THE STATUS OF THE INSTREAM FLOW ISSUE IN ARKANSAS, 1987

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ABSTRACT

Expansion of Arkansas' population with concurrent increases in the state's domestic, industrial, and agricultural water uses and possible out-of-state diversion are placing substantial demands on the state's water resources. In an attempt to address this growing concern, Act 1051 (1985) of the Arkansas legislature was passed requiring the determination of present and future state water needs. A specific area of this mandate was the quantification of instream flow requirements. Basic instream flow needs are maintenance of the aquatic ecosystem and dependent riparian environment. Flow reservation may compliment other instream uses such as recreation, navigation, water quality, and groundwater recharge. However, offstream uses (e.g. irrigation and industry) may compete for these same flows and often at the most critical time of year. In order to answer questions concerning instream flow requirements, over 40 methods of instream flow determination have been developed, the majority in the semi-arid western United States. These individual procedures may be classified into four major methodologies: (1) discharge, (2) single transect, (3) multiple transect, and (4) regression analysis of historical data. Requirements of these four types vary according to necessary level of expertise, time and effort expended, and monetary outlay. In one year, requests for fish and wildlife instream flow needs for approximately 60 stream reaches throughout Arkansas limited the possible options. Modification and further development of a well-known method is outlined as an initial step in the process of quantifying Arkansas' instream flow needs. Examples are given for some of the major river basins throughout the state.

INTRODUCTION

For over 25 years, the western United States has experienced water shortage and appropriation problems. This has been due, in part, to low annual precipitation over large areas and an increasing population which created heavy demands on the limited water resources. As a result, numerous instream flow methods have been developed in that region to plan for the many uses placed on surface water resources. Bayha (1976), summarizing the nationwide water problem, advised eastern states to get ahead of the instream flow problem by formulating plans and finding solutions now.

An instream flow requirement is defined as "the quantity of water needed to maintain the existing and planned in-place uses of water in a stream channel or other water body and to maintain the natural character of the aquatic system and its dependent systems" (Bureau Land Management, 1979). The aquatic and riparian ecosystems and the physical features of the stream are the dependent natural systems. Physical features of a stream include its channel, floodplain, and flow pattern. Some potential uses/needs include maintaining adequate groundwater recharge, navigation, water quality, recreation, and preservation of fish and wildlife populations.

Arkansas has rarely had water quantity problems and legislation granting allocation powers to the Arkansas Soil and Water Conservation Commission (ASWCC) during drought years has seen little use. However, reported plans to pipe surplus Arkansas water to other states as well as possible interbasin transfer of water within the state, have awakened Arkansans to the realization that they may not be water "rich" for long. Declining aquifers and increasing population levels have placed ever higher demands on the state's surface waters for domestic, industrial, and agricultural uses. This same growing human population is utilizing a limited and decreasing stream fishery now more than ever. With increasing angler demands on the stream fishery and increasing diversion demands on the total stream resource, managing agencies such as the Arkansas Game and Fish Commission (AGFC) cannot afford a *laissez faire* approach when it comes to instream flow needs. Instream flow requirements and flow recommendations have become a high priority with natural resource agencies managing stream ecosystems.

It has been calculated that in a normal water year, 69% of the nation's water courses have water available the year around as fish habitat; 17% is usable primarily in spring and summer and 14% is unusable during any part of the year because of low or no flow (Judy *et al.*, 1984). Water quantity problems adversely affect the fish community in 68% of the nation's total waters and 41% of perennial waters. Major water quantity problems include: below optimum flows (32%), occasional low flows (23%), and exessive flow fluctuation (17%). One-half of these waters are adversely affected by natural low-flow conditions. Agricultural diversions adversely affect 14% of all waters.

Excessive demands for water uses were experienced during the drought conditions of 1980, particularly in the delta area of eastern Arkansas. Many streams were literally pumped dry with little concern for the fishery resources. These predictable increases in water demands must be viewed with respect to their effect on all the beneficial uses of the water.

Stalnaker (1981) encouraged fishery and water quality agencies to protect instream resources by aggressively pursuing the establishment of stream flow standards as a parallel effort to water quality standards under the Clean Water Act. He reasoned that stream habitat is very dynamic, changing with the season and the annual water yield.

