Idaho Forest, Wildlife and Range Policy Analysis Group

Report No. 9 March 1993

Analysis of Methods for Determining Minimum Instream Flows for Recreation

by
Troy Merrill
and
Jay O'Laughlin

Idaho Forest, Wildlife and Range Policy Analysis Group
Jay O'Laughlin, Director

Idaho Forest, Wildlife and Range Experiment Station
John C. Hendee, Director

University of Idaho

- The Idaho Forest, Wildlife and Range Policy Analysis Group was established by the Idaho Legislature in 1989 to provide objective analysis of the impacts of natural resource proposals (see Idaho Code § 38-714).

- The Policy Analysis Group is administered through the University of Idaho's College of Forestry, Wildlife and Range Sciences, John C. Hendee, Dean.

Advisory Committee

Policy Analysis Reports

No. 1. Idaho's endowment lands: a matter of sacred trust. *J. O'Laughlin* (March 1990).

No. 2. BLM riparian policy in Idaho: analysis of public comment on a proposed policy statement. *K.L. Johnson, C. Mosley, J.C. Mosley, and J. O'Laughlin* (June 1990).

No. 3. Idaho Department of Fish and Game's land acquisition and land management program. *C. Wise and J. O'Laughlin* (October 1990).

No. 4. Wolf recovery in central Idaho: alternative strategies and impacts. *C. Wise, J.J. Yeo, D. Goble, J.M. Peek, and J. O'Laughlin* (February 1991).

No. 5. State agency roles in Idaho water quality policy. *A.C. Turner and J. O'Laughlin* (February 1991).

No. 6. Silver Valley resource analysis for pulp and paper mill feasibility. *J.G. MacCracken and J. O'Laughlin*, editors (October 1991).

No. 7. A national park in Idaho? Proposals and possibilities. *J.G. MacCracken and J.O'Laughlin* (June 1992).

No. 8. Design of forest riparian buffer strips for the protection of water quality: analysis of scientific literature. *G.H. Belt, J. O'Laughlin, and T. Merrill* (June 1992).

Analysis of Methods

for Determining

Minimum Instream Flows

for Recreation

Idaho Forest, Wildlife and Range Policy Analysis Group

Report No. 9

by

Troy Merrill[1]
and
Jay O'Laughlin[2]

March 1993

[1] Research Assistant, Idaho Forest, Wildlife and Range Policy Analysis Group, University of Idaho, Moscow, ID 83843

[2] Director, Idaho Forest, Wildlife and Range Policy Analysis Group, University of Idaho, Moscow, ID 83843.

ACKNOWLEDGEMENTS

The efforts of the Technical Advisory Committee, listed below, are gratefully acknowledged. These individuals provided guidance on the design of the plan for this study, and provided technical review of the final draft of the report.

Chuck Harris, Ph.D.
Associate Professor
Dept. of Resource Recreation and Tourism
University of Idaho

Bo Shelby, Ph.D.
Professor of Recreation Resources
Dept. of Forest Resources
Oregon State University
Corvallis, Oregon

Douglas L. Grant, J.D.
Professor
College of Law
University of Idaho

Bill Graham
Idaho Dept. of Water Resources
Boise, Idaho

Rinda Just, J.D.
Idaho Attorney General's Office
Idaho Dept. of Parks and Recreation
Boise, Idaho

Two others provided technical review of portions of the final draft of the report:

David J. Walker, Ph.D.
Professor of Resource Economics
Department of Agricultural Economics
and Rural Sociology
University of Idaho

Joel R. Hamilton, Ph.D.
Professor of Resource Economics
Department of Agricultural Economics
and Rural Sociology
University of Idaho

We especially would like to thank the 68 individuals who took time from their busy schedules to respond to our survey questionnaire.

TABLE OF CONTENTS

Acknowledgements . . . . *i*

List of Tables and Figures . . . . *iv*

Foreword . . . . *v*

Executive Summary 1

Introduction 2
- Profile of Survey Respondents 2

Laws and Regulations for Protecting Instream Flow 6
- Survey Results 6
- Water Law Terminology 7
  - Prior Appropriation Doctrine 7
  - Public Trust Doctrine 7
- Protection of Instream Flows in Idaho 8
  - Historical Development 8
  - Current Idaho Law 9
    - Declaration 9
    - Authorization 10
    - State Comprehensive Outdoor Recreation Plan 10
- Federal Statutes and Regulations 10
  - FERC Regulation and Permitting 10
  - Federal Statutes 11
    - Endangered Species Act 11
    - Wild and Scenic Rivers Act 12
    - National Environmental Policy Act 12
  - Federal Reserved Rights 12

Deciding What to Protect 12
- Subjective Evaluation and Conflict Resolution 12
  - Survey Results 14
- Recreation Activities and Experiences 15
  - Survey Results 15
    - Recreation Activities 15
    - Recreation Experiences 16
  - Instream Flow as an Element of the Recreation Experience 17
    - Survey Results 20
  - Protecting Elements of the Stream Environment 21
    - Survey Results 23
- Interdisciplinary Process 23
- Economic Valuation 25
  - Economic Analysis Primer 25
  - Methods for Estimating Recreation Value 27

Instream Flow Valuation Studies . . . 28
Estimating recreational fishery value . . . 28
Estimating recreation value . . . 29
Estimating preservation value . . . 30
Strengths and weaknesses . . . 30

Methods for Quantifying Instream Flow: Literature Review . . . 31
Fisheries-based Methods . . . 31
Recreation-based Methods . . . 32
Single Cross-Section Method . . . 32
Incremental Method . . . 33
Recreation Streamflow Criteria . . . 34
Probability of Use . . . 35
Limitations . . . 35
Survey-based Quantification Methods . . . 35
Survey of Users . . . 35
Survey of Experts . . . 36
Photographic Comparison . . . 36
Canoeing Zero Flow Method . . . 36
Systematic Field Evaluation . . . 36

Survey Results: Methods for Quantifying Instream Flow . . . 37
Which Methods are used Most Often? . . . 37
Which Methods are Most Reliable? . . . 38
Defending Recommended Instream Flow Quantities . . . 38

Conclusions . . . 40

Literature Cited . . . 42

LIST OF TABLES

Table 1. Variables affecting canoeing and aesthetics on two slow-moving rivers in east Texas 19

Table 2. Instream flow regimens for fish, wildlife, recreation, and related environmental resources 31

Table 3. Required stream width and depth minima for various recreation craft as determined by the single cross section method 33

Table 4. Recreation streamflow criteria by activity: safety range and optimal range for stream depth and velocity 34

LIST OF FIGURES

Figure 1. Which organizations responded to the survey on instream flows? 2

Figure 2. In which states have respondents been involved with instream flow protection? 4

Figure 3. Which organizations perceive the need to protect instream flows? 5

Figure 4. Existing laws and regulations used to protect instream flows for recreation. 6

Figure 5. Approaches to reduce controversy over instream flow protection and the relative likelihood of their success 14

Figure 6. Recreation activities used to justify establishing minimum instream flow 16

Figure 7. Importance of protecting the recreation experience 17

Figure 8. Importance of protecting different elements of the stream environment for the recreation experience 20

Figure 9. Adequacy of protection for different elements of the stream environment offered by various quantification methods 23

Figure 10. Frequency of use of different methods of quantifying instream flow 37

Figure 11. Which is the most reliable method of quantifying instream flow? 38

Figure 12. How confident are you in defending the quantity of water at different levels of review? 39

FOREWORD

The Idaho Forest, Wildlife and Range Policy Analysis Group (PAG) was created by the Idaho legislature in 1989 to provide Idaho decision makers with timely and objective data and analyses of pertinent natural resource issues. A standing nine-member advisory committee (see inside cover) suggests issues and priorities for the PAG. Results of each analysis are reviewed by a technical advisory committee selected separately for each inquiry (see the acknowledgements on page *i*). Findings are made available in a policy analysis publication series. This is the ninth report in the series. The other eight reports are listed in the inside cover.

This analysis was requested by the Director of the Idaho Department of Parks and Recreation and, at the inception of the project, the request was endorsed by the Director of the Idaho Department of Water Resources.

The report does not address the political question whether or not minimum instream flows for recreation should be established on various streams and rivers in Idaho. The legislature has designed a process for that purpose. This report provides an analysis of existing methods for determining or quantifying instream flows for recreation purposes, an important and timely topic because several different methods are being applied in this evolving field. The results of this analysis should provide useful information.

John C. Hendee

John C. Hendee, Dean
College of Forestry, Wildlife
and Range Sciences
University of Idaho

EXECUTIVE SUMMARY

What methods are available for determining or quantifying instream flows for recreation purposes? Several methods are described in the literature. Respondents to a survey we conducted used survey-based quantification methods most often, and said they were the most reliable methods.

To put the results of this analysis in context, we briefly describe the legal process whereby minimum instream flows for recreation are established in Idaho, along with a capsule history of the recognition of instream flows as a beneficial use of Idaho's water by the state legislature.

Accompanying the decision to establish an instream flow for recreation purposes is the question, how much water should be protected? To help answer this question, we reviewed pertinent literature, developed a questionnaire based on the literature, and sent it to the 114 people who attended an instream flow conference in Corvallis, Oregon, in March 1991. We received 68 responses from people throughout the West with experience determining instream flow quantities. The complete questionnaire and responses to it are published separately (see Merrill and O'Laughlin 1992). Survey results are summarized as follows.

Most of the 68 respondents work for federal agencies, but a wide variety of state and private organizations also responded (see Figure 1, page 2). Fishing and boating are, not surprisingly, the recreation activities most often used to justify establishing minimum instream flows (Fig. 6, p. 16). The most frequently used laws and regulations for instream flow protection are state water appropriations and federal hydropower permits (Fig. 4, p. 6). Instream flow appropriations are controversial, and the quantification of flows is necessary as proof of beneficial use for any appropriation. Flow quantification studies along with public education are the approaches most likely to reduce controversy over instream flow determination (Fig. 5, p. 14).

The term "minimum instream flow for recreation" is somewhat misleading because there is no single minimum flow for recreation. Each recreation activity has different requirements (Table 4, p. 34), and recreation is an experience, not just an activity. To provide opportunities for satisfactory recreational experiences over a long time period, the stream environment needs to be protected, not just the activities presently occurring within that environment. Both the literature review and our survey results reinforce this point (Fig. 7, p. 17).

As a practical matter, then, various elements of the stream environment that contribute to the recreation experience require protection, including (in the order ranked by the survey respondents (Fig. 8, p. 20), water quality, riparian vegetation, natural channel features, adjacent wetlands, and the opportunity to see and hear moving water. Of these stream features, water quality, riparian vegetation, and adjacent wetlands are, according to the respondents, not very adequately considered for protection by the various quantification methods (Fig. 9, p. 23).

Which is the most reliable method of quantifying instream flow needs for recreation? Respondents have used a variety of methods (Fig. 10, p. 37). Of the 53 replies to this question, 22 said a survey of experts and 14 said a survey of users were the most reliable methods. The rather technical incremental method ranked in third place, receiving only 4 votes (Fig. 11, p. 38).

Establishing minimum instream flows is neither a legal problem nor an overwhelmingly difficult technical problem. It is a political problem. A legal process for appropriating instream flows in Idaho was established in 1978. A variety of technical methods are available for quantifying the amount of water for recreation activities and relating streamflow to environmental attributes of the stream that contribute to the recreation experience. The political challenge in allocating water is determining which uses of water and water courses are in the best interests of society.

INTRODUCTION

This report is not about ***establishing*** minimum instream flows. If an instream flow is to protect water resources for recreation purposes, how much water should be protected? This report analyzes the various methods for ***determining*** or quantifying levels of instream flows needed for various recreational and aesthetic considerations. The analysis is based on a review of literature from which a questionnaire was developed to survey individuals with experience in determining minimum instream flows. The complete survey and responses to it are published separately (see Merrill and O'Laughlin 1992). Summarized results of the survey are interspersed throughout the report, usually in graphic form, following corresponding sections of the literature review.

Profile of Survey Respondents

In 1992, a mail questionnaire was sent to 114 individuals who attended the March 1991 Workshop on Instream Flows for Recreation held in Corvallis, Oregon. A total of 68 usable questionnaires were returned without any follow-up notification, a 60% response rate.

As Figure 1 illustrates, most of the respondents work for federal agencies (46 of 68, or 68%). But people who work for a wide variety of state agencies and private

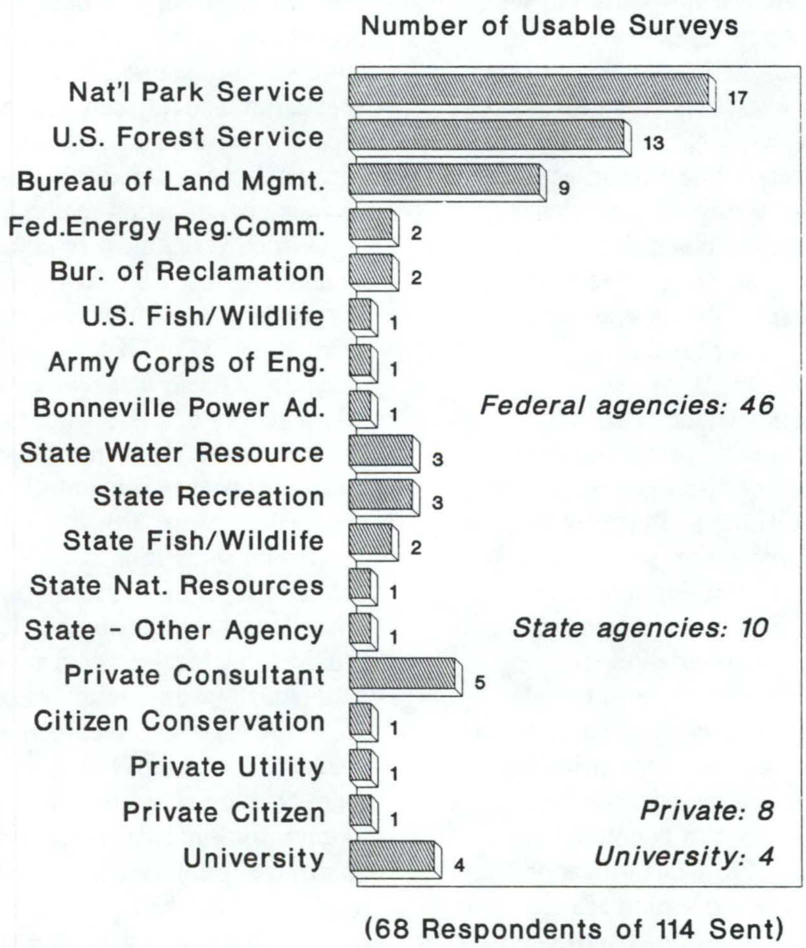


Figure 1. Which organizations responded to the survey on instream flows?

organizations also responded. Ten respondents (or 15%) work for state agencies, 5 in Oregon, 2 in Alaska, 2 in Idaho, and one in Virginia. Eight citizens responded in various capacities, including five employed as private consultants. Four university employees responded (Figure 1).

With one notable exception, the categories of survey respondents are representative of the 114 people who attended the 1991 Workshop on Instream Flows for Recreation in Corvallis, Oregon. The exceptional category is citizen conservation groups. Of the 6 people who attended the workshop listing their primary affiliation with a conservation group, only one returned the survey. Of the 46 non-respondents, 26 (or 57%) were federal agency employees, and 6 (or 13%) were state agency employees. These non-response rates generally reflect the response rates from both federal and state agencies, so we do not feel that there is a non-response bias in our results.

One of the reviewers of this report felt that the disproportionate participation of federal agency personnel in the survey was a major problem. We agree with the reviewer that actual appropriation of water for an instream flow is a state government function. However, most of the studies of instream flows have been conducted by federal agencies. Rather than conduct their own studies to support a request for an instream flow, state agencies have generally relied on federal agency studies.

The reviewer's concern raises a significant question. Did the 10 state agency personnel respond differently than the 46 federal agency personnel? In most cases, no. Analysis of mean responses received from three major employment groups (federal agency, state agency, and non-agency) reveals that in only 5 cases out of the 96 response opportunities in the questionnaire were there statistically significant differences between state agency responses and the other two groups. Compared to the other two groups, state agency personnel who responded were (1) more likely to *agree* that recreational uses of water were given equal consideration with other uses, (2) more likely to *disagree* with the statement that economic considerations are more important in determining instream flow than recreational requirements, (3) wading was more often used to justify instream flow protection, (4) federal reserved rights were less often used to protect instream flow, and (5) less likely to *disagree* with the statement that providing the amount of water for the most common recreation activity is adequate to protect the recreation experience.

Although these five differences between state agency respondents and federal agency or non-agency respondents were statistically significant, they reflect only degrees of difference. In no case did the group of state agency respondents disagree with a statement that other respondent groups agreed with, nor did the state agency group agree with a statement that the other two groups disagreed with.

As Figure 2 reveals, the survey respondents have wide geographic experience, centered in the western states. Most of these states, as indicated in the left bar, use an undiluted form of the prior appropriation doctrine to determine water resource allocations.

Seven other states, listed in the right bar, use a mixture of prior appropriation and riparian doctrine. As indicated at the bottom of Figure 2, a few of the respondents had some experience in 23 eastern states where the riparian doctrine is used.

