A Framework for Ecologically Sustainable Water Management

Water managers face tough challenges in sustaining the health and availability of rivers while meeting increasing demands for their use. One tool that can give hydro project owners guidance is a six-step framework for ecologically sustainable water management developed by The Nature Conservancy.

By Brian D. Richter, Richard Roos-Collins, and Andrew C. Fahlund

Many natural resource managers speak of the principles of sustainability — our use of natural resources should not deplete their availability over time. In the mid-1900s, applications of the sustainability concept to resource management implied the goal was to maintain the condition, health, or volume of natural resources in a stable equilibrium over the long term. Then, in 1987, the World Commission on Environment and Development (also known as the Brundtland Commission) cast the sustainability challenge in a different light. In *Our Common Future*, its report to the United Nations, the commission used the term "sustainable development." Development implies change, expansion, or growth. By connecting sustainability with development, the commission recognized that the human population will continue to burgeon, and resource demands can be expected to mount as well. Hence, the challenge of sustainability today involves continuing to meet the needs of an expanding human population while sustaining the health of our natural resources.

Brian Richter, director of the sustainable waters program with The Nature Conservancy, helped develop the ESWM framework. Richard Roos-Collins, senior attorney with the Natural Heritage Institute, and Andrew Fahlund, vice president for protection and restoration with American Rivers, present the ESWM framework in inter-agency training workshops and advocate for its application in FERC relicensing.

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This article has been evaluated and edited in accordance with reviews conducted by two or more professionals who have relevant expertise. These peer reviewers judge manuscripts for technical accuracy, usefulness, and overall importance within the hydroelectric industry.

Sustainability in the hydro licensing context

This challenge is present in licensing proceedings for hydropower projects under the jurisdiction of the Federal Energy Regulatory Commission (FERC). In 1946, the Federal Power Act called for a "... complete scheme of national regulation which [promotes] the comprehensive development of the water resources of the nation."[1] To promote this vision, the act designated licensing authority to FERC for every non-federal hydropower project that is located on a navigable river or otherwise affects interstate commerce. These operating licenses are intended to assure that a project is "... best adapted to a comprehensive plan of development … of the affected waters."[2] In addition to energy generation, the beneficial uses recognized by the Federal Power Act include flood control, water supply, recreation, and protection and enhancement of fish and wildlife. Thus, the purpose of the statute is to ensure that each license achieves a *planned balance* between energy generation, other environmental uses, and ecological health.

To achieve this balance, we believe it is essential:

1) To consider all stakeholder interests in defining the desired level of river health; and

2) That license conditions limit the effects of hydropower generation such that they do not excessively damage environmental quality.

In recent years, FERC licensing has evolved to accommodate a growing variety of interests, many of which are tied to river health. FERC recently adopted an integrated licensing process (ILP) whereby a licensee, regulatory agencies, and other stakeholders coordinate efforts to develop scientific understanding of the environmental effects of a hydropower project, compare the effectiveness of alternative measures to mitigate such effects, and select measures to advance an appropriate comprehensive plan for the affected waters.

While the ILP will not control the substance of a licensing decision, it has the potential to reduce some of the inefficiencies under the traditional licensing process. These problems have included uncoordinated development of the license application and environmental review, as well as competition between FERC and other regulatory agencies as to who controls this review. Thus, the ILP is a platform that likely will permit interested stakeholders to focus greater effort on assuring that the license includes measurable and enforceable commitments to management objectives for all beneficial uses of the waters, including ecological sustainability.

The ESWM framework

Water managers and regulators face a difficult challenge in balancing a variety of stakeholder interests in a world in which resource demands continue to intensify. To help facilitate integrated water resources management, The Na-