Therefore, alteration of stream flow not only effects habitat conditions but may also change the relative abundance of fish species. This dynamic nature of the fishery rules out use of historic low flows as a realistic minimum flow. Such a proposal ignores the long-term recovery of a fishery that must occur after a severe drought. Establishing historic low flows as allowable minimum levels would reduce the fishery to perpetual worst case conditions.

For these reasons, various instream flow methodologies have been developed. These plans make it possible to satisfy all water uses during some years, while in other years, certain water uses will be unsatisfied. Past management schemes relying on impoundment and manipulation of streams have been only marginally effective in resolving this problem (Sweetman, 1980). In Arkansas, only a few streams are completely unaffected by water diversion. In some areas these effects are slight but, in others, streams show little similarity to natural flows according to Hines (1975).

A discussion of the legalities of reserving instream flows for fisheries is not within the scope of this paper. However, there are laws providing for protection of fish and wildlife as a part of major project development. One such law is Public Law 85-624, the Fish and Wildlife Coordination Act of 1958 (U.S. Corps of Engineers, 1983). Arkansas statute Section 21-1301 allows the state to exercise some control of allocation and distribution of surplus water from water impoundments by requiring said impoundments "to maintain the normal flow of all streams and preserve the fish therein" (Mays, 1981). Section IV, page 7 of the Arkansas Soil and Water Conservation Commission's *Surface Water Allocation Rule Book* (1982), states that full service priorities, which include domestic use and "instream flow required to maintain the stream ecosystem," will be reserved prior to allocation for diversion. Diversion allocations are prioritized as: agriculture, industry, hydropower, and recreation. Finally, in Amendment 35 to the Arkansas Constitution, the Arkansas Game and Fish Commission is given the responsibility and jurisdiction to conserve and manage all forms of fish and wildlife in the state. When applying this responsibility to instream water resources, the AGFC must consider a holistic approach. This requires protection of sport, commercial, non-game, and endangered or threatened fish species. It also includes conservation and management of aquatic animals, protection of migratory bird habitat, maintenance of riparian vegetation and its associated ecosystem, management and needs of dependent terrestrial wildlife, and accessibility by the public to existing and future stream use areas.

The instream flow issue has been introduced to Arkansas through Act 1051 of the 1985 state legislature which requires the ASWCC to determine present and future water needs of Arkansas. As the coordinating agency, the ASWCC has contracted several federal and state agencies for assistance in this matter. In the arena of instream flows, the ASWCC has asked for recommendations from the U.S. Corps of Engineers (navigation), Arkansas Department of Pollution Control and Ecology (water quality), Soil Conservation Service and ASWCC (agriculture and industry), and the Arkansas Game and Fish Commission (fish and wildlife).

INSTREAM FLOW METHODOLOGIES

The need to obtain practical and defensible instream flow requirements has resulted in the development of nearly 40 methods. Many of these are simply modifications of a few basic techniques to compensate for variation in climates, fish species, and river types. Most fisheries biologists agree that the potential of a stream to support a specific assemblage of fish species depends on the amount of water flowing in the stream; however, the technique used to determine the minimum stream flow varies from region to region and state to state.

Four of the best known procedures to quantify instream flows are: (1) single transect methods, (2) multiple transect methods, (3) multiple regression analysis methods, and (4) discharge methods (Metzger and Haverkamp, 1983). Methods 1 and 2 are field methods requiring varying levels of expertise, time expended, and monetary outlay. The single transect method often utilizes a measurement of wetted perimeter to compare stream discharge and fishery potential.

The multiple transect methods may include wetted perimeter, weighted usable area, and several other habitat rating variables, as well as channel characteristics to predict fish presence and abundance. The IFIM (Instream Flow Incremental Methodology) is a multiple transect method that has proven the most scientific and legally defensible instream flow method available in western states where it was developed. However, the IFIM is expensive and time consuming due to the field work required (Stalnaker and Arnette, 1976). The trade-off is to conduct a few, precise instream flow estimates on major streams or to utilize a relative simple, quick method on numerous streams.