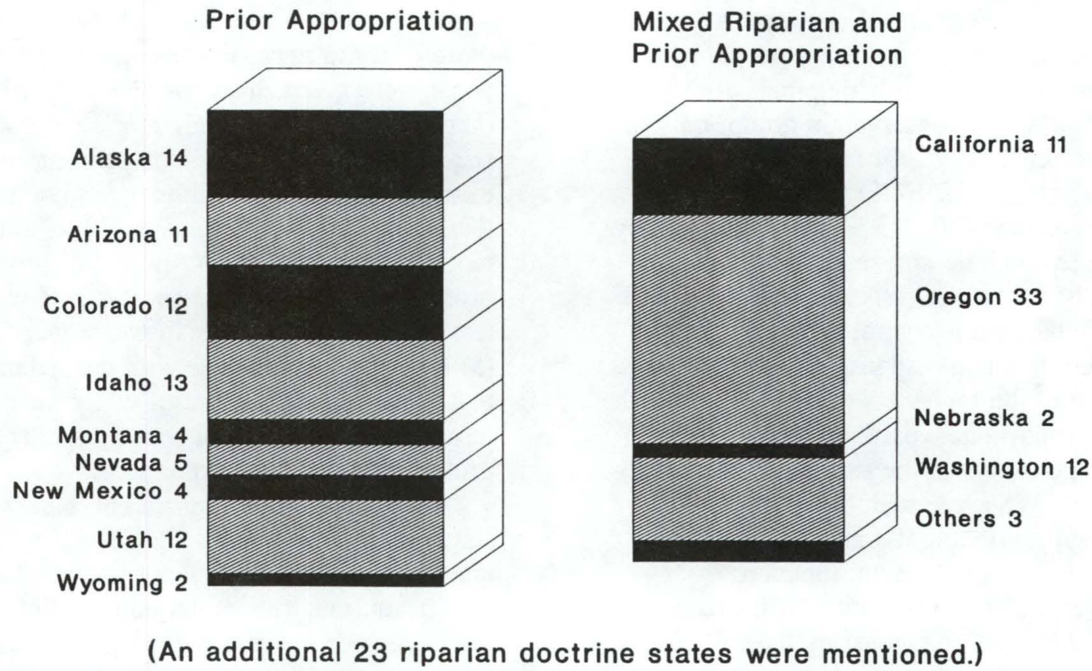
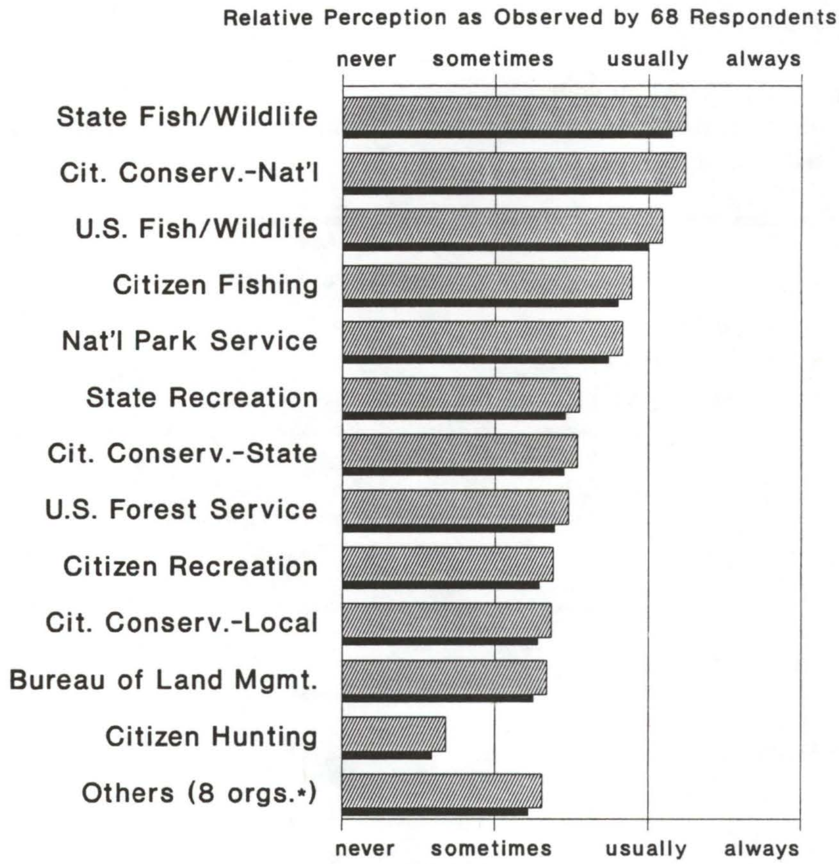


Figure 2. In which states have respondents been involved with instream flow protection?

We asked the respondents to indicate which organizations generally perceive the need to protect instream flow. We listed various organizations and provided a response scale ranging from "never" to "always." The results (Figure 3) indicate that fish and wildlife agencies and national citizen conservation groups are perceived as the organizations that recognize instream flow protection needs to a greater extent than other organizations do.



* Includes counties, state water resource, Indian tribes, outfitters, FERC, Corps of Engineers, nonprofits, planners.

Figure 3. Which organizations perceive the need to protect instream flows?

LAWS AND REGULATIONS FOR PROTECTING INSTREAM FLOW

Existing water laws and regulations are the principal tools for protecting instream flows, and therefore a logical point at which to begin this analysis.

Survey Results

In the survey we asked, "Based on your experience, how often are the following laws and regulations used to protect instream flow?" Results depicted in Figure 4 show that state laws dealing with water appropriation are the most frequently used legal vehicle, followed closely by Federal Energy Regulatory Commission (FERC) hydroelectric regulation and permitting. Federal reserved rights, the Clean Water Act, state water quality policies, and the National Environmental Policy Act (NEPA) environmental assessment process are sometimes used. The few responses in the "other" category were not highly meaningful and are not indicated in Figure 4.

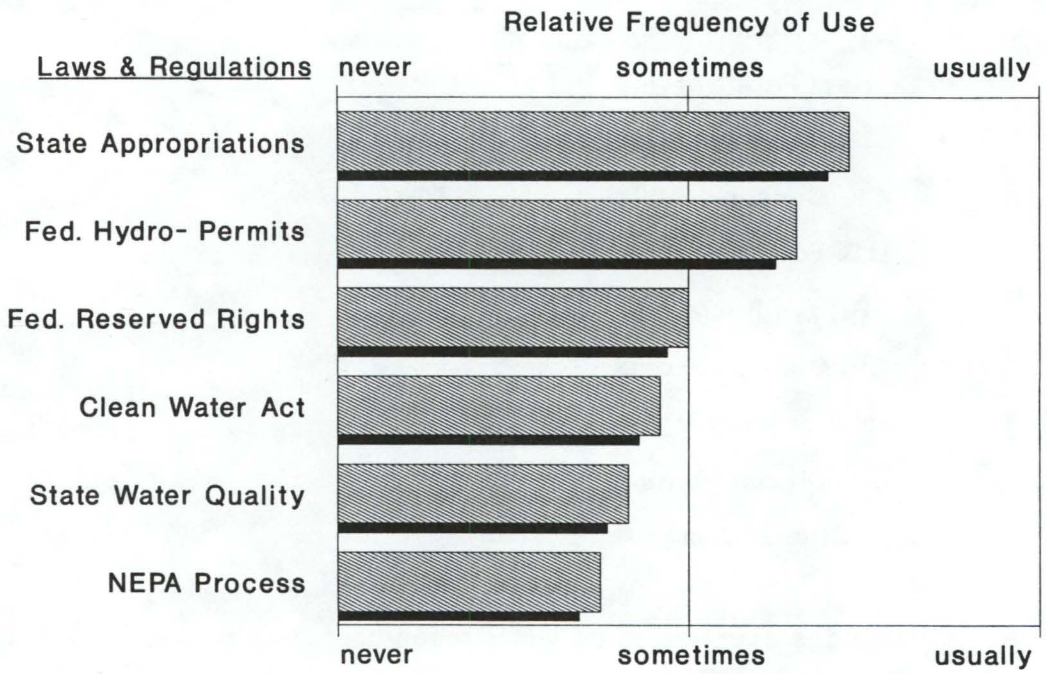


Figure 4. Existing laws and regulations used to protect instream flows for recreation.

One of the reviewers of this report asked for an elaboration of the results portrayed in Figure 4. We are unable to do so, because the survey did not ask when, where, and how each of these laws and regulations are used to protect instream flow. Explanations of the prior appropriation doctrine used by states, the permitting process for hydropower projects by FERC, federal reserved rights, and the NEPA environmental assessment requirements are provided in the remainder of this section of the report. Because state water quality policy is to some degree designed to implement the federal Clean Water Act, there is not much difference between these two categories.

Tied in with the importance of state water appropriation policies, we asked to what degree the respondent agreed or disagreed with the following statement: "Establishing protection for instream flow is less controversial in states with minimum instream flow laws." On a 5-point scale ranging from

Strongly Agree = 1 to Strongly Disagree = 5, the mean response was 2.62, where 2 = Agree and 3 = Neither Agree nor Disagree. The tendency toward a mild general agreement with the statement might indicate only that state appropriation laws establish legal requirements. Such laws are not necessarily a more effective or less controversial means of establishing instream flows.

Later sections of this report provide examples of how and why federal reserved rights have been used to protect instream flows. The ***Protecting Elements of the Stream Environment*** section contains an example of how federal reserved rights were used in New Mexico (Garn 1986). In the ***Interdisciplinary Process*** section are examples of both state and federal rights with explanation of why each was used.

Water Law Terminology

A few basic principles of water law and water rights doctrine are necessary to more fully appreciate this analysis. This is especially important because the principal tools for protecting instream flows are existing water laws and regulations.

Prior Appropriation Doctrine. Water law has developed as a specialized area apart from general property law. In the western United States, water rights are controlled under the prior appropriation doctrine. This means, briefly, that the first individual to put water to a beneficial use historically establishes the right to continue that use. This policy of "first in time, first in right" helped foster the development of the West in the 19th century Shupe (1989).

The right to use water for beneficial purposes is guaranteed by nine western states (Idaho is one) under the prior appropriation doctrine in its pure form, and in ten other states under a mix of the riparian and prior appropriation doctrines (Trelease 1986). According to Tarlock (1991), the classic prior appropriation doctrine is premised on these basic assumptions: (1) water is owned by the state and held in trust for the public, (2) the optimal use of water will result from a system that maximizes private uses and minimizes public uses, (3) private rights should be as secure as possible, (4) rights are based on the priority of application to a beneficial use and endure as long as the beneficial use continues, (5) the whole stream can be diverted during times of peak demand, and (6) a "call" on the water can only be rejected if it would be futile. A "call" is when senior appropriators complain to the water master that upstream junior appropriators are taking their water, and should therefore be regulated. If shutting down the juniors will not improve the seniors water supply, a "futile call" has occurred (Trelease 1986). A futile call may result from carriage losses (Tarlock 1990).

Wilkinson (1990) noted that changes in the West are part of a shared regional consciousness. Population growth (especially urban population), increased recreation, and the acceptance of environmentalism have led many people to call for changes in the prior appropriation doctrine that is, in Wilkinson's words, "too narrow, too absolutist, to meet all the calls of the modern West." Legal and institutional recognition of the public interest in water and instream flow needs are one result of these changes.

Public Trust Doctrine. The future establishment and enforcement of instream flows in Idaho will depend on the role of the public trust doctrine and water distribution policy (Beeman and Arment 1989). We will briefly explain these as a matter of context.

The public trust doctrine has its roots in English common law. The core idea is that the public has a legitimate and continuing interest in navigation, commerce, and fisheries. In order to protect these interests, state titles to tidelands and submerged lands are held subject to a "public trust" that cannot be extinguished. The end result, according to Dunning (1989), is that the public trust serves as an "implied constitutional limitation upon legislative power." According to Tarlock (1992), the public trust doctrine is almost entirely judge-made, and is now being extended to produce judicial limitations on the exercise of all water rights. Although trust lands may be used for recreation, this right has not been recognized as common law in California, Idaho, or Iowa (Tarlock 1992).

The California Supreme Court has ruled that lands associated with navigable waters are subject to the public trust easement, and has held that interference with navigable water can trigger public trust review (Dunning 1989). In the Mono Lake decision (*National Audubon Society v. Superior Court of Alpine County*, 658 P. 2d 709 [Cal. 1983]), the California Supreme Court ruled that diversions by the City of Los Angeles that were lowering the lake level violated the public trust and that California, as a sovereign, had no right to issue permits that "undermine the public values entrusted to it by its citizens" (Shupe 1989). This analysis was adopted by the Idaho Supreme Court later in that same year (R. Just, review comment). Some argue that this decision provided the opportunity to reallocate water from historic uses to instream use, but this has not occurred yet. Shupe (1989) said, "Only in Idaho has the state supreme court followed the lead of California in explicitly recognizing the strength of the doctrine."

According to Shupe (1989, see also Jackson et al. 1989), some people view the public trust doctrine as an underhanded taking of private property rights. Others see the public trust doctrine as a means "through which the public interest in fully appropriated streams can be reestablished without costly expenditures" (Shupe 1989).

Protection of Instream Flows in Idaho

It is appropriate, and necessary as a matter of context, to recognize that instream flow can be a beneficial use of water in Idaho, and to trace the development of that concept by briefly summarizing water law as it pertains to minimum streamflow.

The control of the water within the boundaries of a state generally is a right of state government. There are a few exceptions, including federal reserved rights, interstate commerce, and, to an increasing extent, federally licensed hydroelectric power projects (Rigby et al. 1991). Western states have begun to protect the attributes of free-flowing rivers that were of little concern a century ago, including fish and wildlife habitat and recreation. States have adopted several protection methods such as prohibiting new diversions, denying or conditioning water use permits, appropriating and transferring existing water entitlements, and reserving instream flows (Shupe 1989).

An instream flow reservation, or instream use withdrawal, is the reservation of large quantities of water in place. Such instream "use" of water is a "new" water right that competes with traditional consumptive uses of water (Tarlock 1978). Instream flow appropriations can lead to conflict (see Anderson 1982, Collins 1983). Appropriations for instream flow are public rights that should be the exclusive province of state agencies to achieve state water use objectives (Tarlock 1992). By rule, in Idaho only government entities may petition the Idaho Water Resource Board to seek an instream appropriation (Just 1990).

Historical Development. Since 1978, Idaho has recognized instream flow as a beneficial use of water and allowed the appropriation of water for instream use. The appropriation procedure involves the establishment of a water right held in trust by the Idaho Water Resource Board (IWRB), subject to review by the Idaho legislature.

In 1925, Idaho pioneered the use of appropriation for protecting instream values when the legislature designated certain lakes for protection of "their scenic beauty and recreational values" with the associated water right held in trust by the governor (Shupe 1989, Just 1990).

In 1971, Idaho was again in the forefront in establishing the right to appropriate water for instream use when the legislature passed a law (Idaho Code § 67-4307) directing the Idaho Department of Parks:

> to appropriate in trust for the people of Idaho certain unappropriated waters of Malad Canyon..., [the legislature] declares (1) that

> the preservation of the waters for scenic beauty and recreational uses is a beneficial use of water; (2) that the public use of those waters has greater priority than any other use save domestic consumption, and (3) that the unappropriated state land... preserved in its present condition as a recreational site for the people of Idaho.

In 1974, this act was challenged on two grounds: (1) that scenic beauty and recreation were not beneficial uses under the Idaho Constitution, and (2) the water was not diverted as required by state law. The Idaho Supreme Court ruled on this challenge in *State of Idaho, Department of Parks v. Idaho Department of Water Administration* (96 Idaho 440, 530 P.2d 924). The court accepted the legislature's beneficial use declarations for Malad Canyon and ruled that although a diversion is generally required for an appropriation, the legislature could dispense with that requirement and, in fact, had implicitly done so in the Malad Canyon legislation. The court's opinion constituted a precedent for the legislature to authorize other instream appropriations.

In 1978, after this decision, the Idaho legislature declared that minimum streamflow is a beneficial use of water when preservation for the protection of fish and wildlife habitat, aquatic life, recreation, and other values is done "pursuant to this act." This means the appropriation is made by the IWRB in accordance with Idaho Code § 42-1501. The legislature specified the process and requirements for the establishment of a minimum streamflow in Idaho Code § 42-1503.

According to Beeman and Arment (1989), the Idaho legislature was motivated, in part, by a desire to prevent diversion of water out of the state. Fears of having Idaho's water diverted to California, and strategies to prevent this, have been a central theme in Idaho water policy and Idaho politics since 1964. It is important to keep this interstate rivalry in mind when trying to understand the intent of Idaho water policy (Beeman and Arment 1989). This concern was reaffirmed by a task force recommendation to Governor Andrus (Rigby et al. 1991) to appropriate minimum streamflow for 19 stream reaches in northern Idaho for the specific purpose of preventing appropriation of that water for out-of-state use. The IWRB acted on these recommendations in 1992 and filed for minimum streamflows on 16 of these stream reaches.

In 1988, the Idaho legislature passed a comprehensive rivers planning bill that recognizes the value of instream flows (Idaho Code § 42-1734A):

> ...minimum stream flow for aquatic life, recreation and aesthetics and minimization of pollution and the protection and preservation of waterways in the manner hereafter provided shall be fostered and encouraged and consideration shall be given to the development and protection of water recreation facilities.

The act also provides a system for designating rivers as "natural" or "recreational" and defines procedures for regulating activities on designated rivers (Just 1990).

In 1992, a bill (SB 1328) was introduced in the Idaho legislature to allow the transfer of existing water rights to the IWRB for the purpose of maintaining instream flows. The bill did not pass, but citizen conservation groups and recreation interests may be expected to lobby for similar bills in the future. The interests of various groups in instream flow in Idaho is a subject worthy of study, as Olive (1981) has done.

Current Idaho Law. The establishment of a minimum instream flow for recreation is now provided for in three sections of the Idaho Code, summarized in the following subsections.

Declaration.—State law recognizes the protection of minimum streamflows for specific purposes that include recreation as a beneficial use of water (Idaho Code § 42-1501):

> The legislature of the state of Idaho hereby declares that the public health, safety and welfare require that the streams of this state and their environments be protected against

> loss of water supply to preserve the minimum stream flows required for the protection of fish and wildlife habitat, aquatic life, recreation, aesthetic beauty, transportation and navigation values, and water quality. The preservation of the water of the streams of this state for such purposes when made pursuant to this act is necessary and desirable for all inhabitants of this state, is in the public interest and is hereby declared to be a beneficial use of such water.... It is, therefore, necessary that authority be granted to receive, consider, approve or reject applications for permits to appropriate water of the streams of this state to such uses to preserve such water from subsequent appropriation to other beneficial uses under the provisions of chapter 2, title 42, Idaho Code.

Authorization.—The Idaho Water Resource Board is authorized to submit an application to the director of the Idaho Department of Water Resources to appropriate a minimum streamflow of the unappropriated waters of any stream. In part, the law (Idaho Code § 42-1503) reads:

> Approval of any such application must be based upon a finding that such appropriation of minimum streamflow:
> (a) will not interfere with any vested water right, permit, or water right application with priority of right date earlier than the date of receipt in the office of the director of a complete application for appropriation of minimum stream flow filed under the provisions of this act;
> (b) is in the public, as opposed to private, interest;
> (c) is necessary for the preservation of fish and wildlife habitat, aquatic life, recreation, aesthetic beauty, navigation, transportation, or water quality of the stream;
> (d) is the minimum flow or lake level and not the ideal or most desirable flow or lake level; and
> (e) is capable of being maintained as evidenced by records of streamflows and water levels and the existing or future establishment of necessary gauging stations and bench marks.

State Comprehensive Outdoor Recreation Plan.—This plan is mandated by law (Idaho Code § 67-4223), which in part authorizes the Idaho Park and Recreation Board to:

> prepare, maintain and keep up to date, a comprehensive plan for the development of the outdoor recreation areas and facilities of the state; to develop, operate and maintain outdoor recreation areas and facilities of the state; and ***to acquire lands, waters and interests in lands and waters for such areas and facilities*** [emphasis added].

