town of Ulm.

Numerous tributaries originate in the Big Belt and Little Belt Mountains to join the Smith River. Some of the major tributaries originating in the Big Belt Mountains are Birch, Camas, Beaver, Rock and Hound Creeks. Those from the Little Belt Mountains are Newlan, Sheep, Eagle, Tenderfoot and Deep Creeks.

Approximately 2,500 people reside within the Smith River drainage. A major highway system makes the area accessible to the surrounding urban areas which have a population of over 150,000 people.

In the early 1860's the discovery of gold in the surrounding mountains stimulated a heavy influx of miners. As gold was depleted and mining operations abandoned, farming and ranching began to take over as the predominant economy, and they remain so today.

A substantial portion of the drainage remains under public administration. Land administration in the drainage by percent is as follows: Private - 70, Forest Service - 23, State - 6, and Bureau of Land Management - less than 1.

Methods and Measuring Sites:

Discharge measurements were taken at weekly intervals at 12 stations in the drainage from July 13 to November 1, 1980. General locations of these stations are shown in Figure 65. Measurements were taken following procedures described in a USGS publication by Buchanan and Somers(1968), Measurement sites were chosen as close to the mouths of tributary streams as access permitted. Selection of individual cross sections were made according to USGS methods. The following equipment was employed for discharge measurements:

1. Price type AA vertical axis current meter.
2. A calibrated wading rod for suspension of the current meter.
3. Audible electronic beeper box.
4. Stop watch.
5. 100 foot steel tape.
6. Discharge measurement note cards.

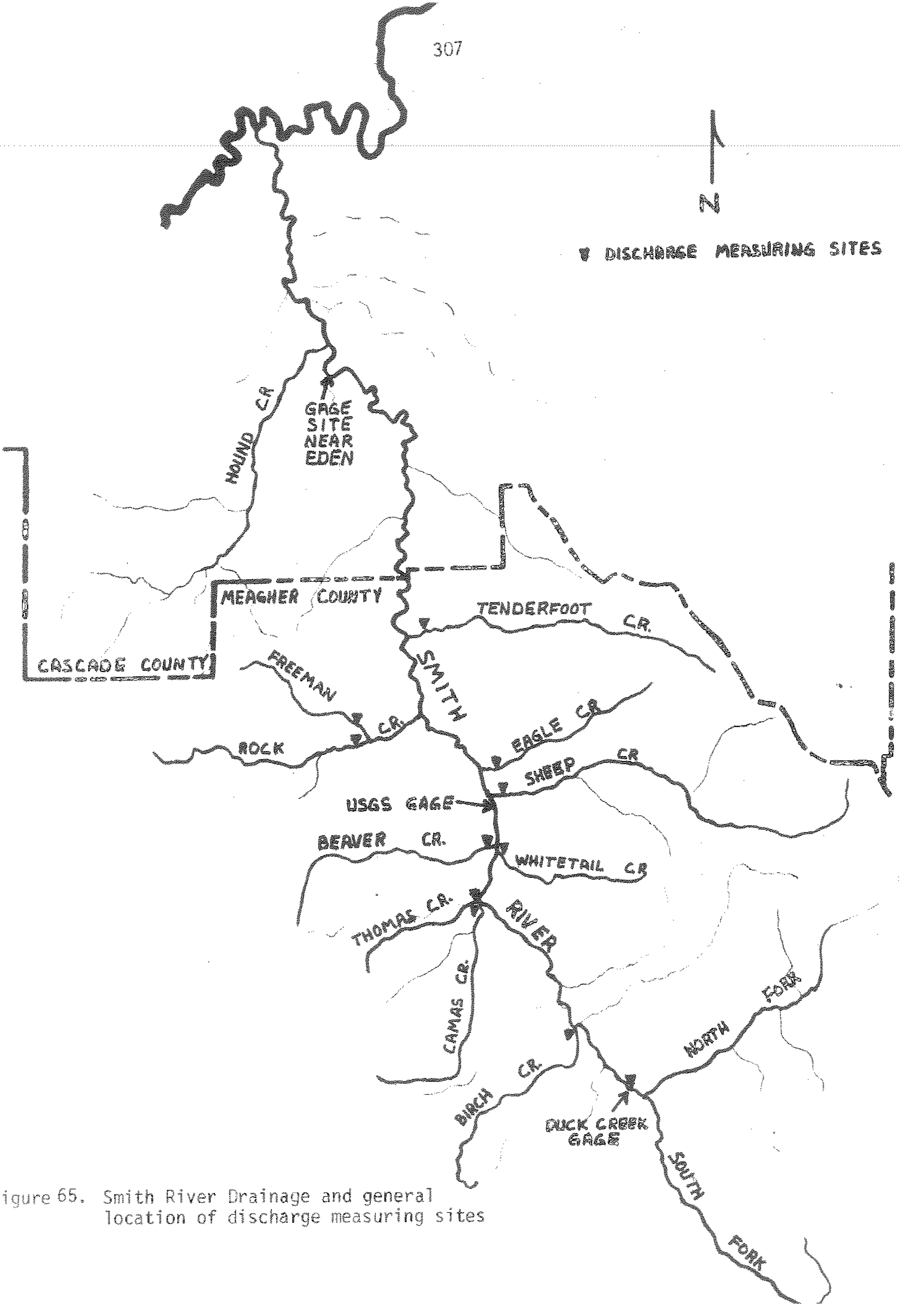


Figure 65. Smith River Drainage and general location of discharge measuring sites

A staff gage was installed at or near each measurement site to record water levels. Staff gage readings correlated closely with weekly discharges measured on streams.