The regression analysis method (Gilbert, 1984) requires a fairly comprehensive stream fish sample database and adequate discharge records over many years. Actual biomass of stream fish communities are regressed against flow measurements when the population samples were collected. Optimal fish populations at specific discharges are the end result.

A request was made for fish and wildlife instream flow guidelines for 56 streams in Arkansas within one year. Use of a labor intensive field technique would not have been logistically possible to meet this request. Major reservations of flow and the establishment of minimum stream levels in the well-watered regions seem better served by broadly applicable and relatively speedy and inexpensive methodologies (Metzger and Haverkamp, 1983). Such methods would enable Arkansas to immediately protect much of its water in a relatively short time while competing offstream demands for that water lie in the future.

The "Montana" method as developed by Tennant (1975) is the best known of the discharge methods and requires no actual field work if precise water flow records are available. With this method, fisheries biologists perform the analysis with the aid of hydrological data provided by the U.S. Geological Survey. Tennant (1975) evaluated his method by using detailed field studies from 11 streams in three states involving physical, chemical, and biological analysis of 38 different flows at 58 cross-sections on 196 stream-miles on both cold and warmwater streams. Results revealed that the condition of the aquatic habitat is remarkably similar on most streams carrying the same portion of the average flow. Similar analysis of hundreds of additional flow regimens near U.S.G.S. gauges in 21 different states during the past 17 years substantiated this correlation on a wide variety of streams. Besides being quick and relatively easy to use, this method assures stream to stream consistency and never produces a zero flow recommendation.

While perfecting his instream flow system and evaluating other techniques, Tennant found that in 86 of 305 instances (28%) in the Missouri River Basin, instream flow criteria modeled from 7Q10's (or historic minimum flow records) resulted in zero flow. In 236 of 305 cases (77%), the 7Q10 was less than 10% of the average flow and was considered by Tennant to be in the severe degredation zone. Criteria from 3-day minimum flow records were worse and historic, all-time, minimum flows would be disasterous causing eventual depletion of the fishery.

Several state and federal agencies have used Tennant's method when time or monetary constraints would not allow use of field transect methods. "The Montana method is a quick, easy methodology for determining flows to protect the aquatic resources on a broad scale and therefore is applicable to regional planning of water uses and needs" (BLM, 1979). Researchers, working on new instream methods to better answer local questions and problems, have found Tennant's method to closely approximate instream flow requirements computed from exhaustive field work. Newcombe (1981) obtained cross-section areas of stream discharges and weighted them in accordance with frequency distribution of water depth and water velocities preferred by life-history stages of native sport fish in the Pacific Northwest. Comparison of his results indicated substantial agreement with Tennant's method.

The Montana method does have inherent limitations which should be understood before it is used. It does not necessarily account for a specific stream's flow fluctuations or seasonal variability characteristics of southeast U.S. streams and does not account for the geometry of the stream channel which can vary in drainges within the same region. However, because of time limitations placed on the agency responsible for required instream flow guidelines, a thorough analysis of this method was done. After careful inspection, the Montana method did not appear totally applicable to Arkansas' instream flow needs because its framework follows hydrologic processes more common to western states. Hydrographs where this method was developed underline the importance of spring and summer snowmelt that provide the majority of water during a single water year. In western climates, winter is not a high flow time of year even though precipitation in the form of snowfall is fairly high. Snowfall is incorporated into the snowpack until the spring and summer months when warming air temperatures begin the thawing and melting process. Arkansas receives its heaviest inflows in the form of rain during winter and spring and experiences a low flow period in late summer to early fall (Fig. 1). This major difference in