The Idaho Department of Parks and Recreation is responsible for the development and implementation of the State Comprehensive Outdoor Recreation Plan, and is the state agency that most often requests an instream flow for recreation, essentially an acquisition of an interest in waters for recreation as provided by Idaho Code § 67-4223, cited above.

Federal Statutes and Regulations

Several federal laws currently do or potentially could affect instream flows. Federal laws can affect instream flow in three ways: (1) through regulatory action, such as the Federal Energy Regulatory Commission (FERC) licensing and relicensing procedures for hydropower projects; (2) by statute, such as the Endangered Species Act of 1973, the Clean Water Act of 1972, or the Salinity Control Act of 1974 requiring sufficient flow to dilute pollutants (Shupe 1989, Shelby et al. 1992); or (3) directly through federal reserved rights. The following sub-sections briefly explore each of these three areas.

FERC Regulation and Permitting. The Federal Energy Regulatory Commission (FERC) issues licenses for hydroelectric projects whether they are on federal lands or not. Many small hydro projects are exempt from FERC licensing, and many other projects are unlicensed (R. Just, review comments).

Turner and O'Laughlin (1991) mentioned the significance of the Federal Power Act (16 U.S.C. § 797 et seq.). The Act requires FERC to adapt projects to "beneficial public uses, including recreational purposes" (16

U.S.C. § 803 (a)) and the effects on anadromous fish (387 U.S. 428). FERC must engage in comprehensive planning and achieve a balance of potential resource uses in its licensing decisions (Shelby et al. 1992). Turner and O'Laughlin (1991) and Bearzi (1991) noted that the Electric Consumer Protection Act amendment of 1986 requires FERC to give "equal consideration to conservation interests in determining the overall public interest." These conservation interests include "energy conservation, the protection, mitigation of damage to, and enhancement of, fish and wildlife ... recreational opportunities and ... environmental quality" (16 U.S.C. § 791(e), see also § 803(j)).

The same consideration of overall public interest must be given in relicensing existing facilities. Approximately 275 facilities around the country will come up for relicensing by the end of the 1990s. According to Patrino (1991), conservationists see this as an opportunity to address management and protection issues not addressed when these facilities were originally licensed. According to Smith (1990), for power producers this means a "seemingly endless review by applicants for new licenses (relicensing) when deciding the feasibility of continuing the operation of existing low cost hydropower facilities."

The U.S. Army Corps of Engineers goes through a similar, though less stringent, review before issuing permits for dams placed in navigable waterways (Shupe 1989).

Water development projects located on federal lands usually require a permit from the federal agency that administers the land. This permit will generally set instream flow conditions. The USDA Forest Service requires "natural" instream flows that support fisheries or recreation be allowed to flow through the structure (Shupe 1989).

Federal Statutes. At least three federal statutes affect the allocation and use of water in Idaho: the Endangered Species Act, the Wild and Scenic Rivers Act, and the National Environmental Policy Act.

Endangered Species Act.—Of special and immediate concern in Idaho is the impact that conservation of several Snake River salmon stocks listed as threatened and endangered under the Endangered Species Act (ESA) may have on water allocation. It is not yet possible to determine what these effects may be.

Coggins (1991) noted that the widening scope of litigated disputes over endangered species illustrates the growing impact of the ESA. In one example—the *Stampede Dam* lawsuit in Colorado (*Riverside Irrigation District v. Andrews* 758 F. 2d 508 [10th Cir. 1985], cert. denied, 105 U.S. 1402 [1985])—the court ruled that the Department of the Interior must protect the spawning grounds of endangered fish from water diversions. Existing water rights have been purchased and new diversions are required to conform to instream flow mitigation measures mandated by the recovery plan for endangered fish species in the Colorado River (Shupe 1989). In another example, the winter run of chinook salmon in California's Sacramento River was listed as threatened in 1989, the first distinct population segment of Pacific salmon to be listed under the ESA. In 1991, the Bureau of Reclamation was asked by National Marine Fisheries Service—the agency responsible for anadromous fish conservation under the ESA—to modify water deliveries to downstream users, coordinate Trinity River diversions, and release water from Shasta Dam to prevent water temperatures in spawning areas from reaching lethal levels (U.S. Fish and Wildlife Service 1991).

Tarlock (1991) argued that the ESA has created a new regulatory water right. Under the ESA, specific but undetermined amounts of water must be released, or not impounded, for fish conservation purposes. These rights have no priority date and do not depend upon the express or implied intent of Congress. These regulatory rights may be viewed as fundamentally inconsistent with western water law, which Tarlock predicted will cause bitter disputes. A second possibility is that federal regulatory rights in the ESA will be reflected in state water law as nonconsumptive water rights gain greater protection under state law.

Tarlock (1991) put it this way: "If species protection is considered an integral element of state law, ESA remedies may take the form of state water rights rather than federal regulatory water rights." (See further discussion in the following section on ***Federal Reserved Rights***.)

Wild and Scenic Rivers Act.—This act counterbalances the licensing of dams by FERC on certain high quality waters by prohibiting construction on protected component segments of the system (Turner and O'Laughlin 1991). Designation of a stream or river as wild or scenic reserves water for the purposes specified in the act, which are to "preserve selected rivers in their free-flowing condition, to protect the water quality of such rivers, and to fulfill other vital conservation purposes" (16 U.S.C. §1271).

National Environmental Policy Act (NEPA).—This law, enacted in 1969, has profoundly influenced the decision-making process of all federal agencies. NEPA requires an environmental impact statement for any "major federal action significantly affecting the quality of the human environment" (NEPA §102(2)(C)). The term "action" has been defined by the courts to include federal projects, state and local programs funded by federal assistance, and private development authorized by federal permits (Mandelker 1992).

Federal Reserved Rights. Under the Winters Doctrine (*Winters v. the United States*, 207 U.S. 564 [1908]), the federal government has the right to sufficient water, originating within or flowing through federally reserved lands, to support or protect the primary purposes for which the reservation was made. The priority date of the right is the date when the reservation was established. *Cappaert v. United States* (426 U.S. 128 [1976]) limited this reserved right to "only that amount of water necessary to fulfill the purpose of the reservation, no more." Under the McCarran Act, federal reserved rights must be adjudicated under state water laws (Shelby et al. 1992, Shupe 1989).

The courts have interpreted federal reserved rights narrowly. For example, in the case of the national forests, only the two purposes contained in the Organic Act of 1897—timber supply and favorable conditions of water flows—qualify for reserved rights protection (*United States v. New Mexico,* 438 U.S. 696 [1978]). The U.S. Forest Service is now seeking rights to instream flow sufficient to maintain viable stream channels, and the agency contends that this is consistent with the purpose of securing favorable conditions of water flows. This approach has not yet been adjudicated (Shelby et al. 1992, Shupe 1989, Jackson et al. 1989).

DECIDING WHAT TO PROTECT

The decision on what a particular instream flow reservation is designed to protect is intermediate between the decision to protect an instream flow with laws and regulations and quantifying how much flow should be protected. This decision can be approached several ways. This section of the report presents four approaches: (1) subjective evaluations, (2) recreation-based evaluations, (3) an interdisciplinary process, and (4) economic valuations.

In brief, "subjective evaluations" have application at the watershed or basin level for resolving water use conflicts. The bulk of the discussion in this section is on recreation-based evaluations. This emphasis is also reflected in the literature and in the results of our survey. An interdisciplinary process incorporates other resource values of the stream or river with recreation. Because many of the benefits of instream flow protection are not valued in a market, economic benefit values are difficult, but not impossible, to estimate. Discussion of each approach based on what we found in the literature follows.

Subjective Evaluation and Conflict Resolution

The desired result of subjective evaluations is a quantified flow regime that optimizes water use based upon predetermined objectives. Subjective evaluations, however, are not methods for quantifying flow needs. It is more accurate to describe them as decision aids used to determine the relative importance of various water uses. They have greatest application in planning at the watershed, river basin, or larger unit level. The references cited in this section all have assumed that flow quantities were available.

Specific instream flow requirements for recreation first received attention in the 1970s. An early symposium focusing on instream flow needs was sponsored by the American Fisheries Society in Boise, Idaho. In the published proceedings, Morris (1976) noted that recreation was gaining acceptance as a legal use for water, and suggested that "subjective evaluations" of the requirements for different water-related activities can be made through observation, by interviews with recreationists, and by participation in the activity. These "subjective evaluations" can then be correlated with measured flow levels. In conjunction with information on other water uses, this information can be displayed in matrix form and used to compare the effects of any one flow level on all identified instream and out-of-stream uses of the water. Morris further suggested that recreation evaluations be categorized from minimum to maximum acceptable levels of flow.

Fontane and Flug (1990) suggested using a formalized and computer assisted approach to "subjective evaluation" in order to resolve natural resource conflicts between interest groups. The steps to accomplish this were:

(1) identify relevant decision criteria,
(2) identify the relative importance of the criteria and compute criteria weights,
(3) identify discrete alternatives,
(4) evaluate the performance of each alternative for every criteria,
(5) organize the ratings of step 4 in an impact matrix,
(6) analyze the matrix using multi-criteria computer software,
(7) if necessary, modify steps 1, 2, or 3, and
(8) after the analysis is completed, for each user or interest group identify compromise rankings.

Gilliland et al. (1985) employed a much more technologically and politically complex system of decision making in the attempt to resolve water use conflicts in the Platte River Basin in Nebraska. They developed the Adaptive Environmental Assessment (AEA) process, consisting of a series of workshops and research activities. The end result was a computer model of the basin that reflected the values and interests of workshop participants. This improved the understanding of the basin system as a whole and fostered the beginning of a consensus approach to water use conflicts. Discussions and disagreements were focused on the construction of a computer simulation model of the system. This focus on model building forced people not only to identify their preconceptions, but also to disaggregate their vested interests. When these preconceptions and value judgments were reduced to the technical detail required by a computer model, they often became transparent.

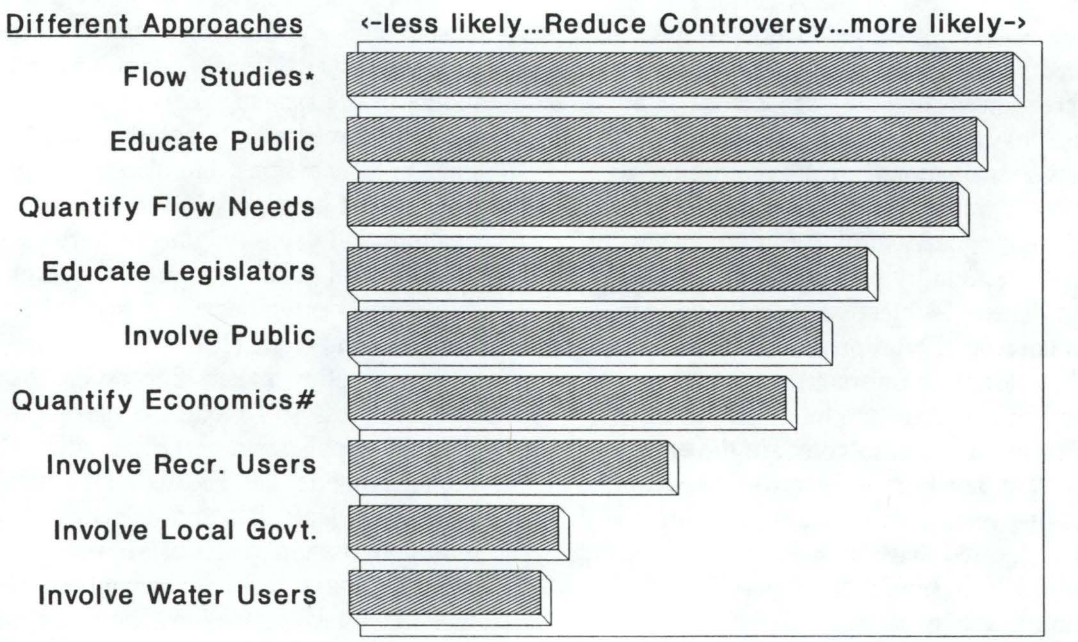
Gilliland et al. (1985) said that the extent to which policy makers understand the strength and weaknesses of models is more important than the sophistication of the model. Although the AEA model had shortcomings resulting from inadequate data and its set of simplifying assumptions, the model users were made aware of those deficiencies, and were able to make qualitative decisions about simulation results.

Did the AEA process work? Three parties who had taken their dispute to court reached compromise positions as a direct result of the AEA process. Gilliland et al. (1985) said that the interaction of people, rather than the accumulation of facts, is necessary for successful conflict resolution.

Brown (1983) described a similar process used to resolve conflict in the Central Arizona Water Project. Its four-stage iterative planning process was: (1) problem identification, (2) plan formulation, (3) impact assessment, and (4) evaluation. Continuous interaction between the planners and affected interests occurred at each stage. The planning team combined active public involvement with multi-criteria computer software. The results of public involvement were used to develop a wide range of alternatives. The multi-criteria software allowed quick evaluation of each alternative and facilitated development of compromise positions.

Collins (1990) described a consensus-building "roundtable" process and mediation in Virginia to resolve water use conflicts that inevitably resulted from implementing new instream flow legislation.

Survey Results. In our survey, we developed a question to explore how controversy over instream flow determinations could be reduced. Respondents were asked to what degree controversy over instream flow protection could be reduced if their organization devoted more effort to each of the nine approaches listed in Figure 5.



* Multi-disciplinary research on water needed to meet multiple identified goals.
# Especially benefit values for cost-benefit analysis.

Figure 5. Approaches to reduce controversy over instream flow protection and the relative likelihood of their success.

The different approaches in Figure 5 were developed from the literature review and are representative of recommendations various authors have made for improving both the quality and likelihood of successful implementation of instream flow decisions.

The results depicted in Figure 5 indicate that the 68 respondents generally felt that involving all publics and evaluating quantified alternatives would be likely to reduce controversy over instream flow determinations. These are the two basic elements of the AEA model and Central Arizona Project described in the preceding section that led to the development of consensus and compromise. Several other approaches are also likely to reduce conflict, including the quantification of instream flow requirements.

Quantification of instream flow as a conflict-reducing method was addressed by two questions. The first asked only if quantifying instream flow requirements would increase or decrease controversy, the second addressed the added dimension of multi-disciplinary flow studies in the increase or decrease of controversy. As there was no statistically significant difference in responses to the question, we cannot conclude that the added dimension of multi-disciplinary studies would be more effective in reducing controversy than just quantifying flows. It is entirely possible that the respondents did not see the questions as addressing separate dimensions. Additional discussion of multi-disciplinary flow studies is provided in the ***Interdisciplinary Process*** section of this report.

There are no statistically significant differences between the five top responses in Figure 5. We interpret this as an indication that quantification, education, and public involvement are seen as being the actions most likely to reduce controversy over instream flow protection. The high correlation between responses to these five actions may be an indication that respondents feel all are needed to reduce controversy.

A reduction in controversy may be assumed to increase the likelihood that instream flow recommendations will be implemented. But there have been cases in Idaho and possibly elsewhere demonstrating that this assumption will not always hold true.

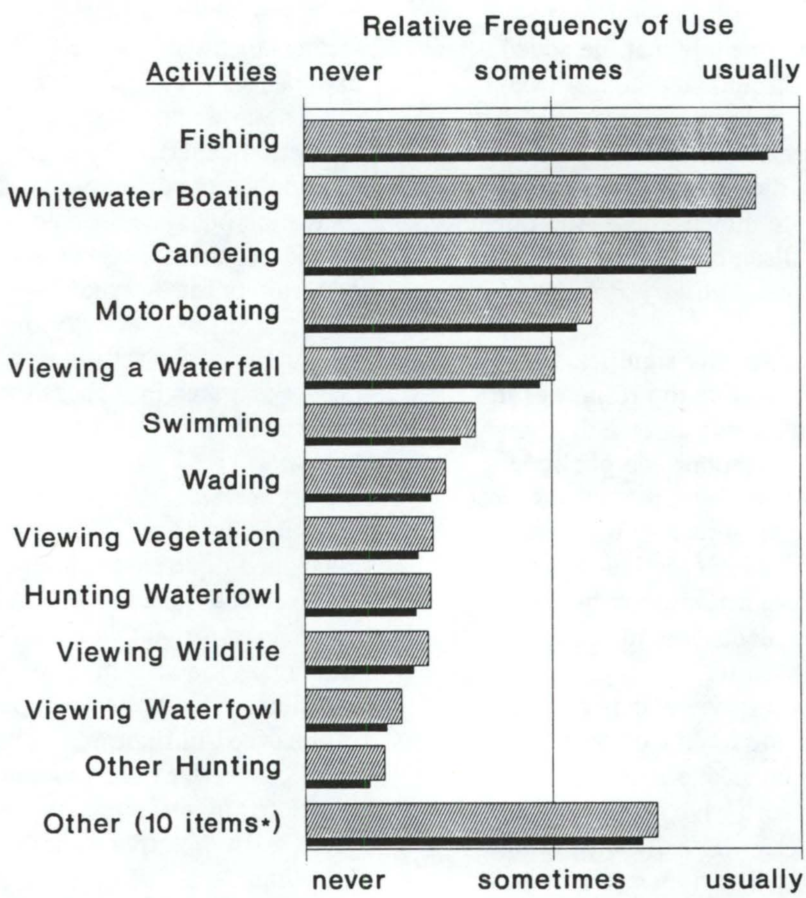
Recreation Activities and Experiences

In order to develop objectives for determining instream flow needs for recreation, it is necessary to understand the nature of the recreation experience. The attention of recreation researchers during the last several decades has focused on recreation as goal directed, purposeful behavior producing specific desired outcomes for the individual. These outcomes, rather than the pursuit of a specific activity, motivate individual recreation participation (Schreyer et al. 1984). The recreation opportunity has been defined as the option to engage in specific activities in specific settings to realize desired outcomes. This definition recognized three facets of recreation opportunity—activity, setting, and experience. The likelihood that people participating in a recreation activity will attain desired outcomes can be increased by providing physical, social, and managerial settings that help people achieve their desired experiences (Manfredo et al. 1983).

These fundamental perspectives on the recreation experience suggest that in order to provide the opportunity for satisfactory recreation outcomes, sufficient instream flows should be maintained not only to allow the opportunity for a certain type of experience by engagement in an activity, but also to protect the quality of the setting in which that activity occurs and thus influences the participant's experience.

Survey Results. Because recreation activities are only part of the recreation experience, we developed different questions pertaining to both recreation activities and experiences.

