WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

A Guide to Instream Flow Setting in Washington State

DRAFT

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This draft document is available on the Department of Ecology, Water Resources Program webpage at: http://www.ecy.wa.gov/programs/wr/instream-flows/isf_guidance.html

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Fact Sheet

Title:	A Guide to Instream Flow Setting in Washington State
Description:	This optional document is intended for use by watershed planning and other groups developing recommendations for instream flows for water bodies within Washington State. The document discusses selected approaches to instream flow setting, potential environmental effects of flow setting at different levels, and common assessment methods.
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Agency Action:	After formalizing this document as a Programmatic Environmental Impact Statement (P-EIS), Ecology intends to initiate the standard rule adoption process based on instream flow recommendations from watershed and other planning groups.
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Comments on the draft:	Comments on this draft guidance document may be submitted online, by postal mail, facsimile (fax), or hand-delivered. Please provide comments by: March 29, 2002. (Note: This is not a formal comment period. All comments will be considered, but we are not able to respond to each individually.)
Public Meetings and Hearings:	Ecology will meet with various planning groups around the state at their request, and schedule informational workshops as needed.
Subsequent Environmental Review:	Watershed planning and other groups can incorporate this document by reference as part of their environmental analysis. Groups will need to provide additional information at the watershed-specific level to fulfill SEPA. See Bibliography for a list of documents incorporated by reference.
Location of Document Information and Documents Incorporated by Reference:	Water Resources Program Washington Department of Ecology 300 Desmond Drive Lacey, Washington
Requests for hard copies:	Contact Rose Bennett: (360) 407-6624 rben461@ecy.wa.gov
Availability on the Internet:	The document is available at: www.ecy.wa.gov/programs/wr/instream-flows/isf_guidance.html

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I. SUMMARY

This guidance document provides information on the process of setting instream flow levels in Washington State. It is intended to assist groups involved in watershed planning, of which instream flows are an important part. By "instream flow" we mean a stream flow level adopted as a regulation and used for regulating water rights. At the time of this writing, there is active legislation pending on the subject of instream flow setting. Therefore the reader should be cognizant that the current version of this document is accurate and consistent with the legislative process as of January 16, 2002. Later this year, once related legislative actions are finalized and feedback on this document is incorporated, this document will be updated and formalized as a Programmatic Environmental Impact Statement (P-EIS), the creation of which was directed by the state of Washington Legislature in their 2001 Session.

This document is for use by those involved in watershed planning (the so-called "2514 areas", under Chapter 90.82 RCW), groups planning outside the 2514 process, and the Department of Ecology. In particular, it is intended to be of help to those developing instream flows to be adopted into rule. (Planning groups under Ch.90.82 RCW must address flows in their strategies, although recommending flows is optional.)

This guidance paper is ***non-prescriptive*** in nature: rather, it is an informational resource for planning groups and others to use in their discussions leading towards flow recommendations. Central to the document are the descriptions and general comparison of four approaches to flow setting, which together form a continuum ranging from high to low instream flow levels. What we have characterized as "Fish Emphasis Flows" are at the high end of the continuum, with "Out-of-Stream Emphasis Flows" at the lower end. Defining appropriate flow levels requires considering the needs of both instream and out-of-stream uses, and is at the heart of water management decisions. Of course, before any new or revised flow levels can be set in rule, groups must first be in compliance with any current state (and federal) laws and regulations that affect flow levels.

Since setting instream flows needs to be considered in the broader context of environmental impacts, this document provides a detailed – albeit general - analysis of potential impacts on elements of both the natural and human-built environments. Consideration of broad-based impacts and ideas for avoiding or lessening potential problems in the future are then examined. Since groups will need scientifically-based stream-specific information at various points in their planning process, the most common flow assessment methods are discussed. And finally, there is an extensive list of additional resources, including a glossary of terms and acronyms.

Use of this document is ***optional***. Groups may choose to incorporate it (or the subsequent P-EIS) by reference into their State Environmental Policy Act (SEPA) analysis or other projects, to be supplemented with basin or stream specific information. It is intended to provide as much basic information on environmental conditions associated with water as possible, so that planning groups will not duplicate efforts when meeting SEPA requirements. However, the information in this document will not, by itself, be sufficient to meet the requirements of SEPA. An environmental assessment describing the specific environmental conditions of a watershed is necessary as part of the SEPA process for an instream flow proposal. Use of this document is optional; SEPA analysis is not.

Readers should be clear that this document focuses only on flows and is not intended to address all the related issues involved in planning the future of a watershed. It does not discuss factors that may lead to a decision to set flows, nor does it discuss actual implementation. (Ecology is currently preparing an environmental impact statement – EIS – to address watershed planning and management issues, of which instream flows are a part. That document, tentatively entitled "Statewide Non-Project EIS for Watershed Planning" is expected to be released in draft form in mid-2002.) This instream flow guidance document is necessarily general in nature: for example, it considers the whole state and all river basins from a general perspective. A paper of this scope cannot possibly cover all the specific environmental conditions in a state as diverse as Washington. And as important as instream flow issues are, the reader is encouraged to keep in mind two points: first, that flows are only one component of an overall watershed plan. Setting flow levels will not – although we may wish otherwise - solve all our watershed problems! And secondly, as you plan, remember that the amount of water in a stream is affected by factors other than flows.

II. CURRENT SITUATION

Summary

In this section we examine:

1. A general overview of instream flows, including definitions, why flows are important, how flows are set into rule, and a brief history of rule setting in Washington State.
2. The Existing Environment: Natural, Human-Built and Regulatory & Policy.

A. General Information and History

1. A review of terminology: what is an "instream flow"?

As with many things, there is a difference between a general understanding of the term "instream flow" and its legal and regulatory meaning. While one might assume the meaning to be "the amount of water flowing in a stream," this description is too general for legal use, since "the amount" (volume) can actually fluctuate widely.

Volume, at any point in time, is influenced by many factors, including recent rainfall, snow or glacial melt, temperature, vegetative cover, characteristics of the soil and geology, and the amount of water (ground water) moving through the soil and feeding into the stream. Seasonal fluctuations must be anticipated: in the winter, the flow may be very heavy and in summer almost non-existent. Volume also varies from place to place along the stream: at narrow points of the channel the water may be fast moving but low in volume, whereas at a wide point in the stream the same amount of water may move quite slowly. Therefore, in this document, the general meaning of a flow in a stream at any given time will be referred to as "*stream flow*."[1]

Ecology uses another term to describe the flow that remains in the stream channel during extended periods without precipitation to replenish it. This stream flow, which essentially comes from ground water feeding or discharging to the stream, is referred to by the hydrological term "*base flow*." In much of the state, base flow sustains many late summer stream flows. In statute, the term "base flow" has frequently been used interchangeably with the term "instream flow" (refer to Ch. 90.54.030(3)(a)).

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[1] Note: In the interest of word choice variety, and to keep wordiness at a minimum, we will use the term "flow" interchangeably with "stream flow" throughout this document.

The legal and administrative meaning of "instream flow" in Washington State (and many others) has traditionally been more abstract than either "stream flow" or "base flow". "*Instream flow*" (or "minimum instream flow") has referred to the volume of water set in a regulation that needs to be present at a given time measured at a specified location. These are flow levels based on the hydrology (that is, the general water conditions) of the stream and its natural variations in both stream flow and base flow, as well as fish habitat needs and factors such as recreation and aesthetics, over the course of the year. "Instream flow levels" have been used for regulatory decisions regarding future water appropriations.

In the current working legislative draft, instream flow" is now specifically defined as:

> A level of stream flow or lake level designated by rule that establishes the rate of stream flow or lake level that cannot be further diminished by water rights issued subsequent to the adoption of the instream flow rule. It is the level of stream flow or lake level which, when not met or exceeded, triggers the department's authority to regulate or otherwise interrupt the exercise of water rights that are conditioned to the instream flow.

2. Why are instream flows important?

Stream flows are important for many reasons. For example, they are necessary for certain instream functions, especially the survival of fish and wildlife. They are also necessary for out-of-stream "consumptive uses", such as irrigation and domestic water supply. Flow levels have an important effect on navigation. And stream flows contribute to the scenic and aesthetic qualities of natural settings. Flows influence ground water, as well as other surface water bodies (wetlands, lakes, ponds, and so on.)

Flows affect the overall health of aquatic systems and stream functions in many ways. For example, it is a crucial determinant in the health of fish stocks. Fish feed on insects drifting in the currents. Young salmon are carried along by flowing waters. Low summer flows can result in fewer fish. As flows subside during the summer, fish tend to congregate in pools, which can increase their vulnerability to predators. Less water heightens competition for food. Also, fish can be stranded if the water continues to recede. In addition, low flows often lead to warmer water temperatures, which can also increase fish mortality.[2]

Stream flow is an important aspect of water quality. In Washington, more and faster flowing water generally means lower water temperatures (although other factors are involved). Temperature is a parameter of water quality and is regulated by the state Water Pollution Control Act (Chapter 90.48 RCW). Reduced flows can also lead to higher concentrations of substances that have been discharged to a stream or other water body. If the amount of water is reduced, but the amount of the substance in the stream is not, the concentration (and often the toxicity) of the substance becomes increased (because there is less water to dilute it). Consequently, insufficient flow can contribute to exceeding state water quality standards. Stream flows are taken into consideration when water quality permits are processed.

Flows can influence instream values besides fish and water quality. Many wildlife species are stream or riparian dependent ("riparian" refers to aquatic systems with flowing water - e.g. rivers, streams, springs - as well as the adjacent areas.). If stream flows are reduced, the associated riparian vegetation may change as well. For example, greatly reduced flows will lead to a reduction in the amount of habitat for such species as the American dipper and kingfisher, which spend a great deal of time in and around streams.

Aesthetic and scenic values are influenced by the flow level in a stream. And higher flows are generally necessary for navigation. Flows affect recreational activities such as boating, rafting, and kayaking, as well as navigation on a larger scale. On a river like the Columbia, for example, if flows fall below a certain level, the river becomes impassable to barges, tugs, and other watercraft.

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[2] Fish are an important focus in the discussion of stream flows for several reasons. There is, of course, simply their inherent value as a life form, and as an important part of the ecosystem to which they belong. Another reason is their value as an "indicator species", that is, their well-being is a marker for the vigor of other instream values. The assumption is that if fish needs are met, the needs of most other instream values are also being met. Thirdly, concern about fish survival has led to state and federal actions which may affect stream flow setting, such as the inclusion of certain species under the federal Endangered Species Act (ESA) and the creation of the Governor's Statewide Strategy to Recover Salmon. (The websites for both ESA listings and the Governor's Salmon Strategy are included in the appendices.)

Of course, a higher flow is not always better. Flows that are too high can cause flooding and damage to human structures. Negative effects from high flows include:

- Scouring the stream channel removing gravel and making the riverbed unsuitable for fish spawning;
- Cause bank slumping by undercutting banks, putting property and structures at risk while depositing sediment and silt in the water and the river bed downstream;
- Flow over the stream banks, causing property damage and leaving fish stranded in fields; and
- Increased danger to sport enthusiasts, such as boaters, white-water rafters and kayakers.

3. Why set instream flow levels?

There is a finite amount of water available at any given moment in the streams and rivers of the state. Clearly if it is being used for one thing, then generally it cannot be used for another. Water needs to be retained in the streams in order to keep the system functioning. Streams and rivers have had, or are at risk of having, so much water withdrawn for out-of-stream uses that instream needs may not be met. Due to withdrawals that have already occurred and continue to occur, many streams and rivers are already seemingly over-appropriated. "Over-appropriated" means that more water rights have been issued (in volume) - and are assumed to be used - than is actually in the stream. (An underlying issue here, that makes quantifying existing stream flow amounts difficult, is that some water rights are not fully utilized: that is, the actual amount used may be less than stated in the water right – the so-called "wet v. dry paper" water right issue).

Streams where current withdrawals bring the stream flow below the instream flow level are also described as "over-appropriated". In many instances, instream flows have been established by rule, but those flows are junior in priority date to the water rights authorizing withdrawal of water from the stream. Therefore, flows established in a rule may not provide protection, because no water is actually "put back" in to a stream. For streams that are not presently over-appropriated, however, instream flow levels can be adopted to prevent future over-appropriation.

Stream flow setting is controversial. It may be difficult to get agreement regarding the appropriate flow levels that should remain in the streams. This is clear from Ecology's history with setting such flows (described in the appendices). Partially this controversy is related to the numerous and often conflicting factors which need to be considered in identifying stream flow needs. For example, how much water should be left instream for fish when it could be used as water supply for growing communities? Managing finite resources is a complicated matter!

With salmon threatened or endangered, streams impaired because of low flows, and increasing population growth, protection and/or restoration of adequate water for instream resources and out-of-stream uses is becoming increasingly important. This need is heightened by the fact that if out-of-stream uses are restricted in certain areas, those uses may be "pushed" to other areas where instream flows have not yet been set, and the cycle of potential over-appropriation would continue.