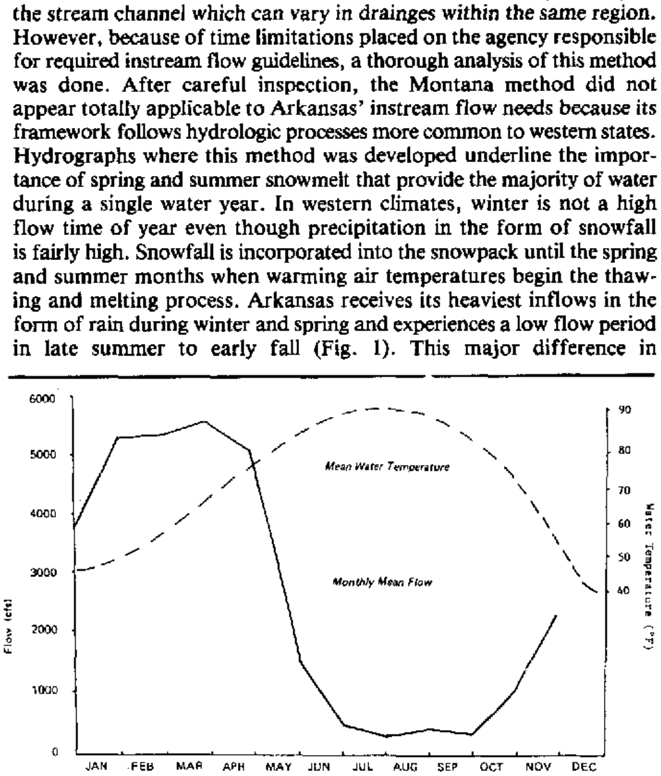

Fig. 1. Monthly Mean Flows and Mean Relative Water Temperatures for the Saline River near Rye, Ark.

meterological conditions kept Arkansas biologists from using the Montana method as outlined by Tennant. However, it did not completely negate consideration of the discharge method of instream flow quantification, since discharge is the primary physical factor that characterizes stream environments (Hynes, 1970). The resultant method developed for utilization in Arkansas is outlined and modifications to the Montana method are discussed in the following section.

THE ARKANSAS METHOD

Since the Montana method does not adequately protect certain critical stages in the life cycle of native Arkansas stream fish, a new method utilizing Tennant's basic principles was developed. Average monthly flows, average annual flows, stage-discharge relationships, and stream channel cross-sections were obtained from the U.S.G.S. office in Little Rock. An instream flow method sufficient for Arkansas' fisheries needs evolved which combined: (1) the use of historic hydrologic records for Arkansas streams; (2) many years of field and educational expertise in fisheries biology (including specific fishery needs and habitat requirements); and (3) a knowledge of natural, seasonal processes occurring in streams in Arkansas' different physiographic regions. This method of computing instream flow needs for fisheries in Arkansas will subsequently be referred to as the "Arkansas Method".

The Arkansas method of instream flow determination is based on the premise that the average flow of a stream is a composite of size of the drainage basin, geomorphology of the stream channel, climate, vegetation type and abundance, and related land uses. This flow reflects the average, natural hydrograph of the stream, and the component aquatic fauna and flora which have evolved to "fit" the specific characteristics of that stream. Vannote *et al.* (1980) observed that "over extended river reaches, biological communities are established which approach equilibrium with the dynamic physical conditions of the channel." One of the primary factors affecting physical conditions of the channel is discharge. The fish population inhabiting a particular stream is an indicator of the combined influence of environmental factors which are affected by stream discharge (Wood and Whelan, 1962).

