STATUS OF INSTREAM FLOW LEGISLATION AND PRACTICES IN NORTH AMERICA

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ABSTRACT

This paper presents the results of two nonstatistical surveys (completed in 1981 and 1986) that solicited information from state and federal agencies concerning instream flow issues and practices in North America. Forty-six states and 12 Canadian provinces responded to the survey. Fifteen of the 46 states reported legislative recognition of instream flows for fisheries protection. In Canada, individual provinces generally lacked instream flow legislation, although federal legislation existed that could be used. The most commonly applied method (in use in 38 states or provinces) for assessing instream flow requirements, as reported in the survey, was the Fish and Wildlife Service Instream Flow Incremental Methodology (IFIM). Major research needs cited by survey respondents included (1) more species habitat information and preference curves, (2) techniques for determining instream flows for atypical conditions, and (3) testing of fish habitat:flow:production relationships.

Increases in the number of proposed water development projects in North America have forced fisheries biologists to predict the level of effects that result from such projects. When water is developed for agricultural, municipal, industrial, and power production uses, the magnitude, timing and duration of natural flows may be altered, thereby affecting the availability and quality of fisheries habitat (Peters 1982). Therefore, the biologist needs to determine the amount of water that must be left in the stream to maintain aquatic resources at some desired level. Such flows are often termed "instream flows." To this end, a number of formal methodologies for prescribing instream flow (IF) needs have been developed (Stalnaker and Arnette 1976; Wesche and Rechard 1980; EA Engineering, Science, and Technology, Inc. 1986).

Today, although various state and federal resource agencies agree that instream flows for fisheries should be a recognized use of water, they differ as to how instream flows are legally perceived and/or derived. In addition, because of geographic differences, instream flow problems will vary by region with fish species (Peters 1982).

In 1981, the Water Development and Streamflow Committee (WDASC) of the Western Division of the American Fisheries Society (WDAFS) surveyed the western United States and part of Canada and Mexico (WDAFS 1981) regarding IF procedures and programs and to assess their effectiveness for providing flows to sustain fishery resources. The WDASC repeated and expanded the survey in 1986 to include all of North America. In this paper, we summarize the results of both surveys, emphasizing the expanded 1986 survey. McKinney and Taylor (1988) provides a more comprehensive summary of some western state programs and we recommend it as a supplement to this paper.

Survey Format

We undertook the 1986 survey by mail using a questionnaire patterned after the 1981 survey, the results of which were summarized but never formally published (WDAFS 1981). The questionnaire solicited information on:

- status, title, and effectiveness of current instream flow legislation;
- name of agency(ies) administering instream flow activities;
- methods used for assessing IF needs;
- basis for selecting a given method;
- ways in which field results are used in formulating an IF recommendation;
- major IF related research needs; and
- other concerns related to IF's.

We sent 202 questionnaires to 186 agencies in the 50 states and to 16 agencies in 12 Canadian provinces that administer fish and wildlife resources, and in some instances water resources. For many states, we also sent questionnaires to the federal agency administering federal regulations in that area, e.g., Fish and Wildlife Service (FWS).

Survey Results

We received responses to 100 of the 202 mailed questionnaires, a return rate of 49.5%. The non-responding states, provinces, and territories were Connecticut, Iowa, Maryland, District of Columbia, Prince Edward Island, Quebec, Saskatchewan, and the Yukon Territory. Summary responses for each state or province are presented in Table 1.

Instream Flow Legislation

Fifteen of 46 states (33%) reported legislative recognition of instream flows for fish and aquatic resource protection (Fig. 1). Several noted that other related legislation addressed instream flows; most commonly, statutes concerning water quality and quantity for industrial, agricultural, and domestic uses. Not surprisingly, 9 of the 15 states (60%) that have IF legislation are in the western U.S. where the concept for and impetus behind the preservation of instream flows for fish and wildlife had its origins (Fig. 1). Water law in

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Table 1. Summary of responses to the 1986 instream flow questionnaire