Discharge was measured at three locations on the mainstem of the Smith River. These sites were: at the Duck Creek road crossing about two miles below the junction of the North and South Forks of the Smith River; at the abandoned USGS gage station about two miles upstream from the mouth of Hound Creek; and at the USGS gauge station located about one mile above the confluence of Sheep Creek. Continual discharge was monitered by the USGS at this latter station.

Results:

Weekly discharge measurements from ten tributary streams are presented in Table 153. Measurements were started near the end of the 1980 spring run-off season but still reflect the timing of low flow during the summer. Several of the tributaries were measured just before their confluence with the Smith River and below the last irrigation diversion. Reaches on Birch, Camas, Thomas and Beaver Creeks are severely dewatered by irrigation, but accretion from waste and ground water prevented them from going dry. Sheep Creek is severely dewatered in the upper reaches, but irrigation waste return and accretion from several forest tributaries add significant flow downstream. One irrigation diversion located on Sheep Creek between the measuring site and the Smith River only slightly dewaters the stream.

The compounded tributary flow to the Smith River was compared to flows measured at the three mainstem locations (Table 154). Significant flow accretions occur to the upper river other than from the tributaries. These accretions are irrigation return flows and groundwater seepage. During low flow periods, discharge at the Duck Creek road is primarily irrigation return and ground water originating from the lower North and South Forks of the Smith River. Other small tributaries such as Independence Gulch, Thompson Gulch, Little Spring Creek, Newlan and Soldiers Creek flow intermittently to the upper river. These tributaries primarily flow due to irrigation return.

Tributary contributions between the USGS gage station above Sheep Creek downstream to the gage site near Eden nearly doubled the flow of the river. However, flow on the lower river was less than one would expect. Throughout August and most of September, the flow was about 20 cfs less than tributary contributions (Columns G and H, Table 154). This is undoubtedly due to evaporation, infiltration into ground water and irrigation withdrawal. Trout Creek and Dry Fork of Smith River, two tributaries to this reach of the mainstem, were not measured. Late summer flow in Trout Creek is about one cfs, while the Dry Fork is intermittent.

Table 153. Weekly discharge measurements on several Smith River drainage streams, 1980 1/

Date Week Of	Birch Creek	Camas Creek	Thomas Creek	Whitetail Creek	Beaver Creek	Sheep Creek	Eagle Creek	Rock Creek	Freeman Creek	Tenderfoot Creek
July 13-19	21.7	38.7	16.8			82.2	9.5	26.8	6.9	
July 20-26				1.6	4.7					37.9
July 27-Aug 2	9.3	11.9	9.6	0.7	1.9	45.0	3.5	18.4	4.7	27.9
Aug. 3- 9	10.3	8.9	8.8	0.7	1.9	39.5	3.7	21.8	5.4	27.6
Aug. 10-16	4.8	11.5	8.6	0.7	1.8	46.4	5.0	19.8	4.6	22.8
Aug. 17-23	2.2	11.5	8.7	0.7	1.5	36.1	1.5	17.0	4.5	22.7
Aug. 24-30	2.4	9.1	8.4	0.7	1.6	30.0	1.5	15.6	4.5	18.9
Aug. 31-Sept 6	2.4	9.1	7.8	0.7	1.5	33.5	1.6	14.7	4.0	16.4
Sept. 7-13	3.0	8.7	8.1	0.7	2.2	24.1	2.1	14.3	4.0	18.7
Sept 14-20	5.6	10.4	8.4	0.7	2.2	36.7	2.5	14.3	4.0	17.9
Sept 21-27	4.2	9.4	7.4	0.7	1.9	35.4	2.1	13.0	4.0	14.3
Sept 28-Oct 4	7.0	7.8	7.5	0.7	1.5	31.5	2.1	12.5	3.7	15.1
Oct. 5-11	9.0	8.1	7.3	0.7	1.5	31.4	2.3	12.4	3.7	13.2
Oct. 12-18	19.2	14.1	7.8	1.8	3.7	38.2	4.3	15.3	4.9	17.3
Oct. 19-25	13.5	13.3	7.2	1.6	4.0	35.8	--	15.2	3.8	--
Oct. 26-Nov. 1	11.2	11.5	7.2	2.1	4.6	29.1	4.2	13.9	3.9	18.0

1/ Discharges in cubic feet per second.

Table 154. Tributary contributions (cfs) and discharges of the Smith River in 1980

Time Period	A Smith R. at Duck Cr. Rd.	B Tributary Inflow Between A&D	C Total of A&B	D Smith R. at USGS Sta.1/	E Accretions Between A&D	F Tributary Inflow Between D&H	G Total of D&F	H Smith River near Eden
July 27-Aug 2	28	33	61	93	32	100	193	171
Aug. 3- 9	28	31	59	89	30	98	187	160
Aug. 10-16	23	27	50	85	35	99	184	162
Aug. 17-23	25	25	50	81	31	82	163	142
Aug. 24-30	27	22	49	85	36	71	156	140
Aug. 31-Sept 6	25	22	47	82	35	70	152	138
Sept 7-13	29	23	52	94	42	63	157	--
Sept 14-20	39	27	66	104	38	75	179	157
Sept 21-27	42	23	65	97	32	69	166	162

1/ Provisional data supplied by USGS.