DESCRIPTION OF PHYSICAL/BIOLOGICAL SEASONS IN THE ARKANSAS METHOD OF INSTREAM FLOW QUANTIFICATION

TIME OF YEAR	NOVEMBER THRU MARCH	APRIL THRU JUNE	JULY THRU OCTOBER
FLOW REQUIRED	60% OF THE MEAN MONTHLY FLOW	70% OF THE MEAN MONTHLY FLOW	50% OF THE MEAN MONTHLY FLOW OR THE MEDIAN MONTHLY FLOW
PHYSICAL/BIOLOGICAL PROCESSES INVOLVED	CLEAN AND RECHARGE	SPAWNING	PRODUCTION
NORMAL CONDITIONS	High average monthly flows. Low water temperatures. High dissolved oxygen content.	High average monthly flows. Increasing (preferred) water temperatures.	Low average monthly flows. High water temperatures. Low dissolved oxygen content common.
FUNCTION AND/OR RESPONSE	Flushing of accumulated sediment & cleaning out of septic wastes. Spawning areas cleaned & rebuilt by gravel & other substrate brought downriver by high flows. Recharge of ground water (aquifers)	High flows & increasing water temperatures spur spawning response in fish: 1) in channel 2) in overbank or 3) upriver after migration. Feeding also activated by high spring flows.	High water temperatures increase primary, secondary, and tertiary production. Low flows concentrate predators (fish) with prey (invertebrates, forage fish).
LIMITING FACTORS	Reduced flows cause: Decrease in benthic production due to accumulated sediment on substrate. Decrease in fish spawning habitat due to reduced flushing. Decrease in aquifer recharge.	Reduced flows cause: Decrease in spawning egg & fry survival & overall reproductive success of important sport & non-game fish. Weak year classes of important sport, commercial, non-game & threatened fish species.	Reduced flows cause: Water temperatures to increase, decreasing survival of certain fish species. Decrease in wetted substrate & therefore decrease in algae, macroinvertebrates. Decrease in dissolved oxygen due to higher water temperatures; fishkills. Increase concentration of pollutants and sediment in water. Additional decrease in groundwater table.

Table 1. Description of physical/biological seasons in the Arkansas method of instream flow quantification.

The Arkansas method divides the water year into three physical/biological units or seasons. These units are categorized by the physical processes that occur in the stream and critical life cycle stages of the fish and other aquatic organisms inhabiting the stream (Table 1). The natural hydrograph of the Saline River at Rye, Arkansas (Fig. 1), indicates November through March is the time of year when increased flows flush sediment laden substrates and septic waste products and bring an influx of inorganic nutrients from the watershed which establish the basic fertility of the stream. Tennant (1975) remarks that 100-200% of average annual flow is good for moving sediment and bedload, and provides for white water types of recreational activities. While Tennant's recommendations appear to be the most widely recognized and used technique in the western states (Reiser *et al.*, 1985), many of the streams it's used on are regulated streams where 200% of the average annual flow can be released at will by the managing agency if the necessary storage capacity is available. Many of Arkansas' streams are not regulated and requests in excess of the average flow for a given month do not appear practical. For this reason, winter flushing flows recommended by the Arkansas Method are often lower than those espoused by Tennant. However, the Arkansas Method flow, 60% of the mean monthly flow (MMF), often is near bank full elevation for many Arkansas streams and should therefore be an effective flow for transporting fine sediments. Recharge of aquifers and groundwater is also an important process occurring during this time.

Seventy percent of the MMF is recommended for fisheries instream flow needs during April through June because it is the primary spawning time for the majority of native Arkansas fish. It is erroneously assumed by some that the late summer low flow period is the only critical time for stream fish populations and, therefore, the only time when instream fisheries requirements need protection. Native fishes must spawn successfully in the spring of each year; otherwise, detrimental effects will be experienced by the population for several consecutive years. Decreases in stream flows contribute to increased mortality by stranding fish eggs and fry or by reducing a sufficient flow of oxygenated water to developing fish eggs or fry. Reduced flows can also result in increased deposition of silt in spawning areas (Peters, 1982). In low gradient streams with expansive floodplains, high water stages may trigger a large portion of the stream fish population to move into backwaters or overbank areas to feed and spawn. The extent of feeding, growth and reproduction is related to the time, coverage, and duration of flooding (Wood and Whelan, 1962). Also, species of native fish such as walleye, white bass, various species of redhorse, and others require high spring flows to migrate upstream to spawn. For these reasons, it is imperative to reserve a high percentage of normal springtime flooding for the fishery. Seventy percent of the MMF often spills onto the flood plain on many Arkansas streams providing necessary spawning habitat and flows.

The final season of this scenario spans July through October when stream flows usually reach absolute minimums and an inverse relationship exists between monthly mean flows and mean water temperatures. Fig. 1 shows this relationship in a typical sine curve. This July-October season is the production time of the biological year when warmer water temperatures accelerate numerous processes in the food chain from bacteria digestion of organic materials to production of plankton, periphyton, macroinvertebrates, forage fish, and predatory fish. However, if water temperatures become too elevated, which can occur with excessive removal of water from a stream, the dissolved oxygen (DO) saturation capacity of water is greatly reduced. Substantial decreases in DO content limit production, growth, and survival of most aquatic life. For example, growth of largemouth bass begins to substantially decrease at DO levels below 4.0 mg/1 and mortality occurs below 1.0 mg/1 (Stuber *et al.*, 1982). Smallmouth bass and other fish species are considerably more sensitive to decreased DO concentrations than are largemouth bass.