State/province	Status of IF legislation	Title of IF legislation	Effectiveness of legislation	Agencies administering IF	IF field methods used	Major IF research needs
Alabama	None	N/A	N/A	FERC, AL Dept. Environ. Mgt; COE	IFIM, AVDEPTH, Tennant	Test validity of IFIM on resident cool and warmwater species; development of preference curves for these species
Alaska	Enacted	AS 46.15.145 of the AK Water Use Act	Untested	AK DNR; AK Dept. Fish & Game	IFIM, Tennant, and other proven methods	Need methods tested and modified for Alaskan conditions; local preference curves, better fish data bases, more gauging stations
Arizona	None; legislation was proposed for 1986 but not introduced	N/A	N/A	AZ Dept. Water Res. BOR, USFWS	IFIM	Preference curves for native species including T&E; do the species including T&E; do the parameters of depth, velocity, substrate and cover adequately predict fish habitat
Arkansas	Enacted	State Act 1051	Untested	AR Soil and Water Comm.	AR method, (discharge) testing, IFIM	Validation of models; develop better mechanistic models based on biomass and numbers; emphasis on evaluating community rather than 1-2 indicator species
California	None (related legislation: Section 5937 of Fish and Game Code)	N/A	N/A	State Water Res. Control Board; CA DF&G determines need and quantity	IFIM (IFG4); USFS has used R-2 cross; other methods considered	Validation of models; flushing flow studies; need more generalized stream models that work with invertebrates; evaluate effects of prolonged low flows on fish populations; is tributary recruitment sufficient to seed mainstem habitat; remove subjectivity of IFIM so it can be uniformly applied
Colorado	Enacted	Senate Bill 97 (passed in 1973); additional legislation in 1987	Variable	CO Water Conserv. Board; flow recommendations made by CO Div. Wildlife	R-2 Cross, as specified in S.B. 97; select cases use IFIM	Validation of weighted useable area (WUA) as a function of fish population; i.e., does habitat relate to fish?
Delaware	None	N/A	N/A	N/A	Evaluate water quality with respect to flow	Instream flows are not a major issue in Delaware and no instream flow problems have developed in the state
Florida	None (related legislation)	N/A	N/A	FL Game and Fresh. Fish. Comm; FL DNR; FL Dept. Env. Reg.	Based on water quality standards and local conditions	Need to determine optimal flow for river systems; address problems of water quality and flow fluctuations
Georgia	None (related legislation)	N/A	N/A	GA Environ. Protection Div; GA Water Res. Mgt.	7Q10; IFIM (PHABSIM)	Need habitat curves for eastern streams; need new techniques for southeastern streams
Hawaii	Enacted	HI Instream Use Act of 1982	Untested	HI Dept. Land & Nat. Res. Div. of Water & Land Dev.	IFJM is being tested; have used Q90 values	Need to define microhabitat requirements of native stream fauna (molluscs, gobies, etc); correlate habitat to fish production; determine applicability of IFIM to high gradient streams
Idaho	Enacted	1978 Minimum Streamflow Act	Unknown	ID Dept. Water Res; ID Dept. Fish & Game makes recommendations	IFIM; Wetted Perimeter	Need more stream and species-specific probability-of-use information
Illinois	None	N/A	N/A	IL Div. of Water Res.	IFIM	Need definition of relationship of flow:habitat:fish population
Indiana	Enacted (several codes relate to flow releases from dams)	IN Code 13-2-6.1, Water Resource Mgt.	Untested	Nat. Res. Comm. of IN DNR, Div of Water provides tech. input	IFIM (IFG4 & WSP); Tennant	Determine which streams need IF protection and how to set flow needs; more individuals trained in IF methods
Kansas	Enacted	1980 Minimum Desirable Streamflow Act	High	Chief Engineer, Div. of Water Res. of Board of Agriculture	IFIM	Validate response of standing crops to varying flow regimes; assess adequacy of established minimum flows
Kentucky	None (pending)	N/A	N/A	KY Div. Water. Nat. Res. & Environ. Protection	Professional judgment; Tennant	More streamflow data for the state, present coverage is thin; flushing flows; water quality effects; low flow augmentation for wastewater plants
Louisiana	None	N/A	N/A	Not Stated	Little need for IF determinations	Preference curves for warmwater stream fishes
Maine	None (related legislation)	N/A	N/A (Related legislation is effective)	ME Dept. Environ. Protection; Dept. Inland Fisheries & Wildlife	HEP and IFIM and modifications thereof; also professional judgment	Accurate predictive models for small watersheds; preference curves for northeastern species; assess population response to flow establishment (follow-up studies); habitat inventories of all watersheds; fish behavior studies related to flow regulations; techniques for using HEP and IFIM in deep, riverine habitat; assess effects of winter-time flow regulation; assess effects of flow regulation on substrate composition