Recreation Activities.—The frequency with which specific activities are used as justification for protecting instream flows is summarized in Figure 6. The potential for conflicts between recreational uses can be illustrated by these results. Respondents were given a list of activities and asked, "How often were these activities used to justify instream flows?" The responses they were asked to circle for each activity were: never, sometimes, usually, and always. Notice in Figure 6 that the two most frequent activities for which instream flow protection is sought are fishing and whitewater boating, activities that generally have dramatically different water needs. River fishing, especially wade-fishing, is usually best at flow levels too low to support whitewater boating. The activities listed in Figure 6 were those given in our survey question. Additional activities or features named by respondents in the "other" category included tubing (2 mentions), fish habitat (2), protecting cultural resources (2), channel morphology (2), navigation, natural resources (activity vs. resource protection), aesthetics in general, maintain riparian vegetation, water quality, and flatwater boating.



* Includes tubing, navigation, flatwater boating, and resource management and protection activities.

Figure 6. Recreation activities used to justify establishing minimum instream flow.

Recreation Experiences.—Survey responses offer some evidence that the concept of recreation as an experience is valid, as recreation literature argues. The survey posed two statements, and respondents were asked to rate the strength of their agreement or disagreement with the statement from strongly agree = 1 to strongly disagree = 5. Results appear in Figure 7. Almost 96 percent of the respondents (n = 65) agreed or strongly agreed that quality of the recreation *experience* was an important consideration when establishing minimum instream flows. Almost 76 percent (n = 53) disagreed or strongly disagreed with the statement that providing enough water for the most common recreation activity was adequate to protect the recreation experience. There was a significant statistical correlation between the mean responses to these two statements, indicating that the statements are related. Taken together, the scaled responses to these two statements and their statistical correlation indicated that respondents felt that it is the recreation experience that should be protected, not just a quantity of water.

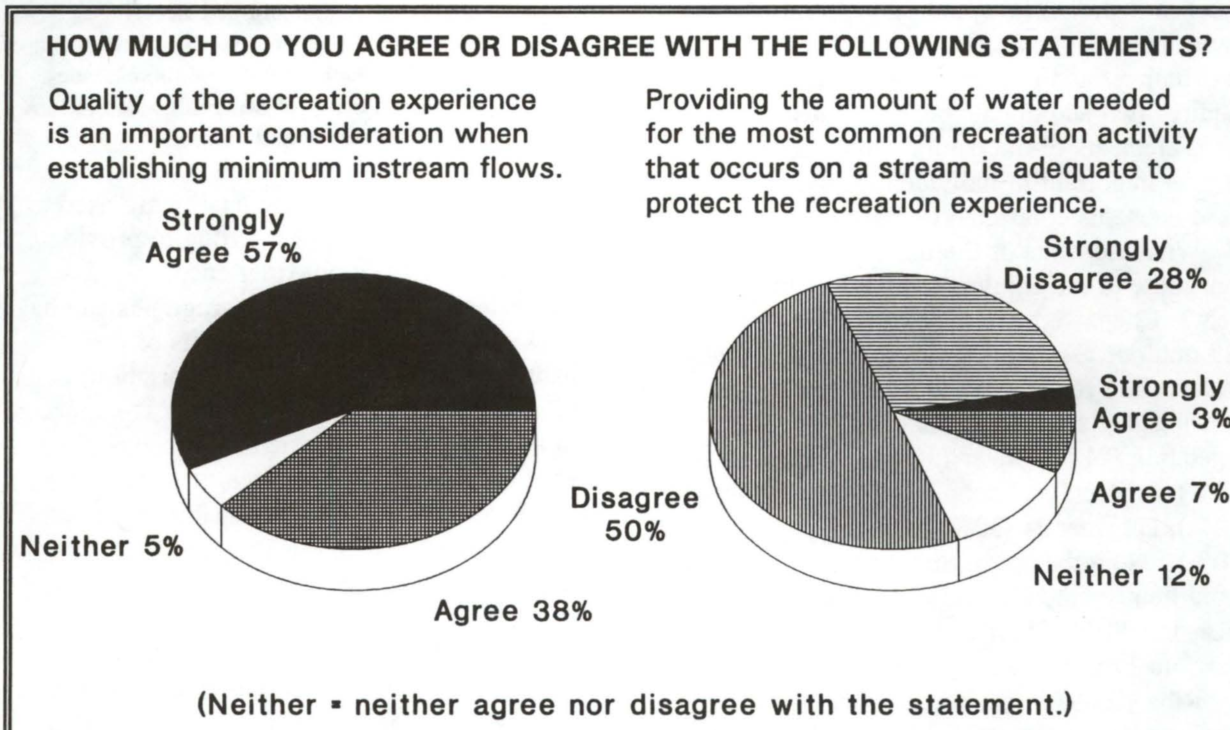


Figure 7. Importance of protecting the recreation experience.

Instream Flow as an Element of the Recreation Experience. People desire more than the opportunity to engage in a specific activity. The managerial challenge for using this information in determining instream flows is connecting elements of the recreation experience to instream flow.

The first step in making this connection is an examination of human motivations for seeking recreation experiences in the natural environment. Early recognition of the experiential nature of recreation appeared in the 1962 Outdoor Recreation Resources Review Commission report (Stevens 1984):

> It shall be the national policy, through the conservation and wise use of resources, to preserve, develop, and make accessible to all American people such quantity and *quality* of outdoor recreation as will be necessary and *desirable* for individual enjoyment and to assure the physical, cultural, and spiritual benefits of outdoor recreation.

The opportunity to engage in a specific activity is only one of several motivations for seeking river recreation. Speaking on behalf of private boaters, Huser (1984) said, "They are interested in preserving and protecting wild, free flowing rivers; in winning the river lottery; in running safe river trips that are complete (fulfilling educationally, physically, emotionally, psychologically) and fun; ..."

Knopf (1988) reviewed the literature on the relationship between humans and nature and identified six reasons why people seek outdoor recreation experiences that "recur in hundreds of studies of outdoor recreationists and throughout the philosophical and popular literature." These reasons are the desires to escape, to socialize, for competence, for meaning, for spirituality, and for natural stimuli.

The importance of the natural environment as an arena for recreation experiences seems to be a consistent finding in studies of motivation to engage in recreation. Unfortunately, "natural environment" is a nebulous term that has little application when it comes to making decisions about water allocation. Knowing that the natural environment is an important component of the recreation experience does not provide any information on the relationship between instream flow and that natural environment. Connecting the natural environment and recreation to instream flow requires two additional considerations: (1) What elements of the natural environment are seen as important to individuals? (2) How are these elements connected to instream flow?

What elements of the natural environment contribute to the enjoyment of that environment? Chenoweth and Gobster (1990) studied 135 outdoor aesthetic experiences of 25 college students and found that the broad categories contributing to the aesthetic experience were: vegetation (21%), water (32%), wildlife (18%), artifacts and people (19%), sensations (12%), ephemerals (30%), and compositions (30%). Note that more than one category could be presented in a response, so the total exceeds 100%. Significantly, water was mentioned most often.

Ribe (1989) reviewed research on the scenic quality of forests. Ideas that emerged from the descriptive literature about forest aesthetics included park-like forests, big expansive trees, visual variety, spatial variety, species variety, lush ground cover, appearances of health and orderliness, and the expression of forest processes. These ideas have generally been supported by empirical research.

Litton (1984) was one of the first to relate perceptions of scenic beauty to streamflow. He hypothesized that aesthetic perceptions would be diminished at both extreme high and low flows. Other research supports this idea (Daubert and Young 1981, Brown and Daniel 1991). Working in California, Litton helped the U.S. Forest Service develop a Visual Absorption Capability for streams and lakes, using the following six streamflow elements:

(1) Streamflow in relation to high, medium, and low use periods.
(2) Predicted effects of streamflow on riparian vegetation.
(3) Predicted effect of streamflow on stream appearances relative to different channel cross sections (shallow bowl, v-shape, vertical banks).
(4) Predicted effect of streamflow alteration of production of whitewater, as related to gradients and stream bed materials.
(5) Predicted effect of streamflow alteration of features—such as falls, pools, cascades.
(6) Predicted effect of streamflow alterations on water clarity and color.

If scenic and aesthetic quality are used to indicate the potential of a setting to provide a satisfactory recreation experience, the ideas suggested in the preceding paragraphs can be used as indicators of the elements of the natural environment that are important to that recreation experience. Vegetation is important in all three of them, which has strong implications for riparian area management.

Brown and Daniel (1991) found a direct relationship between the amount of streamflow and people's judgments of scenic beauty. In their study, two groups—students from the University of Arizona and residents of Fort Collins, Colorado—were shown several sets of videotaped scenes taken at carefully marked photopoints along the Cache la Poudre River near Fort Collins. Scenes were repeatedly videotaped to attempt to capture a full range of flows. The importance of flow rate as a variable was de-emphasized in the formats presented to respondents. The authors found a concave relation between flow quantity and scenic beauty; that is, scenic beauty increased as flow increased up to a point, after which scenic beauty decreased as flow increased. These results are consistent with Litton's (1984) hypothesis that the scenic beauty of streams is diminished at both high flow and low flow extremes.

Daubert and Young (1981) estimated the willingness to pay for various flows by anglers and shoreline users on the same river and found the same concave relationship between flow quantity and scenic beauty. Brown and Daniel (1991) suggested that the willingness to pay found by Daubert and Young may have resulted from the beauty of the scenery at different flow levels. Support for this suggestion was based on evidence of an increased willingness to pay for campgrounds in more attractive forests (Brown et al. 1990).

In a recreation resource inventory of the Angelina and Neches rivers in east Texas, Knotts and Legg (1984) used a step-wise regression system with 30 variables to quantify the natural and man-made resource attributes that affect river recreation. These variables were divided into two categories that were used as filters: (1) canoeability, and (2) resource characteristics. All stream segments were rated first for canoeability. Segments that made it through the first filter were then rated on their resource characteristics. The 19 resource variables thought to be important are identified in Table 1. The variables in filter two were concerned with aesthetic and human interest features. Diversity was the predominant characteristic measured by filter two. Diversity was selected as the variable adding most to the recreation experience because of the lack of exciting whitewater or spectacular scenery in the study area.

Table 1. Variables affecting canoeing and aesthetics on two slow-moving rivers in east Texas.

Remoteness	Geologic interest features
Works of man	Channel diversity**
Vistas*	Vegetation diversity*
Shoreline characteristics**	Acoustic pollution
Diversity of flow**	Historic/cultural
Screening vegetation*	Bank height and slope diversity**
Population of objectionable forest pests*	Water clarity**
Trash/litter	Chemical pollution**
Potential campsites*	Animal and bird life*
Scenic diversity*	

* = variables indirectly influenced by instream flow
** = variables directly influenced by instream flow
Source: Knotts and Legg (1984), except for * and **

The 19 variables in Table 1 were felt to be important in the evaluation of each river segment in addition to the ability to support canoeing activity. Of the 19 variables, seven may be indirectly influenced by the quantity of instream flow and the flow regime over time (see Stromberg and Patten 1990, Stromberg and Patten 1991, Jackson et al. 1989, Brown and Daniel 1991). Six of the variables may be directly affected by the quantity of streamflow (see Hill et al. 1991, Brown and Daniel 1991).

The uniqueness of the recreation experience has also been considered an important management consideration (Wallace 1984). The Chatooga River in South Carolina, where scenes from the popular film "Deliverance" were shot, offers a recreation experience free from evidence of civilization. A primitive environment in that part of the country is rare, and thereby contributes to the diversity of recreation opportunities available in the region. Although not directly connected to instream flow, this point reinforces the idea that recreation is an experience involving more than the engagement in a specific activity. The unique character of an experience increases its economic value, as will be discussed in the economic valuation section.

A team studying Alaska's Beaver Creek, a National Wild and Scenic River, found that flows sufficient for channel maintenance were important to the recreation experience, especially flows to maintain gravel bars for camping and viewing at 80% of virgin spring flow. Keeping portages to a reasonable number, which was related to travel time, required 90% of the lesser of the actual or mean monthly virgin flows (Van Haveren et al. 1987). Channel maintenance, which required periodic flood flows in addition to the acceptable minimum flows for boating and fish habitat, was also found to be important for the Gulkana National Wild River in Alaska (Shelby et al. 1990). On the San Pedro River in Arizona, flow recommendations focused on fish and wildlife habitat, aesthetics, and riparian vegetation (Jackson et al. 1987).

Survey Results.—Our questionnaire asked which elements of the stream environment are important to the recreation experience. Survey respondents rated the relative importance of assuring that instream flows were sufficient to maintain elements of the stream environment for the recreation experience. The results are summarized in Figure 8. The "other" category included the following individual responses: natural channel forming processes, whitewater and waterfalls, floatability and fish passage, variation, quality of activity, channel competence, flooding flows, challenge, healthy aquatic biota, hydraulics, lack of intrusion by man, access/use, amount of flow, fish, safety, and depth and velocity. Although most of these stream elements were rated by individuals as extremely important, we did not include them in Figure 8 because they represent individual opinions, not a group response.

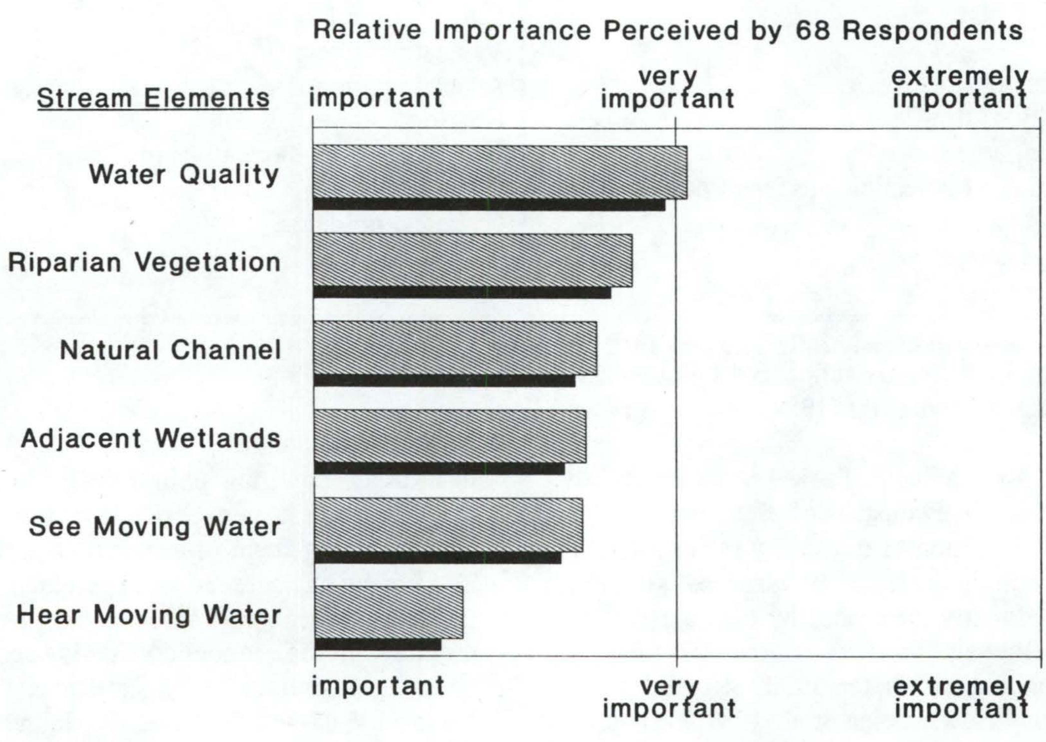


Figure 8. Importance of protecting different elements of the stream environment for the recreation experience.

Elements important to the recreation experience were also addressed by two statements with 5-point agree/disagree scale responses. Almost 83% (n = 58) of the respondents agreed or strongly agreed that flow regimes which include periodic flushing flows to maintain channel morphology were important for protecting instream values. Approximately 80% (n = 56) of the respondents agreed or strongly agreed that preserving scenic beauty was sufficient reason to protect instream flows.

Protecting Elements of the Stream Environment. The controversy over instream flows for wilderness areas illustrates the problems of preserving the wilderness or natural character of an area (Brown 1991). The Wilderness Act of 1964 (16 U.S.C. Idaho Code § 1131) specified six management purposes for wilderness areas: recreation, scenery, education, conservation, science, and history. As managing agencies are pressured by conservationists and others to assert federal reserved rights to protect these purposes, they must decide whether to seek instream flow protection for only the dominant purpose, or for all purposes of a specific wilderness area. For example, is flow for the conservation of aquatic life adequate, or should additional amounts for recreation and scenery be included? Or because of the special nature of protected wilderness areas, Brown (1991) asks, does preserving the "natural condition" require virgin flows? A survey of visitors to an Arizona wilderness area showed that water was rated as the single most important attribute of the area. Visitors were able to perceive small changes in streamflow (Moore et al. 1990).

The BLM, as the managing agency of the wild and scenic designated portion of the Red River in New Mexico, sought and obtained instream flow rights for scenic, recreational, fish and wildlife purposes, and maintenance of water quality to support these purposes. The state of New Mexico does not recognize instream flow as a beneficial use and strongly resisted federal reserved rights for these purposes. Because of extensive and well-documented studies that specified the quantity of water needed for each purpose, the involved parties stipulated they would recognize a federal reserved water right for instream flows. This was the first instream water right recognized in New Mexico (Garn 1986). The supporting studies used the U.S. Fish and Wildlife Service's incremental method, which we explain later.

Shelby et al. (1992) stated that streamflow has both direct and indirect effects on recreation. Direct effects influence the recreation experience of an individual at a specific setting at a specific time, and change immediately when flows change. They are generally restricted to effects that are apparent to the individual. Indirect effects are longer term, and generally refer to streamflow-related processes that maintain the bio-physical resources of the stream environment—including channel morphology, riparian vegetation, and fish and wildlife habitat—that in turn influence the recreation experience.

As was shown on New Mexico's Red River (Garn 1986), existing methods for quantifying instream flows can be used to support a variety of elements of the stream environment once the relationship between those elements and streamflow is understood. The relationship between these bio-physical resources and instream flow is becoming increasingly well understood and quantifiable, as the following studies demonstrate.

Hill et al. (1991) reviewed the physical processes that link riverine ecosystems to streamflow and concluded that multiple flow regimes are required to maintain riverine ecosystems. Flood flows are necessary to form floodplains and valley features; overbank flows are necessary for riparian habitats, adjacent upland habitats, riparian water tables, and soil saturation zones; in-channel flows are necessary to keep streambanks and channels functioning; and in-channel flows are necessary to meet fish requirements. Here again is evidence of the benefits of diversity, but expressed in streamflow regime.

