The HELP (Hydrology for the Environment, Life and Policy) Experience in North America

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Introduction

Gleick (2002) notes that "1.2 billion people live in a life of poverty without access to safe drinking water, and that almost 2.5 billion have no access to proper sanitation." Many in the international water community stress the importance of integrated water-resources management (IWRM) to address these challenges. They argue that this is the most effective means of sustaining economic and social welfare while protecting the health of vital ecosystems. One reaction to this call for more effective management has been the Hydrology for the Environment, Life and Policy initiative, or HELP[1]. HELP has created a framework that enables water-law and policy experts, water-resources managers, and scientists to work together on water-related problems.

HELP is a joint initiative of UNESCO and the World Meteorological Organization (WMO). Its primary goals are to:

- establish a global network of HELP basins with operational links between research scientists and policymakers;
- direct hydrological science toward integrated basin policy and management;
- provide opportunities to learn lessons from other basins; and,
- promote social and economic well-being of stakeholders via sustainable use of water as an ecological resource.

With these goals, scientists, managers, policy experts, and other stakeholders within HELP watersheds address locally defined water-related issues, including water and climate; water and food; water quality and human health; water and environment; and water and conflict.

[1]HELP background information is largely drawn from Varady et al. (in press) and additional information on the program can be found on the HELP Web site at: http://www.unesco.org/ihp/help.

HELP attempts to addresses the traditional separation between water policy, water-resources management, and scientific communities, especially in terms of setting research agendas and the free flow of information for use in management. The separation, or "paradigm lock" between research scientists and management, while not universal, is widespread. Dogmatic and often regulated approaches to resource management promote isolation of knowledge "generators" from knowledge "users." This stifles innovation and leads to management decisions that are often inefficient and ineffective and do not use the best available science.

Reinforcement tends to strengthen each group's isolation from the other.
To break this lock, HELP advocates the critical need for new knowledge that is produced in response to the needs of a community of water users. To be effective, this research should be planned jointly with policy and decisionmakers and socially accountable and reflexive, just as is decisionmaking by elected officials. This requires active engagement and ongoing communication between researchers and decision-makers, as well as building trust between the various groups–an ingredient essential to the process. This typically requires a long-term commitment on all sides. Long-term in this sense, usually exceeds the common three-year grant cycles that fund most natural-resources research efforts.

The initial "assessment stage" of HELP synthesizes existing knowledge, integrates such information across disciplines as part of IWRM, and provides two main outputs: (1) simulation of future change scenarios in the water cycle and supply/demand for different future catchment states, and (2) definition of "gaps" in scientific knowledge that require development of a technical implementation strategy by hydrologists in collaboration with basin stakeholders and managers. The outputs from the assessment stage answer a common criticism from policymakers, especially at the national-government level, that scientists fail to share knowledge with users. Integration of knowledge across disciplines improves IWRM and informs the public. This can be achieved by simulating alternative management decisions linked with ecohydrology and socioeconomic sustainability (Bonnell 2005).

After establishing an agenda for scientific research and creating a science plan, HELP advances to a research stage. This second stage requires continued dialogue with land-water managers and policymakers to ensure that research results are used to update management and policy tools. It is important to realize in evaluating the work of the HELP basins described in this paper, that some, such as the Wil amette and Luquillo Basins are still in the assessment stage, while others, such as the Lake Ontario-St. Lawrence River and the Upper San Pedro Basins, are moving from the research stage into the third stage, implementation.

HELP in North America

There are numerous permutations of watershed/river-basin management approaches. In North America and throughout the world, these depend on the institutional setting of the basin. Recently in North America there has been momentum towards grassroots watershed management organizations. Such organizations, relying on bottom-up public participation and nongovernmental-organization (NGO) involvement, attempt to coordinate management programs of the various fragmented water management institutions in a given basin (regulatory agencies, planning commissions, development agencies, municipalities, etc.). One can view this continuum of institutional organization for water planning and management through the HELP basins in North America. Each type has its merits and transferable lessons that could be added to the "toolkit" of future approaches to integrated water resources management and sustainable development.