Table 1. (*continued*)

State/province	Status of IF legislation	Title of IF legislation	Effectiveness of legislation	Agencies administering IF	IF field methods used	Major IF research needs
Massachusetts	None	N/A	N/A	MA Water Res. Comm; MA Div. Fisheries & Wildlife	MA Balance; Aquatic baseflow; 7Q10	Habitat requirement data of important eastern species for use with IFIM; information on minimum flow needs in flow-through ponds
Michigan	None	N/A	N/A	MI DNR, State Water Res. Comm.	Wetted Perimeter; velocity-habitat method (similar)	HSI model verification; HSI model development for invertebrates; HSI development for nongame fish species
Minnesota	Enacted (1977, 1981)	MN Statutes 195.39, Sub 1, 105.41	Effective	MN DNR. Div. of Waters	In the process of reviewing methods	Assess applicability of existing HSI curves for fish species in Minnesota; develop techniques to assess impacts of peaking flows on aquatic systems; evaluate existing IF methods for use in MN; test validity of fish biomass - habitat relationships
Mississippi	None (attempted but failed in legislature)	N/A	N/A	MS Bureau of Pollution Control; MS Dept. Wildlife & Fisheries	IFIM; also standard hydrological methods	Suitability indices for warmwater systems in southeastern U.S.; research to assess effects of diverted streams and gravel operations
Missouri	Pending (water bill introduced into 1986 legislation)	House Bill 1470	Untested	MO DNR; MO Dept. of Conserv.	IFIM (WSP and IFG4); Tennant; personal experience	More models; more stream gauges to monitor discharge
Montana	Enacted	Water Use Act of 1973	Effective	MT Dept. Fish Wildlife and Parks quantifies rights; DNR and Conserv. reviews applications; Board of Nat. Res. & Conserv. grants rights	Wetted perimeter/inflection point; others considered	Summarize data of biological responses to flows; flow needs for wetlands and riparian habitats; impacts of rapid fluctuations on fish; biological needs of flushing flows; assess impacts of winter water depletion on fish; assess effects on existing small hydro on fish; legal means to augment flows in depleted streams
Nebraska	Enacted (1984)	Instream Appropriations, 46.2, 107 to 46.2, 119; Bill 1106	Untested	NE Nat. Res. Districts (24); NE Game & Parks Comm. specifies reaches; Nat. Res. Comm. files application; Director Wat. Res. grants permit	None specified	Determine channel maintenance flows in alluvial streams; can cross section change in dominant discharge be used to predict long term change in width, depth, etc.
Nevada	None	N/A	N/A	NV State Water Engineer; NV Dept. of Wildlife	None specified	None at present
New Hampshire	None (attempted but failed in legislature)	N/A	N/A	NH Fish & Game; NH Water Res. Board	Aquatic Base Flow; IFIM; HEC-2; site specific data; historical flow data	Suitability curves for northeastern species including Atlantic salmon; determine if differences in SI curves exist between large and small streams
New Jersey	None	N/A	N/A	NJ Dept. of Environ. Protection, Div. of Water Res.	MT Method; New England Method; 7Q10	Better define characteristics of New Jersey's streams; develop minimum flow procedure that will protect aquatic biota; define minimum flows to protect fresh/salt-water interface; more information on fish screening and passage
New Mexico	None (attempted but failed in legislature)	N/A	N/A	NM State Water Engineer	No specific methods; IFIM has been used	Develop curves for T&E species; determine habitat needs of native fish species
New York	None	N/A (regional legislation passed for 31 reservoir releases)	Inadequate	NY Dept. of Environ. Conserv.; Div. of Fish & Wildlife; Div. of Reg. Affairs; NY Dept. of Health	IFIM, professional "eyeballing," flow duration curves	Improved habitat electivity curves for fish & aquatic invertebrates; establish flow; habitat:production relationships; develop electivity curves for recreational activities (boating, fishing, etc.) water quality-flow relationships; assess effects of pulsing or peaking flows
North Carolina	None (related legislation)	N/A	Cumbersome	NC Div. of Wildlife; Res. Div. of Water Res.; Div. of Environ. Mgt.	IFIM, wetted perimeter, September median flow	Warmwater riverine fish preference curves
North Dakota	None	N/A	N/A	ND State Water Comm.; Game & Fish Dept.	Tennant	Habitat needs of forage and gamefish of intermittent prairie streams; better fisheries data on streams; define physical parameters relating habitat to flow; data to define minimal flow needs
Ohio	None	N/A	N/A	OH DNR. Div. of Water	Standard USGS methods	Assess impacts of flow modification due to small scale hydro; need adequate staff and funding to work on instream flow problems
Oklahoma	None	N/A	N/A	OK Water Res. Board	IFIM, Tennant	Determine flow requirements for optimum sportfishing; transbasin flow diversions; impacts of flow regulation on fisherman use; evaluate significance of intermittent streams; develop IF methods for large rivers; work on water quality models