In three study areas in the Southwest, the relationship between riparian vegetation and streamflow has been described and modeled. In studies of two tree species—black cottonwood (*Populus trichocarpa*) and Jeffrey pine (*Pinus jeffreyi)*—on California's Bishop Creek, the largest tributary to Mono Lake, multi-variate statistical analysis revealed that streamflow accounted for 66% of the annual variation in cottonwood annual growth, and prior-year flows had the strongest influence on pine growth (Stromberg and Patten 1990). Instream flows for maintaining cottonwood could be estimated in Bishop Creek by describing (1) annual growing season flow and ring width, (2) ring width and canopy vigor, and (3) ring width and population mortality

(Stromberg and Patten 1991). On the Hassayampa River in northwest Arizona, Stromberg et al. (1991) analyzed the relationship between flood flows and the recruitment of riparian vegetation, and flood-influenced landforms and the distribution of riparian trees, shrubs, and herbs. Floods transport seeds and function to produce "safe-sites"—that is, areas suitable for seedling growth—by depositing river-borne soil material, scouring and covering plant cover, and moistening riparian soils. Floods play an important role in perpetuating the diversity of plant species and age classes in these riparian communities, but additional data are needed to develop flow prescriptions in terms of timing, magnitude, and frequencies of flood flows for riparian recruitment. Some sense of urgency to develop and implement these prescriptions is needed because of the relatively short life span of cottonwoods and willows (less than 200 years) and the "decadence" of many riparian stands in the Southwest that will succumb without restoration of appropriate instream flows (Stromberg et al. 1991).

Instream flow is also related to wildlife populations. Schaefer and Brown (1992) said that protecting the natural integrity of river corridors requires strategies that consider hydrological cycles and instream flow regimes as well as the quality and quantity of habitats within a watershed. In order to accomplish this protection, biological data need to be incorporated into the decision-making process. Schaefer and Brown proposed a strategy that included setting goals, determining species and habitat needs, delineating the corridor, establishing buffers, educating key audiences, selecting regulations and acquisition alternatives, determining compatibility of land uses, designing habitat management, and evaluating the success in achieving goals. This strategy is similar to that of the Platte River Adaptive Environmental Assessment and Central Arizona Water Project discussed earlier, and also the interdisciplinary process discussed in the next section.

Technical knowledge about the relationship between streamflow and elements of the surrounding environment should not be underrated, but several studies have emphasized that the success of any instream flow protection program depends more upon the quality of the decision-making process than the extent of technical information. Brown and Daniels (1991) discussed the usefulness of scenic beauty assessments and pointed out that "knowing the level of scenic beauty does not in itself provide a sufficient basis for determining stream flow policies." Gilliland et al. (1985) emphasized that it is the "interaction of people rather than the accumulation of facts" and the development of a common understanding that is "the necessary prerequisite to conflict resolution." Jackson et al. (1989) stressed the importance of flexibility in making an instream flow determination because each assessment is unique, is based on different resource values, and is made in different legal environments. They said, "The variables are so intensely different in each case that standard technological methods are at best only useful tools available to specialists and at worst may be misleading, inapplicable, or irrelevant and distract from effective problem analysis."

Our survey results also lend some support to the observation that the success of any instream flow protection program may depend more upon the quality of the decision-making process than the extent of technical information.

Survey Results.—We asked, "Do the methods for quantifying the amount of water needed for recreation that you have used adequately protect the listed seven elements of the stream environment?" Figure 9 summarizes how the 68 respondents rated the adequacy of the methods they used to quantify instream flow to protect the same elements of the stream environment that were rated on their importance to the recreation experience, as shown in Figure 8. Protection for water quality, riparian vegetation, and adjacent wetlands all were rated as less than adequate. Because techniques are available to quantify water quality and riparian vegetation (and adjacent wetlands, if there were an agreed-upon definition of wetlands), the lack of adequate protection may reflect more on the process of deciding what to protect rather than the ability to quantify the relationship between these elements of the stream environment and instream flows.

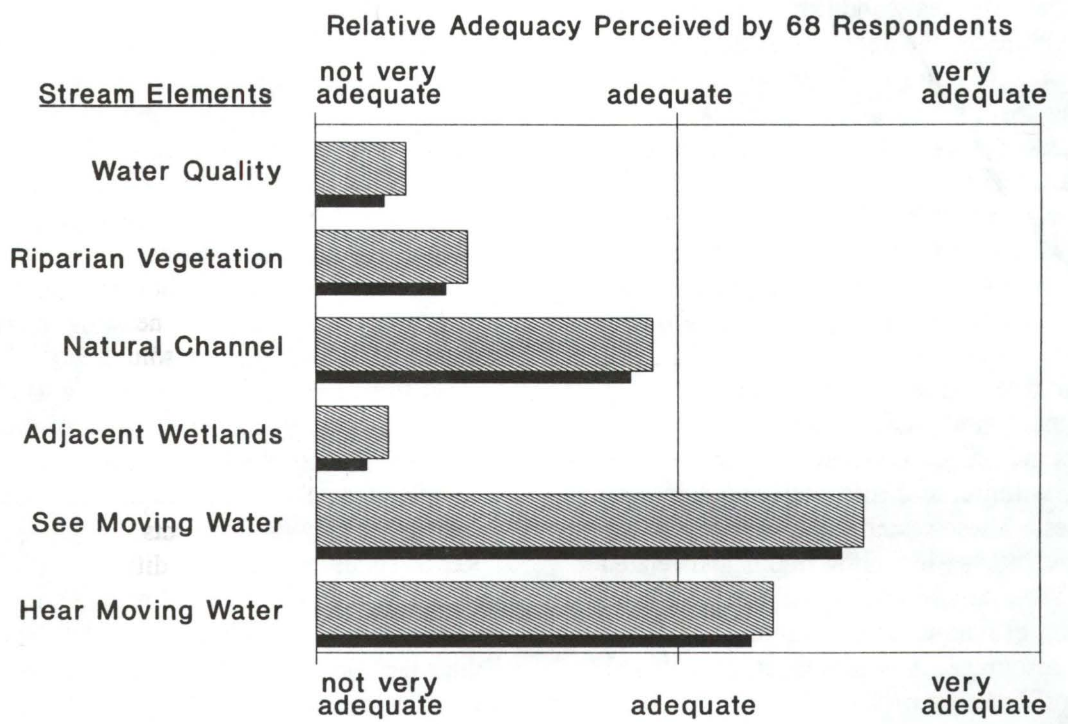


Figure 9. Adequacy of protection for different elements of the stream environment offered by various quantification methods.

Interdisciplinary Process

Decisions regarding which uses of a stream or river's water resources are to be protected involve sensitive and sometimes controversial legal, technical, and political questions. Different uses of water resources involve different management objectives and different types of supporting information. The interdisciplinary process described in this section is what was referred to in Figure 5 as multi-disciplinary flow studies to meet multiple identified goals.

Jackson et al. (1989) described a team-oriented approach to identify the range of flows for recreation. In this process, an interdisciplinary team describes and quantifies the full range of resource values provided by a stream or river. These values could be economic, but are not necessarily so. For recreation purposes, these resource values include, but are not limited to, aquatic habitat, riparian ecosystems and associated wildlife habitat, water-dependent activities such as boating and fishing, and water-enhanced activities such as camping, hiking, or birdwatching. A successful strategy for protecting these recreation resource values integrates them with the quantity of available water and the laws controlling that water (Jackson et al. 1989).

According to Jackson et al. (1989), the interdisciplinary approach has proven to be efficient and economical because of its flexibility in dealing with a variety of issues, institutions, physical conditions, and processes. The flexibility of the approach is demonstrated in the two successful instream flow protection strategies from which this process was developed—the San Pedro River in southern Arizona (Jackson et al. 1987) and Beaver Creek in Alaska (Van Haveren et al. 1987). These two rivers are very different both in the resource values identified and the legal requirements for securing protection of those values.

Resource values identified in the management guidelines for the San Pedro included the unique riparian area and its aquatic, wildlife, archeological, and recreation resources. These resources are all dependent upon streamflow, including floods and related groundwater conditions. In Arizona, surface water and groundwater are administered as two distinct resources, thus complicating the legal situation. Insuring protection of these values first required documenting the relationship between groundwater conditions and surface flow, and second, developing a strategy to protect surface rights from groundwater incursions. In 1988, the U.S. Congress designated the San Pedro River as a Riparian National Conservation Area with legislation that specifically recognized the federal government's interest in protecting instream flows.

Beaver Creek was designated by Congress as a National Wild River in 1980. The enabling legislation identified specific resource values as scenic beauty, primitiveness, the arctic grayling fishery, wildlife, and recreation opportunities. These identified values guided the study team in specifying the amount of water needed to support each value and identifying the most appropriate legal strategy to secure a water right to the specified instream flow. In this case, the legal process was an application through the U.S. Department of Justice to the Alaska Department of Natural Resources.

Based on their work on the San Pedro and Beaver Creek, Jackson et al. (1989) identified six basic steps for using an interdisciplinary approach for determining and protecting instream flows. These steps are summarized in the following paragraphs.

Step 1. Preliminary assessment and study design.—The purpose of the preliminary assessment is to identify cultural and resource values, identify instream flow issues, and develop overall project objectives. Specific instream values considered to need protection, such as fisheries or recreation, are identified. These values may be already mandated by legislation or specified by existing management plans. If not, they should be identified with input from current and prospective users and land managers within the context of the resource management planning process.

The interdisciplinary study team should be selected during this preliminary step. Representatives for each of the identified resource values should be included on the team. Team members should be selected for their technical competence and abilities to interact creatively with representatives of other disciplines.

Step 2. Describing flow-dependent values.—The values identified during step one are further evaluated with a particular emphasis on their relationship to instream flow. Interaction among the resource specialists is crucial at this point to insure that the dynamic relationships between various flow-dependent values are understood.

Step 3. Quantifying hydrology and geomorphology.—Hydrological and geomorphological processes should be described and quantified with an emphasis on delineating "flow value" dependencies. Specialists should understand and describe the relationship between these physical processes and resource values. This may require qualitative analysis.

Step 4. Describing the effects of flows on resource values.—The description and evaluation of flow value relationships can be quantified in the ideal situation. Existing methods of quantification may be applicable and feasible; however, they should not be used simply because they exist. If the flow value dependencies cannot be adequately quantified, the study team should do so by descriptively drawing on information from literature reviews, field reconnaissance, user surveys, or hydrological quantification.

The important element in this step is developing information that can be used to evaluate the effect that incremental changes in flow will have on various resource values. The effects of these incremental changes will form the basis of instream flow recommendations and subsequent decisions regarding instream flow protection.

Step 5. Identifying recommended flows to protect values.—According to Jackson et al. (1989), "The recommended flow regime represents a quantitative merging of resource attributes and hydrology while giving consideration to the opportunities and constraints provided by alternative flow-protection strategies." The recommendations are then evaluated by individuals representing the water-dependent resource values.

These recommendations should be both descriptive and evaluative, defined as follows. Shelby et al. (1992) described the relationship between streamflow and recreation as having both descriptive and evaluative components. The descriptive component provides information on how streamflow affects the bio-physical resource conditions or the ability to engage in an activity. The evaluative component indicates how humans respond to the bio-physical resource conditions. In combination with information on management goals, these descriptive and evaluative components can be used to identify a range of flows that will provide something between the minimum to optimum conditions for recreation.

We analyze the various methods that are available for these evaluations in the **Methods for Quantifying Instream Flow** sections of this report.

Step 6. Developing a flow protection strategy.—The flow protection strategy should blend legal, administrative, and technical alternatives. The strategy needs to be realistic, administratively efficient, and as flexible as possible in recognizing the many overlapping and competing interests in instream water supplies (Jackson et al. 1989).

Economic Valuation

Economic analysis of water resource issues is similar to the interdisciplinary process described in the preceding section. Before economic values can be attributed to water resources, it is necessary to first identify the various uses and how flow regimes are related to those uses. This requires input from affected user groups and technical hydrological data before economic values can be determined. The results of economic analysis should reveal the value of additional quantities of water put to various uses. This incremental approach to determining value is called marginal analysis. Results of recent research (Duffield et al. 1992) indicate that under some streamflow conditions on certain streams and rivers, water may have more economic value to society if left instream for recreation purposes, especially if additional recreation and other uses will occur in downstream areas.

In this section we will define necessary terms and methods and summarize studies that have determined economic values for instream flow.

Economic Analysis Primer. The beginning point for understanding how economic analysis is used to help decision-makers allocate water resources is recognizing the difference between economic value and financial value. Financial value reflects only the revenue received by an individual or firm; that is, financial values can be measured in actual monetary flows. Financial values are a subset of the economic values that reflect the total benefits received by society. Economic values are almost always substantially larger than the financial values received by individuals and organizations that are reflected by market transactions. In terms of recreation benefits, economic values include the off-site benefits of option value, existence value, and bequest value. Option value represents people's willingness to pay for the option of using a site at a future date. Existence value represents the benefit people derive from simply knowing that a site exists. Bequest value represents people's willingness to pay for providing a site to future generations.

An economic efficiency analysis is designed to show the relationship between the benefits and costs of a specific action. Benefits and costs are measured in monetary units or relative indicators based on monetary units. Economic analysis may also identify a particular action that is preferred to all other possible actions (McDonald et al. 1984). Economic (or benefit-cost) analysis always takes a societal point of view and adjusts for the timing differences when costs and benefits occur. The results are generally most useful for comparing different project alternatives.

For the purposes of social benefit-cost analysis (also often called cost-benefit analysis), economic value is used to quantify all benefits and costs. Financial values are appropriate for determining the private profitability of specific activities. Profitability to a firm should not be confused with economic efficiency, which is determined at the societal level (Loomis and Peterson 1984).

There are three reasons why economic values are more appropriate than financial values. First, financial values do not reflect the full value of economic benefit to consumers because they exclude consumer surplus, a theoretical measure reflecting value to consumers in excess of market price. Second, financial values do not account for any external costs associated with production, such as air or water pollution. Third, financial values ignore the economic benefits of recreation activities that are not bought in markets, such as hiking or fishing.

All of the recreation studies cited in this section of the report use economic value to measure benefits. Economic value is appropriate for determining the economic efficiency of instream flow because instream flows meet the two theoretical requirements for an economic good: (1) water in the stream provides enjoyment for or increases the utility received by recreation consumers, and (2) instream flows represent a scarce resource (Loomis 1987).

One of the most difficult aspects of economic analysis is the measurement of future costs and benefits, and the adjustment of those future values to the present time by applying a selected interest rate. This is usually called a discount rate because future value must be discounted to a present value equivalent. Interpreting the result of discounted future costs and benefits presents a problem. When discounted future values are used as a decision criterion—either as a net present value expressed in dollar terms or in a benefit/cost ratio—that does not mean that those actual dollars will be available at a specific time and place for a specific entity. For example, the results of an economic analysis may show that instream flow results in a net present value benefit of $10 per acre-foot; that is, the difference between discounted benefits and costs results in $10 more benefits than costs in present value terms. This does not mean that any identifiable group or person will be able to pocket $10 for every acre-foot of water going down the stream. A more accurate concept would be that society as a whole will have more of whatever good is being valued, and that society as a whole would be willing to forgo $10 worth of other benefits today in order to undertake the activity that would have this outcome.

Economic efficiency analysis of resource use does not address the distribution of costs and benefits. Specific project decisions, however, almost always affect how costs and benefits are distributed among a specified set of interests that may or may not be in a position to capture project benefits or share costs. For example, a farmer hoping to acquire additional irrigation water in order to expand his or her operation is not likely to be swayed by an analysis that shows the water has more value to society when it is left in the stream, because the farmer has no way to capture that value efficiently. In this case, society gains the benefits, not the farmer.

Methods for Estimating Recreation Value. Recreational use of water is commonly classified as an amenity resource, meaning the value of water for recreation is not expressed in market transactions with a pricing mechanism. Economists have developed several techniques or surrogate methods for assigning value to amenity goods and services in the absence of market prices. The two most common methods are the travel cost method (TCM) and the contingent valuation method (CVM). Both methods estimate how much the consumer of the amenity good is willing to pay for it. These methods allow the value of instream flow to be expressed in monetary units, which in turn allows direct comparison with out-of-stream uses that are market-valued in the same monetary units. TCM is a market-based method, estimating instream values by inference from related goods or services that are purchased in conjunction with instream usage. CVM is a simulation method, using a simulated market to determine consumers' willingness to pay for specific instream flows.

The assumption behind using the results of economic analysis as a decision criterion is that the resource use with the highest economic value is the use benefitting society the most. Economic value is a function of the utility of the resource, and the basic assumption of economic utility is that the market will move resources to their highest valued use. However, instream uses of water are nonconsumptive and are not usually traded in a market. The surrogate measurement of amenity resource values with TCM and CVM provide a basis of comparison that would allow public policy makers to allocate water to its highest valued use (Hansen and Hallam 1991), whether instream or out-of-stream.

Both TCM and CVM are less-than-perfect measures of value. Although surrogate methods for estimating values are widely used by resource economists, they are controversial. Non-economists question the assumptions and underlying theory of neoclassical micro-economics, claiming they are too narrow and based on unrealistic assumptions about human behavior. Economists raise many technical issues, summarized by Peterson et al. (1988) as including "concerns about the (1) consistency between economic theory and human behavior, (2) validity of methodological assumptions, (3) adequacy of experimental design, (4) clarity and validity of interpretation, (5) appropriateness of generalization, and (6) adequacy of economic measures to include and represent all relevant dimensions of human concern."

Both TCM and CVM provide an estimate of consumers' willingness to pay, but they do so in very different ways.

TCM bases the estimate of willingness to pay on observable behavior, including the cost of traveling to the site and the cost of equipment purchased to participate in an activity. TCM measures the use value of an amenity resource. TCM is not capable of assessing option and existence values because the consumers' marginal utility derived from the resource is zero (Loomis 1987). TCM can measure site quality improvement benefits, but only if site quality variations are perceived by users and affect their observed participation rate. TCM also requires that the quality of the experience is not reduced by increased users; that is, no crowding problem exists (Ward 1987).

CVM is based on the assumption that an expression of consumers' willingness to pay can be elicited through the construction of hypothetical markets (Loomis 1987). Survey techniques are used. Survey respondents are asked to make tradeoffs between having a certain amount of income or a specified amount of streamflow. The result is a "bid curve" that represents the amount of income respondents are willing to give up in order to have various amounts of streamflow. For an individual, these are the points of indifference on the bid curve, where the consumer feels equally well off having either the income bid or the specified amount of streamflow (Loomis 1987, Walsh et al. 1984).

CVM is the only method available for

estimating option and existence values (Loomis 1987) or estimating the value people have for protecting rivers before changes in river management occur (Sanders et al. 1990). The inclusion of these preservation values is a significant contribution to estimating the present value of benefits that goes beyond what the more traditional travel cost method (TCM) can do (Walsh et al. 1984).

