EVALUATION OF THE "MONTANA METHOD" FOR RECOMMENDING INSTREAM FLOWS IN OKLAHOMA STREAMS

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Monthly hydrographs for 24 Oklahoma streams were analyzed to determine the seasonal adjustments required for application of the "Montana method" for recommending instream flows in Oklahoma. Stream flows were recommended for 30 stream reaches. For use in Oklahoma streams, the Montana method should be modified so that the lower of two recommended base flows apply to the period from July through December, rather than that from October through March. This method should be useful for preliminary instream flow assessments in Oklahoma.

INTRODUCTION

Water flowing through natural stream channels supports a variety of needs, including habitat for fish and wildlife, outdoor recreation, hydropower generation, navigation, and waste assimilation. Construction of dams to impound water, diversion of water for irrigation, and municipal and industrial uses may deplete natural stream flows to the point where these needs are no longer met. Protection of the value of stream resources, therefore, depends upon reserving a portion of the stream flow for instream uses. Federal and state agencies are often required to recommend stream flow regimes to sustain instream uses below proposed dams or other water diversions. However, during the planning phases of these projects, time and money are usually insufficient to allow for intensive field studies upon which these recommendations can be based (1, 2, 3, 4, 5). Therefore, planners must rely on methods that require little or no field work, yet still provide reasonable flow recommendations.

The "Montana method" (6), the most widely used of the reconnaissance-level methods, is based on historical records of discharge; it has been applied to warm-and cold-water streams in the Midwest, Great

Plains, and Intermountain West. This method was developed after measurements of width, average depth, and average velocity in 11 streams in Montana, Wyoming, and Nebraska indicated that the quality of instream habitat changed more rapidly from no flow to a flow of 10% of the average than in any higher range (Figure 1). As a result of these measurements, Tennant (6) concluded that 10% of the average annual flow is the minimum instantaneous flow needed to sustain short-term survival. At this flow, Tennant found that depths and velocities were significantly reduced, substrate was one-third exposed, gravel bars were dewatered, streambank cover was diminished, fish were crowded into the deeper pools, and riffles were too shallow for larger fish to pass. A flow of 30% of the average annual flow was required to maintain good habitat for aquatic life; at this flow, widths, depths, and velocities were generally satisfactory, streambanks provided some cover, and larger

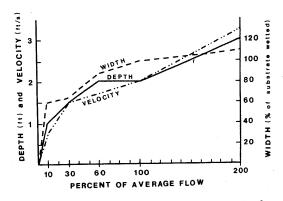


FIGURE 1. Relationships between width, depth, and velocity to percentages of the average annual flow for 11 streams in Montana, Wyoming, and Nebraska (6).

*Present address: Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blackburg, VA 24061. [†]Cooperators are the Oklahoma Department of Wildlife Conservation, Oklahoma State University, and the U. S. Fish and Wildlife Service. fishes could pass most riffles. Optimum habitat was provided by flows of 60-100% of the average annual flow and flushing flows were 200% of the average annual flow. Therefore, to recommend a flow to provide habitat described as minimal, good, optimum, or flushing, a percentage of the average annual flow is selected (Table 1). The Montana method has been infrequently used outside of the western U.S., although Wood and Whelan (7) found general agreement with the recommendations made by this method in southeastern U.S. Therefore, we attempted to evaluate the applicability of this method to Oklahoma streams.

Recommended base-flow regimens for the Montana method are determined by selecting a percentage of the average annual flow (Table 1). Lower base flows are recommended for the season of lowest flow. However, before the Montana method can be applied to Oklahoma streams, the season of lowest flow must be determined, and recommended flows must meet the criterion of water availability. Therefore, the objectives of this study were: (a) to determine the season of lowest flow for Oklahoma streams; (b) to determine the availability of recommended percentages of the average annual flow recommended by the Montana method; and (c) to recommend preliminary instream flow requirements for selected Oklahoma streams.

METHODS

To determine the season of lowest flow in Oklahoma streams, we developed monthly hydrographs that depicted the flows exceeding 10, 50, and 90% of the time during the period for which gaging records were available (U.S. Geological Survey, 8). Twenty-four gaging stations were chosen based on the availability of a sufficient time series of flow data to develop monthly hydrographs (Table 2). The monthly 50-percentile flows were ranked from lowest to highest for each stream and the ranks summed over all streams. The average ranks for each month indicated the season of lowest flow under median conditions. Recommended percentages of the average annual flow (AAF) were compared with the monthly hydrographs to determine the percentage of the time that the recommended flows were equaled or exceeded.

After the season of lowest flow was determined and it was judged that the 10% AAF or 30% AAF was available in most larger streams, the Montana method was modified to take into account the different season of lowest flow. This modified Montana method was then used to make preliminary recommendations of instream flow requirements for 30 stream reaches in Oklahoma.

