DETERMINATION OF THE AMOUNT OF THE RESERVATIONS

This section discusses in detail the methods used to derive the flow quantities requested for each stream reach in the application. The Wetted Perimeter Inflection Point Method was the primary method used. Several alternative methods were also used in situations where the primary method could not be used or where special circumstances required another approach. This volume does not contain the flow requests themselves. Those requests are contained in Volumes 2 and 3 of this application. The specific method used is described under each individual stream reach.

Also discussed in this section is the Water Availability information required by ARM 36.16.105B(2).

Primary Instream Flow Method

Numerous techniques have been developed for determining the instream flow requirements of fish and other aquatic life forms. These range from relatively simple office methods that base their recommendations on some flow quantity derived from the historic flow record, to the derivation of the actual biological-flow relationships from long-term field data collected in drought, normal and above normal water years.

The former approach was not chosen as DFWP's primary means for determining instream flows because DFWP believes that instream flow recommendations should, wherever possible, reflect stream-specific habitat and discharge relationships rather than a flow quantity derived solely from the flow record. Furthermore, the lack of sufficient flow data for the vast majority of Montana's streams precluded the use of almost all office methods. Moreover, the consensus among professionals is that this approach is most appropriate for deriving preliminary or reconnaissance-level recommendations (Estes and Orsborn 1986; Stalnaker and Arnette 1976).

Use of biological-flow relationships was impractical due to the extensive commitment of time, money and manpower that are needed to collect the ten or more years of field data that could be required to define these relationships for each stream or stream reach. The large number of streams in this application precluded the development of biological-flow relationships except in a few cases.

DFWP, recognizing the shortfalls of these approaches for this application, adopted the Wetted Perimeter Inflection Point Method to determine fishery flow needs. This method focuses on the well-founded assumption that the food supply can be a major factor influencing a stream's carrying capacity (the total number and pounds of fish that can be maintained by the aquatic habitat). The principal food of many of the juvenile and adult game fish inhabiting the streams of Montana is aquatic invertebrates, which are produced primarily in stream riffle areas. The method assumes that the game fish carrying capacity is related to food production, which, in turn, is a function of the amount of wetted perimeter in riffles.

Wetted perimeter is the distance along the bottom and sides of a channel cross-section in contact with water (Figure 1-2). As the flow in a stream channel increases, the wetted perimeter also increases, but the rate of gain of wetted perimeter is not constant throughout the entire range of flows.

A plot of wetted perimeter versus flow for stream riffle cross-sections generally shows two points, referred to as inflection points, where the rate of gain of wetted perimeter abruptly changes. In the example, (Figure 1-3), these inflection points occur at approximately 8 and 12 cfs. Below the lower inflection point, the stream flow is spreading out horizontally across the bottom, causing the wetted perimeter to increase rapidly for very small increases in flow. A point is eventually reached (at the lower inflection point) where the water starts to move up the sides of the active channel and the rate of increase of wetted perimeter begins to decline. At the upper inflection point, the stream is approaching its maximum width and begins to move up the banks as flow increases. Large increases in flow beyond the upper inflection point cause only small increases in wetted perimeter.

The area available for food production is considered near optimal at the upper inflection point because almost all of the available riffle area is wetted. At flows below the upper inflection point, the stream begins to pull away from the riffle bottom until, at the lower inflection point, the rate of loss of wetted bottom area begins to rapidly accelerate. Once flows are reduced below the lower inflection point, the riffle bottom is being exposed at an even greater rate and the area available for food production greatly diminishes. The method is intended to describe a threshold below which a stream's food producing capacity begins to decline (upper inflection point) and a threshold at which the loss is judged unacceptable (lower inflection point).

While the inflection point concept focuses on food production, there are indications that wetted perimeter relates to other factors that influence a stream's carrying capacity. One such factor is cover (or shelter), a well-recognized component of fish habitat.