Table 1. (*continued*)

State/province	Status of IF legislation	Title of IF legislation	Effectiveness of legislation	Agencies administering IF	IF field methods used	Major IF research needs
Oregon	Enacted	ORS 536.325 (1985)	Untested	Water Res. Comm.; OR Dept. of Fish & Wildlife (determines flow needs)	IFIM and versions; Oregon method	Evaluate IFIM habitat: flow relationships; develop and validate low cost methods for water resources planning and small projects
Pennsylvania	Enacted	Clean Streams Law of 1975	Low flows still impact fisheries	PA Dept. of Water Res.; PA Fish Comm.	Q(7-10); 30% Avg. Annual Flow (Tennant); 0.25 cfsm	Effects of water quality, flow fluctuations and reduced flow; validate IFIM; and validate fish models for eastern streams
Rhode Island	None	N/A	N/A	RI Div. of Fish & Wildlife	N/A	Current wetlands and dam legislation allows control of instream flows
South Dakota	None (under consideration)	N/A	N/A	SD Dept. Game, Fish & Parks; SD Dept. Water & Nat. Res.	IFIM; sag tape (cursory surveys)	Habitat suitability curves of midwestern fishes; refine and document hydraulic models; water quality changes related to flow regulation; assess fish populations in all SD streams; match populations to available habitat
Tennessee	None (related legislation)	N/A	N/A	TN Office of Water Mgt; TN Wildlife Res. Agency; TVA	IFIM; visual assessment	None stated
Texas	Enacted	House Bill 2, 1985; Parks & Wildlife Code 12.0011 and 12.024	Untested	TX Water Comm.; TX Water Development Board; TX Parks & Wildlife Dept.	IFIM	Assess surface water availability for future development; more extensive data base; effects of flow fluctuations and water quality changes
Utah	Enacted	House Bill 58; Instream Flow Amendment 1986	Untested	UT Div. of Water Res.; UT Div. Wildlife Res. (recommend flows)	IFIM; Tennant	Effects of peaking on fisheries; improve preference curves of cutthroat trout; develop preference curves for non-game-fish; test habitat: fish population relationships; establish flushing flow methods
Vermont	None (attempted in 1974–1980)	N/A	N/A	VT Dept. of Fish & Wildlife; VT Dept. of Water Res.	VT Fisheries Flow Needs Method; IFIM; New England Aquatic Baseflow (ABF)	Regional habitat suitability curves; effects of short-term flow fluctuations on habitat use; long-term effects of flow by-pass on channel morphology; test relationship of flow and fish community structure, growth and abundance
Virginia	None (related legislation)	N/A	N/A	VA State Water Control Board; VA Comm. of Game & Inland Fisheries	Wetted perimeter; 7Q10; IFIM	Validate suitability models for eastern streams; verify model use for warmwater streams; test relationship of habitat and fish production; assess long-term changes in fish population resulting from flow regulation; are instream flows a limiting factor to fish
Washington	Enacted	Minimum Water Flows and Levels Act (1969); Water Resources Act of 1971	Effective but controversial	WA Dept. of Ecology; WA Dept. of Game; WA Dept. Fisheries	IFIM; USGS Toe-Width; Tennant	Methods for high gradient streams; improved salmonid habitat preference curves; verification of habitat preference curves; need big river flow models; test fish production vs. habitat/flow
West Virginia	None	N/A	N/A	WV DNR Wildlife Div.	IFIM; Aquatic Baseflow (ABF); Tennant	More species specific biological information; evaluate fluctuating flows
Wisconsin	None (related legislation)	N/A	N/A (Related legislation effective)	WI DNR	IFIM, hydraulic models; habitat computation using Reynold's numbers; judgment; water quality	Regional life history information; life history information for invertebrates; more hydrological data and gauging stations; user friendly IFIM software
Wyoming	None (attempted but failed in 1985)	N/A	N/A	WY Game and Fish Dept. WY State Conserv. Comm.	IFIM (IFG-4, IFG-1); Habitat Quality Index (HGI); Tennant	Validation of IFIM; winter flow needs; flushing flows; verification of flow recommendations
CANADA						
Alberta	None (related legislation)	N/A	N/A	AB Fish and Wildlife Div.; AB Environ.	Tennant, IFIM	More acceptable biological curves; personal computer programs; hydraulic models for use in ice-covered conditions; public relations to raise awareness of instream flows
British Columbia	None (related legislation)	N/A	Less than 0.5% of water allocated for IF use	BC Ministry of Environ., Water Mgt. Branch; Fish and Wildlife Branch	Tennant; Wetted perimeter; IFIM	Calibrate MT Method to BC validate flow; fish population relation; develop methods to assess recreational needs; multidisciplinary approach to IF studies; validate habitat models
Manitoba	None (related legislation)	N/A	N/A	Government of MB, Water Res. Branch	IFIM; Tennant; correlate year class to spawning flow	Optimum flows for overwintering fish and egg incubation; maximum and minimum flows for spawning; relationship of low flow to water quality
New Brunswick	None (related legislation)	N/A	N/A	NB Dept. of Municipal Affairs and Environ.	25% of Avg. Ann. Flow (Tennant); IFIM	Entire range of instream flow research is needed
Northwest Territories	None (related legislation)	N/A	N/A	Dept. Renewable Res.	N/A	Review of instream flow related research