Instream Flow Valuation Studies. The importance of instream flow in general and specific elements of the stream environment in particular are frequently described in economic terms. A sampling of these economic studies is presented here. Although by no means exhaustive, this sample illustrates the major concepts and techniques used in the valuation of instream flows.

Economic analysis attempts to quantify all resource values using monetary units that can be compared across various resource uses. Many of the conceptual and technical problems with doing this for goods and services that are not traded in a free market under purely competitive conditions are discussed by Harris et al. (1989) and Peterson et al. (1988). In spite of these problems, economic analysis is used to generate information about non-market goods and services.

Estimating Recreational Fishery Value.—The latest published development in economic analysis of recreation instream flow values is the work of Duffield et al. (1992) on Montana's Big Hole and Bitterroot Rivers. They used the contingent valuation method (CVM) and built on the earlier work of other studies cited later in this section. On-site recreation values and downstream recreation and hydropower values were included in their analysis. Results showed that marginal benefits of instream values for recreation and downstream hydropower exceeded the marginal costs of either irrigation or hydropower alone at all flow levels on the Big Hole (a nationally famous high quality trout fishery) and at flow levels of less than 1250 cfs on the Bitterroot.

The Travel Cost Method (TCM) was used by Loomis and Cooper (1990) to estimate marginal instream flow values associated with a California steelhead fishery. Empirical data revealed a statistically significant relationship between streamflow and angler catch. It was assumed that the angler's demand function was partially a function of fish catch. Empirical results indicated a value of $73 per additional cubic foot per second of streamflow to anglers because of increased catch success. Other recreational benefits were not included. Nor were marginal values of out-of-stream purposes.

Johnson and Adams (1988) combined a flow-related fish production model with a contingent valuation method (CVM) study to estimate the marginal value of water for recreational steelhead fishing in an Oregon river. This study is noteworthy for two reasons: (1) increased streamflow was directly related to the good being valued, and (2) the marginal value of the streamflow includes the value of the good, in this case steelhead fishing, wherever it is realized, even outside of the river basin. This is an important conceptual and methodological step, because the benefits of instream flow are not confined to a specific reach of river or stream, but are measured as they continue to accrue throughout the length of the river system. Increased summer flows to enhance fishing had a marginal value of $2.40 per acre-foot, compared to a minimum value of $10 per acre-foot for irrigation. Johnson and Adams (1988) concluded that these values are non-comparable, because a larger portion of irrigation water is consumed in comparison to water left in the stream.

Hansen and Hallam (1991) used a household production model to derive estimates of the marginal value of water left instream for recreational fishing using a variety of national survey data and regional estimates of the value of a day of fishing. The results were that in 51 of the 67 national aggregated subareas (ASAs) where irrigation is significant, the marginal value of water for fishing was greater than the marginal value of water for irrigation. In all the upstream ASAs, the downstream fishing benefits were significant and in most cases exceeded the upstream benefits. As in the Johnson and Adams (1988) study, this work illustrated that benefits continue to accrue as long as the water remains instream. The utility of this large scale model, in the words of Hansen and Hallam (1991), is that "public policy can still allocate water to its highest valued use when the values in nonconsumptive uses are known to policy makers."

Estimating Recreation Value.—Daubert and Young (1981) used a CVM approach to estimate the marginal value of water in the Cache la Poudre River in Colorado for anglers, shoreline users, and whitewater boaters. Using color photographs of physical stream characteristics, interviewers asked respondents their willingness to pay for instream flow in the form of (a) a percentage addition to the present county sales tax on consumptive expenditures, and (b) an increase in a hypothetical entrance fee. As Shelby et al. (1992) reported, the researchers found an inverted U or concave relationship between marginal value and amount of flow for both fishing and shoreline use. This concave relationship is a common finding in studies of instream flow: lower flows are less desirable, and desirability or marginal value increases to an optimal level, then decreases at higher flows. Results of this study also found an increasing linear relationship between marginal value and amount of flow for whitewater boating, which the low flows experienced during the study period may have been responsible for. At certain periods of low flow in the autumn, the marginal value of water for anglers was found to be greater than for irrigators. The values for a visitor day of fishing at the optimal flow level of 500 cfs were $30.00 and were consistent with values for a day of fishing from other studies. Values for shoreline use and whitewater boating were not reported.

Lant and Mullens (1991) noted that CVM studies are hampered by an inadequate conceptualization of the interacting elements of a water body that are of value to people. They proposed to measure the concept of lake or river quality by incorporating the geomorphological, ecological, and aesthetic factors that influence the recreation experience. This broader concept is based on the conditions that the individual actually perceives, and thus increases the correspondence between the quality of the good being valued and the intended behavior. Lant and Mullens suggested that this broader concept be used in place of narrow concepts such as water quality, which is not perceptible to an average user, and instream value, which implies that the value is attached to the water and is transient. The theory behind this concept is consistent with evidence that respondents will report meaningless values for goods, based on unconscious judgmental rules that are poorly defined or unfamiliar. This underscores the need to assure that the goods being valued must be familiar to the respondent. For studies that specifically focus on the quantity of water left instream, it is necessary to establish the link between amount of flow and the perceived goods.

Ward (1987) used the travel cost method (TCM) to identify potential demand for instream flows for the Rio Chama in New Mexico. A demand-benefit model was developed to quantify the benefit gain from extra streamflow to site users in a given time period. This information was used to develop a simulation model of instream flow management, using optimal control techniques to determine how upstream reservoir releases can best be timed. Using data collected on-site from anglers and whitewater boaters, a range of values was determined for an acre-foot of water that took into account natural flow and acre-feet of water available to augment natural flows. Values and optimal release plans determined by this study are site-specific. The theoretical assumptions and the variables included in the models are more general and may have application in other situations where instream flow augmentation is a possibility. Also of interest in this study are the on-site questionnaire data collection methods, which were supplemented by showing interviewees color photos representing seven minimum streamflows to provide them with a more accurate image of the river's characteristics over a wide range of flows. Questions focused on travel distance and travel time; length of stay; socio-economic determinants such as income, city size, age, education; and several questions about proxies for recreational tastes and travel-related monetary expenditures.

Estimating Preservation Value.—Sanders et al. (1990) asked 214 Colorado households to evaluate six reasons why they might value the protection of rivers. Responses were ordered on a 5 point scale, ranging from 1 = Definitely Not Important, to 5 = Very Important. In order of mean response, the reasons were:

(1) protecting the quality of water, air, and scenery (4.67),
(2) protecting fish and wildlife habitat (4.57),
(3) knowing that future generations will have rivers (4.44),
(4) knowing that in the future you have the option to go there if you choose (4.17),
(5) providing you with actual river recreation (fishing, camping, hunting, sightseeing, etc.) (4.03), and
(6) just knowing that rivers exist and are protected (3.96).

Notice that the actual use of a river for recreation activity ranked as only the fifth most important of the six reasons for protecting rivers. This is consistent with the idea presented earlier that the ability to engage in a specific recreation activity is but one element of valuing the recreation resource. It also indicates that people's concern about instream flow issues extends beyond protecting their opportunity to use rivers for recreation activities.

Although Sanders et al. (1990) did not relate economic value to quantity of streamflow, their work is reported here because it shows the contribution that preservation values—including bequest, option, and existence values (reasons 3, 4, and 6 above)—make to the total value of river protection. Of the $39.00 that households were willing to pay to have what they ranked as the three most valuable rivers protected, $32.26 (or 82.7%) was for protection and preservation or non-use value, which is defined as all six reasons stated above except number 5. Of the $74.32 consumers said they were willing to pay for protection of seven rivers, $60.24 (or 81%) was for non-use value. Of the $95.00 for eleven rivers, $77.00 (or 81%) was for non-use value. Of the $101.12 to protect fifteen rivers, $81.96 (or 81%) was for non-use value.

There are two implications of these results: (1) studies that fail to include bequest, option, and existence values may underestimate the total value of river protection, and (2) rivers and streams have value to individuals even if they do not directly use that river for recreation. This would indicate that it is necessary to sample from the general population, not just on-site river recreation users.

The pioneering research of Sanders et al. (1990) demonstrates that the option, existence, and bequest values of rivers and streams to individuals exceeds their willingness to pay just for onsite recreation. No other river valuation studies that we are aware of have been designed to produce comparable results. However, Sanders et al. (1990) cite the work of Peterson and Sorg (1987) that reported comparable results from other studies of resource values, including clean air visibility, grizzly bears, bighorn sheep, endangered species, wildlife habitat, water quality, and the availability of wilderness areas.

Strengths and Weaknesses.—The strength of economic analysis is that it provides an estimate of the value to society of a particular use of resources. This value can then be compared to the value of other uses of that resource. The weakness of this approach is that if a resource is not traded in a market, it does not have a market price for that use and the value must be estimated.

A full discussion of the problems of estimating hypothetical values, such as those developed by TCM and CVM, is beyond the scope of this analysis. Suffice it to say that the valuation of non-market goods is more a matter of art than science. The reader is referred to Harris et al. (1989) and Peterson et al. (1988) for detailed discussions of these problems before attempting to incorporate economic values for non-market goods such as recreation into the decision-making process.

METHODS FOR QUANTIFYING INSTREAM FLOW: LITERATURE REVIEW

Which method of quantifying instream flow is the most appropriate? First of all, that depends on the context of the problem. Lamb (1989) perceived political and environmental problems associated with instream flow as a continuum of action, with long-range planning at one end of the scale and bargaining over specific projects at the other. Long-range planning actions call for instream flow recommendations to guide general preliminary planning, whereas project bargaining involves high-intensity, high-stakes negotiations over specific development projects. The technical method for quantifying instream flows should be selected according to the type of action being taken. For long-range planning, methods based on long-term hydrologic records may be appropriate; for project bargaining, methods that allow for evaluation of incremental changes in flow may be more appropriate.

A variety of methods are available for quantifying instream flows. The most commonly used methods are explained in the following sections.

Fisheries-based Method

One of the first systematic methods developed for making instream flow recommendations was the Tennant (1976) or Montana method. It was based on findings from several studies that the condition of aquatic habitat is remarkably similar on most streams carrying the same average flow. From that basic observation, Tennant determined guidelines for making recommendations for flow regimes, which he called regimens, based on a percentage of the average flow. The Tennant method is acceptable when it is applied to the region, type of stream, and specific fish species that it was developed for (Estes and Orsborn 1986, cited in Shelby and Jackson 1991).

Tennant's (1976) findings on instream flow regimens are presented in Table 2, and summarized as follows.

Table 2. Instream flow regimens for fish, wildlife, recreation, and related environmental resources.

	Recommended Base Flow Regimens (percent of the average flow)	
	October-March	April-September
Flushing or Maximum	200%	200%
Optimum range	60% to 100%	60% to 100%
Outstanding	40%	60%
Excellent	30%	50%
Good	20%	40%
Fair or degrading	10%	30%
Poor or Minimum	10%	10%
Severe Degradation	10% to 0%	10% to 0%

Source: Tennant (1976, p. 360)

The critical point or lower limit for the health of many aquatic organisms, particularly fishes, is 10% of the average flow. Therefore, 10% of average flow is the minimum flow recommendation, and it provides only short-term survival, at best. Most wildlife habitat is lost, riparian vegetation suffers from lack of water, floating becomes difficult, fishing success may possibly improve as fish are crowded into the few remaining pools, and stream aesthetics are badly degraded at the 10% of average flow level.

When 30% of the average flow is provided, good survival habitat occurs, although the time of year is critical, as Table 2 demonstrates. At 30% of average flow, the majority of the substrate is covered, side channels generally have some water, stream banks provide cover for fish and some wildlife habitat. Water quality and quantity should be good for recreation and fishing. Stream esthetics should be satisfactory. When 60% of the average flow is provided, outstanding to optimum habitat for most aquatic life occurs. Seasonal considerations are not as much of a concern when 60% of average flow is provided.

In 1976, when Tennant developed this method, base flows were generally set, if they were established at all, at the historic minimum flow, or 7-day or 3-day minimums—that is, the lowest level recorded for the specified number of consecutive days. Tennant found that these base flows actually resulted in zero flow 28% of the time in the 305 cases he reviewed, thus prompting the need to develop other methods.

Mathews and Bao (1991) compared the Tennant method with their new Texas method and found that the recommended flows of the Tennant method were unrealistically high for maintaining flow requirements for warm water fish species, primarily because the base flow is determined from the mean annual flow, leading to overestimation of flow needs during typically low flow months. This point of difference was based solely upon fisheries requirements in Texas, and did not consider recreation needs.

Hansen and Hallam (1991) used the underlying idea of the Tennant method to estimate the value of recreational fishing at the national level, applying the general statistical relationship between average annual discharge and stream habitat to estimate the economic value of water for recreational fisheries at the national level.

Recreation-based Methods

Because natural streamflow regimes may have peak flow periods that do not coincide with recreation use, an instream flow request based solely on fisheries considerations may not adequately provide for recreational needs (Moore et al. 1990).

The Cooperative Instream Flow Group of the U.S. Fish and Wildlife Service has developed two methods—the single cross section method and the incremental method—for quantifying instream flow needs for recreation that closely parallel methods used for quantifying flows for fisheries. The data collection procedures, the physical and hydraulic simulation of the stream, and the computer models for analyzing the data are the same for both fisheries and recreation (Hyra 1978).

Because recreation instream flow needs are related to fisheries needs in these two methods, agencies may have an opportunity to reduce the individual costs of instream flow studies through cooperative efforts. In some cases, recreation needs may be quantified by using fisheries data that have already been collected.

Single Cross-Section Method. This is a quick, easy, and inexpensive method for determining minimum flows required for different types of boats or recreation craft. As the name implies, a single cross-sectional measurement of the stream channel is taken. The Cooperative Instream Flow Group of the U.S. Fish and Wildlife Service developed a computer program predicting width and depth across a transect at any water surface elevation. These elevations are also translated into cubic feet per second.

The width and depth criteria developed by this method are presented in Table 3. These are to be considered minimum levels. According to Hyra (1978), these depths and widths would not provide a satisfactory recreation experience if the entire river was at this level. This approach is best applied to streams where flows are expected to be higher than the minimum most of the time.

Table 3. Required stream width and depth minimums for various recreation craft as determined by the single cross-section method.

Recreation Craft	Required Depth (feet)	Required width (feet)
Canoe or kayak	0.5	4
Drift boat, row boat, or raft	1.0	6
Tube	1.0	4
Power boat	3.0	6
Sail boat	3.0	25

Source: Hyra (1978)

This method makes two assumptions. First, the cross-sectional measurement will be taken at the shallowest point in the reach. Therefore conditions in the rest of the river will exceed these minimum requirements. The second assumption is that all water exceeding the minimum is equally useful for the activity. Because no other variables, such as travel time, are considered, this second assumption may be unfounded (Shelby et al. 1992).

Only the minimum criteria for boating presented in Table 3 have been developed. The reasoning assumes that if the shallowest section of the stream is of sufficient width and depth for boats, the other sections of the stream will have enough water to support most other instream recreation. Shelby et al. (1992) said this approach is only well suited for applications where a quick assessment of minimum flow is needed, and for activities such as boating, where a single critical stream reach can be identified to represent the entire section under study.

Incremental Method. The Cooperative Instream Flow Group of the U.S. Fish and Wildlife Service developed another, more sophisticated, approach called the incremental method. It describes a relationship between the amount of water in the stream and the associated recreation potential of the stream (Hyra 1978).

The incremental method is best suited for three situations: (1) increments of flow need to be analyzed, (2) the change in streamflow needs to be related to change in recreational potential, and (3) the most "exact answer" available with the state of the art in 1978 is desired (Hyra 1978).

The need for the most exact answer is emphasized by Garn (1986):

> Streamflow requirements made using the instream flow incremental methodology, supported by ancillary methods, considers the variable flow needs of the instream resources and allows the determination of an instream flow recommendation for the best mix of uses within the stream. The process provides numerical estimates of instream flows, on a monthly basis, for a rational and defensible approach to allocating water.

The incremental method is based on three assumptions: (1) water depth and water velocity are the two most important streamflow components for determining whether or not a certain recreation activity may be safely and pleasurably engaged in, (2) certain measures of water depth and water velocity may be considered minimum, maximum, and optimum for an activity, and (3) the measurement of water surface area meeting certain requirements of depth and velocity is a viable method for describing recreation potential for instream recreation uses (Hyra 1978).

The incremental method involves four steps described by Shelby et al. (1992): (1) computer simulation of the depth and velocity of a stream reach based on cross-sectional transect data, (2) use of the computerized model to develop a matrix of the amount of stream surface area at different combinations of water depth and velocity, (3) determination of a composite "probability of use" (PU) for each combination of depth and velocity, and

(4) calculation of the weighted usable surface area (WUA) by multiplying the actual surface areas for a given depth and velocity combination by the composite PU for areas with that combination of depth and velocity. The WUA matrix must be calculated for each recreational use being evaluated and for each different flow level. Comparison among the different matrices will reveal changes in WUA at different flows for each activity.

The following paragraphs explain the development of recreation streamflow criteria, which are used to determine "probability of use" (PU) estimates. We then mention the limitations of the incremental method.

Recreation Streamflow Criteria.—The minimum and maximum water depths and streamflow-velocities used in developing the probability of use (PU) curves are determined by two criteria: (1) the physical, absolute limits or requirements that must be met for engagement to occur, and (2) safety, that is, the water depths and velocities above which participation is unsafe. The optimum depth and velocity combination lies somewhere between the minimum and maximum combinations of depth and velocity. The optimum range of depth and velocity is that which is usable by the largest number of potential participants (Hyra 1978).

Table 4 provides the safety and optimal ranges for 12 of the most popular recreation activities. Hyra (1978) also provided physical minimum and maximum limits that are not displayed here.

Table 4. Recreation streamflow criteria by activity: safety range and optimal range for stream depth and velocity

Activity Type Activity	Streamflow Criteria			
	Depth (feet)		Velocity (feet per second)	
	Safety Range	Optimum Range	Safety Range	Optimum Range
Fishing				
Wading	0.75-3.50	1.00-2.50	0.0-2.50	0.25-2.00
Boat, power	3.00-NA	3.50+	0.0-4.00	0.50-2.00
Boat, nonpower	1.00-NA	2.00+	0.0-3.00	0.50-1.50
Water Contact				
Swimming	3.00-NA	4.00+	0.0-2.00	0.25-0.75
Wading	0.50-3.00	0.75-2.50	0.0-2.50	0.25-2.00
Water skiing	7.00-NA	9.00+	0.0-2.50	0.25-1.50
Boating				
Sailing	4.00-NA	5.00+	0.0-1.25	5.00+
Low power	3.00-NA	3.50+	0.0-6.00	3.50+
High power	3.50-NA	4.00+	0.0-10.0	0.50-8.00
Canoe-Kayaking	1.00-NA	2.50+	0.0-9.00	0.50-7.00
Tubing-floating	1.50-NA	2.00+	0.0-7.00	1.00-5.00
Rowing-rafting-drifting	2.00-NA	3.00+	0.0-12.0	1.00-10.0

NA = not applicable
Source: Hyra (1978)

Psychological criteria related to the quality of the experience might also be considered. However, it would be necessary to determine what experience is sought, which generally has not been done, and the contribution of water depth and velocity to the experience as determined by the individual skill levels of participants. Therefore, Hyra (1978) did not use psychological criteria.