Five of the 11 North American HELP basins (Willamette River, Luquillo Mountains, Upper San Pedro River, Lake Champlain, and Lake Ontario-St. Lawrence River) are described in greater detail in the following sections. Representatives from the basins were asked to assess their current relationship to the HELP program in the context of the following questions.

1. What are the principal/critical water management issues in the basin? Is there "official" institutional (vs. academic) documentation of these issues that could help mobilize communities/agencies and prioritize science funding?
2. What are key innovative scientific breakthroughs that have had a direct and material bearing on recent water management decisions?
3. What key innovative water management initiatives have HELP participants influenced in your basin (e.g., new reservoir allocation; water conservation plans, groundwater management regulations, water quality pollution trading plan, etc.)?
4. Does a watershed Master Plan exist? How/what has HELP participation contributed to the development of this plan?
5. Have you engaged in creating a new institutional framework? What are its elements? What specific authorities does the organization (e.g., watershed council) have?
6. What other HELP basins are comparable to your basin in terms of climate, mix of water uses and water management problems? What practical institutional, management and scientific innovations might be transferable to those basins?

Understandably, representatives from the five basins selected here have chosen to emphasize these questions differently, depending on their stage of development and driving interests in each basin and. Likewise, there are vast differences in scale from the Upper San Pedro Basin to the much larger Lake Ontario-St Lawrence River (LOSLR). Their experiences illustrate both the wide variety of specific issues faced in the different basins and common themes among them.

Willamette River Basin

This basin, located in western Oregon, is one of the most important watersheds in the state. As a major tributary of the Columbia River (the world's most dammed river), the Willamette encompasses 12 percent of the State of Oregon, is home to 69 percent of Oregon's population, and accounts for 31 percent of the timber harvested and 45 percent of the market value of agricultural production in the state. The basin also contains the richest native fish fauna in the state, as well as several threatened or endangered species. Human populations in the basin are expected to double in the next 25 years, creating major challenges for land and water-use planning and management (http://www.oregonwri.org/basin-info/floodrpt.html). The residents of the Willamette Valley (in urban areas such as Portland, Eugene, and Corvallis) have recognized the vital importance of water in sustaining human and environmental health. The Oregon Plan for Salmon and Watersheds (http://www.oregon-plan.org/) atteststo this.

Despite this Oregon Plan for Salmon and Watersheds and other high profile activities and a wide variety of organized groups, no research programs have been forthcoming that would address key water resource issues in the field and integrate them with policy and management needs. With this in mind, the Willamette Basin HELP effort tries to provide a mechanism to bring research more directly into resource management and decisionmaking within the basin. The diversity of well-established institutions and stakeholders – there are, for example, 25 established watershed councils operating in sub-basins of the Willamette – imposes a set of constraints upon the timing of on-the-ground initiatives or decisions that the newly formed HELP effort might develop and implement. At present, these decisions and initiatives are being developed independently of the HELP initiative, albeit generally at a more local sub-basin scale.

Even with a humid setting, water scarcity and water supply under a variable climate are key issues related to watershed planning, given the projected population growth. Tradeoffs in water allocation to reservoir operation are one of the strategies used to address problems with urban water supply, low stream flow, temperature, and TMDLs. The Willamette Basin Planning Atlas (see http://willametteexplorer.info /mappingtools/) is perhaps the biggest breakthrough in providing complete coverage of resources in the basin and planning trajectories for assessing impacts of land use change in the Willamette Valley in the next 40 years.

At the same time, this team has had little material effect on water management activities by state and federal agencies in the basin. However, the HELP group is trying to link stakeholder interests within the realities of water resource manager constraints, by defining the major water transfer processes in the system. Initial research has shown how geological differences in storage regulate flows through the year – where High Cascade groundwater systems exert a disproportionate effect of summer low flows in the main stem. This is an early step in the process of developing a watershed managment plan for the basin.