Table 1. (*continued*)

State/province	Status of IF legislation	Title of IF legislation	Effectiveness of legislation	Agencies administering IF	IF field methods used	Major IF research needs
Nova Scotia	None (related legislation)	N/A	N/A	NS Dept. of Environ.	Tennant; IFIM	Determine if habitat changes influence fish populations; validate hydraulic models; assess salmonid overwintering requirements; assess effects of short-term flow reductions
Newfoundland Labrador	None	N/A	N/A	Dept. of Environ.	Tennant, WSP, IFIM	Examine production vs. flow relationships; develop habitat preference curves for local species; assess river geomorphometry as it relates to flow change
Ontario	None (related legislation: Canada Fisheries Act)	N/A	N/A	ON Ministry of Nat. Res.; Ministry of Environ.	Use various methods - none preferred; have used IFIM; water quality models	Develop data base of flow use and cross-sectional area for important habitats; assess relationship between life stages and flows; evaluate IF methods for Canada; adapt IF methods for other uses; develop methods to evaluate water quality problems; integrate risk assessment into water quality studies

the West is primarily based on the doctrine of prior appropriation which states, "first in time is first in right"; whereas the riparian doctrine predominates in the East. The prior appropriation doctrine has put a premium on unappropriated water in western streams. Three western states, Arizona, New Mexico, and Wyoming noted that legislation had been introduced for consideration, but had failed to pass (note: Wyoming passed IF legislation in 1986).

Six eastern states reported having a formal IF protection statute. In Mississippi, New Hampshire, and Vermont legislation had been introduced but failed to pass; in Kentucky, Missouri, South Dakota, and Virginia legislation was pending as of 1986. The importance of IFs is apparently becoming widely recognized.

Most respondents indicated the effectiveness of newly enacted legislation was largely "untested." States that reported legislation as "effective" include Kansas, Minnesota, Montana, and Washington. Even among these, problems related to budget, overappropriation, and controversy were cited. Passage of formal legislation does not guarantee preservation of fishery resources, although it is an important and necessary first step.

In Canada, formal IF legislation was generally lacking. However, the majority of the provinces noted that related legislation existed that can be used for protecting instream resources. In particular, the Canada Fisheries Act, in force in all of Canada, specifies that the Ministry of Fisheries and Oceans can designate a sufficient flow to protect fishery resources. In Alberta, Saskatchewan, Manitoba, and Ontario (4 of 10 provinces) execution of the act has been delegated to the province. Where it has been applied, it has been effective. An abundance of water and a historical low demand for the resource were cited as reasons for lack of IF legislation in Newfoundland. Indeed, most streams and rivers in Canada remain free-flowing and unregulated. Thus, competition for a limited water resource has not become as intense as in the United States. Canada has the enviable position of having the opportunity to adopt instream flow legislation and reserve instream flows before intense resource competition develops.