Stream flow analysis and decisions must be part of a comprehensive analysis of watershed management. As watershed planning continues around the state (approximately 40 watershed groups are currently undertaking planning under Ch.90.82 RCW), some of those groups will be considering recommending instream flow levels and all will be looking at strategies for future water management. An assessment of stream flows will necessarily be part of most strategies for future water management, as well as being necessary to address Clean Water Act (CWA) and Endangered Species Act (ESA) requirements.

4. How are instream flows set?

From a state perspective, Ecology ultimately has the sole authority to set stream flows in rule. Ecology's general rule-making authority comes under RCW 43.21A.080. The two primary statutes affecting flow setting are Ch. 90.22 RCW, the Minimum Water Flows and Levels Act, and 90.54 RCW, the Water Resources Act of 1971. (Additional specific statutory authorities are detailed in the appendices.) Rule making must comply with the requirements of the Administrative Procedure Act (Chapter 34.05 RCW). An additional option is included under Section 90.82.080(1)(ii)(b) of the Watershed Planning Act, which describes an alternative process using public hearings and notice provided by the county legislative authority.

Rules to establish instream flow levels identify the level of flow that is to be left in the water body at a certain time, and therefore guides decisions regarding the issuance of new water rights permits. Further appropriation of water for out-of-stream uses that reduce the flow below that level cannot be approved without mitigation. The instream flow levels which are adopted may vary by time of year and the rule may include a provision that the levels can be modified if drought conditions exist.

Planning groups should also be aware that certain federal actions may carry instream flow requirements. For example, hydroelectric projects of the Federal Energy Regulatory Commission (FERC) may specify by-pass flow levels; federal fisheries agencies may require certain flows to sustain ESA-listed fish.

Instream Flow Setting Initiated by Watershed Planning Groups

Under the Watershed Planning Act, local planning groups together with Ecology develop instream flow levels and a stream flow management regime based on water management goals and scientific data (and optionally, use of this document.). All parties engaged in this process including Ecology must agree to the instream flow level.[3] (Since presumably Ecology, through the watershed lead, has been involved all along in developing the flow regime and overall watershed plan, Ecology's formal acceptance/agreement should be pro forma). Ecology then initiates rule making to adopt the instream flow as a regulation. (This same general flow setting process is followed whether initiated through watershed planning processes, by those outside of 2514, or by Ecology alone.)

Rule making obligates Ecology to certain outreach efforts such as public hearings (see the Administrative Procedures Act, Ch.34.05 RCW). In hearings or comment periods, issues may be brought forth that the planning group did not contemplate. If, in Ecology's view, the issues are substantial, Ecology will take those issues back to the planning group to incorporate or otherwise address the concern and create a revised flow recommendation. If the planning group cannot reach a resolution, Ecology has the authority under several statutes to go ahead and adopt an instream flow. For example, RCW 90.82.080(5) states: "If the planning unit is unable to obtain unanimity under subsection (1) of this section, the department may adopt rules setting such flows."

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[3]As groups work out flow levels, it is good to keep in mind the importance of including all interested parties throughout the process. This will increase the likelihood that the final regulation will be satisfactory to all affected. See the appendices for some potentially interested parties to consider.

Paraphrasing rule making requirements for Watershed Planning (see RCW 90.82.080), if flows are already set in the watershed, unanimous approval from local governments and Tribes is needed to modify those flows. If there are not adopted flows, the planning unit and Ecology collaborate and attempt to achieve consensus and approval among the members. Approval is achieved if governments and Tribes on the planning unit unanimously support the proposed flows and if a majority of the non-governmental entities are also in support. If the flows are not approved at the local level within four years of the planning unit first receiving funding, Ecology initiates and establishes flows within two years. Draft legislation has proposed that instream flows be adopted for all mainstem rivers and primary tributaries by 2010.

Instream Flow Setting Initiated by Ecology outside the Watershed Planning Process

Historically, the process used to set an instream flow has begun with Ecology consulting other natural resource agencies and affected Tribes to obtain their recommendations. Ecology is required in statute (Ch. 77.5 RCW, Construction Projects in State Waters, formerly Ch. 75.20 RCW) to consult on flows with the Department of Fish and Wildlife (DFW), and under Ch.90.54 RCW to consult with Tribes. These groups are invited to contribute at every stage of instream flow development: participating in studies, providing data, making recommendations, and reviewing proposed regulations and draft reports.

Based on these recommendations and discussions and Ecology's own analysis of supporting data, Ecology proposes a draft instream flow regulation. This draft regulation is then distributed for public and agency review and comment. In many cases, Ecology conducts public workshops to discuss proposals. In all cases, Ecology holds public hearings to invite official public testimony on the proposed regulations. Based on the comments received during the public comment period, Ecology either adopts the regulation, or revises it and then repeats the public review process, if necessary, before reconsidering the proposal for adoption.

Permit Conditions Related to Stream Flow

Determined on a case-by-case basis, new permits may have conditions requiring the diverter to stop using water when the stream or river falls to a certain level. For example, a hydropower project permit could specify a required flow level that must be maintained as water passes through the facility. Ecology consults with the Department of Fish and Wildlife regarding these types of permit conditions.

Instream Flow Levels and Senior/Junior Water Rights

Once adopted, an instream flow rule acquires a priority date similar to that associated with a water right. The priority date, in this situation, is the date of adoption. Any water rights subsequently approved are considered "junior" for the water body, and will include a condition that water diversion must stop when the level reaches the level set as the instream flow. Instream flows adopted into rule do not affect rights senior to them, because those senior rights have a "priority date."

5. What is the history of instream flow setting in Washington State?

Following passage of the Water Resources Act in 1971, the state was divided into sixty-two watersheds called "Water Resource Inventory Areas" (WRIAs). The WRIAs were the geographic basis of Ecology's Basin Management Programs and Instream Resource Protection Programs (IRPPs), which focused first on eastern Washington in the late 1970s, and on western Washington in the 1980s. The basin programs tended to take a comprehensive view of water, while the IRPPs focused on stream flows.

Instream flows have long been a controversial topic for many reasons, including the variety of terms used in statute, the continually evolving science of hydrology and the ongoing challenge of determining instream and out-of-stream needs. Conflict over a draft instream flow regulation proposed in 1986 for the Skokomish-Dosewallips WRIA led to several years of legislatively mandated hiatus in the program. During this period, lengthy discussions and disputes occurred among and between the legislature, the courts, the executive branch, Tribes, citizen groups and others with water interests.

Ecology set instream flow levels by rule in the Skagit River (WRIAs 3 and 4) in March of 2001. Prior to that, Ecology had set no stream flows by rule since 1985. Regulations affecting flows have been adopted in 19 WRIAs, as well as for the Columbia River. A listing and map of watersheds with regulations is included in the appendices.

In addition to WRIAs with adopted instream flows or closures, approximately 350 streams and lakes have been closed to further withdrawals of water. Low flow provisions have been applied to individual water right permits or certificates on about 250 other streams. Ecology Regional

Offices have the details on specific closures. (See also the previous section on Permit Conditions Related to Stream Flow.)

A more detailed discussion of the history of instream flow setting in Washington State is included in the appendices.

B. EXISTING ENVIRONMENT

Once a planning group decides to recommend instream flows, a comprehensive environmental analysis and assessment of the water conditions in their individual watershed must be done as part of the SEPA process for an instream flow proposal. This section serves as a starting point for the environmental conditions associated with water that a planning group will need to consider in their assessment and planning. Ultimately groups should first have a clear picture of their current watershed conditions in order to take the next step: that of determining what flow levels are needed and the potential impact of those flow levels on the existing environment. The "existing environment" as it is referred to in this document includes three discrete elements: the natural environment, the human-built environment, and the regulatory environment.

1. Natural Environment

For our purposes, the features that compose the "natural environment" are estuarine systems (the estuary is where the stream or river flows into the ocean); stream and river systems and their habitats; lakes and lakeshores; and wetlands. In the interest of conciseness, we have chosen to include the majority of detailed information in the appendices. Some recent trends involving the adverse effects of land uses and practices are included.

The broad characterizations and trends presented in the appendix cannot, of course, fully account for the variation across different landscapes and land uses throughout the state. Trends in environmental degradation will occur at different rates depending on the type and intensity of land use, including the pace and character of development in the particular location. Although there are certain areas in the state where environmental improvements have occurred and are continuing, in general, the broad themes presented accurately reflect the situation in most of the state. But readers are reminded that the specific details of the existing environment are most appropriately evaluated and discussed at the local watershed level.

For a general overview of environmental conditions in every watershed (WRIA) in the state refer to the publication *Washington's Water Quality Management Plan to Control Nonpoint Sources of Pollution; Appendix A*. (Washington State Department of Ecology). January, 2000. Publication # 99-26 at web address < http://www.ecy.wa.gov/programs/wq/nonpoint/99-26appa.pdf >.

Environmental Analysis and Assessment

As groups begin the process of determining stream flow levels, it is first important to know what instream values are protected under statute. The Water Resources Act of 1971 describes the fundamental principles for the use and management of the waters of the state. The specific beneficial instream uses of water to be taken into account are listed under RCW 90.54.020. The uses included there are:

1. Fish
2. Water Quality
3. Wildlife
4. Recreation
5. Environmental
6. Aesthetic
7. Navigation
8. Other environmental values
9. And all other compatible uses

It is important that planning groups remember *geographic scale* as they undertake their watershed analysis. Site specific information can be lost if a planning group only examines watershed-wide issues. For stream flow planning, the geographic scope of the planning area and how the different features are handled can have an influence. For example, if a planning group has decided to recommend instream flows for a WRIA, they need to decide if the flows are for the entire basin, just the mainstem river, the mainstem and its tributaries, or on a stream reach-by-reach basis. Similarly, many WRIAs have sub-basins that are not directly connected to the primary river of the basin. A planning group may want to treat those streams differently from the mainstem or its tributaries.

Moving towards a more specific analysis at the local level, another important step for planning groups will be a thorough assessment of the water bodies in their basin. This will be useful for the SEPA environmental assessment. This type of analysis is required for planning groups in the "2514 areas", who must (under Chapter 90.82 RCW) prepare a "water budget" which describes the current nature of water, including water use, in the watershed.

One approach for analyzing the condition of water bodies is to answer a series of questions regarding each water body. The questions are organized into categories that relate, in general terms, to the principle characteristics of water bodies. Responding to these questions will help identify key issues in the watershed and therefore certain factors to consider when recommending instream flow levels. (The questions are loosely based on the draft *Guidelines for Meeting Public*

Trust Responsibilities in River Management developed by the Instream Flow Council - see the appendices for more information.)

1. Hydrology (general water issues)
   - When do the lowest flows occur?
   - When do the peak flows occur?
   - In what months does the majority of the flow occur?
   - What are the sources of the flow (e.g., springs, rainfall, snowmelt, glacial melt)?
   - What is the rate of change between the highest and lowest (peak and base) flows? (Consider rate and magnitude)
2. Geomorphology (appearance, shape, etc.)
   - What is the nature of the stream channel (e.g., alluvial, bedrock, canyon, valley, floodplain, or estuary?)
   - Is the water body a headwater (i.e. a small stream that is the source of a river) or a lowland stream? What is its size?
   - What is the shape and degree of slope of the channel?
   - What is the "aspect" of the channel; i.e., in what direction is its primary exposure?
3. Biology
   - What species of animals are in the area of the stream, including fish, freshwater or estuarine mollusks and other animals, insects, transient animals, etc?
   - What types of vegetation are in the area, such as riparian trees, floodplain vegetation, estuarine vegetation, etc?
   - Is the stream in "sediment disequilibrium", that is, is sediment building up or being reduced on the bottom?
   - What is the composition of the biological communities in the area of the stream?
4. Water Quality
   - Are there existing water quality concerns, such as lowered levels of dissolved oxygen, temperature problems, excessive collection of silt ("siltation"), reduced average water speeds (velocities), existing waste loads (i.e. pollutants in mass from a defined source), or other factors?
5. Connectivity (the relationship between different bodies of water - including ground water, surface water and marine water - such as estuaries, inland marine waters and coastal areas)
   - Are there any physical barriers (e.g. dams or other artificial causes of flow reduction)?

- Are there chemical concerns (e.g. "endocrine disrupters", chemicals in the water that affect the health of living organisms)?
- Are there trends in water levels (surface water or aquifers) and their quality?
- Are there biological concerns (e.g., exotic species, extinct native biota) or existing conditions that affect biota, such as those that would impede fish movement? ("Biota" refers to both plant and animal life.)
- What are the relationships between water bodies in the watershed (i.e., estuaries to rivers, to wetlands to lakes, etc.)
- Are there sea water and fresh water mixing zone effects?