During the production season (late summer), stream flows have less tendency to vary compared to other times of the year. For this reason 50% of the MMF could possibly result in a value less than the 7Q10, especially in spring or artesian dominated systems. In these situations the median flow for the monthly period would provide adequate protection, therefore, the minium flow requirement recommended for the production season is 50% of the MMF or the median monthly flow for groundwater powered systems (Table 1). Fifty percent of the MMF approximates the inflection point for the relationship between discharge

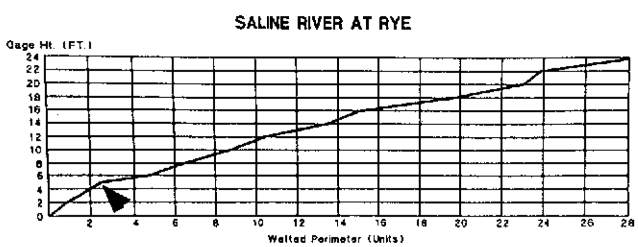

Fig. 2. Relationship Between River Level and Wetted Perimeter for a Cross Section of the Saline River at Rye, AR. Arrow Designates Inflection Point/Minimum Flow for the Low Flow Seasons.

and the wetted perimeter. This inflection point is the basis for most single transect method recommendations. Figure 2 shows this relationship for the Saline River near Rye, Arkansas. In the figure, discharge is represented by the water level gage height. At or below this inflection point (or flow), the change in the relationship between discharge and the wetted perimeter is greatest. This point represents the minimum level a stream should be drawn down since much of the valuable littoral habitat has already been exposed. These flows allow for adequate coverage of the stream substrate or wetted perimeter. Without this magnitude of protection, shoal or riffle areas and sloughs could be exposed, thereby rendering them nonproductive. Stream bank cover for fish would diminish and riparian vegetation and associated wildlife would suffer. Reduced flows would reduce the oxidation capacity of the stream and therefore its ability to assimilate and dilute sewage and other waste products. Concentrations of pollutants and sediments in the water would increase and water quality would be degraded. Extreme low flows result in crowding of fish populations, thereby increasing stress, which can trigger higher levels of fish diseases and parasitic infestations.

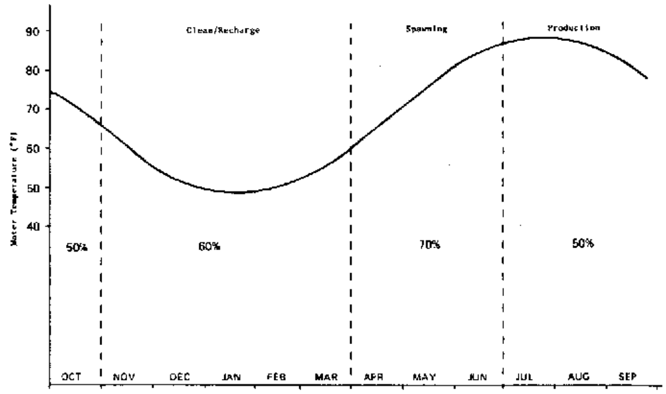

Fig. 3. Temperature vs. Week of Water Year

Fig. 3 illustrates the temperature curve for a typical water year in the Ouachita River near Felsenthal, Arkansas. The instream flow requirements of the Arkansas method are shown on the graph to give an idea of stream water temperature in relation to percent flows necessary for adequate protection of the stream fisheries. Without minimum flows reserved for the fisheries, repetitive abiotic factors such as excessive low flows can control and decimate fish populations (Orth and Maughan, 1980; Layher, 1983).