Discussion:

All streams in the upper Smith River drainage are dewatered by irrigation and domestic diversion. However, a considerable amount of diverted flow returns as irrigation waste or seepage from ground water. State and privately developed irrigation projects help to augment late summer flow in the Smith. Streams that originate on U. S. Forest Service land contribute important flow to upper tributaries, especially the North Fork of Smith River, Birch and Camas Creeks. All water in these streams is claimed for irrigation and livestock use during the summer growing season.

Streams in the middle portion of the drainage (Sheep Creek to abandoned USGS gage station near Eden) contribute important flow for maintaining aquatic habitat. For the most part, these tributaries drain mountainous country where little land development has occurred. Of the three largest watersheds, most of the Sheep and Tenderfoot Creek drainages lie on U. S. Forest Service land while the Rock Creek drainage is mostly private land.

The upper Smith River basin produced less water in 1980 when compared to 1979 and 1978 (Figure 66). Flows through most reaches of the river were less than the amount filed on by the MDFWP for instream rights during these years. Review of historical USGS records collected on the Smith River near Eden also confirms late summer flow is generally below that filed by the MDFWP.

The only significant quantity of tributary water available for instream use during the summer and fall seasons appear to come from Sheep, Rock and Tenderfoot Creeks. These three streams help support a minimum flow in the middle and lower river. This flow rate, though marginal at times, is apparently enough to sustain the fishery. It is recommended that discharges from these three streams be reserved for maintaining instream flow in the Smith River.

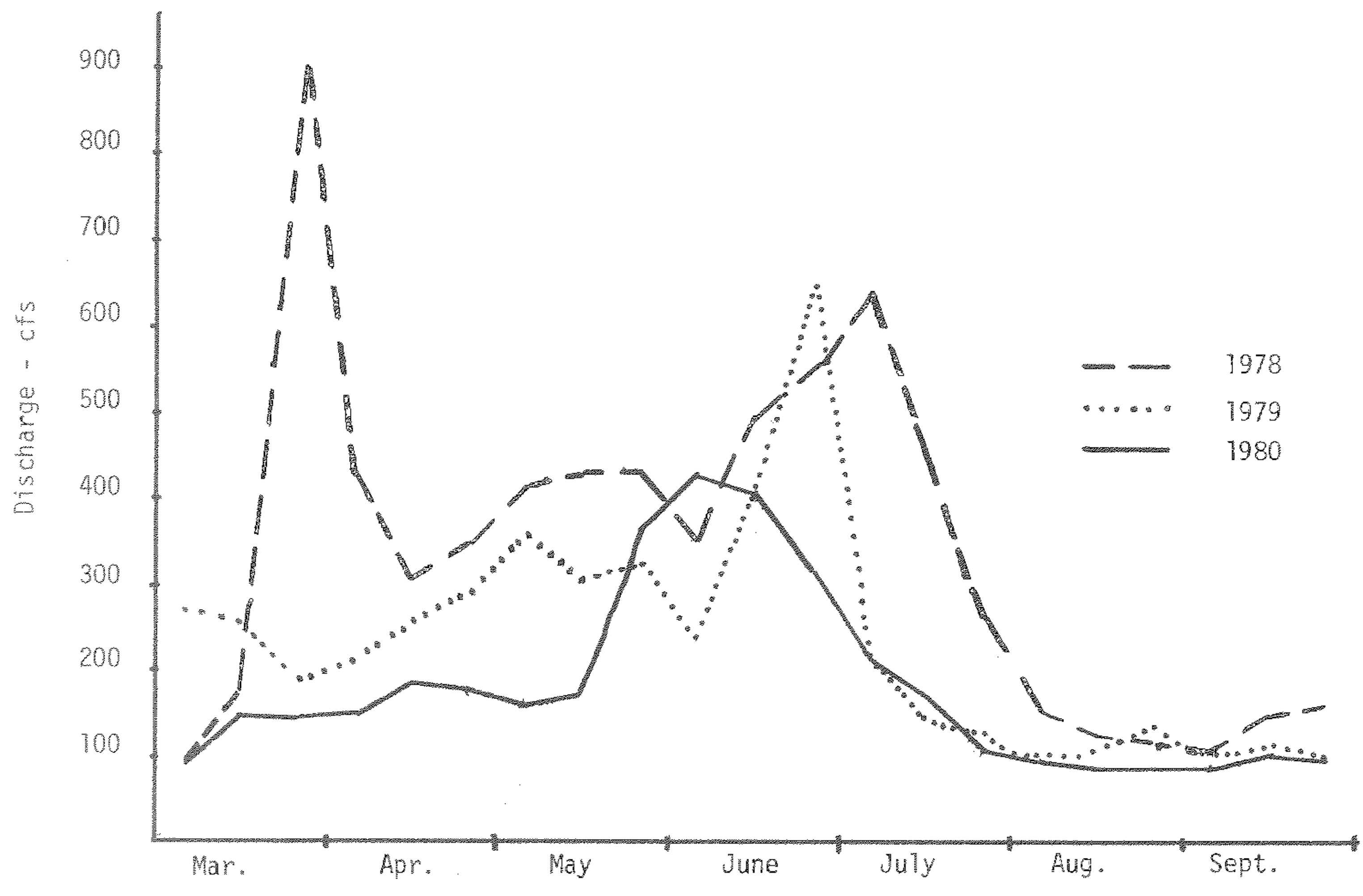


Figure 66. Hydrograph of Smith River at USGS Gage Station near Fort Logan, 1978 - 1980.