6. General questions
    - What are the limiting factors? (A "limiting factors analysis" determines factors restricting fish production.)
    - Are there severe risks to any species?
    - What about the relationships between the 5 previous categories?

2. Human-built Environment

While doing their environmental analysis as part of an instream flow proposal, planning groups will also be considering the human-built environment (i.e. out-of-stream values). The term "human-built environment" as it is used here refers to those parts of the environment affected by human activity and behavior. RCW 90.54.020 also names specific out-of-stream uses that must be protected. These are paraphrased in the following list:

1. Domestic
2. Stock watering
3. Industrial
4. Commercial
5. Agricultural
6. Irrigation
7. Hydropower
8. Mining
9. Thermal power
10. Other environmental values
11. And all other compatible uses

In addition to the above environmental elements centered around human water usage, there are other human-built structures and human activities that may need to be considered. Many times it is not entirely clear whether a change or trend is human-induced or a natural phenomenon; many are probably a combination. These could include:

- land, water and shoreline use – trends in agriculture such as decreased irrigation or change to crops that need more water; trends in recreation such as increased fishing
- public services and utilities (water management facilities, such as diversions, pumps, pipes, etc.)
- other instream structures (e.g. dams, reservoirs, bridges, dikes, etc.)
- transportation facilities, including the extent of impervious (impenetrable) surfaces (such as paved roads), water related transportation, culverts and other blockages
- the level of development in different areas of the watershed, including growth issues associated with land development (increased water withdrawals, more impervious surfaces).

Another element of the human environment that deserves note is that of historical and cultural features. This includes places such as sacred or ceremonial sites, fishing grounds, traditional meeting places and logging or mining encampments. Such features need to be identified and planned for at the local level. Consider researching and building a library of information on these features. Contacts can be made with the Office of Archaeology and Historic Preservation and with affected Tribes. Local historical societies can often provide photographs of historic conditions and recorded anecdotal information from elders.

3. Regulatory and Policy Environment

While not a physical environment in the way that the natural and built environments are, there is a third environment that will ultimately affect decisions around setting instream flows. We are calling it the regulatory and policy environment, and it includes state laws regarding flows (these are included in the appendices), federal laws, treaties and the numerous other legal instruments and agreements that may impact stream flows, as well as the policy direction given in such documents as the Governor's Salmon Strategy. We are giving only brief mention to key ones here, as a starting point for planning. Web addresses and contact information are located in the appendices.

Tribal Concerns

Tribal treaty rights and court cases can be important when considering stream flows. Planning groups should contact any Tribes with an interest in flows in their areas. The Northwest Indian Fisheries Commission and the Columbia River InterTribal Fish Commission can be resources for assistance.

State Initiatives

Salmon Strategy

The Governor's Salmon Strategy (*Statewide Strategy to Recover Salmon*) deals with ensuring adequate water for fish. A discussion of stream flows is included in that document.

Washington Water Action Strategy

The Governor and the Legislature are currently working on water law reform legislation that is expected to provide additional policy guidance on setting instream flows.

Washington Department of Fish and Wildlife (DFW)

The DFW provides recommendations to Ecology for flows. They can also play a role in determining the specific conditions required for water rights permits.

Wells/Washington Department of Ecology (DOE)

Check with the appropriate regional office to determine if there are wells in hydraulic continuity (that is, connected by ground water) with the stream in question. Pumping from a well can affect the instream flow level; the exact influence can be difficult to determine. Studies may exist, or may be needed.

Washington Department of Natural Resources (DNR)

DNR can provide information of rare and endangered plants in your area. Additionally, if a watershed analysis for forestry has been prepared by DNR, critical resource areas will have been identified.

Salmonid Stock Inventory (SaSI) Report

The DFW's 1992 SaSI discusses the status of salmonidae stocks. Additionally, DFW has a listing of Priority Habitats and Species at **http://www.wa.gov/wdfw/hab/phspage.htm**.

Salmon Recovery Funding Board

Administered through the Interagency Committee for Outdoor Recreation, this group oversees salmon-related funds.

Limiting Factors Analysis

Under Chapter 77.85 RCW, Salmon Recovery, conditions that limit the ability of habitat to fully sustain populations of salmon are analyzed. Originating as 1998 legislation, ESHB 2496 focused on assembling existing information rather than generating new. Local technical groups have assembled the information and make it available to all interested individuals or organizations (including watershed planning groups). In the flow arena, technical advisory groups examine flow alterations, along with other factors that influence salmon.

Federal Programs

There are a number of federal agencies that have an interest in stream flow setting. Which agencies need to be involved depends on the specific situation. The Environment Protection Agency (EPA) has Clean Water Act authority, and the National Marine Fisheries Service (NMFS) and Fish and Wildlife Service (FWS) have ESA authority. The Federal Energy Regulatory Commission (FERC) can require specific flow levels as part of their hydropower licensing function. The Bureau of Reclamation and the Corps of Engineers have authority over certain federal water projects. The Forest Service, National Park Service, Department of Defense (Military Reservations), Department of Energy, and Bureau of Land Management also have an interest in flows in streams on lands under their control.

Cross-boundary Concerns

Planning efforts in areas where a stream is shared with British Columbia, Idaho or Oregon may need to be coordinated with appropriate agencies, Tribes and others in those jurisdictions. Similarly, cross-boundary issues within the state should be considered, such as adjacent planning areas.

Water Quality Issues

Water quality and water quantity need to be managed together, since actions affecting one will affect the other. Several water quality issues should be considered when addressing stream flows. Specific information can be obtained from the Water Quality Program at Ecology's regional offices.

1. TMDLs

When a water body is impaired, it can be placed on the Clean Water Act §303(d) list. A plan to deal with the impairment is called a Total Maximum Daily Load, or TMDL. Information on TMDLs can be found at <http://www.ecy.wa.gov/programs/wq/tmdl/index.html>.

2. 7Q10

"7Q10" refers to the lowest average stream flow expected for seven consecutive days with an average frequency of once in ten years. It is used in a water quality permitting context to help ensure water quality standards are being met.

3. Stormwater

Ecology has revised the Stormwater Management Manual for Western Washington. Even though it is focused on the western part of the state, many of the concepts apply statewide. Runoff flow control requirements now address the problems of both how high the flows get as well as how long they last. Stormwater management is needed to control runoff from hardened surfaces like parking lots and roofs.

4. Permitting Considerations

Permits allowing discharge to a water body may have a flow component. Contact the water quality section in the regional Ecology office for more information on specific water bodies.

Enforcement

The effectiveness of instream flows is predicated on the enforcement of the flow levels. It does not much matter what flow level is set if regulations are not properly enforced. Planning groups need to think about the enforceability of the flows they recommend.

III. AN APPROACH FOR DETERMINING INSTREAM FLOWS

Summary

Many planning groups will be recommending a flow for regulatory purposes: an "instream flow." These recommendations will fall somewhere along a continuum of "higher" to "lower" flows, always meeting the existing statutory requirements, pursuant to Chapters 90.54 and 90.22 RCW. In this section, a conceptual framework based on such a continuum is presented, and the implications for each of four approaches are examined:

1. Fish Emphasis Flow: optimized water for fish, but probably not met in most years.
2. Out-of-Stream Emphasis Flow: meeting out-of-stream needs while ensuring adequate water for fish, most of the time.
3. Natural Resource Base: other options, including a combination between 1 + 2.
4. No Action: continue management of the stream as it is today.

Also included in this section is a discussion of the current legal meaning of "instream flow", how the choice of a flow level is translated into a rule recommendation, and a rationale for how these four particular approaches were selected.

Choosing an instream flow approach must arise out of a planning group's overall goals, and be based on sound science. Defining the "appropriate level" of flows for both instream and out-of-stream uses will take into account biological, hydrological and societal needs, and is at the crux of water management. (Planning groups under Ch.90.82 RCW must address flows in their strategies, although recommending an instream flow is optional.)

<u>Instream flows</u>

As of this writing, an "instream flow" is defined as:

> A level of stream flow or lake level designated by rule that establishes the rate of stream flow or lake level that cannot be further diminished by water rights issued subsequent to the adoption of the instream flow rule. It is the level of stream flow or lake level which, when not met or exceeded, triggers the department's authority to regulate or otherwise interrupt the exercise of water rights that are conditioned to the instream flow.

Out-of-Stream Emphasis Flow

This option emphasizes flows for out-of-stream uses while providing enough water for adequate fish production. The flow regime would be achievable and intended to be met most of the time, as hydrology allows. Under this approach, relatively more water would be taken out-of-stream rather than being left in the stream for instream uses.

Natural Resource Base (NRB)

This level of flow includes other approaches, including combinations somewhere between the Fish and Out-of-Stream options. This hybrid allows gains and pains from water short or water rich years to be shared between instream and out-of-stream uses. Adequate water for a properly functioning, healthy watershed would be available most of the time. (The term "Natural Resource Base" is derived from and is consistent with the *Statewide Strategy to Recover Salmon*. It refers to having a sufficient "base" or "foundation" from which to manage and maintain a stream.)

No Action

This option continues the management of stream flows as they are managed today, with no additional flows being set or modified. "No Action" means to keep the current protection level based on current regulations. (Watersheds currently with flow regulations are listed in the appendices.)

Current legislative proposals would amend Chapter 90.22 RCW to state that instream flows must:

1. Be scientifically based,
2. Be sufficient to meet the biological needs of fish species at various life stages, and
3. Be obtainable, consistent with the hydrology of the stream.

An "instream flow" is therefore the stream flow level set in regulation which is established through planning processes or by Ecology. The level is established through consideration of scientific data, practical demands, existing regulatory context (which includes state and federal laws), past history and practices of the watershed, and other factors. This regulatory flow level is a mechanism for meeting the statutory requirements for protection of instream values as listed in RCW 90.54.020. The exact number will vary from watershed to watershed: it is a level neither optimized for fish nor the bare minimum needed for fish survival.

The instream flow level is the point above which Ecology will consider issuing new water rights. Further appropriation of water for out-of-stream uses that reduce flow below that level cannot be approved without mitigation. It will not affect existing water rights.

Four Stream Flow Approaches

There are many ways to approach making a determination of flow levels, but we have chosen four to consider in this document. The flow options presented represent a continuum, ranging from low to high instream flow levels. Fish emphasis flows are at the high end of the continuum and out-of-stream uses are at the lower end. We are working under the assumption that most groups will ultimately recommend flow levels that fall somewhere in-between the high and low ends of this continuum, but always meeting the statutory requirements pursuant to Chapters 90.54 and 90.22 RCW. The four approaches considered here are:

<u>Fish Emphasis Flow</u>

This approach optimizes water in streams for preserving or securing fish across species, fish being the indicator for the vigor of other instream values. The assumption is that if fish needs are met, the needs of most other instream values will also be met. The level of flow needed would probably not be met in most years due to hydrology, but if the water were there the fish would use it.

Relationship of Approaches

Figure 1 shows the general relationship between the options.

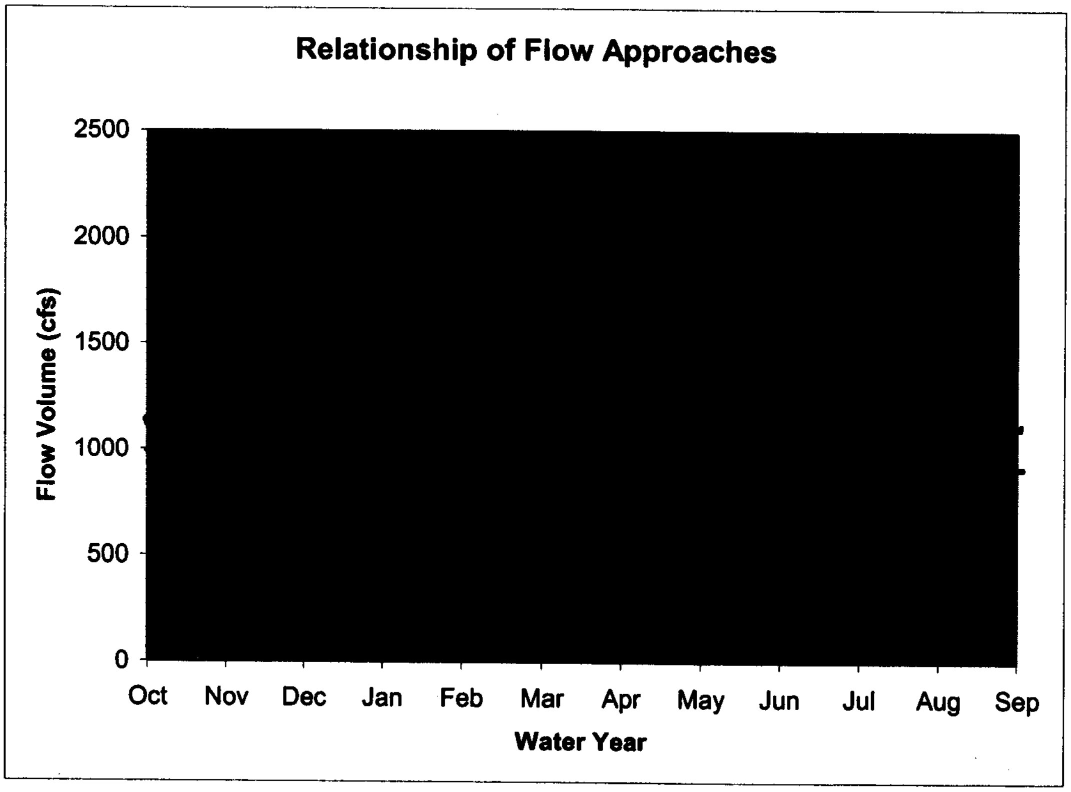

Figure 1

This figure depicts hypothetical stream flow levels over a water year in a snow melt stream. Flow levels will vary over time (seasonally, yearly, etc.) in a curve shape with low flows in the summer and early fall, and higher flows during the times of precipitation and/or snowmelt. In this illustration, with a Fish Emphasis Flow, there is water in excess of fish needs from about mid-April until August that could potentially be allocated for other uses. Most of the time, the majority of water would go to fish. When the actual flows are below fish emphasis levels, there are opportunities for flow restoration by storage, conservation, and so on.