The Pacific Northwest Hydrologic Observatory (PNW HO) will be the new institutional framework. This team is bringing together the various science, management and policy groups to address the key issues (both scientific and policy relevant) for new organization around quantification of how much water, what quality, what timing and at whose expense.

The Willamette Basin Planning Atlas is a template that others could follow for defining resources in one comprehensive volume with change trajectories to be explored.

Luquillo Mountains Basin

In northeast Puerto Rico, the Luquillo Mountains are a major source of municipal water, a major recreation attraction, and a center for regional biodiversity. Within the Luquillo Mountains, only the highest elevations are protected by the USDA Caribbean National Forest (CNF). This forest, also known as the Luquillo Experimental Forest (LEF) or El Yunque, is a tropical rainforest that receives up to 5000 mm of rain each year and yields nearly on average 276 hm^3/yr (200 million gallons of water per day; Scatena and Johnson 2001). It is also home to over 400 species of plants and 143 species of terrestrial animals, fish, shrimp, and freshwater snails. The CNF is also a United Nations Man and Biosphere Reserve dedicated to nature preservation and scientific research. As an important recreation and tourist attraction, the Luquillo Mountains receive about 700,000 visitors per year.

Seven major rivers have headwaters in the Luquillo Mountains. While 11,330 ha of land in the headwaters of these rivers have been protected for over a century, the lowlands are not. In recent decades, land use in the periphery of the Luquillo Mountains has changed drastically. For instance, between 1936 and 1995, agricultural lands decreased 47 percent, forest land increased 92 percent and urban areas increased by 2,185 percent (Lugo et al. 2004).

In addition to posing a threat to proclaimed forestlands, urban expansion has exerted high pressure over water resources. By the early 1990s, it was estimated (Nauman 1994; Scatena and Johnson 2001) that, on a typical day, more than 50 percent of the water draining the Luquillo Mountains was appropriated before it reached the ocean. More recent estimates suggest that this has increased over the last decade (C. Pringle, 2005).

Future population scenarios suggest that water demands will continue to increase as urban development continues. Population in the Luquillo Mountains is projected to increase from 280,000 to 320,000 inhabitants over the next 20 years at an average rate of 0.35 percent per year (Puerto Rico Planning Board 1995). In addition, water use efficiency and productivity is low. By 1995, per capita water use in the Luquillo Mountains region was among the highest in the world at 193.5 gallons/pc/day (Ortiz-Zayas and Scatena 2004). Leaks in the water distribution system, illegal connections, and accounting errors consume nearly 42 percent of the water.

Seeking international collaboration and information exchange on IWRM, the Luquillo Mountains joined the pilot phase of the HELP Program in 1999. The Luquillo Mountains HELP Project seeks the sustainable development of the region by implementing IWRM strategies as a mean for protecting the ecological integrity of the forest and the ecosystem services that it provides. It also disseminates water-related information among all stakeholders interested in water management in this area. These groups include communities that are supplied with water generated in the Luquillo Mountains, forest managers, aquatic research scientists, water resources managers, and those in charge of developing public policy.

Over the last decade, an increased level of environmental awareness and recent federal and state legislation has prompted new approaches to water resources management in the Luquillo Mountains, including productive interagency collaborations. The incorporation of a hyporheic water-extraction system in the Río Mameyes and the construction of off-stream reservoirs in Río Fajardo and Río Blanco that allow migration of river fauna and reduce sedimentation resulted from collaboration between water interest groups. In addition, changes in water extraction schedules that favor the life cycles of amphidromous fish and shrimp have resulted from applied limnological research. Another important step towards IWRM is the promotion of wastewater reuse as an alternative water source for irrigation of golf courses. Lastly, the recent designation by the U.S. federal government of two rivers draining the Luquillo Mountains as Wild and Scenic Rivers represents the first designation of this type made in Puerto Rico and in a tropical U.S. territory. This means that the rivers and riparian zones will remain in an essentially primitive condition and free of anthropogenic modification.