YELLOWSTONE AND SHIELDS

RIVER TRIBUTARIES

1. STREAM

Big Creek

2. DESCRIPTION

Big Creek originates on the east slope of the Gallatin Range in southwest Montana and flows in an easterly direction for about 17 miles before discharging into the Yellowstone River. Stream elevations at the origin and mouth are 9,200 and 4,940 ft, respectively. The stream gradient averages approximately 250 ft/mile. Big Creek drains an area of about 82 sq miles.

A gauging station located at stream mile 2.7 was operated by the USGS from September 1973 to September 1979. The mean, maximum and minimum flows for the period of record are 66.1, 818 and 16.0 cfs, respectively. The mean monthly flows for the period of record are given in Table 155.

Twenty-nine water appropriations, amounting to 179.8 cfs, have been filed on Big Creek (State Engineer's Office, 1951). In addition, 23 decreed rights amounting to 63.6 cfs are also on file. Water diverted from Big Creek and its tributaries irrigates about 998 acres of land. The lower creek is totally dewatered during the summer irrigation season.

Table 155. Mean monthly flows of record for Big Creek.

	Mean Flows (cfs)[a/]
Jan	23.3
Feb	25.0
Mar	24.2
Apr	43.7
May	120.4
Jun	256.8
Jul	134.2
Aug	43.4
Sep	32.1
Oct	32.8
Nov	30.3
Dec	26.3

[a/] Derived for a 6-year period of record (1973-79) for the USGS gauge at stream mile 2.7 (T6S, R7E, Sec. 20).

The logging of private lands is the primary land use activity within the drainage. A current infestation of pine bark beetles will probably spur interest toward timber salvage operations on public lands within the drainage, but to date no timber sales are proposed.

Recreational activities in the drainage are centered around hunting. This drainage is extensively hunted for big game species during the general season. Approximately five miles of USFS road provide access into the Big Creek drainage. A foot and horse trail heads at the end of the road. Other recreational activities include hiking, backpacking, camping, cross-country skiing, picnicking and fishing. A mail survey conducted by the MDFWP for the period of May 1975 through April 1976 estimated fishing pressure on Big Creek at 84 man-days/year (MDFG, 1976).

Big game species found in the Big Creek drainage are elk, mule deer, black bear and cougar. Upland game birds, such as ruffed and blue grouse, and furbearers such as beaver, mink, marten and river otter are also present.

The Montana Department of Fish, Wildlife and Parks was granted an instream flow reservation on Big Creek for purposes of maintaining the fish and wildlife resources. The reservation, which has a priority date of December 15, 1978, is contained in the Order of Board of Natural Resources Establishing Water Reservations. For Big Creek from the mouth to Millfork Creek and Millfork Creek to Bark Cabin Creek, the MDFWP was granted an instream reservation of the 20th percentile of the flow for the months of October through April and for the 50th percentile for the remaining months. Consequently, the instream reservation limits the availability of water for new consumptive uses established after December 15, 1978. With the reservation, water is presently for new consumptive uses in two of ten years for the months of October through April and five of ten years for the months of May through September. The granted percentile flows are presently unquantified in terms of cubic feet of water per second and acre-feet per year.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Big Creek were surveyed by electro-fishing on August 27 and September 12, 1980. Game fish captured in descending order of abundance were rainbow x cutthroat hybrids and brown trout. Fish that appear to be a pure strain of Yellowstone cutthroat trout were also present in small numbers. These fish were grouped with the rainbow x cutthroat hybrids since it is difficult to reliably separate pure and hybrid trout under field conditions. The electro-fishing survey data are summarized in Table 156.

Table 156. Summary of electro-fishing survey data collected for a 1,000 ft section of Big Creek (T6S, R6E, Sec. 13D) on August 27 and September 12, 1980.

Fish Species	No. Captured	Length Range (inches)
Rainbow x Cutthroat Hybrids	35	3.3-10.8
Brown Trout	6	4.0-10.4

The standing crop of rainbow x cutthroat hybrids was estimated using a mark-recapture method (Table 157). The estimate shows that this 1,000 ft section supports about 32 hybrid trout, weighing nine pounds. The population of brown trout was too sparse to reliably estimate.

Table 157. Estimated standing crop of trout in a 1,000 ft section of Big Creek (T6S, R6E, Sec. 13D) on August 27, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 Ft Number	Per 1,000 Ft Pounds
Rainbow x Cutthroat Hybrids	3.3 - 5.9	a/	
	6.0 - 9.9	31	
	10.0 -10.8	1	
		32 ($\pm$11)	9 ($\pm$3)

a/ A population estimate for this length group is unavailable due to insufficient recaptures.

1. STREAM

Big Timber Creek

2. DESCRIPTION

Big Timber Creek originates at the outlet of Blue Lake in the Crazy Mountains of southcentral Montana and flows in a southeasterly direction for 20.6 miles before discharging into the Yellowstone River near Big Timber, Montana. The stream gradient averages about 204 ft/mile. Stream elevations at the origin and mouth are about 8,200 and 4,000 ft, respectively.

Water diverted from Big Timber Creek is used to irrigate about 3,261 acres. Water diverted from tributaries of Big Timber Creek irrigates an additional 7,117 acres (State Engineer's Office, 1950).

A gauge station was operated by the USGS on Big Timber Creek at stream mile 10.6 from April 1912 to September 1924. The mean, maximum and minimum flows for the period of record are 76.9, 1,960 and 0.0 cfs, respectively. Mean monthly flows for the period of record are given in Table 158. Flows at this gauge reflect the diversion of water to irrigate about 5,000 acres upstream of the gauge.

Table 158. Mean monthly flows of record for Big Timber Creek.