If there was an Out-of-Stream Emphasis, as shown by the bold solid line, more water would be taken from the stream and less would be left for fish. Most of the time, the majority of the water would go to out-of-stream uses.

In the NRB in this example, the water available for out-of-stream uses is represented by the area *above* the dashed line and below the existing flow. Correspondingly less water would be left in the stream for fish (the area *below* the dashed line). If actual flows are lower than the NRB level, there are opportunities for flow restoration.

The No Action option would initially keep stream levels pretty much "as is". It presumes that in many cases flows are inadequate for fish and other instream resources.

There are trade-offs in selecting a flow approach. The trade-offs need to be assessed and balanced according to the goals of the individual planning group. If, for example, water is left in the stream for fish, it is not available to be taken out for domestic or agricultural uses.

A Range of Flows

In recommending instream flows, planners need to remember that flows vary seasonally, yearly, daily and in climatic cycles (such as La Nina, El Niño and Pacific Decadal Oscillation). These variances need to be factored into the planning equation the local group uses to develop their recommendations. Since no single number is "the" number for an instream flow level and because flow levels need to vary seasonally to generally mimic nature, a range of flows is the most practical approach to set instream flows. Groups should therefore be aware that setting a flow in rule implies setting a range of flows that vary over the year.

The definitions of the four flow setting approaches are thus intentionally broad so that all levels of flows can be captured within them. We anticipate that stream flow levels recommended by planning groups will be for a range of flows, over a specified time and measured at a control point. (See the appendices for a generic instream flow rule outline.)

In addition to the range of flows, thought should be given to when in time (i.e. the dates) you want the designated flows in the river, where the flows will be measured and the frequency of measurement (as necessary). (Flows have traditionally been set with a certain flow having to be met at a specified measurement point - a control point like a USGS gauge - during a specified time period.). Also important to consider is where the flow levels will apply – this might include:

- Mainstem only
- Tributaries only
- Mainstem and tributaries
- Non-associated streams (streams within the WRIA but not in the main riverine system drainage - an example is a stream that drains directly to Puget Sound rather than into a larger river).

A proposed amendment to RCW 90.22.010 addresses all these various considerations, stating:

> The instream flows shall vary, according to the biological needs of fish and the stream hydrology, within a basin between the mainstem and tributaries, among stream reaches, and throughout the year according to the seasons; and may vary from year to year in consideration of natural condition including variations in weather.

Federal programs involved with water management have sometimes specified a separate "target flow" in connection with permitting. A target flow is a flow to be reached at some future date. Such flows have been used by federal agencies in the Yakima and Methow Basins.

Flows in Rules - Revise or Set Anew

A watershed planning group will be recommending setting instream flows under one of two scenarios:

1) Where flows are currently set in regulation, that is, Washington Administrative Code, "WACs" (for a listing of those WRIAs, see the appendices), or
2) Where flows are NOT currently set in regulation.

In a case where instream flows are set, a planning group may affirm existing flows, revise the existing flows, or establish a new set of flows. Changes affecting an existing instream flow require justification: Ch. 90.82 RCW has specific requirements. A planning group may decide additional or revisited flow studies are needed to validate or reestablish an instream flow. Any revised flows set in regulation would affect only water rights issued subsequent to the adoption date of the rule.

If flows are not set in regulation, the watershed planning group can opt to recommend instream flows as part of their water management strategy. While it is voluntary for watershed planning groups to recommend instream flow levels, it is not voluntary to meet them after they have been set. If a local planning group opts not to set stream flows, Ecology will set them. However, Ecology prefers to work collaboratively with local planning groups to determine appropriate flows. The flow setting process for watershed planning groups (the so-called "2514 groups") is specified in RCW 90.82.080.

Conceptual Framework

The conceptual framework the four approaches represent was chosen for a number of reasons. One of its strengths is that it effectively covers a great many conditions around the state by its emphasis on the watershed system as a whole. Other approaches tended to look at individual components of the system, such as biology or hydrology or geomorphology. A variety of instream values and flows can be addressed because this approach covers a spectrum.

Also important in choosing this framework is the language in amendments to Ch. 90.82 RCW in the 2001 legislation: maintaining, preserving and enhancing. These terms bring together concepts from existing statutes and, over the years, have taken on an array of meanings. It was simpler to define the approaches used in this document in broad enough terms to encompass the "old" terms and thus avoid the controversy and confusion associated with them.

There are other approaches for "providing adequate protection of aquatic resources" that would not result in administrative rules (regulations). But, because of directives in statute (such as Chapter 90.82 RCW), the focus for this document is limited to the above four-approach framework, which will culminate in rule development for flows at the watershed level.

IV. IMPACTS ON THE EXISTING ENVIRONMENT

Creating a mutually agreed upon, overall vision for a watershed is the significant challenge facing planning groups. The vision is the first step; designing strategies to bring that vision to fruition is the next hurdle. In order to successfully accomplish their goals, groups must not only have a clear vision of what they want, but also anticipate the impacts of those choices, and take steps to mitigate problems before they occur.

At the most general level, if a group's plan emphasizes out-of-stream water uses, they must anticipate and plan for the fact that there will be proportionately less water in the stream for instream values such as fish, recreation and aesthetics. Conversely, if a planning group's goals are to maintain or increase stream flows, there will be correspondingly less water available for out-of-stream needs, such as irrigation, industrial and domestic uses.

The nature of the possible impacts and therefore, the measures to reduce those impacts, will vary according to local watershed conditions, as well as the site-specific circumstances. Specific proposals affecting flows may be subject to state, local and even federal permitting requirements (e.g., Hydraulic Project Approvals, local grading and excavation permits, Section 404 dredge and fill permits, Section 401 Certification, shoreline development permits). Generally it is through these permit review processes, which generally also come under the purview of SEPA, that site-specific impacts and measures to address those impacts (e.g. mitigation, conservation, etc.) are developed.

<u>Effects of Varying Stream Flows on Elements of the Environment</u>

The effect of a flow level on a stream will depend on the specific conditions of a given stream and the myriad of other factors that together form the ecosystem in which the stream exists. Flows always need to be considered within this larger context. Although we may wish otherwise, the mere fact of establishing instream flows will not solve all our watershed problems! For example, there are groups who will have fish protection as one of their goals. While higher flows are generally better for fish (create a better fish habitat), many other factors contribute to the quality of life for fish (such as adequate food supply, temperature and cover for hiding.) Flows in a stream are only one component of a larger system and need to be integrated with other factors.

The big picture notwithstanding, we can still state that in general, higher flows are more beneficial to instream values. The impact a stream flow level might have on a resource will vary with the actual level of the flow, the timing and the duration. Table 1 provides an extensive - albeit general - look at the most commonly anticipated effects of varying stream flow levels on specific elements of both the natural and human-built environments. Note that only three approaches are included (Fish, Out-of-Stream and No Action). Since the Natural Resource Base (NRB) option covers all flow levels that fall in between the Fish and Out-of-Stream Flow Emphases, there was no feasible way to discuss the effects over such a range. It falls upon the reader to make his/her own determination of the possible effects within their watershed of a specific NRB flow level, given the information available for each end of the continuum.

Local watershed planning groups and others will need to supplement the information provided in Table 1 with information specific to their situations. That analysis is intended to provide an overview of what can happen to various instream and out-of-stream resources under varying flow conditions, and give planning groups a starting point for thinking about the impacts of the flow level decisions they make. Predicting influences in advance is difficult because there are so many variables. Therefore the analysis does not intend to address, nor can it, every conceivable situation that could arise.

After looking at specific potential impacts in some detail, we provide a series of questions a planning group could ask (related to those same elements of the environment) to assist them in defining watershed scale impacts (Table 2). Finally, at the end of this section, broader impacts and effects are discussed ("Additional Considerations").

Table 1

Environmental Effects of Stream Flow Level Approaches

	Fish Emphasis "Higher flows"	**Out-of-Stream Emphasis "Lower flows"**	**No Action**
Description of Approach → **Element of the Environment ↓**	Emphasizes water in streams for preserving or securing fish productivity. The assumption is that if fish needs are met, the needs of other instream values will also be met.	Flow levels set with an emphasis on out-of-stream uses while providing enough water for fish productivity.	Continues the existing management of flows.
FISH AND OTHER AQUATIC RESOURCES (including hatcheries)	*1.* New fish hatcheries would need to meet higher flow levels, which could influence location & design. *2.* Restoration of flows on some streams could enhance instream resources (esp. fish production). *3.* There can be secondary benefits to aquatic resources, as water quality is improved by increased flow. *4.* Cumulative effects on instream resources would likely be positive. *5.* Hatcheries could obtain water rights for non-consumptive use. To be exempted from instream flows the facility would return diverted water to the stream near the point of diversion. Most hatcheries have backup water supplies.	*1.* Meets fish and other aquatic resources needs most of the time. *2.* Under natural conditions, a broad range of stream flow conditions affect the production of aquatic organisms, which in turn affects the life in the stream. *3.* Would increase the frequency and duration of low instream flow levels and negatively affect aquatic resources. *4.* Isolated fish populations would probably survive, but this level might not sustain recreational or commercial fisheries because of the reduction in fish numbers associated with reduced flows. *5.* Might affect the viability of many aquatic species, especially	*1.* Risk of gradual, incremental degradation through *di minimus* and other uses. *2.* Generally more likely to present a problem for creeks up to medium-sized rivers during the summer/fall rearing & spawning seasons. *3.* IFIM studies show larger rivers (e.g. Lewis, Skagit) appear to normally have adequate water to meet fish and aquatic resource needs under current management. *4.* Habitat may not be fully used due to over harvesting, pollution & other environmental issues. Hatcheries could obtain water rights for non-consumptive use. To be exempted from

	6. Could encourage more storage development, which could result in more water for fish.	larger cold water fish like salmon and steelhead. *6.* Lower flows would reduce cover, food supply, and water quality (especially temperature) which could cause increased predation and competition for space and food. *7.* Populations on the edge of viability could be forced to extinction by low levels. *8.* Migration could be impeded (e.g. fish could not move from pool to pool in low flows). *9.* Exempt small water uses could incrementally impact flow levels. *10.* Cumulative effects on instream resources from withdrawals could be harsh. *11.* Future fish facilities might be impacted by reduced water availability. *12.* Some hatcheries depend upon capture of wild fish for egg sources and at lower flows there may be fewer fish and less species diversity. *13.* Lower flows influence water quality and quantity, which affects hatcheries. *14.* Hatcheries could obtain water rights for non-consumptive use. To be	instream flows, the facility would return diverted water to the stream near the point of diversion. Most hatcheries have backup ground water supplies.

		exempted from instream flows the facility would return diverted water to the stream near the point of diversion. Most hatcheries have backup ground water supplies.	
WATER (Quality & Quantity)	*1.* The more water left in the stream, the less available for out-of-stream uses. *2.* New activities removing water from streams would be mitigated by putting water back at appropriate locations. Water quality would likely be better due to dilution and higher velocity. *3.* At this level of flows, there generally would not be adverse impacts. *4.* Water quality potentially improved with more water instream, which in turn benefits instream resources. *5.* More sediment could result causing turbidity (muddiness) problems. *6.* Could increase mixing with salt water. *7.* Could increase flushing actions in estuaries and near-shore environments. *8.* Conservation efforts, out-of-stream to instream water right transfers, and efforts to improve flow conditions of heavily	*1.* Basic protection of water quality and quantity would be accomplished most of the time *2.* Might cause a usage shift to ground water since surface water availability could be reduced. *3.* Water velocity and depth could be reduced affecting habitat for fish & other biota. *4.* Streambank erosion might be lessened. Reduced stream flow and velocity would affect transport of sediment and other materials moving along the bottom ("bedload"). Delta formation (which occurs when sediment and bedload are deposited) could be impacted since less sediment might be transported. *5.* There could be salt water upriver from estuaries with the associated impacts on wildlife and vegetation. *6.* Water temperature, dilution ability and other aspects of water quality would be affected. *7.* Impacts to ground water	*1.* Risk of gradual, incremental degradation through *di minimus* and other uses. *2.* Impacts to ground water should be expected, as man-made development occurs.