Probability of Use.—Hyra (1978) developed criteria and probability of use curves for each of the activities listed in Table 4. Appendices in Hyra (1978) provide probability of use curves associated with the recreation streamflow criteria in Table 4.

The depth and velocity combinations that occur between the minimum and maximum values each have a different probability of use. Between the minimum physical limit and the minimum safety limit, the probability of use ranges from .01 to .49. Similarly, the probability of use between the maximum safety limit and the maximum physical limit ranges from .49 to .01. Between the safety minimum and the optimum level, the probability of use ranges from .5 to .99. Similarly, the probability of use between the optimum level and the safety maximum ranges from .99 to .5. The probability of use at the optimum level is 1.0

Limitations.—Hyra (1978) pointed out that although the incremental method can describe the impact of changes in flow or identify an optimum flow, there is no such thing as an optimum flow or flow regime for recreation. The principal reason is that the ability to quantify the amount of water required for a specific activity does not resolve the problem of conflicting uses. Each activity has different flow requirements that may conflict with the requirements of other activities. For example, the optimum flow for kayaking is not the same as that for wade-fishing (Table 4). A further limitation of the incremental method is that it provides a measure of recreation potential, which is not necessarily the same thing as recreation desired by the public.

Survey-based Quantification Methods

Survey-based methods involve the preparation and administration of questionnaires to carefully selected populations of people. This may be the general population, specific recreation users, or experts. These social science methods can produce useful and reliable results, but only if carefully designed and administered.

Survey of Users. A full discussion of social science research methods is not possible here, but surveys are seldom as straight-forward as they seem. The opportunities to introduce bias occur in study design and administration of the questionnaire (Babbie 1989), as well as, data analysis and interpretation of results.

Addressing temporal considerations, Schreyer (1980) said, "A user study may represent a single point in time for a dynamically evolving resource. As most surveys are conceived as 'one-shot' operations, changes may go unnoticed." This raises a key question that we do not have an adequate answer for. Are current desires for specific recreational opportunities a suitable criterion for establishing instream flows when future opportunities may be restricted or eliminated?

Surveys are useful tools for gathering information. But how the information is collected and how that information is to be used are important considerations when evaluating the validity and reliability of recommendations based upon survey results. Shelby et al. (1992) divided studies emphasizing formal surveys to obtain user opinions into three groups: (1) flow levels experienced, where each respondent had experienced only one flow level, (2) flow levels depicted photographically, and (3) flow levels described verbally.

A central issue in designing, evaluating, or using survey results is determining who is to be surveyed. Because the economic values of instream flow have been shown to include non-use preservation values in addition to recreation activity values (Sanders et al. 1990), surveys restricted only to on-site users may understate the social benefits of instream flows.

Survey of Experts. Surveys of experts have all the shortcomings of user surveys, and may even have greater shortcomings. Who is an "expert"? Is it someone with special knowledge about fishing, whitewater boating, or cultural values? The information experts provide, while likely to be of high quality, will reflect the needs of their fields of expertise, and may fail to consider the needs of other activities or uses.

Photographic Comparison. Several studies have used photographic comparisons to evaluate the effects of different instream flows. Use of photographs or videotape allows the same individual to be presented with several alternative environmental conditions under controlled conditions (Brown and Daniel 1991). Although scenic quality evaluations based on photographs are similar to evaluations made by observers in the field, Shuttleworth (1980) warned that, "in general, photographic simulation proved most reliable when dealing with the overall perception of the landscape, but less reliable when dealing with perception of detail elements and characteristics in the landscape."

Canoeing Zero Flow Method

Determining a minimum flow with the canoeing zero flow method was developed by Corbett (1990). It is based on an empirical relationship between mean annual flow and the minimum requirements for recreational boating. It has the advantage of requiring data only on mean annual flow, which is easily obtainable. This method is useful when it is not possible to conduct more extensive flow studies (Shelby and Jackson 1991). Its disadvantages are that it is based on the needs of a single specialized activity, canoeing, and the average annual flow is a highly generalized stream attribute that does not adequately describe the seasonal variability of streamflow. The relationship modeled by Corbett was developed from data on low, uniform gradient eastern rivers that have less seasonal variability than characteristic western rivers with steep, non-uniform gradients carrying very high spring runoffs.

Systematic Field Evaluation

Giffen and Parkin (1992) suggested that systematic field evaluations that involve actually using the river for the activities in question can result in a clearer understanding of instream needs. The evaluation should involve a variety of recreation users, agency personnel, and outside experts who have no stake in the outcome. This method is particularly well suited for situations where the study team can experience different instream flow levels within a short period of time; for example, where a dam operator can release various flows in a short time span. This allows the evaluation to be completed while memories of different flows are still fresh in the mind of the study team. Although field evaluation by itself can provide accurate information on flow levels that are necessary and best suited for recreation activities, the technique is most powerful when used in conjunction with other methods, such as surveys of user preferences.

Giffen and Parkin (1992) suggest five tests that must be met by systematic field evaluation methods if they are to provide useful information on instream flows. These are:

(1) reliance on available technology,
(2) efficiency in terms of both time and money,
(3) accuracy of results,
(4) recognition of the qualitative, as well as the quantitative, nature of recreation research, and
(5) ability to build consensus and trust among competing interests.

SURVEY RESULTS: METHODS FOR QUANTIFYING INSTREAM FLOW

Which Methods are Used Most Often?

Our survey measured the frequency with which various methods for quantifying instream flows are used. Respondents were presented a list of quantification methods developed through the literature review, and asked, "Which of the following six methods for ***quantifying*** the amount of water needed for recreation have you had experience with?" Results are summarized in Figure 10.

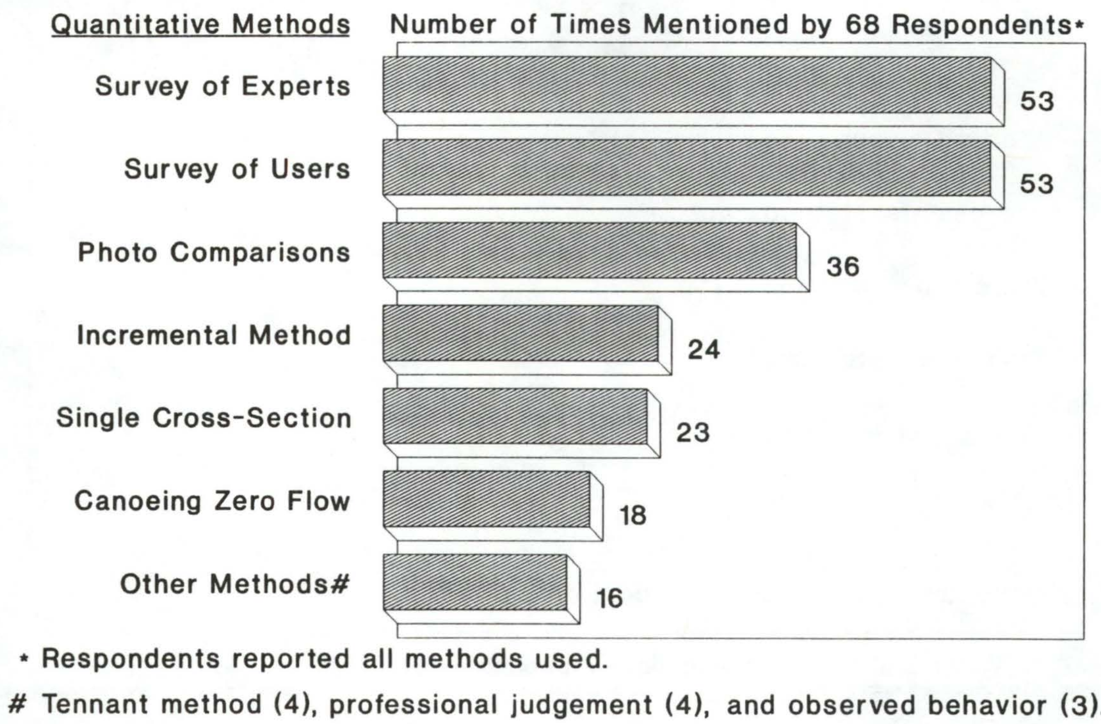


Figure 10. Frequency of use of different methods of quantifying instream flow.

Surveying users was the most frequently used method reported by respondents to our survey. We did not give respondents the opportunity to state what kind of survey they used. Shelby et al. (1992) described three types of user surveys, all considering different ways to consider flow levels: (1) experience, (2) photographs, and (3) verbal description.

When we listed "survey of experts" as a method, next to it was the explanation "(i.e., raft guides)" so respondents would know what we meant.

We did not include the fisheries-based Tennant method in our survey. Although Tennant (1976) claimed that this method will support recreational use, it was developed primarily for fishery protection. Any application to recreation is suspect, because the requirements for recreation were unspecified by Tennant. Nonetheless, four respondents to our survey have used it (Figure 9)

If the reader is interested in a model survey that could hasten the permitting process and increase the likelihood of permit approval, we suggest the study conducted by Moore et al. (1990) at Aravaipa Canyon Wilderness, Arizona. Our suggestion is based on the endorsement this work received from a deputy counsel with the Arizona Department of Water Resources.

Which Methods are Most Reliable?

Respondents were also asked, "Which method that you have used do you feel provides the most reliable measure of the amount of instream flow needed for recreation?" Results are summarized in Figure 11.

Respondents considered a survey of experts to be the most reliable method, followed by a survey of users.

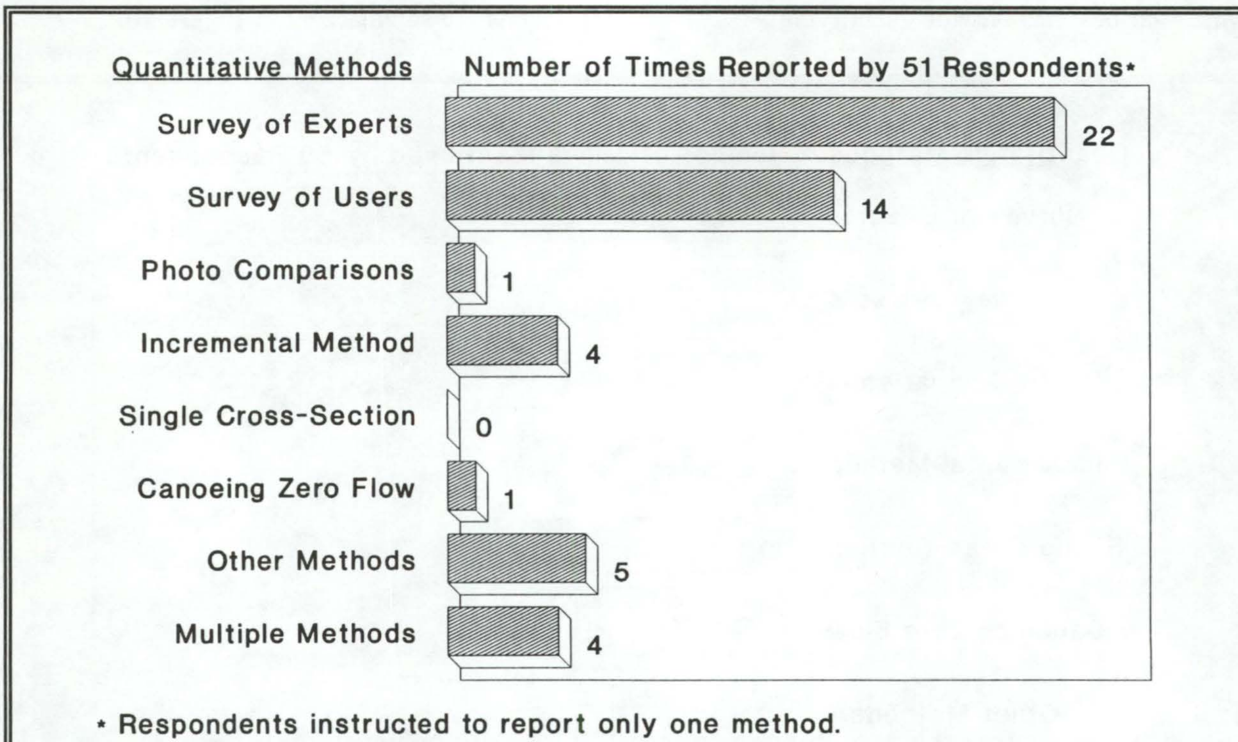


Figure 11. Which is the most reliable method of quantifying instream flow?

Defending Recommended Instream Flow Quantities

Because of the conflicts involved in instream flow appropriations, the requested quantity of water will likely be subjected to thorough scrutiny and review. It therefore needs to be defensible. We asked survey respondents about their experience defending recommendations for instream flow quantities. One of the technical reviewers felt that these particular survey results were of questionable value because the majority of the survey respondents were federal agency personnel who may have had only limited experience defending instream flow requests. This particular reviewer, a state agency employee, said these are matters for state natural resource agency personnel, not federal employees. Because only 11 of the 68 respondents indicated that their recommendation had been challenged, this review comment seems to be valid, and the reader is forewarned.

We asked, "How confident are you in defending the quantity of water, determined by the method you checked, before various levels of review?" We listed the seven levels of review in Figure 12, and provided a 5-point response scale, ranging from Extremely Confident to Not At All Confident, with Confident in the middle. The results portrayed in Figure 12 have combined the Extremely Confident and Very Confident categories and the Not At All Confident and Not Very Confident categories.

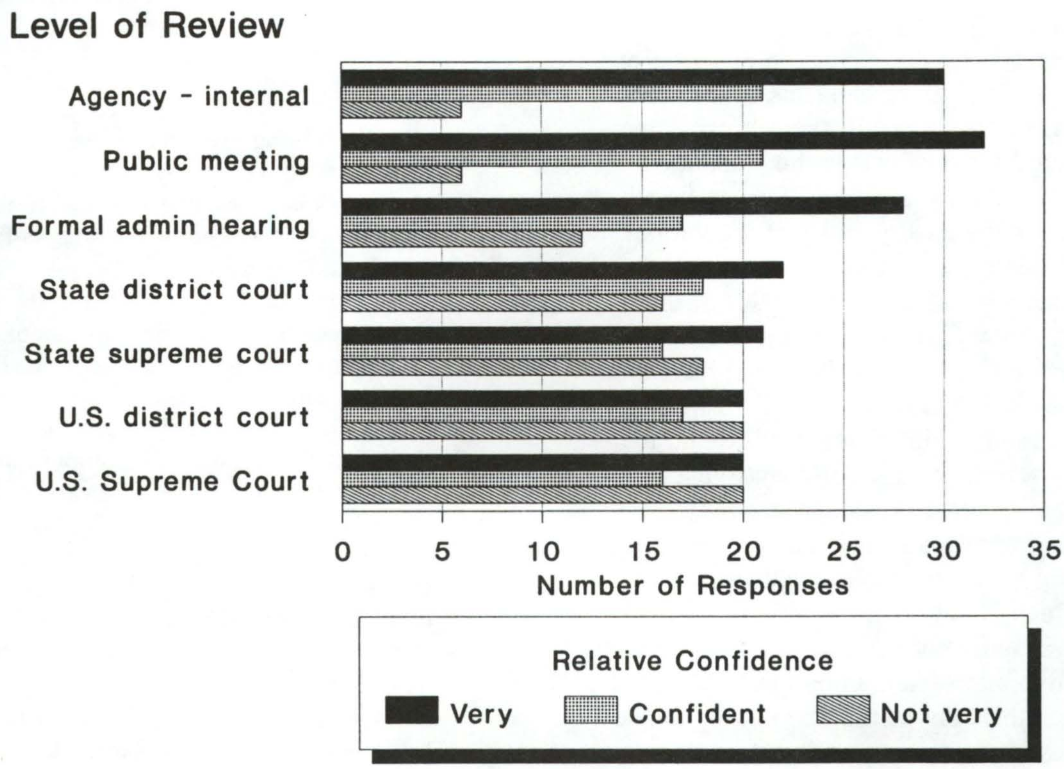


Figure 12. How confident are you in defending the quantity of water at different levels of review?

It is apparent in Figure 12 that the respondents have a substantial amount of confidence in their preferred methods for quantifying instream flow. This is especially evident at the agency and informal public meeting level, where only six of 58 respondents said they were Not Very Confident (none said they were Not At All Confident). As reviews became more formalized at the administrative hearing level, confidence levels slipped only slightly. They slipped a bit more as state and then federal courts were posed as the review levels. But even at the level of judicial review, at least as many respondents remained Very Confident as those who were Not Very Confident, and a solid core of Confident respondents remained throughout all levels of review, varying from 21 to 16 respondents (Figure 12).

We also asked, "Has your recommendation for an instream flow, determined by the preferred method you checked, been challenged?" Of the 58 respondents who replied, only 11 said yes (10 did not answer the question). We asked the 11 respondents who had been challenged whether or not their recommendation was upheld, and 7 replied affirmatively. We asked, "At what level was the dispute resolved?" The replies, two with multiple responses, were: 6 in formal administrative hearings, 2 in state district courts, 3 in state supreme courts, and 2 in U.S. district courts.

CONCLUSIONS

Recreation activities have different requirements, and the recreation experience depends on features or elements of the stream environment. As a result, there is no single best method for quantifying the amount of instream flow for recreation. Survey-based methods are the most popular of the various methods that have been used.

According to Rinda Just (1990) of the Idaho Attorney General's Office, the quantification of instream flows for recreation and aesthetic purposes is more difficult than it is for fish and wildlife habitat. She said the lack of a scientific basis for quantifying recreation instream flows has allowed petitioning agencies in Idaho some flexibility in making a case for a particular instream flow, which is important because of Idaho's statutory requirement that an instream flow be a "true minimum," not an optimum flow. Just said this allows the petitioning agency to use expert testimony to support instream flow requests. She added that determining minimum flows for aesthetic purposes has been more difficult, and has relied on opinions of observers during varied periods of flow. Just was not sure that these methods would be successful in the future, and said, "it may be difficult to defend such unscientific methods for determining minimum flows."