	Mean Flows (cfs)[a]
Jan	17.0
Feb	16.5
Mar	22.8
Apr	47.8
May	145.0
Jun	310.0
Jul	176.0
Aug	56.2
Sep	35.3
Oct	31.0
Nov	24.2
Dec	20.5

[a] Derived for the April 1912 to September 1924 period of record for the USGS gauge station at stream mile 10.6 (T2N, R14E, Sec. 6).

A mail survey conducted by the MDFWP for the period of May 1975 through April 1976 estimated fishing pressure on Big Timber Creek at 209 man-days/year or about 10 man-days/stream mile/year (MDFG, 1976).

The Montana Department of Fish, Wildlife and Parks was granted an instream flow reservation on Big Timber Creek for purposes of maintaining the fish and wildlife resources. The reservation, which has a priority date of December 15, 1978, is contained in the Order of Board of Natural Resources Establishing Water Reservations. For Big Timber Creek at its mouth, the MDFWP was granted an instream reservation of 28,267 acre-feet per year with approximate monthly flows as shown in Table 159.

Table 159. The instream flow reservation of the Montana Dept. of Fish, Wildlife and Parks for Big Timber Creek at its mouth.

Month	CFS	Acre-Feet
Jan	10	615
Feb	10	555
Mar	10	615
Apr	20	1,190
May	85	5,225
Jun	180	10,710
Jul (1-20)	100	3,967
Jul (21-31)	30	655
Aug	25	1,535
Sep	20	1,190
Oct	13	800
Nov	10	595
Dec	10	615
	(Av. 39 cfs)	28,267 Acre-Feet

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Big Timber Creek (T3N, R12E, Sec. 1D) were surveyed by electro-fishing on August 26 and September 11, 1980. Game fish captured in descending order of abundance were brook, rainbow and brown trout. No other fish species were captured. The electro-fishing survey data are summarized in Table 160. Trout populations were too sparse to reliably estimate using the mark-recapture method.

Table 160. Summary of electro-fishing survey data collected for a 1,000 ft section of Big Timber Creek (T3N, R12E, Sec. 1D) on August 26 and September 11, 1980.

Fish Species	No. Captured	Length Range (inches)
Brook Trout	19	4.9 - 9.1
Rainbow Trout	9	5.4 -11.1
Brown Trout	5	6.0 -10.1

1. STREAM

Brackett Creek

2. DESCRIPTION

Brackett Creek originates on the east slope of the Bridger Range of southwest Montana at the confluence of its north, middle and south forks. The creek flows in an easterly direction for about 18 miles before discharging into the Shields River two miles south of Clyde Park, Montana. The stream elevations at the origin and mouth are 5,795 and 4,740 ft, respectively. The stream gradient averages about 59 ft/mile. Brackett Creek drains an area of approximately 58 square miles.

A USGS gauge station located at stream mile 4.7 was operated from March 1921 to September 1957. The mean, maximum and minimum flows of record are 27.8, 1,400 and 0.5 cfs, respectively. The approximate median monthly flows of record for this gauge are given in Table 161. These median flows reflect the diversion of water to irrigate about 650 acres of land upstream of the gauge.

Table 161. Approximate median monthly flows of record for Brackett Creek.

	Approximate Median Flows (cfs)[a]
Jan	7.1
Feb	6.3
Mar	9.2
Apr	41.7
May 1-15	91.3
May 16-31	100.8
June 1-15	96.7
June 16-30	61.4
July 1-15	36.3
July 16-31	18.8
Aug	10.9
Sep	10.7
Oct	9.9
Nov	9.0
Dec	6.6

[a] Derived for a 19-year period of record (1937-1955) for the USGS gauge at stream mile 4.7 (T1N, R8E, Sec. 1).

Twenty-five water appropriations, totaling 244.9 cfs, have been filed on Brackett Creek (State Engineer's Office, 1951). In addition, 26 decreed rights, totaling 89.4 cfs, are also on file. Seven tributaries of Brackett Creek have 13 water appropriations plus 7 decreed rights, totaling 42.4 cfs.

Brackett Creek flows primarily through agricultural lands. Principle commodities produced are grains, cattle and hay.

Recreational uses on Brackett Creek are restricted due to controlled access by the adjacent private land owners. A mail survey conducted by the MDFWP for the period of May 1975 through April 1976 estimated fishing pressure at 533 man-days/year or about 30 man-days/stream mile/year (MDFG, 1976).

Mule deer and elk are the principle big game species associated with the Brackett Creek drainage. Upland gamebirds include hungarian partridge, ruffed, sage and sharptail grouse. Furbearers in the area include beaver, muskrat, mink, marten, river otter and coyote. Ducks and bald eagles are commonly observed in the drainage.

The Montana Department of Fish, Wildlife and Parks was granted an instream flow reservation on Brackett Creek for purposes of maintaining the fish and wildlife resources. The reservation, which has a priority date of December 15, 1978, is contained in the Order of Board of Natural Resources Establishing Water Reservations. For Brackett Creek from its mouth to Sheep Creek, Sheep Creek to Skunk Creek and Skunk Creek to one mile up the north, middle and south forks, the MDFWP was granted an instream flow reservation of the 50th percentile for the months of January through December. Consequently, the instream reservation limits the availability of water for new consumptive uses established after December 15, 1978. With the reservation, water is presently available for new consumptive uses in five of ten years for the months of January through December. The granted percentile flows are presently unquantified in terms of cubic feet of water per second and acre-feet per year.