Use of Instream Flow Methodology

Respondents reported a wide array of methods for determining instream flows (Fig. 2), ranging from office methods such as the Tennant (1975) and Aquatic Baseflow (ABF; USFWS 1981) techniques which are based largely on historical flow records, to field/office methods such as the Instream Flow Incremental Methodology (IFIM; Bovee 1982) and the Habitat Quality Index

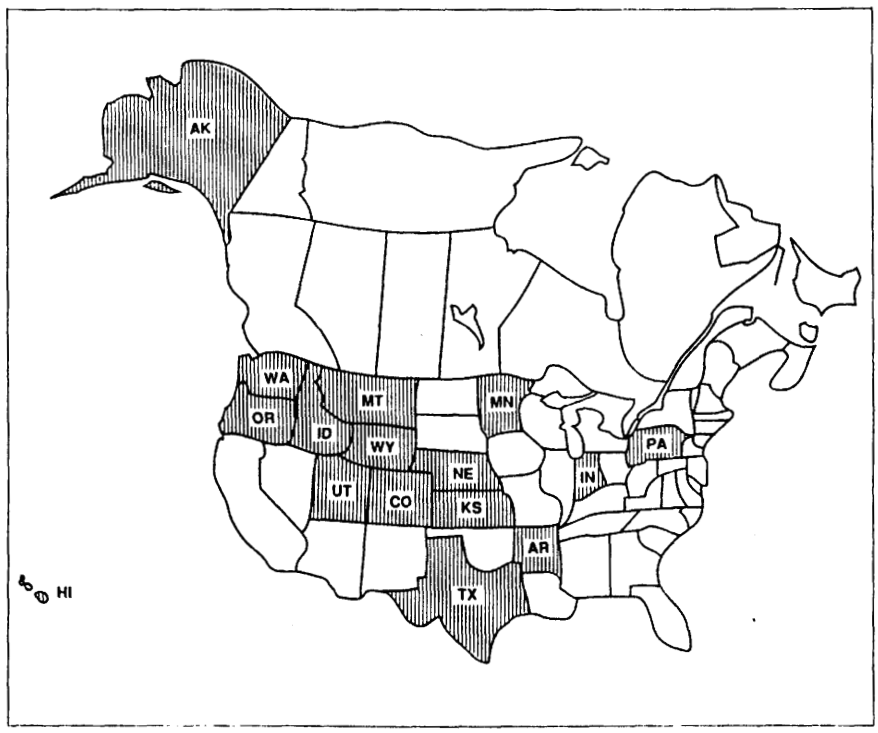

Figure 1. States having formal instream flow legislation as of 1986.

(HQI; Binns and Eiserman 1979) in which the collection of detailed field data is integral to making flow recommendations. We refer the reader to the summary review reports of Wesche and Rechard (1980), Stalnaker and Arnette (1976), EA Engineering, Science, and Technology, Inc. (1986), and the proceedings of the Symposium on Instream Flow Needs (Orsborn and Allman eds. 1976), for detailed information on specific methods.

The most commonly used instream flow method is the IFIM. This method was cited as being used in 38 states or provinces, and was listed by 24 respondents as the preferred method. In California, Washington, and Idaho it is the required technique for conducting instream flow studies. The IFIM and its component computer software package, the Physical Habitat Simulation (PHABSIM) system, were derived in the late 1970s by the FWS Instream Flow Group (IFG) (now the Instream Flow and Aquatic Systems Group), in Fort Collins, Colorado. The method was a modification of earlier techniques (Waters 1976; Collings 1972), which provided incremental assessments of effects of flow reduction on fish habitat. Unlike other methodologies, the IFIM is an interdisciplinary process used to evaluate the effects of individual or combined flows on habitat availability for individual or combinations of species and life phases. The most commonly practiced IFIM technique is to collect physical and biological data following procedures that allow for analyses using the PHABSIM, a series of computer programs. The IFIM provides the most detailed and graphic approach for assessing effects of water resource developments on fish habitat. Due to its utility, the many reports and information papers produced by the IFG since 1976, and the IFG short-course offerings of "hands-on" training, it is not surprising that the IFIM is so widely applied today.

The Tennant Method is frequently used in selected states and provinces. Twelve respondents listed the method as commonly used, usually as an office technique for providing reconnaissance-level evaluations of instream flow requirements. In Alaska, New Jersey, and North Dakota, the Tennant Method or a modification thereof (Estes 1987) was cited as the primary technique for deriving instream flow recommendations. In North Dakota, it is the only method recognized.