RESULTS AND DISCUSSION

The average rankings of the 50-percentile flows of the 24 streams studied were as follows: August, 1.6; September, 2.5; October, 3.2; November, 4.6; July 5.2; December, 5.6; January, 7.2; February, 8.5; June, 9.1; March 9.6; April 10.2; and May, 10.5 (9).

A recommended base flow of 10% of the average annual flow (AAF) was exceeded more than 50% of the time during July

TABLE 1. Montana method for prescribing instream flow regimens for fish, wildlife, recreation and related environmental resources. For Oklahoma streams, the flows recommended (6) for Oct.-Mar. are recommended for July through December and the Apr.-Sept. flows are recommended for January through June.

	Recommended base flow regimens (Percent of average annual flow)		
Description of flows	OctMar.	AprSept.	
Flushing or maximum	200	200	
Optimum range	60-100	60-100	
Outstanding	40	60	
Excellent	30	50	
Good	20	40	
Fair or degrading	10	30 10	
Poor or minimum	10		
Severe degradation	0-10	0-10	

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7 Cr. Atoka 073350	Oct. 1942-Sep. 1	498		299	249	199	149	100	50
a 073365		1,699	3,398	1,019	849	680	510	340	170
McCurtain 0/55/9	Oct. 1961-Sep.]	456		274	228	182	137	91	46

TABLE 2. Recommended percentages of the average annual discharge for 30 Oklahoma streams. Minimum instream flows are 10% for July through December and 30% for January through June.

*Not included in the 24 stations used to determine season of low flow. **Includes regulated and unregulated periods.

through December in 12 of the 24 stream reaches for which hydrographs were developed. Stream reaches in which the 10% AAF was exceeded less than 50% of the time during July through December were usually in smaller streams. Median drainage size for streams where 10% AAF was not available from July to December was 1,159 km² compared with 10,153 km² for streams for which the 10% AAF was available. Therefore, in general, availability of the 10% AAF was associated with streams with larger drainage basins. However, size of the drainage area was not the only factor associated with availability of the 10% AAF. Two streams in western Oklahoma (Beaver River, Salt Fork of Red River) had large drainage areas, but low rainfall resulted in low flows during summer and fall. In spite of higher average rainfall in streams in eastern Oklahoma, steeper stream gradients and greater seasonal fluctuation in discharge (Big Cabin, Sallisaw, Poteau, Fourche Maline, Muddy Boggy, Kiamichi, Glover) also resulted in an unavailability of the 10% AAF under median summer conditions.

A base flow of 30% of the average annual flow was exceeded more than 50% of the time during January through June in almost all of the 24 streams investigated. A notable exception was Council Creek, an intermittent stream in central Oklahoma where the 50 percentile flows ranged from 5 to 15% AAF during January through June.

Based on this analysis of stream flow, we recommend a minimum instream flow of 10% of the average annual flow for July through December and 30% AAF for January through June (Table 1). Examples of the application of this methodology are presented (Table 2) for 30 stream reaches in Oklahoma. Alternative flow recommendations can also be made by using the other recommended percentages of the AAF (Tables 1, 2). Minimum instream flows (*i.e.*, 10% AAF) were compared with flow duration curves (U.S. Geological Survey, 8) for five stream reaches regulated by impoundments. The percentages of the time during which these minimum flows were exceeded were: 54% in the Caney River below Hulah Lake; 46% in Wolf Creek below Fort Supply Lake; 38% in the North Canadian River below Canton Lake; 52% in the Poteau River below Wister Lake; and 56% in the Washita River below Foss Reservoir. In the North Canadian River, the minimum instream flow was exceeded 64% of the time before impoundment compared with 38% after impoundment. In the Washita River, the minimum instream flow was exceeded 64% of the time before impoundment compared with 56% after impoundment. In these cases minimum flow releases were probably based on the reliability of flows under drought conditions, rather than on the needs of fish.

To make preliminary flow recommendations that take into consideration the needs of fish and other aquatic life, the Montana method can be used in Oklahoma. However, it should be modified by adjusting the season of lowest flow to cover the period from July through December. We recognize that the recommendation of base flows for two 6-month periods is inadequate to closely simulate the natural stream flow regime or to provide flushing flows. A similar approach could be taken to recommend flows on a quarterly basis. However, the Montana method can still be useful, because it enables planners to obtain a preliminary estimate of the quantity of flow necessary for instream uses. With these estimates, engineers and planners can proceed with preliminary feasibility studies while taking into account the instream-flow needs of aquatic life. However, the limitations of the Montana method dictate that its use be restricted to initial planning and that it be followed by more intensive field analysis.

Flows of 10% of the average annual flow during July through December and 30% during January through June should be considered the minimum stream flows required to prevent degradation. Higher percentages of the average annual flow may be recommended for streams with greater values as fishery resources. Also, higher percentages may need to be recommended for larger, permanent streams. Recommendation of instream-flow needs for intermittent streams presents a problem, because there is no natural flow during much of the year. Further investigation is necessary to identify the value of these streams and to develop a method for deriving reasonable flow recommendations.

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