	appropriated streams would tend to restore more natural flow and improve water quality conditions. *9.* Increased appropriation of water due to high flows might result in some minor reduction in flooding. ***10.*** Increased impacts to ground water would be expected, as less surface water was available for out-of-steam uses.	should be expected, as man-made development occurs. ***8.*** The replenishment of ground water can be affected which can, in turn, affect the exchange between ground water, streams and wetlands.	
WILDLIFE	***1.*** Flows at this level generally meet or exceed basic biological needs (but these levels would not be met in most years). ***2.*** Likely a positive influence since ecosystem functions would approach natural conditions more than under the other approaches. ***3.*** Would benefit terrestrial and aquatic species dependent on water flows. ***4.*** Abundance of prey species would mean more stable and numerous populations of species at higher levels in the food chain. ***5.*** Higher flows would retain a more natural range of flows than the other two approaches. ***6.*** Would provide good protection for most wetlands wildlife in that natural flow regimes would undergo little change.	***1.*** Flows at this level would meet basic biological needs most of the time, but at a lower level than higher flows. ***2.*** Adequate water would probably remain to supply wildlife needs, such as drinking water, movement corridors, vegetation for food, cover. ***3.*** There could be less riparian vegetation cover than with higher flows and therefore less available food and sanctuary. ***4.*** Water quality could be impaired through reduced dilution ability. ***5.*** Lower flows affect fish and other aquatic organisms, indirectly affecting wildlife dependent upon these species as prey. ***6.*** Could change the composition and distribution of	***1.*** Risk of gradual, incremental degradation through *di minimus* and other uses.

		riparian vegetation, favoring some species. *7.* Wildlife, including rare, unique, threatened or endangered species, could be impacted by low flows over time. *8.* Man-made development would likely be greater than at higher flows, and this can affect instream resources. *9.* Lower flows affect wetlands by altering the local hydrologic regime and this in turn affects biota (plant and animal life). ***10.*** Lowered freshwater inflow to estuaries and associated environs might affect their biological productivity (and therefore affect some food sources).	
RECREATION	*1.* Most recreational activities would be enhanced, up to the point where access is impaired for activities such as wading and fishing. *2.* Recreation requiring high flow levels could benefit, such as kayaking and river rafting. *3.* Fisheries-related river recreation activities would benefit because fish numbers would be increased. *4.* Wildlife viewing and water-	*1.* Some recreational activities would be enhanced at this flow level while others might be impaired. *2.* Water-dependent and water-related recreation could be impacted. *3.* Would reduce the frequency of flows needed by kayakers, canoeists, boaters, and rafters. *4.* Fishing recreation would likely be reduced due to decreased fish populations.	*1.* Risk of gradual, incremental degradation through *di minimus* and other uses. *2.* Some recreational activities are enhanced at current flow levels, while others are impaired.

	related hunting would benefit. *5.* Sightseeing of water-related resources would benefit. *6.* Sediment transport would increase, feeding some beach areas and stripping others of sand. *7.* Increased erosion could impact upland recreational sites and uses.	*5.* Lower summer flows in rivers might create pools, which could benefit swimmers. *6.* The number of recreation sites by free-flowing rivers could be reduced, which could aggravate the demand for recreation.	
AESTHETIC & SCENIC (As with the phrase "Beauty is in the eye of the beholder", what is aesthetically pleasing to one person might be to another, and what is pleasing in one situation might not be in another time and place.)	*1.* Aesthetic effects would depend on the situation - some conditions are enhanced at a higher level while others are impaired. *2.* Can cause erosion resulting in muddy water. *3.* Aesthetic impacts were evaluated for the Snoqualmie Falls Hydroelectric Project and it was found that viewing pleasure was increased at higher flows – at least to a point - and included width of flow and associated spray and noise.	*1.* Aesthetic effects would depend on the situation - some conditions are enhanced at lower levels while others are impaired. *2.* Waterfalls and other outstanding natural and scenic features would be impacted by the reduction in the amount of water available. *3.* There could be lowered inflow to lakes. *4.* There could be reduced replenishment of groundwater.	*1.* Aesthetic effects would depend on the situation - some conditions are enhanced at current levels while others are impaired.
NAVIGATION WAC 332-30-106(40): "Navigability or navigable" means that a body of water is capable or susceptible of having been or being used for the transport of useful commerce. The state	*1.* Generally, the higher the flow, the better it is for navigation.	*1.* Access and passage may be restricted at some lower flow levels, depending on the specific situation. *2.* Big rivers would likely be less impacted than small ones. *3.* There might be an increase in dredging. *4.* There might be an increase in spoils disposals concerns	*1.* Navigation would pretty much continue as currently practiced.

of Washington considers all bodies of water meandered by government surveyors as navigable unless otherwise declared by a court.		(material that comes up with dredging).	
OTHER ENVIRONMENTAL VALUES & COMPATIBLE USES (including wetlands and land use) "Other environmental values" refers to environmental values not covered under other parameters and includes other forms of recreation such as swimming and wading. (F-EIS 1979 Western Washington Instream Resources protection program, page D-13.)	*1.* Likely a positive influence on many environmental values since ecosystem functions would approach natural conditions more than with the other approaches. *2.* Reduced availability of water supplies could become significant factors in land use decisions sooner (because of lack of alternative sources). *3.* To keep water in the stream might lead to construction of water storage projects sooner, in order to maintain the flow level. *4.* Effects would depend on the specific flow level and the resource value being considered. *5.* Depending on how high flows are, wetlands could be increased in area with an associated increase in values; but too high and rapid a flow could cause flushing.	*1.* Effects would depend on how low the flow would be and the resource value being considered. *2.* With lower flows, man-made development would likely be where the water was easiest to get. *3.* Shoreline areas could be affected by water project construction, because more land would be exposed than at higher flows. *4.* If flows were stabilized at a lower level, it could reduce disturbance that rejuvenates the stream channel. *5.* Wetland size and diversity could be reduced if there is not enough water to maintain them (adequate volume and water flow through the wetland). This would result in associated species and habitat changes. *6.* If flows are sufficiently low, access to some wetlands may be	*1.* Risk of gradual, incremental degradation through *di minimus* and other uses. *2.* Should be consistent with Growth Management Act and Shorelines Management Act. *3.* Residences along or near shorelines and wetlands would probably continue, but new ones could be more restricted.

		cut-off for certain species and uses, such as for salmon rearing. *7.* Over time, wetlands could dry up.	
RIPARIAN VEGETATION	*1.* Function would be at least maintained and, in the case of restoration flows, could improve some vegetation and reestablish others. *2.* Flows fluctuating within a natural range would favor naturally occurring biota. *3.* Pioneering riparian vegetation could be lost if carried away by high flows or flooding. *4.* There is the potential for spreading riparian vegetation.	*1.* The margin of the riparian zone could migrate toward the stream channel. *2.* If the flows were stabilized at a lower level, it could reduce disturbance that favors the rejuvenation of certain vegetation. *3.* Reduced disturbance from lower flows favors some biota over others. *4.* Reduced amounts of water could affect biota, including rare or unique plant species.	*1.* Risk of gradual, incremental degradation through *di minimus* and other uses.
ECOSYSTEM HEALTH	*1.* Meets water needs for instream values most of the time. *2.* Returns flows to near natural levels to benefit ecosystem health.	*1.* Adequate water for a healthy watershed most of the time, but less than if the flows were higher.	*1.* Risk of gradual, incremental degradation via *di minimus* and other uses.
HISTORICAL-CULTURAL With our diverse cultural heritage, there are inherent conflicts among different cultural values.	*1.* Case-by-case assessment is needed since the effect depends on the feature you are trying to protect. *2.* Maintaining a rural agricultural lifestyle and farming (implying irrigation in some cases) may be harmed. *3.* This approach has the least	*1.* Case-by-case assessment is needed since the effect depends on the feature you are trying to protect. *2.* Water development projects could become more prevalent because there would be more water available for out-of-stream uses. There would be potential	*1.* Case-by-case assessment is needed, but at present there is risk of gradual, incremental degradation through *di minimus* and other uses. *2.* Historical and cultural resources would be essentially unaffected - or at least no more impacted than

	impact on native cultural resources. *4.* The potential for disruption of stream-side religious sites would be greatest with this approach. *5.* Flow restoration on over-appropriated streams would likely lead to enhanced fish production in some currently depressed streams. *6.* Fish production would be maximized and positively affect tribal and non-Indian fishing cultures.	impacts on both religious and archaeological sites by construction. *3.* Development projects could also potentially impact religious and archaeological sites by submerging those sites under water.	at present. *3.* Protection of Indian religious areas is not directly addressed under Ecology's current water policies. *4.* Current management must keep fish available for treaty-based commercial and ceremonial fishing. *5.* Current management perpetuates cultural heritage and lifestyle for many tribal members and others. *6.* The health of many tribal economies and community cultures depends largely on the availability of fish. Fish are currently impacted, of course, and will continue to be by ongoing development.
INSTREAM STRUCTURES "Instream structures" includes, but is not limited to: bridges, dams and hydropower facilities, fences, diversions, pipes (intakes and screens), moorage and pilings, utility poles, and other features of the "built" environment.	*1.* Case-by-case assessment is needed since the effect depends on the feature you are trying to protect. *2.* Could discourage development of run-of-river developments (i.e. where water essentially just passes through) due to high instream flows and closures. *3.* Could increase the need for construction of storage dams and reservoirs to provide reliable sources for out-of-stream water	*1.* Case-by-case assessment is needed since the effect depends on the feature you are trying to protect. *2.* Could encourage development of run-of-river projects (i.e. projects where water essentially just passes through) that have lower bypass flows. *3.* Could reduce the need for storage dams in some areas, but provide economic incentives for new dams in order to provide	*1.* Case-by-case assessment is needed since the effect depends on the feature you are trying to protect. *2.* Energy development related to instream flows would remain the same: related primarily to hydro development and cooling water requirements. *3.* Ecology continues cooperating with the state Energy Facility and Site Evaluation Council (EFSEC),

	uses and to maintain flows. *4.* Hydroelectric projects would be sized to pass higher instream flows, which could render some projects untenable. *5.* Sufficient water needs to be available to meet both instream flows and energy-related needs, or run the risk of frequent seasonal shutdowns of diversions. *6.* Would likely require higher bypass flow requirements, which could redirect development to selected larger rivers, or to streams where the negative effects on certain fish (and other instream values) would be lessened. *7.* Could influence construction and allocation of storage projects.	consistent flow. *4.* Hydro projects would still have to comply with federal requirements for higher bypass flows, since flow conditions are generally project-specific. *5.* Considerable deference is given by the Federal Energy Regulatory Commission (FERC) to state, federal and tribal fish and wildlife agency recommendations for instream flows. *6.* Ecology advises the state Energy Facility and Site Evaluation Council (EFSEC) on energy facility siting, and flows that might be needed. *7.* Could increase the need for construction of storage dams and reservoirs in order to keep flows at a prescribed level.	& the Northwest Power Planning Council. *4.* Policy of negotiating project-specific instream flows for hydroelectric projects would continue. *5.* Ecology continues incorporating instream flow provisions in water rights and water quality certifications issued for hydropower development.
OUT-OF-STREAM USES: Municipal-Domestic	*1.* Case-by-case assessment is needed since the more water left instream, the less water available for out-of-stream uses. *2.* Municipal and domestic uses could be constrained by being subject to higher instream flow levels. *3.* Interruptions of diversions would occur frequently, assuming they were junior to the adoption	*1.* Case-by-case assessment is needed since the more water left instream, the less water available for out-of-stream uses. *2.* Impacts for "lower" flows would be generally of the same type as with the "higher" flow approach, but with less impact to out-of-stream uses. *3.* Uses would be less constrained than with higher	*1.* Case-by-case assessment is needed since the more water left instream, the less water available for out-of-stream uses. *2.* Under current management, shortages occur and voluntary conservation measures are advised. *3.* Water rights issued are expected to be curtailed some