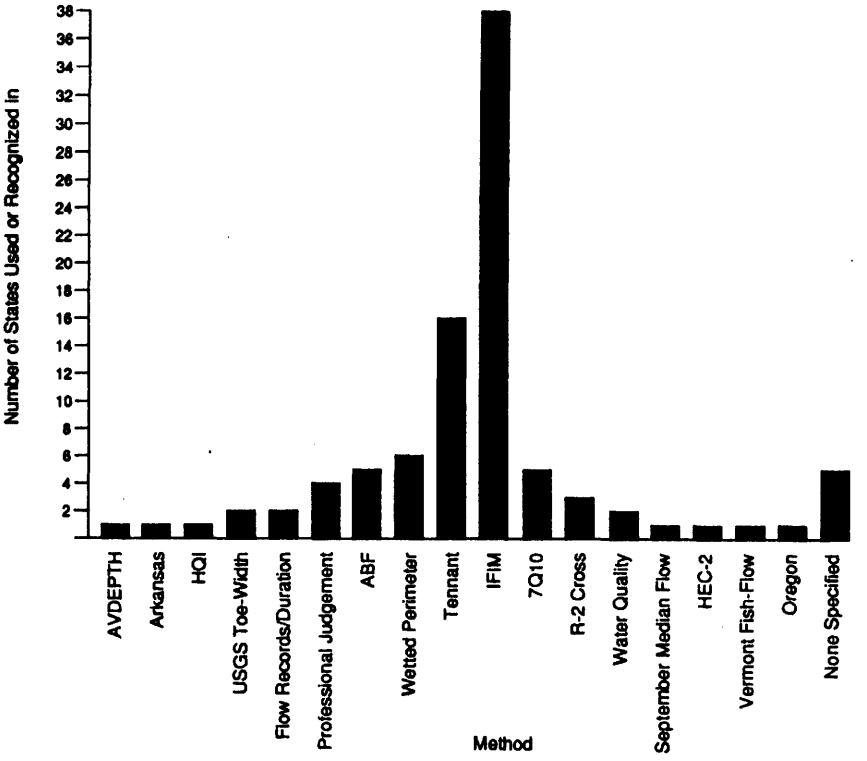

Figure 2. Instream flow methods presently applied in North American and their relative frequency of use. For a description of methods, see Wesche and Rechard (1980), and EA Engineering, Science, and Technology, Inc. (1986).

Other commonly applied methods are the Wetted Perimeter (WP), the ABF, and the 7Q10. The WP method was listed as the primary technique in Michigan and Montana, the latter requiring its use for making instream flow recommendations. The ABF technique was developed for and is used primarily in New England. The 7Q10 method (defined as the flow which is greater than the 7-day 10-year low flow event) is generally applied when instream water quality problems exist. Eastern and southeastern states have used it most frequently (Fig. 2).

Professional judgment was also cited as a viable and currently used approach. We find this encouraging and hope that the application of all methodologies, no matter how complex or sophisticated, leaves room for professional judgment in formulating recommendations.

Several respondents noted that specific methods for quantifying IF requirements have not been designated. Minnesota, for example, was reviewing various methods for applicability to their stream systems. Other states in this category lack a general instream flow statute, for example, Nevada and New Mexico. More states and provinces will probably adopt or require specific methods for conducting IF investigations. This would insure that all studies are conducted and flow recommendations derived using the same techniques. However, there are risks in requiring a set method, the major one being that new or revised methods may be developed which are more appropriate or valid than those previously required. In addition, the complexity and costs for application of a "required" method, may, under some circumstances and for some projects, be more than necessary for assessing flow regulation effects on the aquatic resource, as determined by less rigorous methods. Thus, it may be more appropriate to establish guidelines for determining whether an analysis is valid as opposed to specifying which analysis is performed.

Needs for Instream Flow Research

The major areas of instream flow research cited by respondents as needed are listed on the next page in order of decreasing frequency (the

number of times each area was listed as a primary or secondary need respectively, is shown in parenthesis).