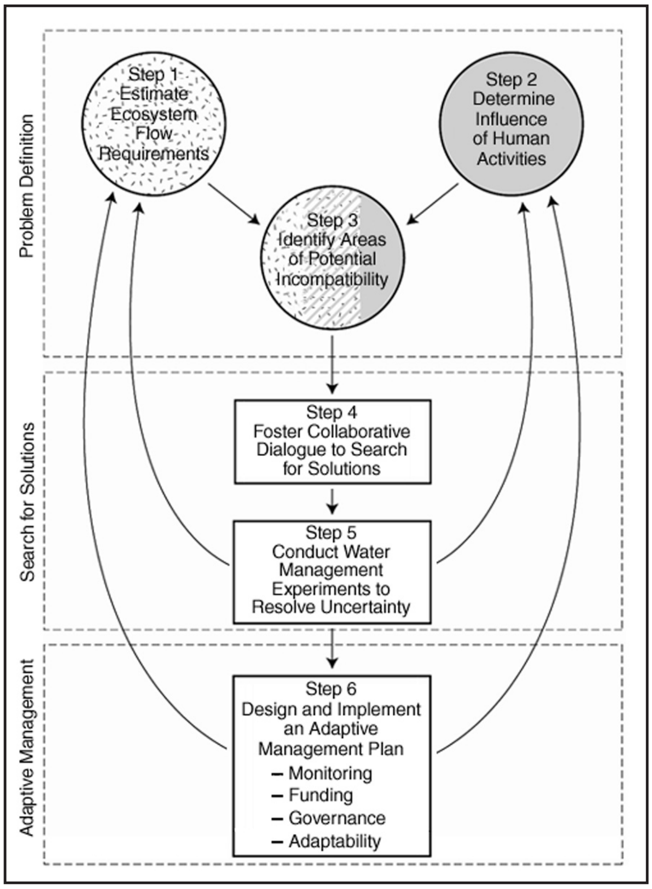

Figure 1: The six-step framework for ecologically sustainable water management is designed to help hydro project owners identify incompatibilities among various human and ecosystem needs for water and resolve those incompatibilities through collaboration.

ture Conservancy developed a new decision-making framework. (See Figure 1.) This framework for ecologically sustainable water management (ESWM) can help water managers organize, analyze, and build the information and knowledge required to identify incompatibilities among various human and ecosystem needs for water. Moreover, it provides a structure for resolving those incompatibilities through collaboration and experimentation.

The ESWM framework is built on the understanding that societal values for a river are optimized when water is stored, diverted, and released in a manner that meets human needs for energy production, water supply, and other municipal and industrial needs while maintaining adequate flows to sustain a healthy ecosystem. The ESWM framework recognizes the need to develop a sound scientific understanding of the water needs of the entire river ecosystem and its associated species as a cornerstone of any sustainable water management plan (see the first step in Figure 1). Some of the implications of applying the framework to determine instream flow requirements below hydropower projects include:

— A focus on whole, functioning ecosystems;

— A focus on variable instream flow regimes; and

— Use of interdisciplinary science teams.

A focus on whole, functioning ecosystems

To date, most instream flow requirements incorporated into FERC licenses have been based on assessments of the habitat needs of individual fish species. We believe it is necessary to consider not just the aquatic species living in the river, but also the health of riparian vegetation, floodplain wetlands, downstream estuaries, and the wildlife populations dependent upon these habitats. In our opinion, protecting the health of these water-dependent ecosystems — along with the associated ecosystem services and products humans value — requires consideration of a much broader spectrum of components and functions than has been addressed in most FERC proceedings.

A focus on variable instream flow regimes

In contrast to “minimum” instream flow specifications designed to protect fish, we think a much fuller spectrum of river flow variability — ranging from low flows, to occasional high-flow pulses, and even controlled flood events — may be needed to sustain ecosystem health. High-flow events may be needed to maintain adequate in-channel habitat conditions (such as spawning bars, riffles, and pools) or to enable regeneration of floodplain forests. It also may be important to allow the river to occasionally drop to very low levels to dry out floodplain soils and enable certain plants to reproduce, or to purge troublesome introduced (especially non-native) species. As a result, instream flow recommendations may change from flatline minimum flow targets into seasonally-varying prescriptions that might change in dry, average, or wet years.

Use of interdisciplinary science teams

Because of the complexities inherent in developing instream flow recommendations for a variety of ecosystems and species, the necessary science expertise is diverse. Ideally, multi-disciplinary teams would include experts in hydrology, hydraulics, fluvial geomorphology, water quality, fish biology, riparian ecology, and, where appropriate, estuary scientists. Instead of applying any single instream flow assessment tool or method — such as a fish habitat simulation model or a “rule-of-thumb” approach — these interdisciplinary teams would draw from a variety of tools to address a broad array of ecosystem considerations. Additionally, given the variety of societal interests that require consideration, we believe social scientists who can facilitate and integrate public input will be essential in addressing the full spectrum of social values.

Applying the framework

The first three steps of the framework are designed to maximize the potential for resolving incompatibilities between human uses and ecosystem needs for water. When water managers, scientists, and water users focus on a well-defined set of conflicts, they will be much more capable of finding mutually compatible solutions. However, as illustrated by the Roanoke River example in the box on page 90, the ecosystem’s water needs, future human demands, and even present levels of water use cannot be known with perfect certainty. These sources of uncertainty commonly frustrate a collaborative search for solutions.

Increasingly, water managers are embracing the concept of adaptive management as a means to address these uncertainties. A key aspect of adaptive management is the use of pilot tests or experiments to improve understanding of the natural and human systems. Rather than “trying something and watching what happens,” adaptive management needs to be a carefully designed process of *deliberate learning* using planned experiments.