In the headwater streams of Montana, overhanging or submerged bank vegetation and undercut banks are important components of

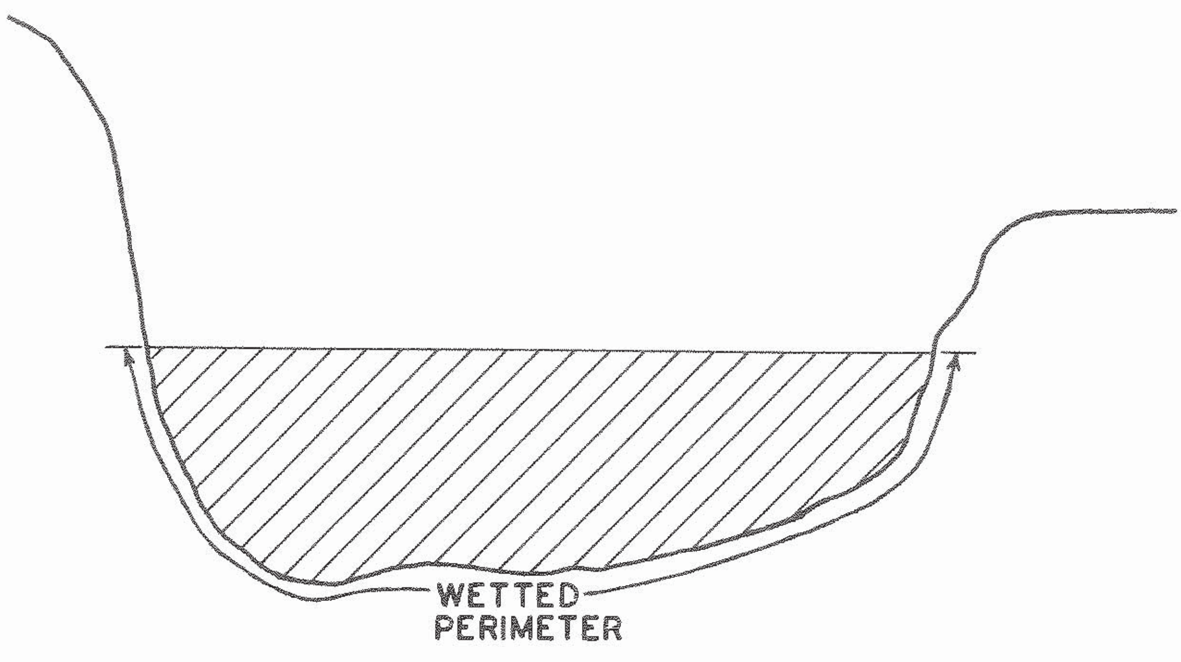

Figure 1-2. The wetted perimeter in a channel cross-section.