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of Brackett Creek were surveyed by electrofishing on August 28, September 12 and October 6, 1980. Game fish captured in descending order of abundance were Yellowstone cutthroat trout, mountain whitefish, brook trout and brown trout. The mottled sculpin was the only non-game species captured. The electrofishing survey data are summarized in Table 162.

Table 162. Summary of electrofishing survey data collected for a 1,000 ft section of Brackett Creek (T1N, R7E, Sec. 4D) on August 28, September 12 and October 6, 1980.

Fish Species	Number Captured	Length Range (inches)
Yellowstone Cutthroat Trout	133	3.3 - 11.7
Mountain Whitefish	84	3.1 - 13.7
Brook Trout	53	3.5 - 11.1
Brown Trout	3	5.0 - 14.0
Mottled Sculpin	-	-

The standing crops of game fish in the section were estimated using a mark-recapture method (Table 163). The estimates show that this 1,000 ft section supports about 451 cutthroat trout, weighing 43 pounds, and 92 mountain whitefish, weighing 33 pounds. Three brown trout and 53 brook trout captured in the section are not included in the total standing crop estimate. The population of brown trout was too sparse to reliably estimate, while the population of brook trout could not be estimated because adult brook trout were suspected of entering the study section subsequent to the marking run, thereby violating a condition necessary for valid mark-recapture estimates.

Table 163. Estimated standing crops of game fish in a 1,000 ft section of Brackett Creek (T1N, R7E, Sec. 4D) in August-September, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Number	Per 1,000 ft Pounds
Yellowstone Cutthroat Trout	3.3 - 5.9	303	
	6.0 - 9.9	127	
	10.0 - 11.7	21	
		451(±191)	43(±13)
Mountain Whitefish	5.5 - 5.9	4	
	6.0 - 9.9	68	
	10.0 - 13.7	20	
		92(± 31)	33(±10)
Total Game Fish		543(±193)	76(±16)

Standing crops of fish were estimated in the immediate vicinity of the 1980 population section in September, 1975. In 1975, standing crops of 168 cutthroat trout, weighing 17 pounds, and 123 mountain whitefish, weighing 21 pounds, were estimated per 1,000 ft of stream (Table 164). The total standing crop of game fish was estimated at 291 fish, weighing 38 pounds, per 1,000 ft. Twenty-seven brook trout and twelve brown trout captured in the section are not included in the total standing crop estimate.

Table 164. Estimated standing crops of game fish in a 2,000 ft section of Brackett Creek (T1N, R7E, Sec. 4) on September 5, 1975. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Number	Per 1,000 ft Pounds
Yellowstone Cutthroat Trout	3.1 - 5.9	96	
	6.0 - 9.9	71	
	10.0 - 10.3	1	
		168(±43)	17(±5)
Mountain Whitefish	4.1 - 5.9	69	
	6.0 - 9.9	32	
	10.0 - 13.2	22	
		123(±46)	21(±5)
Total Game Fish		291(±63)	38(±7)

1. STREAM

East Boulder River

2. DESCRIPTION

The East Boulder River originates on the east slope of the Boulder Plateau of the Beartooth Mountains in southcentral Montana. The river heads at an approximate elevation of 8,880 ft and flows in a northeasterly direction for about 21 miles before discharging into the Boulder River at an approximate elevation of 4,800 ft. The stream gradient averages about 195 ft/mile.

The USGS operated a gauge station at stream mile 0.8 from August 1907 to December 1909. The mean, maximum and minimum flows for the period of record are 86.1, 1,180 and 6.0 cfs, respectively. The mean monthly flows for the period of record are given in Table 165.

Table 165. Mean monthly flows of record for the East Boulder River.

	Mean Flows (cfs)[a/]
Jan	17.0
Feb	15.0
Mar	15.4
Apr	19.1
May	101.1
Jun	481.5
Jul	217.5
Aug	56.5
Sep	41.1
Oct	38.0
Nov	29.2
Dec	22.0

[a/] Derived for the August 1907 through December 1909 period of record for the USGS gauge at stream mile 0.8 (T2S, R13E, Sec. 33).

The headwaters of the East Boulder River lie within the "Stillwater Complex," a highly mineralized area along the northern edge of the Beartooth Mountains. Preliminary exploration has shown that deposits of chromite, nickel-copper sulphide, platinum, gold, silver and iron are present in commercial quantities. Extensive road systems were built to service the exploration activities. Detrimental effects have occurred in other drainages in the "Complex" and it has been recommended that road building be limited in the East Boulder drainage.

Recreational activities in the East Boulder drainage include hunting, camping, hiking and fishing. A mail survey conducted by the MDFWP for the period of May, 1975 through April, 1976 estimated fishing pressure on the E. Boulder River at 631 man-days/year or about 30 man-days/stream mile/year (MDFG, 1976).

The Montana Department of Fish, Wildlife and Parks was granted an instream flow reservation on the East Boulder River for the purposes of maintaining the fish and wildlife resources. The reservation, which has a priority date of December 15, 1978, is contained in the Order of Board of Natural Resources Establishing Water Reservations. For the East Boulder River at its mouth, the MDFWP was granted an instream reservation of 23,146 acre-feet of water per year with approximate monthly flows as shown in Table 166.

Table 166. The instream flow reservation of the Montana Department of Fish, Wildlife and Parks for the East Boulder River at its mouth.