Despite these advancements, new issues associated with urban expansion will likely emerge. To prevent future water-related conflicts a more formal planning forum for effective IWRM implementation is necessary. The fact that Puerto Rico is developing a new water plan that promotes watershed-level organizations offers an opportunity to formalize interactions between stakeholders, scientists, water managers, and policy makers. Such an interaction should yield a watershed management plan for the Luquillo Mountains with broad public and institutional participation.

Upper San Pedro Basin

The semi-arid Upper San Pedro River Basin (USPB) originates in northern Sonora, Mexico, and flows north into Arizona. The upper watershed encompasses an area of 7600 km^2 with approximately 1800 km^2 of that area in Mexico. Annual precipitation ranges from around 300 mm in the lower portions of the basin to over 750 mm in the mountains with large inter-annual variability.

As the last perennial stream in the region, the San Pedro River serves as an international flyway for over 400 species of birds. One of the most ecologically diverse areas in the western hemisphere, the basin contains as many as 20 different biotic communities, supports a number of endangered plant and animal species, and supports the second highest known number of mammal species in the world. It has been designated a globally important bird habitat by the Audubon Society and one of the World's Last Great Places by The Nature Conservancy.

In 1988, the United States Congress established the San Pedro Riparian National Conservation Area (SPRNCA), the first of its kind in the nation, to protect riparian resources north of the US-Mexico border. The aquifer that sustains perennial flows in the San Pedro is the sole source of water for two major, and growing, economic drivers in the basin: The Cananea mines in Mexico which produce 2-3 percent of the worlds copper; and the Fort Huachuca Army base is the largest employer in southern Arizona.

The most critical water management issue in the basin is ensuring sufficient water for: (1) current and future residents of the basin; (2) mining of still extensive copper ore bodies; and, (3) maintaining the viability of the riparian system in a bi-national basin.

Water quality is also a major challenge in the Mexico portion of the basin. The existing deficit in the basin water balance and the threat of continued growth of groundwater pumping to this riparian system prompted the first application of international environmental law within the U.S. via the North American Free Trade Agreement (CEC, 1999).

In 2002, the U.S. Fish and Wildlife Service issued its most recent Biological Opinion regarding Fort Huachuca's operations in relationship to endangered species. In this document, numerous conservation measures were proposed by the Fort over a ten-year period to offset 60 percent of the groundwater deficit.

Several innovative scientific findings have had a direct bearing on water management decisions; invasive mesquite trees can reverse sap flow direction and effectively bank precipitation and surface water (even in the winter when the trees appear dormant) below the root zone of competing shallow rooted plants (Hultine et al., 2004). This finding accelerated efforts by Bureau of Land Management to remove mesquite in riparian areas to reduce plant water use and alter overall basin water budgets. Unlike humid regions where urbanization reduces recharge, in arid and semi-arid regions, urbanization increases opportunity for recharge as water is concentrated in ephemeral channels that would normally infiltrate and transpire or evaporate on upland hill slopes (Goodrich et al., 2004, GeoSystems Analysis, 2004). As a result, the city and county are designing flood control structures to optimize recharge.

In the Sierra Vista subwatershed in the U.S. portion of the basin, HELP members have participated in the development and consideration of over 50 water conservation and augmentation strategies, many currently being implemented by the USPP (http://www.usppartnership.com/documents.html#consplan).

In Mexico, HELP has facilitated binational technological discussions and environmental education workshops leading to an analysis and prioritization of transboundary water treatment, water delivery, and conservation projects. Lack of funding is blocking implementation of these projects, but HELP is also facilitating discussions with the World Bank via the GEF program to seek financial resources.

The USPP publishes an annual "Working Water Conservation and Management Plan" (http://www.usppartnership.com/documents/2004.plan.pdf). HELP members are actively involved in the development of this plan on an on-going basis. A formal plan does not exist in the Mexican portion of the San Pedro but is a stated national goal of the Mexican Water Commission (CNA) in their "culture of water" formulated in 2001.