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	date of the flows. *4.* Could encourage conservation programs to be implemented. For new or expanded water supply systems, mitigation may be required to achieve higher flows. *5.* New water withdrawals may have to tap deeper aquifers to avoid impact to surface water or contiguous ground water, to meet higher flow levels. *6.* Could limit water availability for out-of-stream diversions, which could impinge growth.	flows, since they're subject to lower instream flow levels. *4.* Interruptions of diversions would occur less frequently than at higher flows. *5.* Could reduce the urgency for conservation programs since the level of flows to be left instream would be less. *6.* There still may be some shift to ground water resources - particularly noncontiguous - but less than at higher flows. The need to develop alternative or supplemental sources might be reduced. *7.* There could be a need for water systems with few supply options to combine into more efficient operations (including annexations). *8.* Out-of-stream diversions could be limited and therefore impinge growth (to the degree water is available).	of the time, depending on basin rules. *4.* To try and ensure sufficient water, current management allows alternative or supplemental ground water sources, transfer of existing rights, marketing, or storage. *5.* Under current management, growth may be restricted due to lack of water. Conservation measures can be required. *6.* Stream closures are often recommended by the resource agencies for small streams, especially in urban areas.
OUT-OF-STREAM USES: Industrial-Commercial	*1.* Case-by-case assessment is needed since the more water left instream, the less water available for out-of-stream uses. *2.* Could result in limited and/or unreliable supplies if the water right is junior to the instream flow rule, since such water rights could frequently be interrupted.	*1.* Case-by-case assessment is needed since the more water left instream, the less water available for out-of-stream uses. *2.* Impacts for "lower" flows would be generally of the same type as with the "higher" flow approach, but with less impact on out-of-stream uses.	*1.* Case-by-case assessment is needed for new water rights applications. *2.* Because new water rights would most likely be junior to existing rights and therefore interruptible, there could be some hardships on industries in need of secure

	3. Could push businesses to invest more in conservation measures to make water go further. *4.* Could shift use to ground water for all or part of a business's water supply. *5.* If a business considered the cost or bother too high to meet higher flows, they could relocate geographically, delay development, or try to negotiate some sort of relief from state or local government.	*3.* Could result in limited and/or unreliable supplies if the water right is junior to the instream flow rule, since such water rights could frequently be interrupted. *4.* Investment in conservation measures may be encouraged, but at a lower level than if higher flows were required. *5.* Could push businesses to shift to ground water for all or part of their use, but at a lower level than if higher flows were required. *6.* If a business considered the cost or bother too high in meeting flows, they could relocate geographically, delay development, or try to negotiate some sort of relief from state or local government.	future water supplies. *3.* Current management sometimes results in water restrictions during times of drought or extremely low flows. *4.* To avoid interruption of water supply, many businesses have initiated conservation programs to reduce water use. Current management encourages conservation practices. *5.* Under current management there is sometimes a shift of use to ground water. *6.* Because of the current difficulty in obtaining new water rights, many high water-use industries and businesses choose locations where utilities have sufficient water rights to meet their needs or locate outside Washington State.
OUT-OF-STREAM USES: Agricultural	*1.* Case-by-case assessment is needed since the more water left instream, the less water available for out-of-stream uses. *2.* Future water rights would be subject to higher level stream flow provisions and would be	*1.* Case-by-case assessment is needed since the more water left instream, the less water available for out-of-stream uses. *2.* Issues are essentially the same as for the higher flow approach but with less urgency,	*1.* Existing water rights would not be affected by regulations, but future rights would be and therefore are potentially interruptible. *2.* In the current system, supplemental water sources

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	interruptible whenever flows fall below the minimum in the regulation. *3.* Water may only be available seasonally for new out-of-stream uses, including agriculture. *4.* Could lead to more efficient use and distribution of water. *5.* Could encourage more storage development for irrigation.	since there would be comparatively more water available for out-of-stream use.	or storage is sometimes needed.
RESOURCE SUSTAINABILITY (keeping the natural system functioning in a self-perpetuating manner)	*1.* Retaining or restoring flows to a relatively higher level creates a more sustainable situation than with the other approaches. Since analytical tools are not sufficiently sophisticated to fully analyze an ecosystem, we do not know the long-term effects of some of our activities.	*1.* A flow level where flows are adequate "most of the time" is not considered sustainable since the peak flows would be gone. (Peak flows are the highest flows that occur during a given time period.)	*1.* Risk of gradual, incremental degradation through *di minimus* and other uses. In many cases, flow levels are already below the level of sustaining natural resource functions.

The following table includes a series of questions to help planning groups explore some of the broader watershed issues that may be associated with specific elements of the environment.

Table 2

Watershed-scale Environmental Impacts

Element of the environment	**Questions to assist in defining watershed scale impacts**
FISH AND OTHER AQUATIC RESOURCES **(including hatcheries)**	Are there any ESA-listed species in the watershed? Check with National Marine Fisheries Service. Are there impediments to spawning? Are there passage barriers? Is there concern for genetic mixing of hatchery and wild stocks? Any fish concerns in Salmonid Stock Inventory (SaSI)? Check with Department of Fish & Wildlife. Has a "limiting factors analysis" (i.e. an analysis of factors that limit salmonid production) been completed and what were the results? If the flows are set in regulation, what are the effects?
WATER (Quality & Quantity)	Volume of water diverted or withdrawn? Check with Ecology regional offices. CWA §303(d) listings? TMDLs underway? Hydraulic continuity (i.e. the connection between ground water and surface water); Base flow and recharge rates? (Base flow: a stream flow that is essentially fed by ground water; Recharge rate: the rate at which surface water replenishes ground water) Are there any municipal water reservations? Amount of actual water use versus amount of water recorded on paper ("wet" water vs. "paper" water). Flooding/drought issues? Naturally occurring water quality concerns? (sedimentation, metals, etc.) Special water quality concerns? Water quality permits? Facilities or operations carried out under a general permit, such as gravel pits, dairies, stormwater? Stream channel as a conveyance for water to fulfill a water right? If the flows are set in regulation, what are the effects?

WILDLIFE	Are there water or riparian dependent species? Are there any ESA-listed species in the watershed? Check with US Fish & Wildlife Service. If the flows are set in regulation, what are the effects?
RECREATION	What type of recreation occurs on the stream? Is there a timing factor for that recreation? Is there specialized recreation requiring certain flow levels, such as kayaking? Are there exposed dangerous rocks, etc. at low flows? If the flows are set in regulation, what are the effects?
AESTHETIC & SCENIC	Are there exposed rocks at low flows? High flows leaving debris, silt in trees along shoreline? If the flows are set in regulation, what are the effects? Water falls, springs, artesian effects, etc.
NAVIGATION	Boat passage? Log rafting or other transport? If the flows are set in regulation, what are the effects?
OTHER ENVIRONMENTAL VALUES & COMPATIBLE USES	Cumulative effects? Are there mitigation opportunities? If the flows are set in regulation, what are the effects?
RIPARIAN VEGETATION	Are there any ESA-listed species in the watershed? Check with US Fish & Wildlife Service. Contact Department of Natural Resources Natural Heritage Program to see if there are plants of concern. Relationship to instream flows? Increasing or receding? Species changes? Relationship to wildlife? If the flows are set in regulation, what are the effects?
ECOSYSTEM HEALTH	What does the system look like compared to 50 or 100 years ago? Adjacent uses? Land use changes? Estuarine effects? Cumulative effects of activities within or affecting the watershed? Smells? (e.g. methane) If the flows are set in regulation, what are the effects?

HISTORICAL-CULTURAL	Historical/cultural entities exposed at low flows? Historical/cultural entities threatened at high flows? Any listed archeological sites? Check with local tribal and historical societies. Contact state Office of Archaeology and Historic Preservation. If the flows are set in regulation, what are the effects?
INSTREAM STRUCTURES	If the flows are set in regulation, what are the effects? From either a high or low flow perspective?
OUT-OF-STREAM USES	If the flows are set in regulation, what are the effects? From either a high or low flow perspective
RESOURCE SUSTAINABILITY	Would adoption of a flow regulation encourage/discourage sustainability? What will the system look like in 5, 10, and 100 years if the recommended flow were implemented?
WETLANDS (including constructed wetlands)	Are there any ESA-listed species in the watershed? Check with US Fish & Wildlife Service. Smells? (e.g. methane) Contact DNR's Natural Heritage Program to see if there are wetland plants of concern. Relationship of wetland health and adjoining/feeding streams? If the flows are set in regulation, what are the effects?

ADDITIONAL CONSIDERATIONS

The previous matrices (Tables 1 and 2) examine both specific and watershed-wide potential impacts in relation to elements of the existing environment. As planning groups develop their flow recommendations, there are also some broad concepts and tools for dealing with possible impacts that would be helpful to consider.

Mitigation

Mitigation means an action "to make or become less severe or intense". In a water management context, it means to reduce certain consequences of a proposed action by modifying the action, or by picking an alternative approach with less deleterious effects.

Mitigation will depend on the specific water body situation. With regard to flows, it can include efforts to maintain flows while still meeting out-of-stream needs. For example, conservation measures could be employed to put water back into a stream - either to restore flows or to increase the availability for other out-of-stream uses. To make this example more specific, if a business wanted water from a stream, they could buy enough low flow toilets for a community so that the water those toilets would save was at least equivalent to the amount of water taken out.

Another potential mitigation measure could be buying existing water rights and putting that water in stream through the Trust Water Rights program (Ch. 90.42 RCW, Water Resource Management). This is a state program whereby water rights are returned to a stream and protected from further appropriation. The water is thus considered held in trust. Additional examples of mitigation measures include dry year leases (leasing of water rights by the state to have water available in dry periods), educational and voluntary approaches, tax incentives, water use rates, zoning, and increased compliance.

Planning groups/Ecology may want to consider the use of monitoring, to determine if intended management measures were implemented and how they are working. Are the flow levels being met? Are they effective in doing what was intended? Should they be adjusted?

Mitigation proposals on a state-wide basis regarding flows would be hard to predict, but there are a few approaches. If the preferred flows are high, a levee system can be installed (with its associated costs and benefits). If flows are low, possible approaches for increasing flows include the augmentation of flows with ground water and the regulation of flows through reservoirs (with the source of the water in the impoundment – reservoir - being either surface or ground water or a combination). (See the appendices for suggestions of ways to get water back into a stream.)

Mitigation may also be applied to specific instream values or out-of-stream uses. Appropriate mitigation will depend on the resource impacted, the severity of the impact, and other related conditions. This level of mitigation must be determined on a case by case basis. It is probably best addressed during the more detailed, site-specific environmental analysis that individual watershed planning groups will prepare.

Adaptive Management

An adaptive management approach to setting flows can be used. "Adaptive management" is collecting and using scientific information to evaluate and improve resource status and management decisions based on data and information gathered.

There are numerous ways adaptive management can be applied to management of flows. A flow level can be developed and adopted into rule with the stipulation for review at prescribed intervals against criteria and then adjusted, as needed, to meet those criteria. It would probably be helpful for groups to build adaptive management capabilities into their original plans, since biological and hydrological systems are dynamic and the science is continually evolving.

Cumulative Effects

A series of small, unrelated projects can have an impact on instream resources. The most obvious example is the small amount water diverted or withdrawn by individuals for domestic use, which by themselves are *di minimus*, but when taken cumulatively can be a substantial amount of water. Even if the total withdrawals do not equal a large volume of water, the timing of the withdrawals may be important, for example if they are during a low flow period. These small impacts would then have an effect and have to be addressed.

Cumulative effects need to be addressed within the context of watershed planning. As a part of this, planning groups need to keep abreast of water management in both adjacent watersheds and on a regional scale, since there may be a relationship between local and regional efforts.

Changes in environmental and related processes (like land use practices, including residential development or logging) induce changes in watershed processes (for example, run-off volume, water quality, channel shape and habitat). And a combination of changes can produce interacting responses. It is therefore important to monitor and anticipate these changes and potential interactions over time. (A thorough discussion of cumulative effects can be found in Reid's research; see the Bibliography in the appendices.)

Certain global conditions can have a cumulative effect on stream flows. For example, air warming can cause snow or glacial melting, increases in the frequency or intensity of storms, and increases in frequency and/or amount of rainfall/snowfall. Higher flows would result.

Sustainability

Planning efforts need to consider the sustainability of their flow recommendations and how these recommendations fit within the overall water management framework for their watershed. "Sustainability" is best exemplified by the following kinds of questions: Can the proposed flow level be continued over time? How will the impacts of your decisions be manifested in five, ten, or twenty years from now (and so on)? If the current rate of withdrawal continues, what will the impact be out into the future?

An example of a sustainability approach for flow levels is to examine water quality and quantity as a system, rather than separately. Since managing one aspect of water without taking into account the other is a potential setup for problems in the future, considering both together increases your chances of successfully meeting your goals. For example, consider both quantity and quality when making permitting decisions.. The lesson here is that the more you are able to anticipate ramifications now, by thinking and planning systematically, the less damage control you may need to do in the future.