Our analysis of the literature and survey of those experienced with quantifying instream flows indicate that survey-based methods are widely used and considered to be reliable. We would suggest, however, that someone with training in the social sciences be involved in the preparation and analysis of surveys of experts, recreation users, or the general public in order to avoid the "unscientific" concerns and the "should we have asked for more?" dilemma expressed by Just (1990).

Standards for quantifying instream flows for fisheries have been suggested (Beecher 1990). A standardized approach for quantifying instream flow for recreation has not been offered, but is under development. A consulting engineer made some pertinent observations about this at the conclusion of the 1991 Workshop on Instream Flows for Recreation at Corvallis, Oregon (DiGennaro 1991):

> I was impressed by the range of projects presented at the conference and the variety of techniques being used to determine instream flow needs for recreation. However, I was also somewhat discouraged to realize that so much research was occurring with so little coordination.
>
> I am particularly interested in the development of standardized methodologies for evaluating instream flow needs for recreation. I am not convinced that there is one methodology that should be developed and pushed as the "answer" (a multiple approach to a given research question is always more valuable than a single approach), however, I think we could all benefit from a level of consistency that would generate comparable data. If we are going to use an on-site user survey approach we should be asking the same questions. Likewise, if we are going to interview experienced boaters or coordinate controlled float trips at different flows we should be asking similar questions and evaluating similar resource conditions. More research is obviously needed before we can decide on such standards, but the sooner that we begin to coordinate that research the sooner we can begin to implement consistent assessment methods.

According to Whittaker (1991), there is a high level of interest among recreation instream flow researchers and practioners in more focused "how to" workshops, particularly on designing "flow-recreation" studies. There is overwhelming support for the notion of standardizing general methods and approaches, and support for the idea of standardizing vocabulary and survey questions and analysis. There is considerably less priority placed on standardizing "study outputs." All of this suggests the need to develop standards and guidelines for instream flow recreation studies, and the National Park Service has provided initial funding to undertake the project (Whittaker 1991).

We encourage those facing the professional challenge of instream flow quantification to contact Doug Whittaker, National Park Service, 2525 Gambell Street, Anchorage, AK 99503. He presented the topic "A hierarchy of survey-based methods: lessons from the BLM studies" at the Corvallis Workshop in 1991, and leads the National Park Service effort to develop guidelines and standards for instream flow quantification.

In the past two decades, said Tarlock (1990), instream flow protection has become a legitimate use of water in the western states. He added that the interesting question is, what will be the future of instream flow protection? He concluded that there is much work for both professionals and politicians in carrying forward instream flow protection. We hope that this review of methods and supporting survey of experts will be helpful to those who will be involved in that work, and in resolving the inevitable conflicts that will result.

LITERATURE CITED

Anderson, Raymond L. 1982. Conflict between establishment of instream flows and other water uses on western streams. *Water Resources Bulletin* 18(1): 61-65.

Babbie, Earl. 1989. *The Practice of Social Research*. Fifth edition, Wadworth Publishing, Belmont, CA. 501 p.

Bearzi, Judith A. 1991. The delicate balance of power and nonpower interests in the nation's rivers. *Rivers* 2(4): 326-332.

Beecher, Hal A. 1990. Standards for instream flows [for fisheries]. *Rivers* 1(2): 97-109.

Beeman, Josephine P., and Kenneth R. Arment. 1989. Instream flows in Idaho. In: Instream Flow Protection in the West. Lawrence J. MacDonnell, Teresa A. Rice, and Steven J. Shupe, editors. Natural Resources Law Center, Boulder, CO. Pp. 265-277.

Brown, Curtis A. 1983. The central Arizona water control study: a success story for multiobjective planning and public involvement. Unpublished paper, Bureau of Reclamation, Denver, CO. 22 p.

Brown, Thomas C. 1991. Water for wilderness areas: instream flow needs, protection, and economic value. *Rivers* 2(4): 311-325.

___, and Terry C. Daniel. 1991. Landscape aesthetics of riparian environments: relationship of flow quantity to scenic quality along a Wild and Scenic River. *Water Resources Research* 27(8): 1787-1795.

___, ___, H.W. Schroeder, and G.E. Brink. 1990. Analysis of ratings: a guide to RMRATE. USDA Forest Service General Technical Report RM-195, Fort Collins, CO. 40 p.

Chenoweth, Richard E., and Paul H. Gobster. 1990. The nature and ecology of aesthetic experiences in the landscape. *Landscape Journal* 9(1): 1-8.

Coggins, George Cameron. 1991. Snail darters and pork barrels revisited: reflections on endangered species and land use in America. In: *Balancing On The Brink Of Extinction: The Endangered Species Act and Lessons for the Future*. Kathryn A. Kohm, editor. Island Press, Washington, D.C. Pp. 62-74.

Collins, Michael A. 1983. Discussion: conflict between establishment of instream flows and other water uses on western streams, by Raymond L. Anderson. *Water Resources Bulletin* 19(1): 137.

Collins, Richard C. 1990. Sharing the pain: mediating instream flow legislation in Virginia. *Rivers* 1(2): 126-137.

Corbett, Roger C. 1990. A method for determining minimum instream flow for recreational boating. Special Report 1-239-91-01, Science Applications International Corp., McLean, VA. 23 p.

Daubert, John T., and Robert A. Young. 1981. Recreational demands for maintaining instream flows: a contingent valuation approach. *American Journal of Agricultural Economics* 63: 667-676.

DiGennaro, Bruce. 1991. Comments from a consultant. In: Workshop Summary: Workshop on Instream Flows for Recreation, Corvallis, OR. Doug Whittaker, editor. National Park Service, Anchorage, AK. Pp. 26-28.

Duffield, John W., Christopher J. Neher, and Thomas C. Brown. 1992. Recreation benefits of instream flow: application to Montana's Big Hole and Bitterroot Rivers. *Water Resources Research* 28(9): 2169-2181.

Dunning, Harrison C. 1989. Instream flows and the public trust. In: Instream Flow Protection in the West. Lawrence J. MacDonnell, Teresa A. Rice, and Steven J. Shupe, editors. Natural Resources Law Center, Boulder, CO. Pp. 103-135.

Estes, Christopher C., and John F. Orsborn. 1986. Review and analysis of methods for quantifying instream flow requirements. *Water Resources Bulletin* 22(3): 389-398.

Fontane, Darrell G., and Marshall Flug. 1991. Introduction to multi criteria methods and selected software. In: Water Resources Planning and Management and Urban Water Resources. Jerry L. Anderson, editor. American Society of Civil Engineers, New York, NY. Pp. 449-453.

Garn, Herbert S. 1986. Quantification of instream flow needs of a Wild and Scenic River for water rights litigation. *Water Resources Bulletin* 22(5): 745-751.

Giffen, R. Alec, and Drew O. Parkin. 1992. Using systematic field evaluations to determine instream flow needs for recreation. Land and Water Associates, Hallowell, ME. 19 p.

Gilliland, Martha W., et al. 1985. Regulation and decision making: the Platte River basin in Nebraska. *Water Resources Bulletin* 21(2): 281-290.

Hansen, LeRoy T., and Arne Hallam. 1991. National estimates of the recreational value of streamflow. *Water Resources Research* 27(2): 167-175.

Harris, Charles C., B.L. Driver, and William J. McLaughlin. 1989. Improving the contingent valuation method: a psychological perspective. *Journal of Environmental Economics and Management* 17: 213-229.

Hill, Mark T., William S. Platts, and Robert L. Beschta. 1991. Ecological and geomorphological concepts for instream and out-of-channel flow requirements. *Rivers* 2(3): 198-210.

Huser, Verne. 1984. The needs, interests and concerns of the private river recreationist. In: Proceedings, 1984 National River Recreation Symposium. Joseph S. Popadic, et al., editors. Louisiana State University, Baton Rouge, LA. Pp. 46-55.

Hyra, Ronald. 1978. Methods for assessing instream flows for recreation. In: Instream Flow Information Paper No. 6, U.S. Fish and Wildlife Service FWS/OBS-78/34, Fort Collins, CO. 52 p.

Jackson, William L., Anthony Martinez, P. Cuplin, Bo Shelby, William L. Minkley, P. Summers, D. McGlothlin, and Bruce P. Van Haveren. 1987. Assessment of water conditions and management opportunities in support of riparian values, San Pedro River, Arizona. Report to USDI Bureau of Land Management, Denver, CO. 180 p.

___, Bo Shelby, Anthony Martinez, and Bruce P. Van Haveren. 1989. An interdisciplinary process for protecting instream flows. *Journal of Soil and Water Conservation* 44(2): 121-127.

Johnson, Neil S., and Richard M. Adams. 1988. Benefits of increased streamflow: the case of the John Day River steelhead fishery. *Water Resources Research* 24(11): 1839-1846.

Just, Rinda. 1990. Recreational instream flows in Idaho: instream flows—they're not just for fish anymore. *Rivers* 1(4): 307-312.

Knopf, Richard. 1988. Human experience of wildlands: a review of needs and policy. *Western Wildlands* 14(3): 2-7.

Knotts, David M., and Michael H. Legg. 1984. A two-step filter system for evaluating the canoe recreation potential and aesthetic quality of slow-moving rivers. In: Proceedings, 1984 National River Recreation Symposium. Joseph S. Popadic, et al., editors. Louisiana State University, Baton Rouge, LA. Pp. 545-560.

Lamb, Berton L. 1989. Quantifying instream flows: matching policy and technology. In: Instream Flow Protection in the West. Lawrence J. MacDonnell, Teresa A. Rice, and Steven J. Shupe, editors. Natural Resources Law Center, Boulder, CO. Pp. 23-39.

Lant, Christopher L., and Jo Beth Mullens. 1991. Lake and river quality for recreation management and contingent valuation. *Water Resources Bulletin* 27(3): 453-460.

Litton, R. Burton, Jr. 1984. Visual fluctuations in river landscape quality. In: Proceedings, 1984 National River Recreation Symposium. Joseph S. Popadic, et al., editors. Louisiana State University, Baton Rouge, LA. Pp. 369-383.

Loomis, John B. 1987. The economic value of instream flow: methodology and benefit estimates for optimum flows. *Journal of Environmental Management* 24: 169-179.

___, and Joseph Cooper. 1990. Economic benefits of instream flow to fisheries: a case study of California's Feather River. *Rivers* 1(1): 23-30.

___, and George L. Peterson. 1984. Economic information in river recreation management. In: Proceedings, 1984 National River Recreation Symposium. Joseph S. Popadic, et al., editors. Louisiana State University, Baton Rouge, LA. Pp. 260-271.

Mandelker, Daniel R. 1992. *NEPA Law and Litigation*. Second edition, Clark Boardman Callaghan, Deerfield, IL. (looseleaf)

Manfredo, Michael J., B.L. Driver, and Perry J. Brown. 1983. A test of concepts inherent in experience based setting management for outdoor recreation areas. *Journal of Leisure Research* 15(3): 263-283.

Mathews, Raymond C., and Yixing Bao. 1991. The Texas method of preliminary instream flow assessment. *Rivers* 2(4): 295-310.

McDonald, Cary D., William E. Hammitt, and F. Dominic Dottavio. 1984. An individual's willingness to pay for a river visit. In: Proceedings, 1984 National River Recreation Symposium. Joseph S. Popadic, et al., editors. Louisiana State University, Baton Rouge, LA. Pp. 605-618.

Merrill, Troy, and Jay O'Laughlin. 1992. Methods for determining instream flow for recreation: results from a survey of experts. Contribution 667, Idaho Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow, ID. 35 p.

Moore, Steven D., Mary E. Wilkosz, and Stanley K. Brickler. 1990. The recreational impact of reducing the "laughing waters" of Aravaipa Creek, Arizona. *Rivers* 1(1): 43-50.

Morris, James A. 1976. Instream flow evaluation for outdoor recreation. In: Proceedings, Instream Flow Needs, (Boise, ID). American Fisheries Society, Bethesda, MD. Volume II: 352-358.

Olive, Stewart W. 1981. Protecting instream flows in Idaho: an administrative case study. U.S. Fish and Wildlife Service FWS/OBS-82/35, Washington, D.C. 30 p. Reviewed in *Rivers* 1(4): 318-321 (1990).

Patrino, Beth. 1991. Getting to know FERC. *Rivers* 2(1): 83-86.

Peterson, George L., B.L. Driver, and Robin Gregory. 1988. *Amenity Resource Valuation: Integrating Economics with Other Disciplines*. Venture Publishing, State College, PA. 260 p.

Peterson, George L., and Cindy F. Sorg. 1987. Toward the measurement of total economic value. USDA Forest Service General Technical Report RM-148, Fort Collins, CO. 44 p.

Ribe, Robert G. 1989. The aesthetics of forestry: what has empirical preference research taught us? *Environmental Management* 13(1): 55-74.

Rigby, Ray, John Rosholt, Scott Reed, A. Kenneth Dunn, Brian Donesley, Reed Hansen, Gene Gray, J.D. Williams, and R. Keith Higginson. 1991. In defense of Idaho's water: a report to Governor Cecil D. Andrus. Boise, ID. 33 p.

Sanders, Larry D., Richard G. Walsh, and John B. Loomis. 1990. Toward empirical estimation of the total value of protecting rivers. *Water Resources Research* 26(7): 1345-1357.

Schaefer, Joseph M., and Mark T. Brown. 1992. Designing and protecting river corridors for wildlife. *Rivers* 3(1): 14-26.

Schreyer, Richard. 1980. Survey research in recreation management—pitfalls and potentials. *Journal of Forestry* 82(6): 338-340.

___, Richard C. Knopf, and Daniel R. Williams. 1984. Reconceptualizing the motive-environment link in recreation choice behavior. In: Proceedings, Recreation Choice Behavior Symposium. USDA Forest Service General Technical Report INT-184, Missoula, MT. Pp. 9-17.

Shelby, Bo, Bruce P. Van Haveren, William L. Jackson, Douglas Whittaker, D. Prichard, and D. Ellerbroek. 1990. Resource values and instream flow recommendations, Gulkana National Wild River, Alaska. Report to USDI Bureau of Land Management, Denver, CO. 76 p.

___, and William L. Jackson. 1991. Determining minimum boating flows from hydrologic data. *Rivers* 2(2): 161-167.

___, Thomas C. Brown, and Jonathan G. Taylor. 1992. Streamflow and recreation. USDA Forest Service General Technical Report RM-209, Fort Collins, CO. 26 p.

Shupe, Steven J. 1989. Keeping the waters flowing: streamflow protection programs, strategies and issues in the West. In: Instream Flow Protection in the West. Lawrence J. MacDonnell, Teresa A. Rice, and Steven J. Shupe, editors. Natural Resources Law Center, Boulder, CO. Pp. 1-21.

Shuttleworth, Steven. 1980. The use of photographs as an environment presentation medium in landscape studies. *Journal of Environmental Management* 11: 61-76.

Smith, W.B. 1990. The controversial effects of instream flow determinations. *Rivers* 1(1): 3-5.

Stevens, Lawrence N. 1984. The Wild and Scenic Rivers Act: in perspective. In: Proceedings, 1984 National River Recreation Symposium. Joseph S. Popadic, et al., editors. Louisiana State University, Baton Rouge, LA. Pp. 6-14.

Stromberg, Julie C., and Duncan T. Patten. 1990. Riparian vegetation instream flow requirements: a case study from a diverted stream in the eastern Sierra Nevada, California, USA. *Environmental Management* 14(2): 185-194.

___, and ___. 1991. Instream flow requirements for cottonwoods at Bishop Creek, Inyo County, California. *Rivers* 2(1): 1-11.

___, ___, and Brian D. Richter. 1991. Flood flows and dynamics of Sonoran riparian forests. *Rivers* 2(3): 221-235.

Tarlock, A. Dan. 1978. Appropriation for instream flow maintenance: a progress report on "new" public western water rights. *Utah Law Review* 21(2): 211-247.

___. 1990. A decade of instream flow literature in context: review of government publications. *Rivers* 1(1): 70-73.

___. 1991. Western water rights and the [Endangered Species] Act. In: *Balancing On The Brink Of Extinction: The Endangered Species Act and Lessons for the Future.* Kathryn A. Kohm, editor. Island Press, Washington, D.C. Pp. 167-180.

___. 1992. *Law of Water Rights and Resources.* Release #4, Clark Boardman Callaghan, Deerfield, IL. (looseleaf)

Tennant, Donald Leroy. 1976. Instream flow regimens for fish, wildlife and recreation and related resources. In: Proceedings, Instream Flow Needs, Boise, ID. American Fisheries Society, Bethesda, MD. Volume II: 359-375; see also *Fisheries* 1(4): 6-10 (1976).

Trelease, Frank J., and George A. Gould. 1986. *Water Law, Cases and Materials.* Fourth edition, West Publishing Co., St. Paul, MN. 816 p.

Turner, Allen C., and Jay O'Laughlin. 1991. State agency roles in Idaho water quality policy. Report No. 5, Idaho Forest, Wildlife and Range Policy Analysis Group, University of Idaho, Moscow, ID. 212 p.

U.S. Fish and Wildlife Service. 1991. Region 1 news. *Endangered Species Technical Bulletin* 16(6): 2.

Van Haveren, Bruce P. 1986. Management of instream flows through runoff detention and retention. *Water Resources Bulletin* 22(3): 399-404.

___, William L. Jackson, Anthony Martinez, Bo Shelby, and Lou Carufel. 1987. Water rights assessment for Beaver Creek National Wild River, Alaska. USDI Bureau of Land Management BLM/YA/PT-87/014 + 7200, Denver, CO. 232 p.

Wallace, Joseph P. 1984. Developing a river management plan in a regional context. In: Proceedings, 1984 National River Recreation Symposium. Joseph S. Popadic, et al., editors. Louisiana State University, Baton Rouge, LA. Pp. 110-115.

Walsh, Richard G., Larry D. Sanders, and John B. Loomis. 1984. Measuring the economic benefits of proposed wild and scenic rivers. In: Proceedings, 1984 National River Recreation Symposium. Joseph S. Popadic, et al., editors. Louisiana State University, Baton Rouge, LA. Pp. 301-315.

Ward, Frank A. 1987. Economics of water allocation to instream uses in a fully appropriated river basin: evidence from a New Mexican Wild River. *Water Resources Research* 23(3): 381-391.

Whittaker, Doug, editor. 1991. Workshop Summary: Workshop on Instream Flows for Recreation, Corvallis, OR. National Park Service, Anchorage, AK. 41 p.

Wilkinson, Charles F. 1990. The historical context of instream flows. *Rivers* 1(1): 6-7.