For example, in developing flow recommendations for the Savannah River in Georgia (see Figure 2), scientists

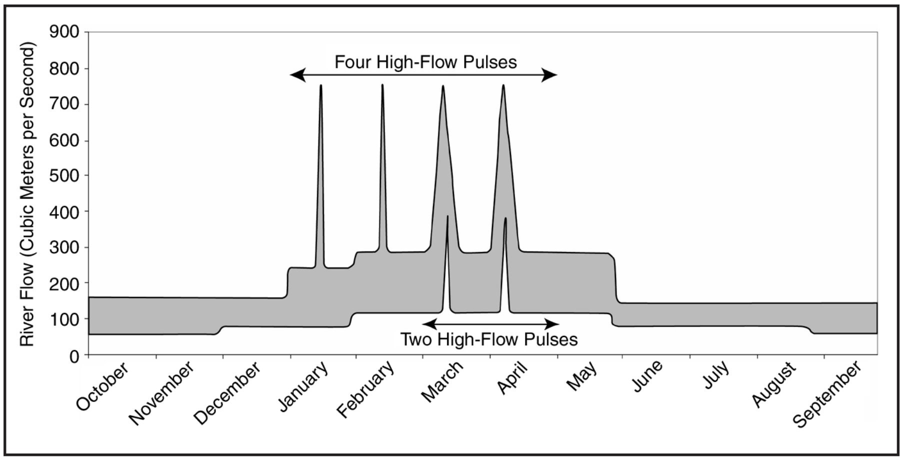

Figure 2: Instream flow recommendations for the Savannah River were specified for three types of water years (dry, average, wet). The shaded band reflects desired flow conditions. In dry years, water managers will follow the lower end of the band range; during wet years, flows will be closer to the upper band limit.

were somewhat uncertain about the level of high-flow releases necessary to enable certain fish species, such as sturgeon, to move upstream past the 280-MW J. Strom Thurmand Dam. Participants in the flow recommendations workshop represented the South Carolina Department of Natural Resources, U.S. Geological Survey, U.S. Fish and Wildlife Service, University of Georgia, Southeastern Natural Sciences Academy, and other concerned organizations. To determine the necessary releases, in March 2004, the U.S. Army Corps of Engineers began experimental high-flow pulse releases from Strom Thurmond Dam. By monitoring fish movements, scientists can verify that fish are able to pass at the targeted flow level.

After the first high pulse release, scientists discovered that the water temperatures were too cold to attract fish to their spawning grounds at the time of the release. The scientists learned they need to verify that the fish have begun moving upstream to their spawning grounds when scheduling future pulse releases. The Corps performed the most recent high pulse release in March 2005, after determining that the fish appeared ready for spawning.

The first three steps of the ESWM framework focus on characterizing human uses of the available water supplies and assessing the effect of these uses on the water conditions necessary to sustain healthy ecosystems. In any river basin, humans use water in a variety of ways, in varying amounts, and at different times of year. Computerized hydrologic simulation models enable water managers to better understand these spatial and temporal complexities. These models typically are developed for the purpose of understanding how much water might be available at any point in the river basin over time, thereby enabling assessments of water supply reliability or opportunities for revenue generation, such as in hydropower production. Hence, the development of hydrologic simulation models is essential in applying ESWM. These hydrologic models are equally useful in determining the availability of water to meet the ecosystem flow recommendations developed in the first step of the ESWM framework.

Importantly, a hydrologic simulation model can enable water managers, scientists, and stakeholders to identify *where* and *when* water use conflicts might exist, now or in the future. Pinpointing the incompatibilities between water management activities and ecosystem needs makes it easier to design solutions to resolve those conflicts. A variety of innovative solutions are being applied, ranging from urban or agricultural water conservation measures that make more water available for instream uses, to environmental purchases of water use or storage rights, to modifying hydro project release patterns. By focusing on the locations or times of year at which problems arise, water managers can work to find the most appropriate solutions.

Applying ESWM in FERC proceedings

To successfully implement the ESWM framework in a FERC licensing proceeding, five areas of emphasis are needed.

First, an individual proceeding needs to be structured in light of the circumstances of the project and individual stakeholders, to maximize the probabilities for adequate scientific study and design of collaborative solutions within the three years allowed for application development. Specifically, we recommend the proceeding be designed to facilitate completion of the first four steps of the ESWM process.

Second, the study plan needs to be structured to produce useful and reliable results about the causal relationship between project flow regulation and ecosystem condition. This means the plan needs to include assessment of the project's effect on the natural variability of low flows, high flow pulses, and floods, and the consequences of flow alterations need to be assessed across a full range of ecosystem components — including aquatic, floodplain, wetland, and estuary habitats. The three-year period in which a license application is developed often is too short to conduct intensive ecological research or undertake controlled experiments that could provide better certainty about proposed strategies for improving ecosystem health. We encourage parties to be careful not to use this lack of certainty as an excuse to do nothing. Instead, we recommend the study plan be designed to learn as much as possible about the full spectrum of potential project effects.