For more information

The IFC *Guidelines* do a good job of describing the potential impacts of different flow levels, and there are a wide array of other documents that do essentially the same thing (see the Bibliography in the appendices). (The IFC *Guidelines* also includes discussions on natural flows and the need for an ecosystem approach, the importance of flows in shaping environment and alternatives for instream flow management.)

V. COMMON FLOW ASSESSMENT METHODS

Summary

In this section we look at:

- how planning groups can choose and use flow assessment studies
- commonly used methodologies in Washington State, including PHABSIM and IFIM, Toe-width, Tennant and Correlation
- resources for more information

Introduction

Flow assessment methods provide scientifically-based information that can help decision-makers assess and set flow levels. Simply put, flow assessment methods are tools to help you describe the current stream conditions, get an idea of what is possible for a given study area, and determine how much water needs to be in the stream to protect instream values. The United States Geological Service (USGS) and Ecology, among others, can provide basic hydrological information about flow levels that would include amounts of water and timing of flows. But additional information is often needed to formulate specific recommendations, of the kind that assessment studies can provide. The flow assessment methodologies, the "science", are part of the basis upon which flow regulations can be set.

As useful a role as assessment studies play, it is important to remember that science is only one factor to inform the discussion regarding flows. The *policy* side of flows considers the environmental, social, political and other factors to be considered when deciding on appropriate flow levels. Policy issues will be considered in the nonproject watershed EIS planned for release in mid-2002.

Flow assessment tools can be helpful at many points along a group's planning process, but in the context of this guidance document we will look at using such studies to help a group decide what actual flow levels should be in order to meet their goals. To put this in context: first a planning group decides to recommend instream flows as one of their overall strategies. The next step is to ask, what information do we need in order to actually determine the appropriate stream level(s)? It is at this juncture that a decision to conduct new or updated scientific studies is made. More specifically, the group will need to decide on the type of study needed, which will depend on the type of information needed. Once the study is completed, the results become one factor a planning group uses in selecting the desired flow level(s). These levels are then formally recommended to Ecology. The studies will become an integral part of the group's overall environmental analysis, as required under SEPA.

Different types of studies measure different things. One "size" does not fit all. Methodologies are available to quantify the necessary instream flows for such specific values as fish, wildlife and recreational use. Studies can then be even further focused; for example, a given fish-oriented method may be best at modeling certain salmonid (that is, fish in the salmon family plus bull trout) life stages. The methodologies vary in sophistication and precision, ranging from simple visual judgments estimating the sufficiency of flows to elaborate computer models.

Choosing a Flow Study Method

There are many tools available for assessing instream flows. Groups need to select a study method based on their goals and watershed-specific circumstances. To begin a discussion on choosing the appropriate assessment tools, there are a number of resources that can be helpful, including the IFC's *Guidelines*. We have chosen to use a framework proposed by Clair Stalnaker, who is generally recognized as a leading expert on instream flows. Stalnaker et al. (Stalnaker, 1995) note that:

> . . . when choosing a technology, the analysts' concentration is often initially directed to the technical details of the procedures, such as measurement of stream transects or operation of computer models. However, experienced professional biologists and engineers responsible for assessments recognize that harder policy questions must first be answered. Analysts ultimately decide to use a technique as much because it fits the political and environmental problems they face as because the technology meets scientific standards (Lamb 1986).

Stalnaker et al. then set up a paradigm for looking at political and environmental problems based on the objectives of the decision process. They use the terms "standard-setting" and "incremental". If the planning group ultimately needs a recommendation for an instream flow requirement "to guide general and, usually, low-intensity decisions setting a limit below which water cannot be diverted", this is referred to as a "standard-setting problem." At the other end of the spectrum is "a high-intensity, high-stakes negotiation over a specific development project", called an "incremental problem." Stalnaker et al. caution that "rather than a clear dichotomy, it may be appropriate to picture these two types of decisions on a continuum ranging from the setting of non-controversial standards for overall planning to conflict over establishing incremental differences in flow levels."

The Stalnaker et al. paradigm can help planning groups in the initial stages of choosing a study method. At this point, a group is asking: What are the conditions of our watershed, what problems are we facing and what kind of results are we looking for? The more complex the issues, the more rigorous the flow assessment method will need to be. The paradigm is summarized in Table 3 below.

Table 3

Standard-setting	Incremental
Low controversy project	High controversy project
Reconnaissance-level planning *	
Few decision variables	Many decision variables
Inexpensive	Expensive
Fast	Lengthy
Rule-of-thumb	In-depth knowledge required
Less scientifically accepted	More scientifically accepted
Not well-suited for bargaining	Designed for bargaining
Based on historical water supply	Based on fish or habitat

(* Refers to planning being done at a general, rather than detailed, level; an overview)

The Stalnaker et al. paradigm is helpful for clarifying decisions on a flow assessment method at a general level. As planning groups' discussions continue, they will need to become more focused. For the next tier of questioning/discussion, it may be useful to consider the following factors:

<u>Process-related questions</u>

- Type of result desired/Level of detail needed (e.g. reconnaissance-level, legal defensibility, credibility, legal obligations, etc.)

  What is the level of detail needed on which to base a decision? If you know you are likely to be sued, you may want to increase the level of rigor in your assessment to ensure its validity. Are you under a legal or legislative directive that tells you the level of detail to which you must go?

- Time, money and labor constraints.

  Do you have enough time and other resources to undertake the study being contemplated? Are you trying to buy a Cadillac on a VW budget? Are you thinking about undertaking a comprehensive study taking measurements over several years when the fish you are trying to protect may run out of habitat in six months?

- Suitability to project scope.

  This can be related to the level of controversy - the higher the level of controversy, the more credible and thus more defensible you want your science to be. Additionally, some methods are more applicable to certain sized systems (for example, Toe-width is generally used on smaller streams than is IFIM).

- Target management species (e.g., game, non-game, threatened and endangered).

  Is the type of study appropriate to the resource(s)? Certain methods are more accurate when applied to certain species and if there is more urgency. If a fish species is ESA-listed, you probably want better information.

- Assessment of instream values and priorities (fish, wildlife, recreation, etc.)

  Is a suite of studies necessary to adequately describe stream/riparian ecosystem functions of which flows is one component? Although one species and/or lifestage may be emphasized, how does the study appraise other species and lifestage needs? How well does the assessment method apply to the instream value of concern? In some cases, we simply have limited models for assessing resources.

- Availability of historical flow records.

  Many flow assessment methods are based on historical hydrological information or recently collected data. If the basic data is shaky from an accuracy perspective, the assessment will not be credible. In some cases, there may be local custom for measuring water. A certain period of record is needed in order to have credible hydrological data.

- Anticipated level of controversy.

  If a town's future water supply, or the future of an ESA-listed fish, or a world class kayaking area are at stake with the flows levels being contemplated, the science backing the flow level needs to be good.

<u>Method-related questions</u>

- Present use and acceptability of methods.

  Is the method being contemplated one that is accepted by credible instream flow practitioners in the areas? Is it an experimental method that has only limited acceptance?

- Flexibility of method (i.e. ability to refine, modify method to meet specific needs).
- Capability of method to predict probable consequences of flow modifications.

  Is the method applicable in your area? How accurate have the techniques been when applied in the past and is that level of accuracy sufficient?

Flow Assessment Methods Commonly Used in Washington

This discussion of methods is not intended to be exhaustive, but rather an overview of the flow assessment methods commonly used or just coming into use in Washington state. The methods to be examined in detail are PHABSIM, IFIM, Toe-width and Tennant. For each, we describe the method and its objectives, constraints, how it works, and the cost, time, resources and personnel needed to implement. Following a detailed look at those four, the Correlation and other methods are discussed.

Keep in mind that these assessment methods are literally "models", and as models, their results will need verification. Models can only predict; you have to go out into the field to confirm how accurate a model ultimately is. The correlation between what the model says and what is actually there in reality needs to be examined and found to be within acceptable limits.

The first step in any study will be to assemble and analyze hydrologic information. You need to first know the present flow in the stream and the quantity of any diversions.

Physical HABitat SIMulation System (PHABSIM) system, an Instream Flow Incremental Methodology (IFIM) Variant

Description and objectives

PHABSIM is the most commonly used study method for instream flows in Washington State. The U.S. Fish and Wildlife Service developed it in the late 1970s (Bovee, 1982). It produces a model that shows the relationship between stream flow levels and the physical habitat for various life stages of one or more species of fish. Four key measurable elements of fish habitat are considered: depth, velocity (water movement), substrate (material on the stream bottom) and cover (material that fish can use to hide from predators, like logs, leaves and so on.) Since it considers multiple factors, Stalnaker et al. include it in a category called "mid-range techniques," which are methods "a little more than basic standard-setting but not quite incrementalism."

PHABSIM can generally be described as having three main components. First there are actual field measurements of depth, velocity, substrate material and cover, taken at specific sampling points on a cross section, at different flow levels. This data is used to create hydraulic models (that is, models that have to do with the movement and force of water) which evaluate the four habitat variables at different flows. This data, in turn, is combined with "species suitability criteria," a model that evaluates how suitable a given habitat attribute is for the life stage and species under consideration. The final result is an index to the amount of microhabitat (that is, the immediate environment of a fish in a stream) available for different life stages for different species at different flow levels.

Constraints

There are several common criticisms of PHABSIM. One is its use of species suitability criteria. This criteria is not universally accepted, since some subjectivity is involved in its use of direct observation and/or expert opinions to characterize what the life requisites are for a given species. Another criticism is the species by species analysis of habitat, which may not account for interspecies competition. And although not a criticism per se, it is also important to remember that PHABSIM only considers four habitat factors. Other variables such as fish passage, food supply (aquatic insects), competition between fish species, and predators (birds, larger fish, etc.) may also be of importance, particularly at certain flows, such as extreme low flows. Even allowing for its possible shortcomings, PHABSIM is used nationwide and is accepted by most resource managers as one of the best available tools for determining, in the broadest sense, the relationship between flows and fish habitat.

How it works

This method involves putting site-specific stream flow and habitat data into a group of models collectively called PHABSIM (Physical Habitat Simulation). Within PHABSIM are models of fish habitat as affected by hydraulics. The most common model is IFG4, which uses multiple transects (cross sections) to predict depths and velocities in a river over a range of flows. IFG4 creates a cell (measurable area) for each measured point along the transect. Each cell has an average water depth and water velocity associated with a type of substrate or cover for a particular flow. The cell's area is measured in square feet.

After the IFG4 model is calibrated (that is, adjusted to the situation being modeled) and run, its output is entered into a species suitability criteria model (HABTAT, or Habitat Simulation Program) which has data describing fish habitat preferences for depth, velocity, substrate, and cover. These preferences vary according to fish species and life-stage (adult spawning and juvenile rearing). The output of the HABTAT model is an index of fish habitat known as Weighted Useable Area (WUA).

A summation of all the transect cells' areas results in the total number of square feet of preferred habitat available at a specified flow. This quantity is normalized to 1,000 feet of stream or river. The final model result is a listing of fish habitat values (WUA) in units of square feet per 1,000 feet of stream. The WUA values are listed with their corresponding flows (given in cubic feet per second).

The Departments of Fish and Wildlife and Ecology prefer 3-flow modeling, although it is not available through all training agencies. Note that various practitioners have adapted the PHABSIM method to include different capabilities. The version you use can make a big difference. (Beecher, personal communication, 2001)

Cost, Time, Resources and Personnel

This method is relatively expensive as used in Washington, due to visiting sampling sites three times in order to get three flow levels (low, medium, and high flows). It typically takes a week or so of field work spread over three or four months to take measurements, and then from six to twelve months to run the model, analyze data and write the report. Getting measurements at the appropriate time is crucial and is highly contingent on how fast stream flows are rising or falling.

On some streams, particularly large streams such as the Nooksack and Spokane, there are real safety concerns to consider. Measurements have to be taken in the water, which sometimes means using a boat and cable. (Recently radar-based systems have been developed that can take measurements remotely. These are likely to become state-of-the-art, however they are still quite new, very expensive, and will need some time to gain acceptance.)

Personnel need relatively intense training to carry out this method. The current IFIM training available through the USGS emphasizes 1-flow hydraulic modeling in IFG4. (See the USGS, Midcontinent Ecological Science Center – MESC - website). (Ecology and DFW prefer 3-flow modeling.) Consultants and others involved in setting up IFIM studies will find it helpful to review the *Instream Flow Study Guidelines* specific to Washington State, which are available on Ecology's web page under Instream Flows (ISF Primer/Background Flow Measurement Methods).

Costs vary depending on the intensity of the study, distance from office, and how many "false starts" there are (missing a rising flow measurement). Estimates for collecting data for the 3-flow approach with seven or so transects, running the model and analyzing the data, and writing the report come in between $30,000 to $40,000.