Although specific stream flow requirements for terrestrial and semi-aquatic wildlife are not addressed, when flow needs for fisheries are met, many instream requirements for these species should be satisfied. Site-specific wildlife problems, such as water level fluctuations during waterfowl season, may require special consideration from professional wildlife biologists. For example, Nichols *et al.*, (1983) showed that the availability of winter water, time of year and duration of inundation may directly affect food utilization, nutrition distribution, annual survival, and recruitment of ducks, particularly mallards. Mallards are the number one harvested duck in Arkansas and the foundation of the multi-million dollar duck hunting "industry" in the state.

SPECIFIC INSTREAM FLOW NEEDS

Figure 4 shows the 12 major river basins in the state where instream flows for fisheries were computed. Tables 2-3 list specific monthly instream flows for the year as computed using the Arkansas method of flow reservation for two streams representing major river basins in the state.

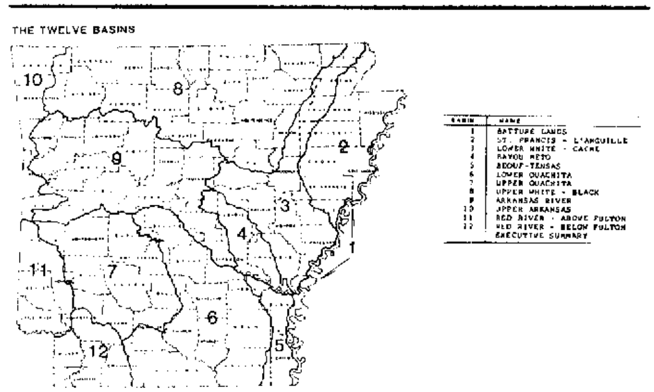

Fig. 4. Map Illustrating 12 Major River Basins in Arkansas.

Table 2. Minimum Instream Flow Requirements for Fisheries by Month for the Ouachita River at Malvern, Arkansas.

MONTH	MONTHLY MEAN FLOW (CFS) 1929 - 1983	INSTREAM FLOW REQUIREMENTS ARKANSAS METHOD (CFS)	INSTREAM NEEDS BY STAGE HEIGHT (FT.)
JANUARY	3,617	2,290	3.6
FEBRUARY	3,442	2,065	3.4
MARCH	3,335	2,001	3.4
APRIL	3,627	2,539	3.8
MAY	3,560	2,492	3.8
JUNE	1,728	1,210	2.7
JULY	1,032	706	2.1
AUGUST	913	592	2.0
SEPTEMBER	1,127	792	2.3
OCTOBER	1,231	932	2.4
NOVEMBER	1,899	1,139	2.6
DECEMBER	2,959	1,775	3.2

Table 3. Minimum Instream Flow Requirements for Fisheries by Month for the Arkansas River at Murray Lock and Dam.

MONTH	MONTHLY MEAN FLOW (CFS) 1928-1984	INSTREAM FLOW REQUIREMENT ARKANSAS METHOD (CFS)
JANUARY	33,520	20,112
FEBRUARY	41,190	24,714
MARCH	50,760	35,532
APRIL	64,960	45,472
MAY	77,490	54,243
JUNE	61,450	43,015
JULY	35,060	24,230
AUGUST	17,450	12,560
SEPTEMBER	17,730	13,820
OCTOBER	24,430	12,320
NOVEMBER	29,010	16,438
DECEMBER	30,730	18,438

ANNUAL MEAN FLOW = 40,270 cfs

Figures 5-6 show monthly mean flows (top line), Arkansas method instream flow (bottom line) and surplus water (shaded area). The minimum stream flows and stream stage heights recommended are guidelines for the ASWCC for minimum values to maintain and protect stream fisheries. Determination of higher flows or stage heights at which ASWCC's water allocation duties begin is not the responsibility of the agencies involved in setting fisheries instream needs.