Third, hydrologic modeling needs to capture all significant influences on the flow regime within the watershed, so that the nature of the licensee's contribution to effects on flow can be ascertained. This would involve modeling at the full watershed scale, with incorporation of all existing water infrastructure and significant diverters.

Fourth, the license should be structured to assure that the licensee's contribution to ecological sustainability is proportionate to project effects. While the ecosystem scope is necessary context for understanding the project's direct, indirect, and cumulative effects, the license may only hold the licensee responsible to address its contribution to such effects. Conservation groups and agencies should not hold the licensee solely responsible for effects that may result from multiple effects, just as licensees should not use the complexity and abundance of effects within a river basin to avoid taking responsibility for

Using the ESWM Framework in a FERC Relicensing

During recent settlement discussions for Federal Energy Regulatory Commission (FERC) relicensing of the 230-MW Gaston and 100-MW Roanoke Rapids hydro projects on the Roanoke River in Virginia, the ecologically sustainable water management (ESWM) framework was used.

Dominion Generation owns and operates the Gaston and Roanoke Rapids projects. The original FERC operating license was issued in 1951, and the projects began operating in 1955 and 1963. During relicensing proceedings, conservation interests and other stakeholders expressed concerns about project-related effects to fisheries and wildlife inhabiting the river's extensive floodplain forest.

Scientific analysis helped pinpoint key conflicts between the water needs of the ecosystem (Step 1 of the ESWM framework, as shown in Figure 1 on page 86) and hydropower operations (ESWM's Step 2). One area of potential incompatibility, discovered in Step 3 of the ESWM framework, involved tree growth. During each summer growing season, tree seedlings sprout on the forest floor. But each year, prolonged high flow releases from the upstream hydro projects submerge and kill the young trees.

Scientists from The Nature Conservancy formulated some hypotheses about how much flooding the seedlings could take, but these scientists were hesitant about locking in new management requirements for 30 to 50 years — the typical term of a FERC license. The scientists also knew Dominion would be reluctant to commit to license conditions that required a change in operations — and reduced hydropower revenues — when they could not be assured that the new requirements would enable the forest to regenerate properly. The Nature Conservancy and other conservation interests met with Dominion several times to discuss what Dominion knew about the flooding effects on tree regeneration and asked Dominion to consider reducing the unnatural flooding during the summer growing season (Step 4). Specifically, the conservation interests asked Dominion to implement an adaptive management program.

Under the terms of the resulting settlement, Dominion will reduce flow alterations from its hydro projects in stages until the forest begins to reproduce at a sustainable rate (Step 5). Specifically, Dominion will lessen flooding caused by its hydro projects by 50 percent in the first five years and will reduce its remaining flow effects by half in each subsequent five-year period. Under an adaptive management plan, The Nature Conservancy and other scientists will monitor the response of the forest (Step 6). Once the desired ecological conditions are attained, Dominion will not need to make any further adjustments.

This adaptive approach has many attractive features. Conservationists are assured that desired ecological conditions will be attained, even though it will take some time before the forest regains its health. The utility is assured that the changes imposed on its operations will not overshoot what is required to attain the ecological goals, because each restoration step is a short one. Further, the restoration steps are taken at a pace that enables the company to develop ways to offset the loss of electrical power generation capacity and revenues from the Roanoke River projects.

some portion of its condition.

Finally, interested parties need to be willing to commit to a longer-term, adaptive management program that targets any critical scientific uncertainties remaining after the study plan is complete (see the final step in Figure 1). We recommend the license settlement be quite specific about the goals of the adaptive management program and responsibilities for monitoring progress toward those goals, and provide adequate clarity about the range of likely operational adjustments that could be imposed as a result of any new findings during the adaptive management program. This latter point is important in providing the licensee with sufficient certainty to enable planning for future revenue and power generation.

Changing expectations

The rules of the water game are changing rapidly. Our society holds different expectations for protecting rivers and associated fish and wildlife populations than it did just two decades ago. Scientific understanding of the water needs of river ecosystems and species has advanced substantially in the past decade. Water managers and users face considerable challenges in their efforts to adapt to a changing suite of laws, regulations, and social values that affect the governance of water and rivers. We believe the ESWM framework can help facilitate an efficient exploration for compatible management solutions that address the needs of both people and nature, while maintaining flexibility in an ever-changing world. ■

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Notes

[1] *First Iowa HydroElectric Cooperative v. Federal Power Commission,* 328 U.S. 152, 180 (1946).

[2] 16 U.S.C. § 803(a)(1); *Udall v. Federal Power Commission,* 387 U.S. 428 (1967).

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