In Mexico the CNA has provided guidelines in 2001 for restructuring the management of water resources and aquifers through watershed councils (SEMARNAT CNA 2002). The formation of watershed councils has been one of the slowest aspects of the reform program, and since very few are operative, when such a council is officially created, the San Pedro Basin may be in the vanguard of the reform process in Mexico (Browning et al. 2004). HELP is attempting to facilitate this process.

The Luquillo Mountains Basin (Puerto Rico) offers an opportunity to share with the San Pedro Basin lessons learned about (1) establishing an effective institution for water use planning and allocation, (2) evaluating land use change and river integrity, (3) obtaining funding for stakeholder-driven research, and (4) understanding the decentralization of water services. In addition, woody species invasion into semi-arid grasslands is occurring worldwide.

The scientific findings of desert plant physiology and water use as well as recharge mechanisms will be applicable to all HELP basins with similar characteristics. Another set of lessons could be learned from a comparison of the collaborative process and partnership strategies of the San Pedro and *Lake Champlain Basins.*

Finally, the San Pedro Basin provides an example for other HELP basins in the importance of communication and networking within and across a transboundary basin – a situation that vastly complicates issues and amplifies disparities. Legal and institutional differences across international borders are especially stark, and overcoming the obstacles they pose offers a special challenge to planners, scientists, and policymakers

Lake Champlain Basin

The Lake Champlain basin occupies 21,326 km^2 just south of the St. Lawrence River in the United States and Canada. Approximately, 56 percent of the basin lies in Vermont (USA), 37 percent is in New York (USA), and 7 percent is in Quebec (Canada). The lake level at about 29.5 m AMSL and the highest point in the basin is in New York at Mt. Marcy (1629 m). Lake Champlain is about 193 long and 19 km at its widest point and occupies 1,136 km^2. There are 18 rivers that drain the Lake Champlain watershed, each of which is gauged. Lake Champlain consists of five distinct segments, each with its own physical and chemical characteristics. Annual discharge from Lake Champlain (Richelieu River) is 9.5 x 10^9 m^3. The region has a continental climate and is seasonal, with warm humid summers and frigid humid winters.

The land use and land cover in the Lake Champlain Basin varies from alpine meadows in the mountains to lakeside floodplain forest. A century ago over half of the land surface of the basin was cleared for timber, firewood and farming and forestry and agriculture continue to be important land uses. Currently, 70 percent of the land is forested, 15 percent is agricultural, and 5 percent is urban and suburban. The basin's human population is about 600,000 (2000 US Census, 2001 Census of Canada), largely in small towns, villages and hamlets. Approximately 45 percent of basin population lives in shoreline towns. Important resource uses associated with the lake include water supply for 200,000 residents, recreational fisheries, recreational boating and water sports, and cultural heritage tourism.

The Lake Champlain Basin Program (LCBP) was established to provide an institutional framework for the implementation of a management plan for Lake Champlain and its watershed. The LCBP is a partnership between the States of New York and Vermont, the Province of Québec, the USEPA, other federal and local government agencies, local NGO groups and citizen leaders. Created by Congress through the Lake Champlain Special Designation Act of 1990 (Public Law 101-596) and updated with a continuing authorization in 2002 (Public Law 107-303), the primary work of the LCBP is implementation of *Opportunities for Action,* the basin wide comprehensive management plan approved by all involved jurisdictions. The LCBP has substantially reduced water pollution and has informed and mobilized governments and citizen's groups to improve watershed management.

Principal water-management issues, expressed in *Opportunities for Action* (2003), detail needed actions, timelines, costs, and likely implementation partners. The plan identifies four high priorities that guide remedial, preventive and restorative actions by New York, Vermont, Quebec, and U.S. federal agency partners:

- Phosphorus Reduction: Phosphorus concentrations in shallow and near-shore areas of the lake are high enough to support excessive algaepopulations.

- Toxic Substance Reductions: Lake water contains unacceptable levels of polychlorinated biphenyls (PCBs) and mercury (Hg), prompting New York and Vermont to issue health advisories to limit the consumption of certain fish species. Toxins periodically generated by cyanobacteria in certain parts of the lake having excessive nutrient concentrations represent a significant public concern, though most of the lake is unaffected by cyanobacteria blooms.