	CFS	Acre-Feet
Jan	15	922
Feb	15	832
Mar	15	922
Apr	15	892
May	20	1,229
Jun	165	9,815
Jul	50	3,073
Aug	22	1,352
Sep	20	1,189
Oct	18	1,108
Nov	15	892
Dec	15	922
	(Av. 32 cfs)	23,146 Acre-Feet

3. FISH POPULATIONS

Fish populations in a 1,000 ft section of the E. Boulder River were surveyed by electrofishing on August 26 and September 11, 1980. Game fish captured in descending order of abundance were rainbow, brown and brook trout. No other fish species were captured. The electrofishing survey data are summarized in Table 167.

Table 167. Summary of electrofishing survey data collected for a 1,000 ft section of the E. Boulder River (T3S, R13E, Sec. 29C and 32B) on August 26 and September 11, 1980.

Fish Species	Number Captured	Length Range (inches)
Rainbow trout	187	3.2 - 10.6
Brown trout	23	3.7 - 13.7
Brook trout	7	5.4 - 8.6

The standing crop of rainbow trout, the predominant trout species, was estimated using a mark-recapture method (Table 168). The estimate shows that this 1,000 ft section supports about 393 rainbow trout, weighing 40 pounds. The populations of brown and brook trout are too sparse to reliably estimate.

Table 168. Estimated standing crop of rainbow trout in a 1,000 ft section of the E. Boulder River (T3S, R13E, Sec. 29C and 32B) on August 26, 1980. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Number	Pounds
Rainbow Trout	3.2 - 5.9	226	
	6.0 - 9.9	157	
	10.0 - 10.6	10	
		393($\pm$81)	40($\pm$7)

The standing crop of trout was estimated in the immediate vicinity of the 1980 population section in September, 1974 (Stoneberg and Stewart, 1977). In 1974, standing crops of 255 rainbow trout, weighing 25 pounds, and 104 brown trout, weighing 18 pounds, were estimated per 1,000 ft of stream (Table 169). The total standing crop was estimated at 359 trout, weighing 43 pounds, per 1,000 ft.

Table 169. Estimated standing crop of trout in a 2,823 ft section of the E. Boulder River (T3S, R13E, Sec. 29) in September, 1974. Eighty percent confidence intervals are in parentheses.

Species	Age Group	Mean Length (inches)	Per 1,000 ft Number	Per 1,000 ft Pounds
Rainbow Trout	I	3.5	105	
	II	5.5	63	
	III	7.4	57	
	IV & Older	9.5	30	
			255($\pm$43)	25($\pm$3)
Brown Trout	I	4.1	35	
	II	6.2	25	
	III	8.0	31	
	IV & Older	11.6	13	
			104($\pm$17)	18($\pm$2)
Total Trout			359($\pm$46)	43($\pm$4)

In the summers of 1972 and 1973, the standing crop of trout was also estimated in a section of the E. Boulder River located about 4 miles upstream of the 1980 and 1974 population sections (Stoneberg and Stewart, 1977). These estimates are summarized in Table 170. In 1972, this section supported an estimated 242 trout, weighing 24 pounds, per 1,000 ft and in 1973 supported an estimated 247 trout, weighing 29 pounds, per 1,000 ft.

Table 170. Estimated standing crop of trout in a 2,410 ft section of the E. Boulder River (T4S, R13E, Sec. 2 and 11) in summer, 1972 and 1973. Eighty percent confidence intervals are in parentheses.

Species	Age Group	Per 1,000 ft Number	Per 1,000 ft Pounds
	July - August 1972		
Rainbow Trout	I and Older	208(±33)	19(±2)
Brown Trout	I and Older	34(±10)	5(±1)
Total Trout		242(±34)	24(±2)
	August 1973		
Rainbow Trout	I and Older	193(±29)	22(±2)
Brown Trout	I and Older	54(±11)	7(±2)
Total Trout		247(±31)	29(±3)

1. STREAM

Rock Creek (Shields River Tributary)

2. DESCRIPTION

Rock Creek originates at the outlet of Rock Lake in the southern portion of the Crazy Mountains of southcentral Montana and flows in a westerly direction for 20.1 miles before emptying into the Shields River. Stream elevations at the origin and mouth are about 8,800 and 4,740 ft, respectively. The stream gradient averages about 202 ft/mile.

The reach of Rock Creek between the mouth and about stream mile 15 lies within private agricultural lands. Cattle and grains are the principle commodities produced. Recreational use within this reach is controlled by adjacent private landowners.

The reach from about stream mile 15 to the headwaters lies within forested and agricultural lands. Access to this reach is via a foottrail heading and traversing private lands to Forest Service lands. Hunting, fishing, backpacking and camping are the major recreational activities within the upper drainage. A mail survey conducted by the MDFWP for the period of May, 1975 through April, 1976 estimated the fishing pressure for Rock Creek at 541 man-days/year or about 27 man-days/stream mile/year (MDFG, 1976).

Sixty-one water appropriations, amounting to 704.6 cfs, have been filed on Rock Creek (State Engineer's Office, 1951). In addition, 82 decreed rights, amounting to 241.5 cfs, are also on file. Water diverted from Rock Creek and its tributaries irrigates about 5,117 acres of land.

Wildlife species found in the Rock Creek drainage include elk, mule deer, whitetail deer and mountain goat. Upland gamebirds include hungarian partridge, sage, ruffed and blue grouse. The portion of the upper drainage between the forest and grass-sagebrush interface serves as an important elk calving area. Furbearers found are raccoon, coyote, badger, beaver, muskrat, mink, marten, and river otter. Ducks and eagles are commonly observed within the drainage.