Currently, Ecology uses the results from PHABSIM to determine new water right permits on a case-by-case basis. Ecology has either completed or nearly completed IFIM studies in 24 watersheds. IFIM studies by other agencies and consultants have been done in another 14 watersheds.

Instream Flow Incremental Methodology (IFIM)

Description and objectives

See the discussion on PHABSIM. PHABSIM is a component of a "full" IFIM study, but people confuse the two. Stalnaker et al. make the distinction that whereas "IFIM is a general problem-solving approach employing systems analysis techniques, PHABSIM is a specific model designed to calculate an index to the amount of microhabitat available for different life stages at different flow levels".

A computer-modeling approach, IFIM is generally used where resource values and controversy levels are high and is considered state-of-the-art. It is one of the more rigorous incremental techniques examined by Stalnaker. IFIM is considered "incremental" since it looks at changes in flow as they relate to habitat conditions. IFIM deals with several habitat features and predicts habitat levels based on those features, at varying flow levels. An IFIM approach can be applied to other instream values, such as recreation.

IFIM is unique because it simultaneously analyzes habitat variability over space and time.

Constraints

Data collection and analysis are time consuming. Study design can take years to set up and all stakeholders need to have input. After the study is completed and the report written, deliberations can continue for months discussing the results. See also the discussion under "Criticisms of IFIM" (below).

How it works

In IFIM, habitat suitability data comes in two forms: macrohabitat and microhabitat. Macrohabitat suitability refers to variables that vary as you move downstream, such as water quality, channel shape (morphology) and temperature. Microhabitat suitability refers to the same variables used in PHABSIM analysis: depth, velocity, substrate material, and cover. IFIM uses computer software to integrate these two measures of habitat into habitat units that are then related to flow over time, resulting in a Habitat Time Series (HTS). The HTS describes habitat changes, based on the factors inputted, over time and at various flows.

Cost, Time, Resources and Personnel

See PHABSIM discussion and then factor in additional time since more variables are analyzed and modeled. While the fact that IFIM examines many variables one of its strengths, integrating all those variables is time-consuming and challenging work.

Fairly substantial training is required and much is offered (such as from the USGS - http://www.mesc.usgs.gov/training/mesc-training.html).

In addition to the PHABSIM models, IFIM may include reviewing water quality, sediment, channel stability, temperature, hydrology and other variables that affect fish production. These additional variables are not analyzed in this document.

Criticisms of IFIM

In recent years several prominent scientists have criticized the IFIM in print. Generally these criticisms were valid for what *has been called* IFIM, but good application of IFIM would likely have met with their approval. Most people who do IFIM stop at the PHABSIM modeling, usually only calculating the WUA, that is, the index of (micro-) habitat or living space, as a function of flow.

The proper application of IFIM includes an evaluation (subjective or objective) of: (1) potentially limiting factors, such as water quality and pollution; (2) watershed processes and how they affect the stream channel; (3) meso- (middle range) and macrohabitat factors not considered in microhabitat modeling; (4) natural hydrology and connection with ground water (connectivity); and (5) fish life history and species requirements as an organizing factor for WUA interpretation. All these factors must be considered when developing a flow recommendation using IFIM. Unfortunately, few use it this way.

The application of IFIM is often poor, but the method is sound. The newer 2-dimensional hydraulic models allow even better descriptions of habitat and better modeling of what we think fish perceive as habitat. What we learn from IFIM/PHABSIM is not the whole answer, but it is an important part of the information needed to develop an intelligent answer. In the end, educated judgment must be used in the interpretation and development of flow recommendations.

Remember that the more complex a study, the more open to criticism it will be. Since PHABSIM and IFIM are complex methods of flow assessment, they will tend to come under far more scrutiny than simpler methods. It is therefore important that all interested parties stipulate to the study of choice so that the results are buffered from legal attack, since the interpretations are open to criticism.

Toe-width method

Description and objectives

In this standard-setting approach, the "toe-width" of a stream is measured and put into an equation that yields a prediction of salmon and steelhead spawning flows. The "toe" of a stream basically refers to that point in a stream which is the juncture between a pool (deep, slow water) and a riffle (shallow and fast-moving water). This point is called the "tail" of the pool. Other characteristics of this point are that it is where the gravel (characteristic of the bottom of a stream) meets the dirt (the bank of the stream), usually at a sharp incline. And it is at this point that fish like to spawn. Measuring the toe-width is to measure the distance from the toe of one streambank to the toe of the bank across the stream channel.

Constraints

This method yields a single number for the flows fish prefer for spawning and rearing young ("spawning and rearing flows"), which says nothing about the relationship between habitat and flows - which can be critical in a decision-making process. Toe-width tends to somewhat overestimate flows in very small streams and underestimate in large ones. It is best suited for use in small streams.

How it works

The toes of the bank on each side of the stream channel are located and measured based on the angle of the slope and the substrate. Measurements are then averaged and used in species and life-stage specific equations for steelhead and salmon to calculate spawning and rearing flows.

Cost, Time, Resources and Personnel

The Toe-width methodology is the most commonly used (along with PHABSIM) by the Departments of Ecology and Fish and Wildlife for setting flows. A relatively simple tool to use, it yields a lot of useful information for a minimum of effort. Requiring only a measuring tape, the time it takes to drive to the stream, and 10 minutes to do calculations, a dozen Toe-width studies can be done in a day. The method takes only minutes to learn, and it can take as little as a week from data collection through report writing.

Most of the 250 instream flows set by rule in Washington state were done with Toe-width. It was a method created specifically in response to the Water Resources Act of 1971 and is still valid today. The results compare favorably with those from IFIM/PHABSIM.

Many times, quick Toe-width estimates will be adequate for management purposes. For example, the Toe-width flow numbers on the Dosewallips River were only around 10-15% higher or lower than the IFIM flow numbers. To give an example using numbers: say the median flow for a stream in October is 70 cfs. For spawning chinook, the IFIM/PHABSIM number is 300 cfs and Toe-width says 325 cfs. That is not a significant difference; with both numbers you know that the stream should be closed to protect spawning chinook in October.

In most of our rain-fed streams and small rivers (with little snow), the results from either Toe-width or IFIM/PHABSIM will likely say the stream should be closed from May through October to fully protect fish habitat. Planning groups are therefore reminded that they may be able to answer many of their instream flow questions with the simpler and less expensive methods. For example, one can calculate diversions using water rights information, or make hydrographs based on data from USGS or others. Such data would help determine what flows are needed for fish, how much water is diverted, how much water can be restored, and if a target flow for restoration could be developed. Factors including stream width, depth and velocity need to be considered when determining which method is used - along with the time involved, cost constraints and the level of controversy.

Tennant Method

Description and objectives

This standard-setting methodology was developed in 1976 based on personal observations by Don Tennant. An in-office method, it is based on hydrologic records and field measurements and predicts flows based on averages. It assumes a relationship between habitat and annual flow levels.

Constraints

There are assumptions on hydrology that will need to be field verified to determine if they make sense in a specific application of this approach. These include the fact it is based on the average annual flow, which does not reflect seasonal variations, and also the fact that it does not address biological diversity. The method assumes a relationship between flows and fish, which should be confirmed region to region. Because this approach is only based on hydrological data, it has been criticized for being over-simplified, since there are many other factors that are not taken into account. One danger is to treat an altered system (that is, one with dams or where water is taken out, for example) as if it were natural or uninfluenced. The data generated by this approach needs to be carefully considered against the group's objective(s) to determine how useful it will be.

How it works

Relying on USGS hydrologic flow data, this method is based on the assumption that aquatic habitats are very similar when they carry the same proportion of average flows. Hydrologic records are consulted and average flows determined or calculated. Ten percent of the average flow is the minimum instantaneous flow recommended to sustain short-term survival habitat for most aquatic life forms. Thirty percent is recommended as a basic flow level to sustain good survival conditions for most aquatic life forms and general recreation. Sixty percent provides excellent to outstanding habitat for most aquatic life forms during their primary periods of growth and for the majority of recreational uses. Interestingly, Tennant recommended having periodic high flows for "flushing and scouring", that is, maintenance of the habitat by bringing in new gravel and taking out the old, removing debris such as leaves and twigs, and so on.

Cost, Time, Resources and Personnel

Since this is an office approach, it requires low effort. Once adequate records are obtained, it is easy to calculate average flows.

This method can be useful in generating information quickly when a fast response is needed, such as for evaluating a water right application's potential impacts in a large river.

<u>Correlation method</u>

This method takes the available data for one basin and applies it to a nearby basin with apparently similar characteristics. The data considered would include flow records, area, slope, "predominant aspect" (that is, the general lay of the land), precipitation and other factors related to hydrology and geography. The underlying assumption here is that the basins are similar enough that information from one is applicable to another. Current management dictates that for any flow assessment at least Toe-width measurements need to be done, and so the Correlation method might only be used for the initial, gross planning analysis of a basin, but probably not for decision-making. Since its use is so limited, a more in-depth analysis of Correlation as a flow assessment method will not be done in this document.

Other methods

While more of a goal than a method per se, use of the "normative" river approach has been proposed for determining flow levels in the White and Cowlitz Rivers. The essence of this approach is to mimic the natural conditions in the river system. The hydrograph might change slightly (due to withdrawals), but its overall shape would remain much the same. Therefore the peaks may be lower but would occur at the same time. An advantage of the normative approach is that it looks at the *whole system,* not simply flow levels.

Another approach to consider is the Range of Variability methodology developed by Richter et al. (1996 and 1997) which estimates "without project" or "natural" flows (flows without interference from human-built structures) and compares them to existing or "project" flows for major rivers. The purpose is to compare statistics between the two flow regimes to determine differences between the two. The King County Department of Natural Resources currently uses a modified Range of Variability approach in the Green River (King County DNR, 2000, draft). This approach could be useful to a planning group comparing alternative flow levels and could be incorporated into an instream flow setting methodology or assessment. (Carlson, personal communication, 2001).

The critics of studies such as the IFIM suggest that in order to set flows, all you need to know is the natural hydrology (water conditions) with year-to-year as well as season-to-season variability, then duplicate this (or modify it slightly so that the new hydrology reflects the natural variations). This is an excellent approach for an undisturbed watershed in a refuge. However, in a modified watershed, particularly one that has dams, storage, pavement, and confined banks (e.g. Spokane River), using natural hydrology or even scaled (e.g., 60% or 75%) hydrology might be counterproductive. This is because some of the watershed processes are no longer functioning naturally, so the relationship between current conditions and natural hydrology is not necessarily straightforward.

Critics have also advocated adaptive management: develop a flow regimen, apply it, monitor the values expected to respond to it, then change the flows and repeat the process if the first attempt does not yield satisfactory results. Most (probably all) instream flow practitioners support this approach. Unfortunately, the prior appropriation doctrine of western water law does not accommodate adaptive management very well. Adaptive management was proffered as one option during the first major review of Washington's water laws in 1986 and was rejected, even though existing rights would not have been affected.

Other flow assessment methods or strategies are acceptable provided they demonstrate the scientific rigor, credibility, reliability and applicability needed for watershed planning and in order to meet state laws. Groups should remember that valuable information could be gleaned from sources other than formal studies. For example, smolt radio-tracking, snorkeling surveys, and juvenile fish trapping can all yield useful information with regard to fish size, numbers, species and habitat utilization.

Flow assessment methodologies are continually evolving. In fact, the American Fisheries Society recently published an article by a panel of scientists who recommended establishing only interim flow levels, supplemented by adaptive management. We understand this position as follows: since instream study methods are rapidly changing, our ability to accurately assess stream conditions is constantly improving. Therefore the scientists concluded it may no longer be appropriate that water rights are issued for an indefinite period with no stated limit. (Castleberry et al. 1996.)

Riverine habitats are diverse, and we don't yet have models to accurately describe them all. For example, we do not have good assessment tools for stream side-channel habitat, or certain wetlands, or for some types of rare plant and animal species. Planning groups should keep in mind that while instream flow assessment methods play a significant role in determining instream flow levels, they have their limitations, are constantly improving, and finally, they are only one factor to be considered in flow discussions.

For more information

For a more complete discussion of flow assessment techniques, there are three key types of resources to check. For writing focused on instream flows, see the Instream Flow Council's current draft of *Guidelines for Meeting Public Trust Responsibilities in River Management*, or *The Instream Flow Incremental Methodology: A Primer for IFIM*, and the references listed at the end of each of those publications. A second source is the user surveys that played a part in determining the recreational instream flow needs at several hydroelectric projects (e.g. Nisqually, Lake Chelan, Sullivan Creek). Finally, books on recreation, such as whitewater guide books (by Douglass North and others), offer a third perspective.

For a more detailed historical perspective on the approaches Ecology has used in setting instream flows, refer to "Instream Flows in Washington State: Past, Present and Future," which can be found online at <http://www.ecy.wa.gov/programs/wr/wrhome.html.