- Need more species habitat information and preference curves developed for local areas, including curves for threatened and endangered (T&E) species, warmwater species, and regional curves developed for eastern, southeastern, and southwestern species (11,4).
- Develop new methods or techniques for determining flow requirements for different conditions. Respondents indicated that specific methods are needed for assessing instream flow problems: in small watersheds and high gradient streams; to assess peaking impacts; for determining channel maintenance flows; for assessing effects of short term flow fluctuations; for sport fishing and recreational needs; to determine incubation flows and overwintering flows; and for planning purposes. (9,10).
- Validate and test the IFIM to determine if Weighted Usable Area (WUA) does relate to fish production (5,1).
- Determine if a relationship exists between Flow: Habitat: Fish Production and define the relationship (5,10).
- Validate and test the existing Habitat Suitability Index Models (HSI) and modify to local conditions (3,2).
- Develop more hydrologic and water resource data throughout the state or province (2,2).
- Develop new and validate existing water quality models (1,5).
- Modify and adapt the IFIM to local conditions (e.g., high gradient streams or large, deep rivers) (0,3).
- Validate existing and develop new hydraulic models (0,3).
- Determine flushing flow requirements for streams (0,3).
- Need more fish life history information (0,2).
- Need more funding support and staff to handle IF issues (0,1).
- Develop public awareness programs explaining the benefits of IF uses (0,1).
- Need to assess the adequacy of existing flows for maintenance of the fishery resource (0,1).

With regard to the most frequently cited research need, preference curves are required for application of the IFIM, and the frequency of interest in this research need relates to the widespread use of the IFIM technique. The development of appropriate curves for use with the IFIM PHABSIM is often the most time-consuming and controversial aspect of its application. Most respondents citing this need were from the eastern and midwestern portions of North America, including Georgia, Louisiana, Massachusetts, Minnesota, Mississippi, New Hampshire, North Carolina, New York, South Dakota, Vermont, and Virginia, where the IFIM PHABSIM has only recently been applied. Two western states, Arizona and New Mexico, cited the need for development of curves for T&E species.

There is still an apparent need for the development of new methods to address specific IF problems. Nineteen respondents cited this need, listing several areas of application. One area receiving little attention to date is that of assessing recreational IF needs. This includes sport fishing opportunities, rafting and canoeing, fish and wildlife viewing, and other recreation associated with riverine systems. To date, essentially all methods have focused on IF requirements from a biological perspective. In the future, methods will be needed for integrating sociological needs into the flow-need assessment process.

The validation of the relationship between flow, habitat, and fish production was cited as a research need 21 times, 6 of which specifically mentioned the validation of the IFIM PHABSIM. All quantitative IF methods in use are based on determining flows needed to meet some quantity of habitat assumed to be crucial for sustaining fish populations. Unfortunately, the linkage establishing a relationship between habitat and fish populations has not been adequately established. Thus, flows necessary for habitat preservation may be different from flows required for sustaining the fish population. Interestingly, it has been a decade since Wesche (1980) noted the fallacy in the then "state of the art" IF methods that no available methodology addresses the question of potential biological consequences. This same deficiency remains today. Although some research has attempted to address this issue, (e.g., Scott and Shirvell 1987; Conder and Annear 1987; Orth and Maughan 1982) the results have been inconclusive, narrowly useful, or controversial in interpretation. Clearly, as indicated by the number of respondents, this area of research should be intensified in the future.

Comparison with 1981 Survey Results

Since 1981, an additional three states have enacted formal IF legislation: Hawaii (limited to certain islands), Utah, and Texas. Wyoming, Arizona, and New Mexico have made repeated unsuccessful attempts to pass IF legislation during 1981–1986; Wyoming has since enacted such legislation.

As in 1986, the 1981 respondents emphasized the need to collect local data on spawning, incubation, rearing, and fish-passage habitat data to refine or develop stream-specific habitat suitability curves. They also stressed the need to improve and simplify procedures for evaluating aquatic habitat alterations and a need to share information and procedures. Some respondents stressed the importance of quantifying federal reserve water rights linked to federal lands (e.g., national forests and lands administered by the Bureau of Land Management). The methods used in 1981 were similar to those employed in 1986 and ranged from IFIM to professional judgment, with the selection of a given method based on the nature of the problem, time, financial and logistical constraints, and the reliability and legal acceptability of the method.

The 1986 survey of instream flow issues reveals increasing emphasis on preserving aquatic resources in North America's rivers. It should be useful not only for comparing present programs among states or provinces, but also for prioritizing research efforts among those areas perceived as most needed and with the widest application. A similar survey in about 5 years (1992) might usefully update the status of instream flow activities in North America.

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