- Non-native Aquatic Species Management: Ecosystem integrity and human enjoyment of Lake Champlain have been profoundly impacted by infestations of non-native aquatic nuisance species, such as sea lamprey, water chestnut, Eurasian water milfoil, and zebra mussels. The discovery of alewife adults in Lake Champlain is the latest of invasive species management challenges.

- Human Health Protection: Illness from coliform bacteria contamination in parts of Lake Champlain can be due to agricultural wastes, failed septic tanks, combined sewer overflows and sanitary sewer overflows, and urban storm water runoff. Toxins associated with blue-green algae blooms in parts of the lake are a new threat. Beach closings to protect public health are more frequent and cause both environmental and economic concerns.

To address these priorities, the LCBP supports annual long-term water quality and biological monitoring at 14 lake stations (22 parameters) and 18 major tributaries entering the lake (15 parameters). This program has been funded and maintained by the LCBP since1992, so monitoring data and summary statistics describing the basin are available online at http://www.lcbp.org. Annual reports for each year and long term trend analyses are available in the Technical Report Series and open files of the LCBP. A compendium of baseline information on the Lake Champlain Basin is available in Manley and Manley (1999).

The LCBP funds essential new research to inform critical management issues, including an Ecosystem Indicators Program that is tailored to the special needs of the basin, a library of Technical Reports, an Atlas of the Basin, and numerous innovative resources available at http://www.lcbp.org. Innovative water management_arising from the efforts of the LCBP is guided by the best available physical and natural science in a consensus-based collaborative approach involving a broad array of stakeholders. The plan encourages partnerships with existing agencies and organizations to implement needed actions rather than unfunded regulatory mandates. Water quality protection is advanced through an ecosystem approach in the context of watershed rather than political boundaries. Pollution prevention is emphasized as a cost-effective means to protect the environment by eliminating pollution before it is generated.

The LCBP was established prior to HELP and has established a history of science-based adaptive management, policy development, and plan implementation. Sister lake programs and involvement in international lake management networking, including support for the development of Lakenet, have been an integral part of the collaborative program history. This history aligns very closely with HELP priorities and provides a working model of participatory, science-based management incorporating cross-boundary initiatives

Lake Ontario-St. Lawrence River

There are numerous permutations of watershed/river basin management approaches, mostly dependent on the institutional setting of the basin. There is significant recent momentum toward grassroots watershed-management organizations that, in the absence of a dominant institution, such as those established by binational treaties or agreements, attempt to coordinate the programs, relying on bottom-up public participation and NGO involvement, of the various fragmented water-management institutions in a given basin (regulatory agencies, planning commissions, development agencies, municipalities, counties, etc.). This continuum of institutional organization for water planning and management exists in the North America HELP basins, each having its merits and transferable lessons that could be added to the “toolkit” of future approaches to IWRM and sustainable development.

The Lake Ontario-St. Lawrence River (LOSLR) study represents a more traditional approach, relying on a long functioning institution, the International Joint Commission (IJC), to develop a binding solution to an important subset of continuously evolving or emergent problems of the basin. The IJC deals with many different problems of the Great Lakes (water diversions and export, system operations, navigation improvements, water quality, and invasive species).

However, the fact that the IJC is coordinating all these separable actions and study boards, both within its multidimensional jurisdiction, as well as with all the federal, state, provincial and local entities, ensures a fair amount of cohesiveness and integration of the respective implementation actions. Much of the progress and advances in water management occurs when existing institutions with implementation authority undertake water management initiatives. The IJC is one such institution, established in 1909 to resolve water-related disputes along the 4,988 kilometer (3,100 mile) border of US and Canada. Their mandate encompasses fairly large river basins such as the Columbia, Red River, the Great Lakes, and numerous smaller watersheds.