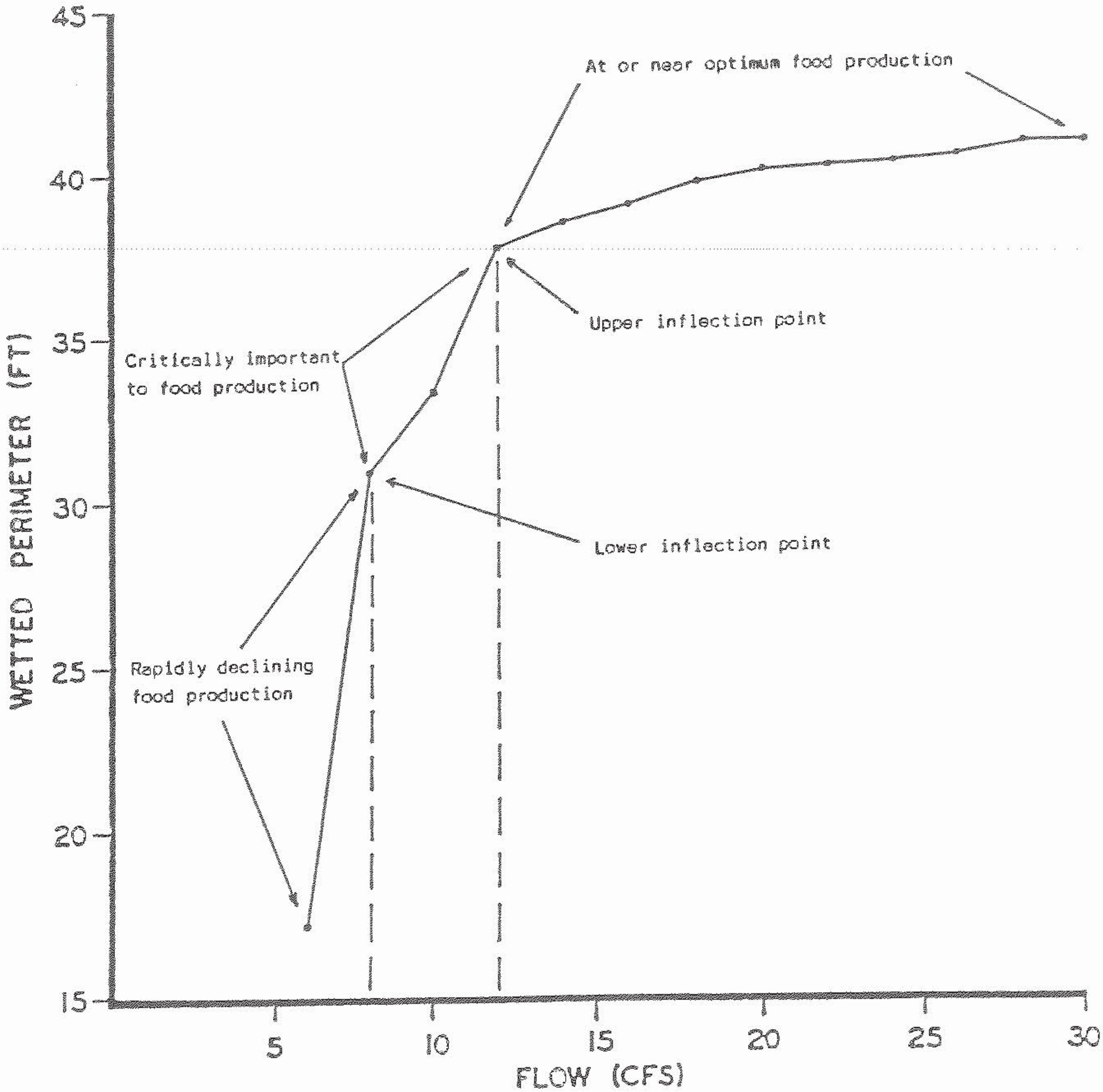

Figure 1-3. An example of a relationship between wetted perimeter and flow for a stream riffle cross-section showing upper and lower inflection points and their relationship to fish food production.

cover. The wetted perimeter-flow relationship for a stream channel is, in some cases, similar to the relationship between bank cover and flow. Flows exceeding the upper inflection point are considered to provide near optimal bank cover. Below the upper inflection point, the water pulls away from the banks, decreasing the amount of bank cover associated with water. At flows below the lower inflection point, the water is sufficiently removed from the bank cover to severely reduce its value as fish shelter. Support for this relationship is provided by Randolph (1984), who found a high correlation between riffle wetted perimeter at various flows and the total area of overhanging bank vegetation (r=0.88-1.00) and undercut banks (r=0.84-0.97) for three study sections in a small Montana stream.

In addition to producing food, riffles are used by many game fish species for spawning and the rearing of their young (Sando 1981 and Loar et. al. 1985). Consequently, the protection of riffles helps ensure that the habitat required for these critical life functions is also protected.

Riffles are the area of a stream most affected by flow reductions (Bovee 1974, Nelson 1977 and Loar et al. 1985). By requesting a flow that covers a large portion of the available riffle area, we are, at the same time, protecting both runs and pools--areas where adult fish normally reside.

The Wetted Perimeter Inflection Point Method provides a range of flows (between and including the lower and upper inflection points) from which a single instream flow recommendation is selected. Flows below the lower inflection point are judged undesirable based on their probable impacts on food production, bank cover, and spawning and rearing habitats, while flows at and above the upper inflection point are considered to provide near optimal conditions for fish. The upper and lower inflection points are believed to bracket those flows needed to maintain high and low levels of aquatic habitat potential. These habitat 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: (a) provide the high population levels needed to ensure the continued existence of that species, or (b) provide the flow levels above those which would adversely affect the species.

(2) Low Level of Aquatic Habitat Potential -- That flow regime which will provide for only a low population of the species present. In the case of game fish species, a limited 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 generally selected from this range of flows by a consensus of the biologists who collected, summarized and analyzed all relevant field data for the stream of interest. The biologists' analyses of the stream resource form the basis of the flow selection process. Factors considered in the evaluation include: (1) level of recreational use, (2) existing level of environmental degradation, (3) water availability, and (4) size and composition of existing fish populations. Fish population information is a major consideration for all streams. A marginal or poor fishery may only 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 westslope cutthroat trout, for example) warrant a higher flow. In general, streams with exceptional resident fish populations, those providing crucial spawning and/or rearing habitats for migratory populations, and those supporting significant populations of "Species of Special Concern" should be considered for flow recommendations that are at or near the upper inflection point. The Missouri Basin streams in this application are generally those with the highest resident fishery and/or spawning values and, consequently, for most of these streams upper inflection point flows are requested.