The Montana Department of Fish, Wildlife and Parks was granted an instream flow reservation on Rock Creek for purposes of maintaining the fish and wildlife resources. The reservation, which has a priority date of December 15, 1978, is contained in the Order of Board of Natural Resources Establishing Water Reservations. For Rock Creek from the mouth to the Forest Service West Boundary in Section 8 and from the Forest Service West Boundary in Section 8 to Smeller Creek, the MDFWP was granted an instream reservation of the 50th percentile for the months of January through December. Consequently, the instream reservation limits the availability of water for new consumptive uses established after December 15, 1978. With the reservation, water is presently available for new consumptive uses in five of ten years for the months of January through December. The granted percentile flows are presently unquantified in terms of cubic feet of water per second and acre-feet per year.

3. FISH POPULATIONS

Due to access problems caused by a private landowner, fish population information could not be collected for Rock Creek in 1980.

Two sections of Rock Creek were electrofished by the MDFWP on August 26, 1974 (Berg, 1975). The brown trout was the predominant trout species in the lower section and brook trout the predominant species in the upper section. The electrofishing survey data are summarized in Table 171.

Table 171. Summary of electrofishing survey data collected for a 150 ft section (T2N, R10E, Sec. 30) and a 250 ft section (T2N, R10E, Sec. 24) of Rock Creek on August 26, 1974 (from Berg, 1975).

Fish Species	No. Captured	Length Range (inches)	Mean Length (inches)
		Lower Section (150 ft)	
Brown Trout	27	2.5-10.1	7.4
Brook Trout	14	3.3-10.9	7.9
Yellowstone Cutthroat Trout	2	7.9-10.4	9.2
		Upper Section (250 ft)	
Brook Trout	76	2.4- 9.2	5.5
Yellowstone Cutthroat Trout	16	3.9-10.8	6.6

1. STREAM

Rock Creek (Yellowstone River Tributary)

2. DESCRIPTION

Rock Creek originates on the east slope of the Gallatin Range in southwestern Montana. The stream heads at an elevation of about 9,120 and flows in a easterly direction for about 13 miles before discharging into the Yellowstone River at an elevation of about 5,014 feet. Stream gradient averages approximately 316 ft/mile. Rock Creek drains an area of about 34 square miles.

Five water appropriations, amounting to 107.8 cfs, are filed on Rock Creek (State Engineer's Office, 1951). In addition, three water appropriations, amounting to 12.5 cfs, are filed on a Rock Creek tributary. Water diverted from Rock Creek irrigates about 104 acres.

Logging is the primary land use activity within the drainage. In the past, logging has occurred on both private and public lands, but is now confined to private holdings within the national forest. Proposals now exist to open the drainage to the public for firewood gathering. Rock Creek is served by a USFS controlled access road.

Recreational activities within the drainage include hunting, hiking, camping and fishing. A mail survey conducted by the MDFWP for the period of May 1975 through April 1976 estimated fishing pressure on Rock Creek at 36 man-days/year or over 2.5 man-days/stream mile/year (MDFG, 1976).

Wildlife species found in the Rock Creek drainage include big game animals, such as elk, mule deer, black bear and cougar, and upland game birds, such as ruffed and blue grouse. Furbearers include beaver, muskrat, mink, marten and river otter.

The Montana Department of Fish, Wildlife and Parks (MDFWP) was granted an instream flow reservation on Rock Creek for purposes of maintaining the fish and wildlife resources. The reservation, which has a priority date of December 15, 1978, is contained in the Order of Board of Natural Resources Establishing Water Reservations. For Rock Creek from the mouth to Steele Creek, the MDFWP was granted an instream flow reservation of the 20th percentile for the months of October through April and for the 50th percentile for May through September. Consequently, the instream reservation limits the availability of water for new consumptive uses established after December 15, 1978. With the reservation, water is presently available for new consumptive uses in two of ten years for the months of October through April and five of ten years for the months of May through September. The granted percentile flows are presently unquantified in terms of cubic feet of water per second and acre-feet per year.

3. FISH POPULATIONS

An electrofishing survey was conducted on a 500 ft section of Rock Creek (T7S, R6E, Sec. 20A) on August 26, 1980. No fish were captured during this survey.

A trout standing crop estimate for a section of Rock Creek located downstream of the 1980 study section was made by the MDFWP in September, 1975 (Table 172). The estimate shows that this section supports about 113 Yellowstone cutthroat trout, weighing 16 pounds, per 1,000 ft of stream.

Rock Creek is one of a relatively few Yellowstone River tributaries that still support a game fish population consisting solely of genetically pure Yellowstone cutthroat trout. The native cutthroat populations of the vast majority of Yellowstone tributaries have been replaced by brook, brown and rainbow trout, species introduced to the Yellowstone drainage. In many tributaries, the introduced rainbow trout have hybridized extensively with the native cutthroat, resulting in the contamination of the gene pool and a decline in the abundance of genetically pure cutthroat. The rainbow traits eventually dominate these hybrid populations. Hybridization is very common in the resident populations of the upper Yellowstone tributaries.

A railroad bridge near the mouth of Rock Creek blocks fish movement between the creek and the Yellowstone River. This impassable barrier is probably responsible for the existence and relative abundance of the genetically pure cutthroat population of Rock Creek.

Table 172. Estimated standing crop of trout in a 4,000 ft section of Rock Creek (T7S, R6E, Sec. 15) on September 11, 1975. Eighty percent confidence intervals are in parentheses.

Species	Length Group (inches)	Per 1,000 ft Number	Per 1,000 ft Pounds
Yellowstone Cutthroat Trout	4.0 - 5.9	58	
	6.0 - 9.9	53	
	10.0 - 11.0	2	
		113($\pm$20)	16($\pm$3)

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