The original priorities for Lake Ontario regulation were stipulated to be municipal and industrial water supply, irrigation water, navigation and hydroelectric power. Upon completion of the St. Lawrence Seaway and installation of a series of hydroelectric power plants, which required new operating rules for the LOSLR system, coincidentally there occurred a significant shift in hydrology (lowest flows of record in 1963-66, followed by 40 years of above average lake levels), coupled with evolving demands from three new major interest groups (recreational boaters, riparian homeowners, and environmentalists) to modify the regulation plan to accommodate their needs and adjust to the modern hydrologic regime.

One of the unique aspects of the study is that the fourteen member Study Board, with equal representation from the U.S. and Canada, including Native Americans, is an independent body that makes recommendations to the IJC. The IJC also has engaged a 24-member, independent Public Interest Advisory Group (PIAG), which assists the Board with public outreach, involvement, and advice. The Study Board organized ten Technical Working Groups, which engage over 150 scientists, engineers, ecologists and economists from academia and federal, state and local agencies to undertake the scores of studies, extensive primary data collection, and development of state-of-the art models for evaluation and decision-making that are required to provide answers to the basic issues.

Numerous planning, evaluation, public involvement and technological innovations were required to answer the basic mandate – i.e. how to develop new operating rules that increase the benefits for three new, politically powerful water using sectors without diminishing the benefits of the pre-existing economically important sectors mentioned in the treaty as priorities identify. Original science and technological work was undertaken to answer the questions and issues raised by the public:

- Primary, baseline data collection (bathymetric and topographic LIDAR mapping of entire shoreline, 32 monitored wetlands sites; 700 boating marinas, 70 water supply intakes and wastewater effluent pipes, 600 indicator species; erosion and flood survey; etc.) and modeling was undertaken for each one of the sectors, so that the economic and environmental information could be equally available.

- Public participation generated key information needs for technical analysis, basic scientific research, plan formulation and evaluation – this included the development of preferred lake levels and water flows (over 90 hydrologic criteria) and evaluation impact indicators (over 60 principal performance indicators, and 600 environmental indicators).

- The development of a suite of specific econometric, ecological, hydrological, climate change, and decisionmaking models for each of the sectors to generate predictions and impacts under a wide range of regulation plans, climate change scenarios and stochastic hydrologic conditions. These include the Integrated Ecological Response

Model (IERM); the Flood and Erosion Prediction System (FEPS); and the principal decision-aiding "Shared Vision Model". The latter model was developed and updated in concert with all the technical working groups, the PIAG and public workshops. The model is on the website, and available for participants to formulate their own options and evaluate them against the hydrologic criteria, existing regulation plans and performance indicators.

Conclusions

Clearly, the issues that these five basins are attempting to address are fundamental and diverse. The interests of managers, policy makers, and communities in the other basins within the HELP network are equally complex and reflect the concerns of those living and working in basins. The U.S is fortunate in that it does not have to deal with some of the more pressing issues associated with water quantity and quality faced by developing countries, but it does share transboundary management concerns with Mexico and Canada.

Moreover, the availability of sufficient quantities of water of acceptable quality for a variety of intended or expected uses, ranks as one of the most critical issues policy makers and water managers face in North America as populations grow and economies expand. In the past well-intentioned efforts at water basin management have had unexpected consequences, or decisions made without wide consultation have generated unforeseen conflicts.

Often, the science behind these decisions has been sound and supported by the knowledge of the day. Conflicts arose not because the science was at fault, but because decision makers did not - or would not - engage in a fully consultative process. In recent decades, the power of stakeholder consultation has been proven and is widely accepted and applied. Nevertheless, the role of science in the decision-making process is still widely misunderstood by stakeholders and even by researchers themselves.

The fundamental purpose of HELP is to provide a synthesis of knowledge, tools, and experience that will facilitate better decisions about water management. While the HELP Program was initiated relatively recently, this paper indicates that it is beginning to offer practical scientific, institutional, and management innovations that are transferable not only to other HELP basins, but to other basins trying to implement integrated and sustainable water policy and practices. Once other North American HELP basins are further into the implementation stage of their programs, a more comprehensive evaluation of their accomplishments will be possible.

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