Other streams considered for upper inflection point recommendations are streams that have the capacity to provide an outstanding fishery, but are prevented from reaching their potential because of stream dewatering. Flows at the upper inflection point provide a goal to strive for should the means become available to improve streamflows through such measures as water storage projects or the purchase and/or lease of irrigation rights. Streams that are subjected to other forms of environmental degradation, such as mining pollution, and which have the potential (assuming other habitat factors are suitable) to support significant fisheries if reclaimed, are additional candidates for upper inflection point recommendations. Both of these categories describe some streams in this application.

The wetted perimeter-flow relationships for the streams of the Missouri Basin were derived using a wetted perimeter predictive (WETP) computer program developed in 1980 for the DFWP. WETP is a relatively simple computer model that eliminates the more complex data collecting and calibration procedures associated with similar computer programs in current use, while at the same time providing more accurate and reliable wetted perimeter predictions. An in-depth description of the WETP computer program and data collection procedures is provided in a publication titled "Guidelines for Using the Wetted Perimeter (WETP) Computer Program of the Montana Department of Fish, Wildlife and Parks" (Nelson 1989) (see Attachment 1).

When deriving instream flow recommendations for the rivers and streams of Montana, DFWP normally divides the annual flow cycle into two separate periods: (1) a relatively brief snow runoff or high flow period, when a large percentage (about 75%) of the annual water yield is passed through stream channels and (2) a non-runoff 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.

The Wetted Perimeter Inflection Point Method is normally applied only to the low flow period, and a separate method that addresses the high flow functions of channel maintenance and flushing of bottom sediments is applied to the high flow period. However, because most water users, particularly irrigators, are unable to divert a significant portion of the high runoff flows and, therefore, are incapable of materially impacting the high flow functions of bedload movement and sediment transport, the need for high flow recommendations may be unnecessary in most cases. The most probable causes for high flow reduction in most of Montana's unregulated streams would be mainstem impoundments. Therefore, extending the wetted perimeter recommendations through the high flow period -- a practice applied to the streams in this application -- should not jeopardize the maintenance of adequate high flows for most streams. Furthermore, Montana law [85-2-316(6), MCA] limits the granting of instream flows to no more than 50% of the average annual flow on gauged streams, thus eliminating (in many cases) flushing and channel maintenance flows from consideration in a reservation application.

Attachment 2 to this application is a comprehensive survey of the instream flow methods literature (Leathe and Nelson 1989), which relates the significance of existing methods to Montana's Wetted Perimeter Inflection Point Method. This synopsis includes the history of instream flow development, the relationship between streamflows and fish populations, a survey and analysis of instream flow methods (including available techniques, advantages and limitations, evaluation studies, and criteria for selecting an instream flow method), and finally, a discussion of why Montana chose to use the Wetted Perimeter Inflection Point Method in its instream flow program. This synopsis is an important component of DFWP's method and justification for the flows requested in this application and should be used in conjunction with the above method discussion.

In summary, the primary method used to determine the requested instream flows for streams and stream reaches in this application is the same -- the Wetted Perimeter Inflection Point Method combined with a knowledge of flow conditions and the fishery gained through field observations and electrofishing surveys. For a relatively few remaining waters, other methods, which are discussed in the following section, were used to derive recommendations.

Alternative Instream Flow Methods

While most of the flow requests in this application were derived from the Wetted Perimeter Inflection Point Method, some were based on the following four approaches:

1. Fixed Percentage Technique

Various non-field or office methods that use existing hydrologic information to derive instream flow recommendations are described in the literature. These methods are similar in that they are usually performed in the office with few, if any, on-site visits required. Office methods are generally deemed most appropriate for deriving preliminary or reconnaissance-level recommendations. Final recommendations are typically derived using various field methods. In Alaska, however, levels of instream flow protection granted by the governing authorities were based solely on office methods (Estes 1988), indicating that such methods are being accepted as primary instream flow methods in certain situations.

One of the better known office methods is the Tennant Method, sometimes referred to as the Montana Method (Tennant 1975). Recommendations of the Tennant Method are based on a fixed percentage of the average annual flow. Tennant describes 30% of the average annual flow as necessary to sustain good survival habitat for most aquatic species, and 60% as providing excellent to outstanding habitat for most aquatic species during their primary periods of growth and for the majority of recreational uses. Ten percent of the average is suitable only for sustaining short-term survival habitat, according to Tennant. The percentage selected as a recommendation depends on the stream's numerical rating in a fisheries classification system. The higher the rating, the greater the percentage recommended.

The purpose of this section is to describe the fixed percentage method used in this application to derive instream flow recommendations for the relatively few (27 total) streams in which