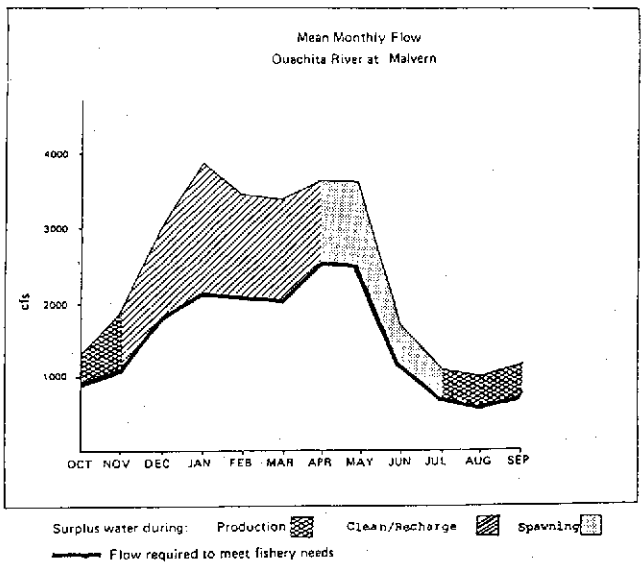

Fig. 5. Minimum Instream Flow Requirements for Fisheries by Month for the Ouachita River at Malvern.

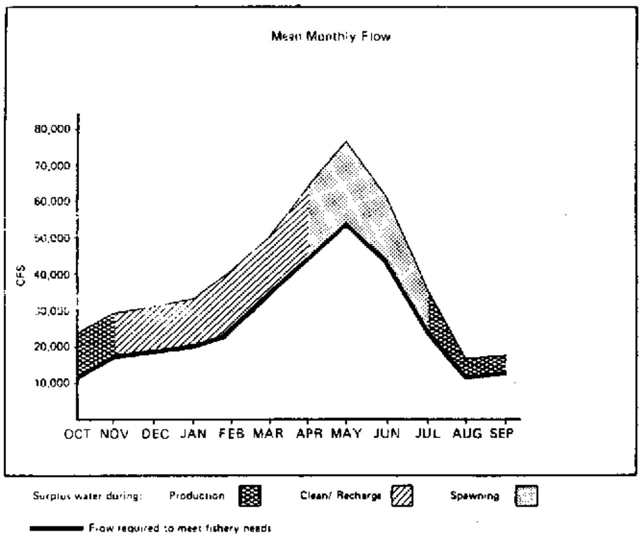

Fig. 6. Minimum Instream Flow Requirements for Fisheries by Month for the Arkansas River at Murray Lock and Dam.

Since only a few sites and instream flow recommendations can be computed, water users above and below the stations specified will need to be advised of minimum instream flow reservations in their area. These will need to be computed on a watershed size basis at the point of interest, or by some other suitable method determined by the administering agency.

Agencies responsible for the conservation and management of the fishery resources should only have to justify that portion of a stream flow actually required to fulfill specific instream needs. Therefore, if fisheries instream needs require a flow of 14,000 cfs in a stream segment and the USCOE requires a flow of 13,000 cfs for navigation purposes at the same time of year, only a flow of 1,000 cfs should have to be justified for the fisheries needs at that time.

Finally, only streams with a 7Q10 value greater than 1 cfs are currently being considered by ASWCC for fisheries instream flow requirements. A large number of streams with 7Q10's less than 1 cfs located in the Ouachita and Ozark Mountains have high water quality and exceptional recreational fisheries. These smaller streams are in as much or greater need of protection as the larger ones. With low or no flow in late summer through early fall, fish populations are often at their tolerance limit. Any water diversion at this critical low-flow period could have devastating effects on the stream's fishery. This matter needs to be addressed in the near future and would seam to be a logical extension of the current instream flow evaluation.

The concept of instream flow reservation in Arkansas is a relatively new problem associated with an increasing population and demands for a limited water resource. All facets of the aquatic and associated terrestrial environment can be affected by the resolution of this issue. Cooperation between coordinating agencies is necessary to insure proper water conservation and utilization on a statewide basis. Since great seasonal variability in surface water availability exists in Arkansas, a concerted effort to store high winter and spring flows for later use during peak irrigation times is necessary. Limiting summer-fall (low flow) pumping/diversion from many state streams will protect the aquatic ecosytem associated with these streams. In the future, wise management of Arkansas' streams through adequate instream flow reservations will benefit domestic water uses, fish and wildlife, agriculture, industry, navigation, water quality, and recreation.

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